



## BEATRICE FIELD, INNER MORAY FIRTH

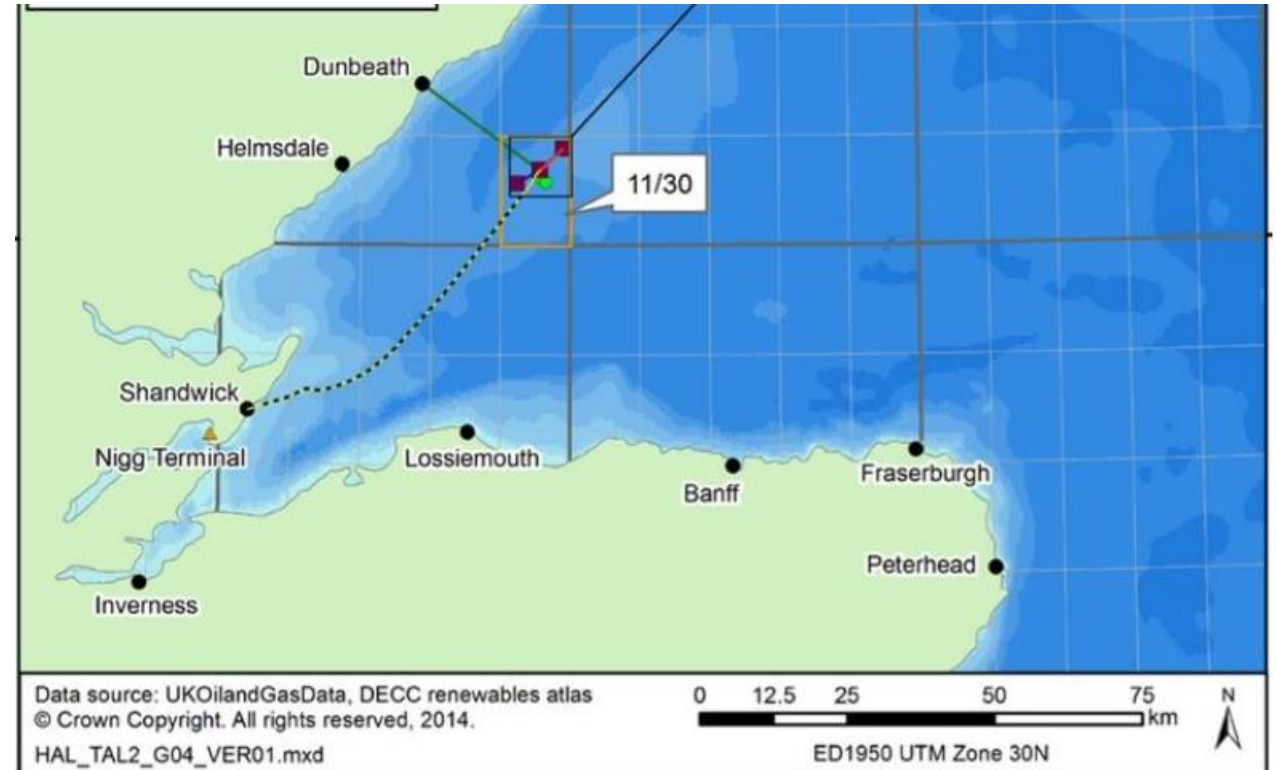
A Case Study In The Management Of Well Integrity From  
CoP Through To Well Abandonment

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7<sup>th</sup> June 2023

# Beatrice Field: Block 11/30a

- ▶ Discovered in 1976 by Mesa Petroleum
- ▶ 3 platforms, Alpha, Bravo & Charlie
- ▶ Sold to BNOG in 1978, first oil in 1981
- ▶ BNOG privatised to become Britoil in mid-80s
- ▶ BP acquired Britoil and became operator in 1988
- ▶ Acquired from BP by Talisman in 1997 as part of BP MAST
- ▶ Leased to Ithaca 2008 to 2015, Wood Group as Duty Holder
- ▶ Duty Holder transferred to Repsol Sinopec Resources UK Ltd in 2015
- ▶ Bravo & Charlie wells decommissioned 2017-18



# Beatrice Alpha

- ▶ 30 wells in total (32 slots)
  - Free flow / ESP Producers
  - Water Injectors
- ▶ Wellheads 1978-80 vintage
- ▶ Most wells have had multiple workovers
- ▶ Q4 2018: All Alpha wells prepared for Not Normally Attended (NNA) operations:
  - All wells plugged
  - Flowlines removed
  - FWVs removed and blank-flanged
  - Wireless Digital Gauges installed on annuli & tree cap
- ▶ Well abandonment planned for 2024

## PLATFORM WSIT

Asset Name: BEATRICE

Well Name: All

Slot No.: All

Well Type: All

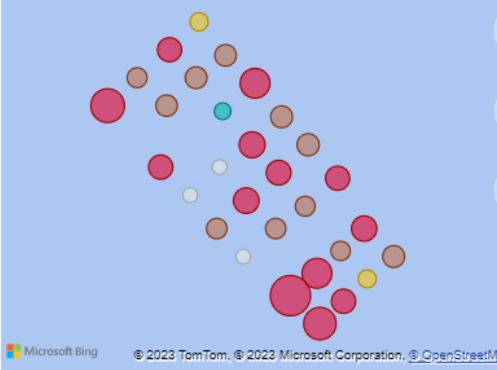
Well Status: All

Highest Risk: All

Clear all filters

Asset	Well	Slot No.	Well Type	Well Status	Potential Flow Rate (BBL/day)
BEATRICE	11/30a-A05	1	ESP/JET	Plugged	100.00
BEATRICE	11/30a-B10	1	ESP/JET	Abandoned 2	0.00
BEATRICE	11/30a-A31	10	Water Injection	Plugged	101.00
BEATRICE	11/30a-A09	11	Water Injection	Plugged	0.00
BEATRICE	11/30a-B07	11	Water Injection	Abandoned 2	0.00
BEATRICE	11/30a-A26Z	12	ESP/JET	Plugged	100.00

WSIT Map

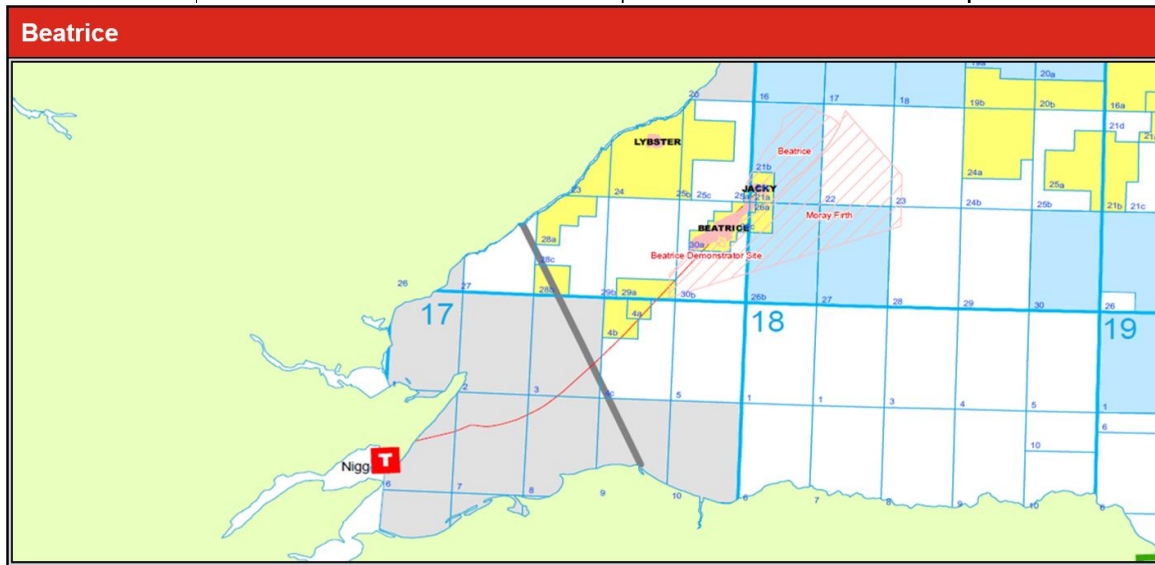


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# Environmental Concerns

	<b>SG / API</b>	<b>Vis. (temp.)</b>	<b>Pour Point (°C)</b>	<b>Wax Content (%)</b>	<b>Asphaltene (%)</b>
<b>Beatrice Crude</b>	0.844 / 36.15	13.86 cSt @ 30°C	Min. 12 /Max. 24	28.5	0.05
<b>Release source</b>	Well blowout from A18 (13)		<b>Flow rate</b>	147.86 m <sup>3</sup> / day	
<b>Anticipated well self-kill (days)</b>			Unlikely to self-kill within relief well drill timings (175 days)		

Location	Distance
Lybster, UK	22 km (NNW)
Orkney Islands	71 km (N)



**Well Blowout**

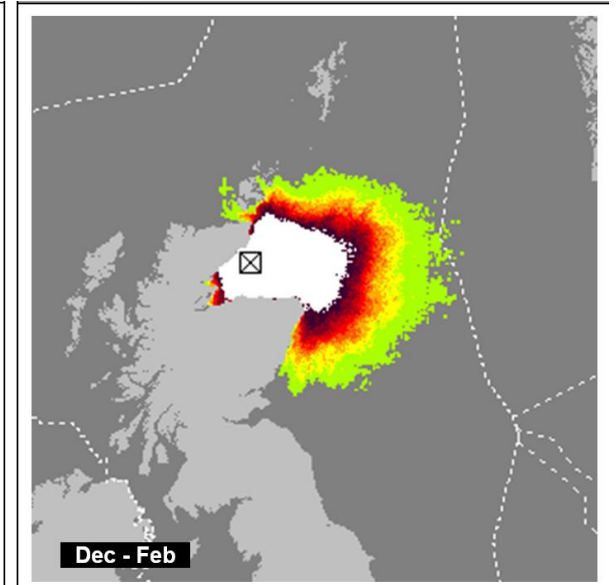
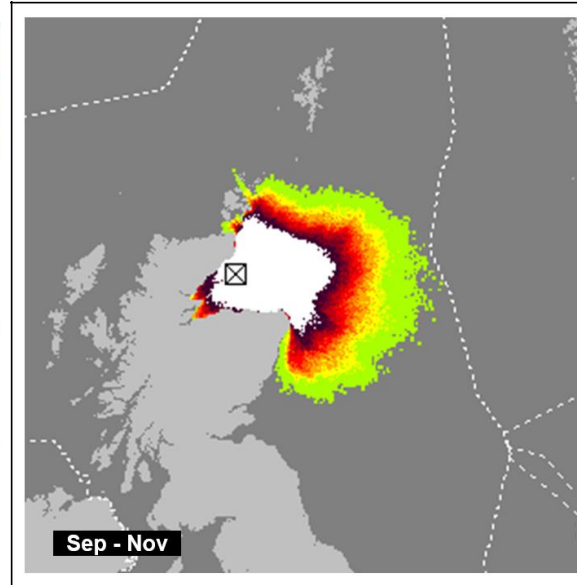
**Probability of Surface Oil Meeting or Exceeding 0.3 µm**

**Map Key**

- ☒ Release Site
- Median Line

**Probability (%) of surface oil meeting or exceeding 0.3 µm**

10 - 20	30 - 40	50 - 60	70 - 80	90 - 100
20 - 30	40 - 50	60 - 70	80 - 90	



# Well Verification

- ▶ 6 Monthly WVR: March
  - Function all valves
  - Inflow test DHSV (where installed)
  - Pressure Test / Inflow Test Control Lines
  - Inflow test plugs (1 hour)
  - Wireless gauge verification
  - KP4 survey (external condition inspection)
- ▶ 12 Monthly WVR: September – as above plus:
  - Inflow / pressure test tree and annulus valves
  - Sting wellhead voids
- ▶ Biennial Annulus Top-Up & Test
  - Each annulus topped up to surface with inhibited water
  - Pressure test to Operational MAASP



# Verification Findings

- ▶ Trees and wellheads generally in good functional state – very few issues
- ▶ A number of UMV seized open - due to limited operation (not required as barriers)
- ▶ Control Line failures occur occasionally. Injected with sealant if leak-off rate is adequate
- ▶ Since 2019 – a number of plug failures have been recorded (to be discussed on following slides)
- ▶ Main issue with Well Verification is NPT: WOW
- ▶ Typical down-time
  - March 30 – 40%
  - September 40 – 55%
- ▶ WOW is factored into the campaign duration and additional days may be added if required to complete the workscope

Well No.	A01	A02	A03	A04	A05	A06	A09	A10	A11	A12	A13	A14	A15
Tree Cap Inspection	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
Tree Cap Needle Valve	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Xmas Tree Body	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
Swab Valve SV	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
Upper Master Valve	Fail	Good	Fail	Good	Not Test	Fail	Fail	Good	Good	Good	N/A	Good	Fail
LMV	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
FVV	N/A	N/A	Good	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MFVV	Fail	Good	N/A	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
KWV	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
KW Needle Valve	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	N/A	Good	Good
Susp. Flange Valve	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Good	N/A	N/A
A-ann Valve – LS Inner	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
A-ann Valve – LS Outer	N/A	N/A	N/A	Good	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
A-ann Valve – OS Inner	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
A-ann Valve – OS Outer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B-ann Valve – LS Inner	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
B-ann Valve – LS Outer	N/A	N/A	N/A	N/A	Good	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B-ann Valve – OS Inner	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
B-ann Valve – OS Outer	N/A	N/A	N/A	N/A	Good	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C-ann Valve – LS	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
C-ann Valve – OS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
INRV / SAS – LS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
INRV / SAS – OS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

## Risk Assessment

Risk Assessment	Field	Well
WRA2473	Beatrice	A01
WRA2474	Beatrice	A19
WRA2475	Beatrice	A12z
WRA2476	Beatrice	A18
WRA2551	Beatrice	A01
WRA2552	Beatrice	A12
WRA2553	Beatrice	A18
WRA2554	Beatrice	A19
WRA2555	Beatrice	A29
WRA2556	Beatrice	A30
WRA2690	Beatrice	A32
WRA2706	Beatrice	A15
WRA2757	Beatrice	A04
WRA2758	Beatrice	A05
WRA2759	Beatrice	A10
WRA2760	Beatrice	A14
WRA2761	Beatrice	A16
WRA2762	Beatrice	A17
WRA2763	Beatrice	A22
WRA2764	Beatrice	A25
WRA2765	Beatrice	A26z
WRA2766	Beatrice	A27

## Dispensation

### Well Impairment Notification Search Criteria

**Impairment D**

Site:  Location:  Well ID:

WDISP No.:  Well Type:  Status:

Procedure(s) Contravened:  Consequence:  Severity:

Primary Failure:  Secondary Failure:  Scope:

### Results

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WDISP No.	Site	Location	Impairment Type	Status
WDISP002222	Beatrice	Platform	Prohibition	Plugged
WDISP002221	Beatrice	Platform	Prohibition	Plugged
WDISP002220	Beatrice	Platform	Prohibition	Plugged
WDISP002219	Beatrice	Platform	Prohibition	Plugged
WDISP002218	Beatrice	Platform	Prohibition	Plugged
WDISP002217	Beatrice	Platform	Prohibition	Plugged
WDISP002146	Beatrice	Platform	Deviation	Plugged
WDISP002145	Beatrice	Platform	Prohibition	Plugged
WDISP002139	Beatrice	Platform	Prohibition	Plugged

## Well Status Summary

Asset	Well	Slot No.	Well Type	Well Status
BEATRICE	11/30a-A05	1	ESP/JET	Plugged
BEATRICE	11/30a-B10	1	ESP/JET	Abandoned 2
BEATRICE	11/30a-A31	10	Water Injection	Plugged
BEATRICE	11/30a-A09	11	Water Injection	Plugged
BEATRICE	11/30a-B07	11	Water Injection	Abandoned 2
BEATRICE	11/30a-A26Z	12	ESP/JET	Plugged

### WSIT Map

## Well Status Indicator

Asset Name	Well	Slot No.	Well Type	WSIT Rank No.	WSIT Well Status
Beatrice A	11/30a-A19	/15	WI	26	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A01	/07	FF	11	Plugged
Beatrice A	11/30a-A02	/05	WI	28	Plugged
Beatrice A	11/30a-A02	/05	WI	28	Plugged
Beatrice A	11/30a-A02	/05	WI	28	Plugged

### Well Status Map

## Maximo

41 - 60 of 60

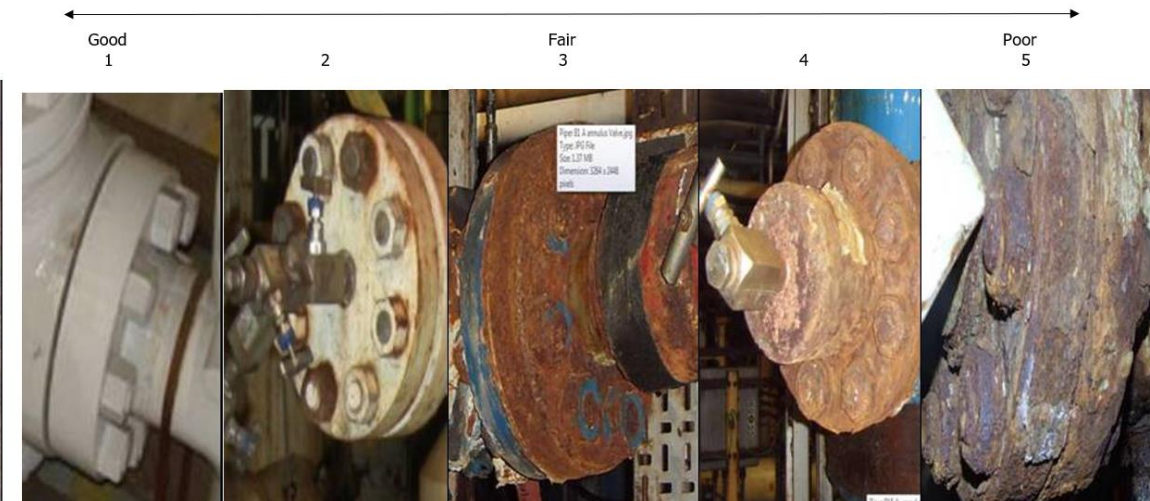
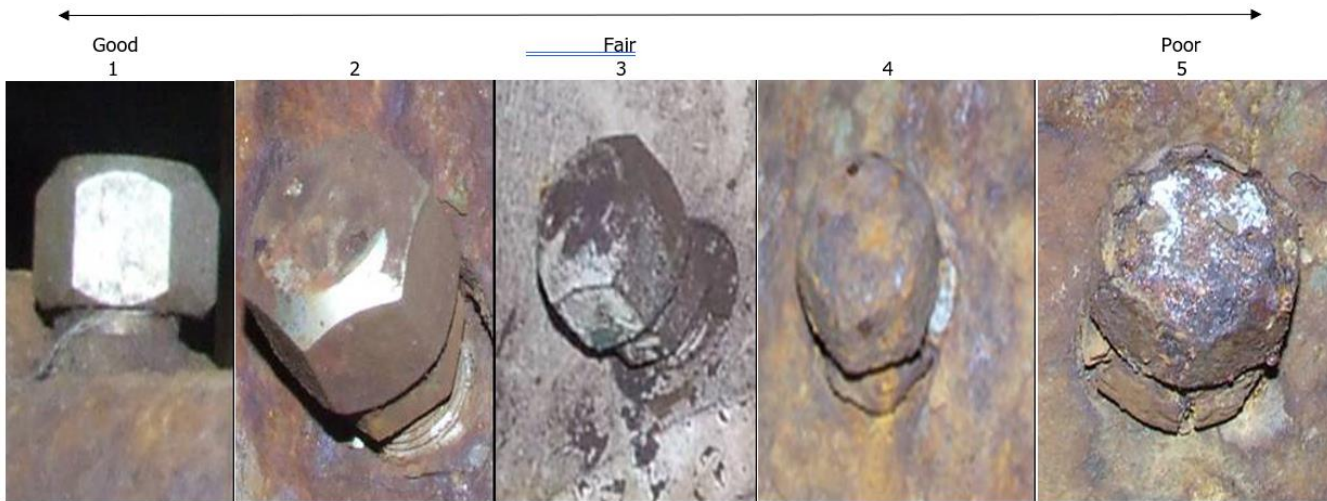
**Description**

- Beatrice 11/30a-B6A Suspended Well (Stage 1)
- Beatrice 11/30a-A3 Suspended Well (Stage 1)
- Beatrice 11/30a-A6 Suspended Well (Stage 1)
- Beatrice 11/30a-A29 Suspended Well (Stage 1)
- Beatrice 11/30a-A2 Suspended Well (Stage 1)
- Beatrice 11/30a-A4 Suspended Well (Stage 1)
- Beatrice 11/30a-A1 Suspended Well (Stage 1)
- Beatrice 11/30a-A5 Suspended Well (Stage 1)
- Beatrice 11/30a-B10 Suspended Well (Stage 1)
- Beatrice 11/30a-B8 Suspended Well (Stage 1)
- Beatrice 11/30a-A23 Suspended Well (Stage 1)
- Beatrice 11/30a-A20 Suspended Well (Stage 1)
- Beatrice 11/30a-A17 Suspended Well (Stage 1)
- Beatrice 11/30a-A33Z Suspended Well (Stage 1)

# KP4 Inspection: External Condition Assessment

- ▶ We are required by HSE / BEIS to conduct a KP4 inspection every campaign due to NNA status, as a means to monitor any ongoing degradation (other platforms every two years)
- ▶ The crews score each component against a set of reference photos
- ▶ In addition, on each campaign a set of digital photos of each component are taken as a record
- ▶ Scoring and photo references are recorded in a spreadsheet (one worksheet per well)

REPSOL SINOPEC		Wellhead and Tree Inspection Form			
		TLM-WEL-121			
Platform	Arbroath	Well No.	T-02	Date:	16/12/2020
WH Manufacturer	McEvoy/Cameron	Tree Manufacturer		Technician	
<b>IMPORTANT:</b> Refer to WEL-PRO-TLM-073 when using this Worksheet					
<span style="background-color: #90EE90; padding: 2px;">Good</span> <span style="background-color: #FFD700; padding: 2px;">Moderate</span> <span style="background-color: #FF0000; padding: 2px;">Bad</span>					
TREE CONDITION	Tree Size	4 1/16"	Pressure Rating	5000psi	
SWAB	3	7			
UMV	4	2			Weeps ?
LMV	3	9			
KWV	3	3			
FWV	4	5			
Test/grease fittings	3	7	16		
Needle Valves	3	3	4		
Gauge	Rating				Calib Cert
Impulse Line to Gauge					Weeps ?
Tree Cap	4	1	8		Weeps ?
Remarks					
FWV actuator has been removed					

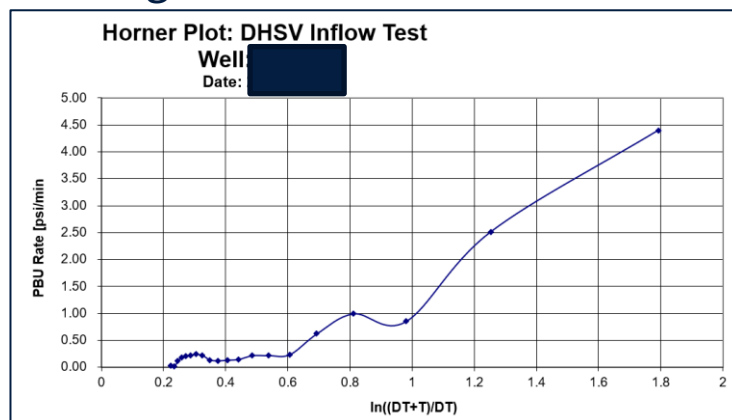




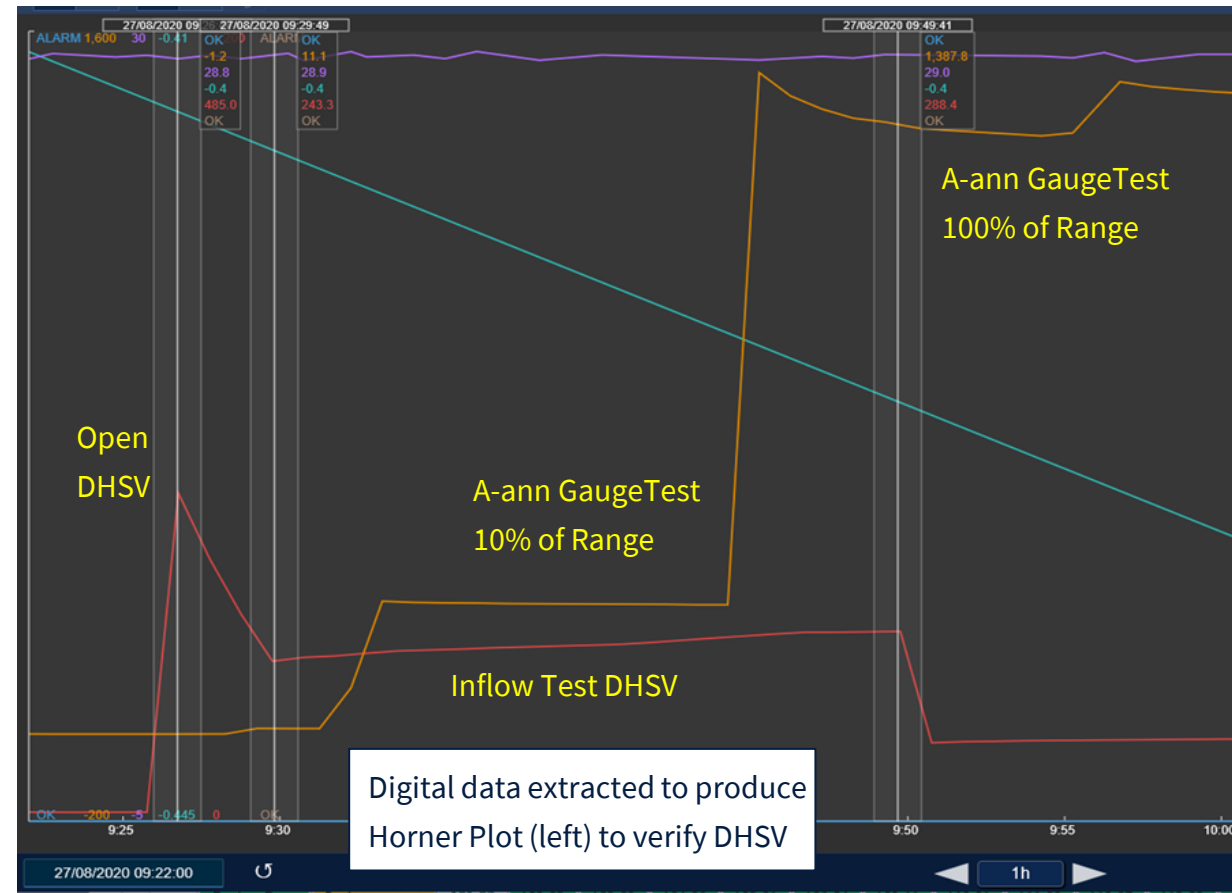


# Remote Annulus Management: Digital Gauge System

- ▶ 10 year battery life
- ▶ No maintenance / No calibration
- ▶ Data sampling every 1 minute
- ▶ Live data feed to PI Vision
- ▶ Email alerts for % of MAASP and for Rate of Change (ROC)
- ▶ Response routinely verified in PI
- ▶ Data can be extracted to Excel using PI DataLink

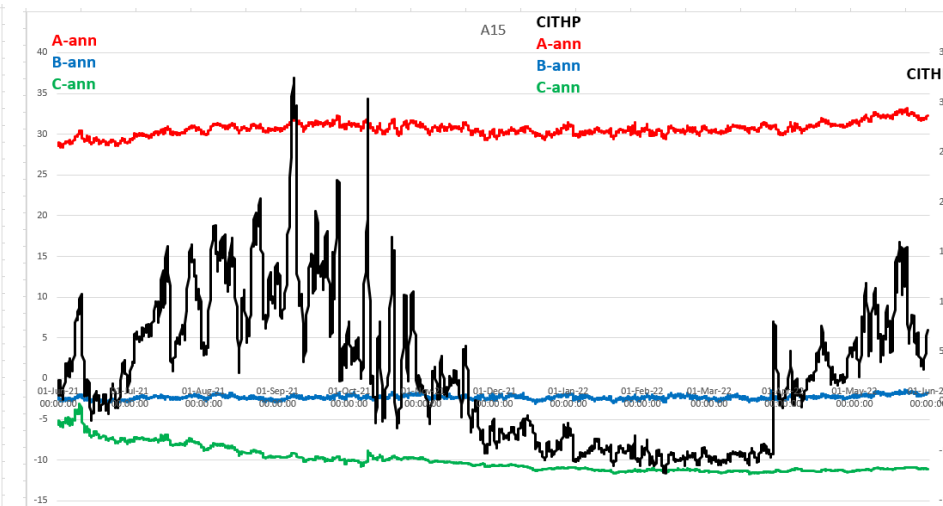
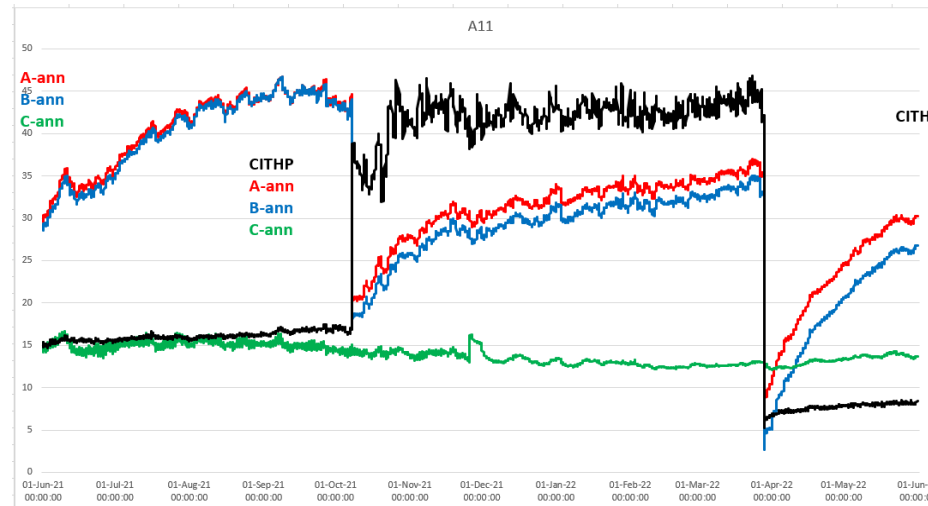
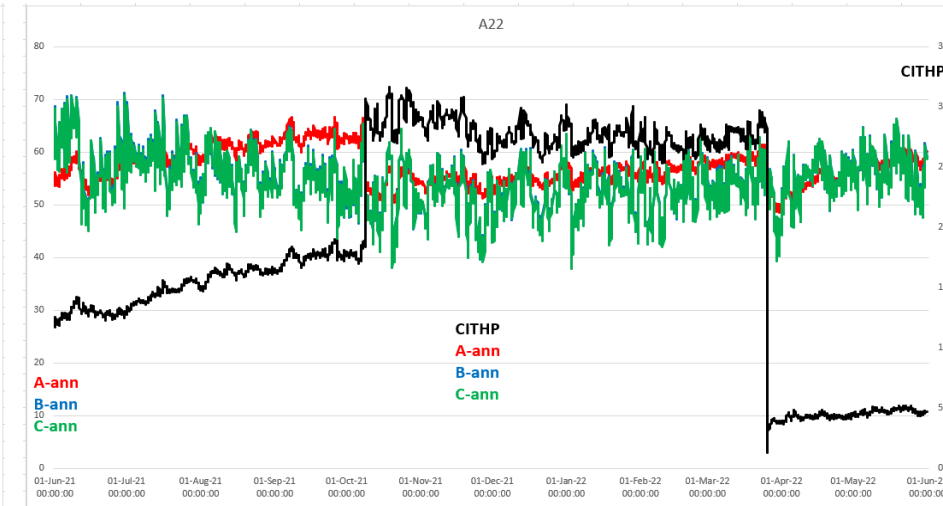
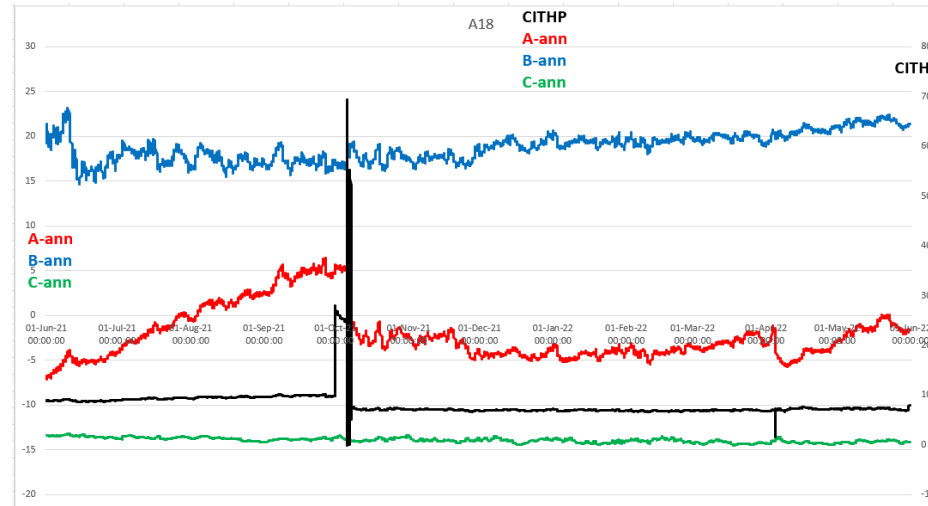


## Routine Verification Tests For Gauge Response



# Annulus Reviews

- ▶ Detailed annulus monitoring program in place long before NNA
- ▶ Annulus behaviour is well understood
- ▶ No threat of MAASP excursions during winter unmanned period (end of September to start of March)
- ▶ No reactive annulus management to date



# Annulus Sampling

- ▶ Annulus reviews identify wells of interest, based on:
  - Sustained annulus pressure (SAP)
  - Charging after blowdown
  - Effluent properties (i.e. regularly blowing down gas)
- ▶ Extensive sampling campaign conducted September 2022 (40 total)
- ▶ Sampling objectives:
  - Determine fluid contents of annulus (gas / liquid) and potential source
  - Gas: C1-C10, N2, CO2, H2S by Gas Chromatography
  - Hydrocarbon liquid – base oil / refined oil / crude by Gas Chrom / Fingerprint Analysis
  - Water – 16 Ion analysis
- ▶ Results to form input to well abandonment design

Well	A-ann	B-ann	C-ann	Well	A-ann	B-ann	C-ann
A01/07		1		A18/13		1	
A02/05	1			A19/15	1	1	
A03/03		1		A20/16	1		
A04/06		1		A21/17	1		
A05/01				A22/32	1	1	1
A06/04	1	1		A23/09		1	
A09/11		1		A25/14	1		
A10/31	1	1		A26z/12	1	1	
A11/22	1	1		A27/24	1		
A12/27		1	1	A28/18			
A13/29				A29/02	1	1	
A14/28	1			A30/08	1	1	
A15/21	1			A31/10			
A16/30	1	1		A32/26	1	1	
A17/19	1			A33z/20	1	1	
<b>Total A-ann</b>						<b>19</b>	
<b>Total B-ann</b>						<b>18</b>	
<b>Total C-ann</b>						<b>2</b>	

# Gas Ratio Analysis

▶ Haworth, Sellens & Whittaker: 1985

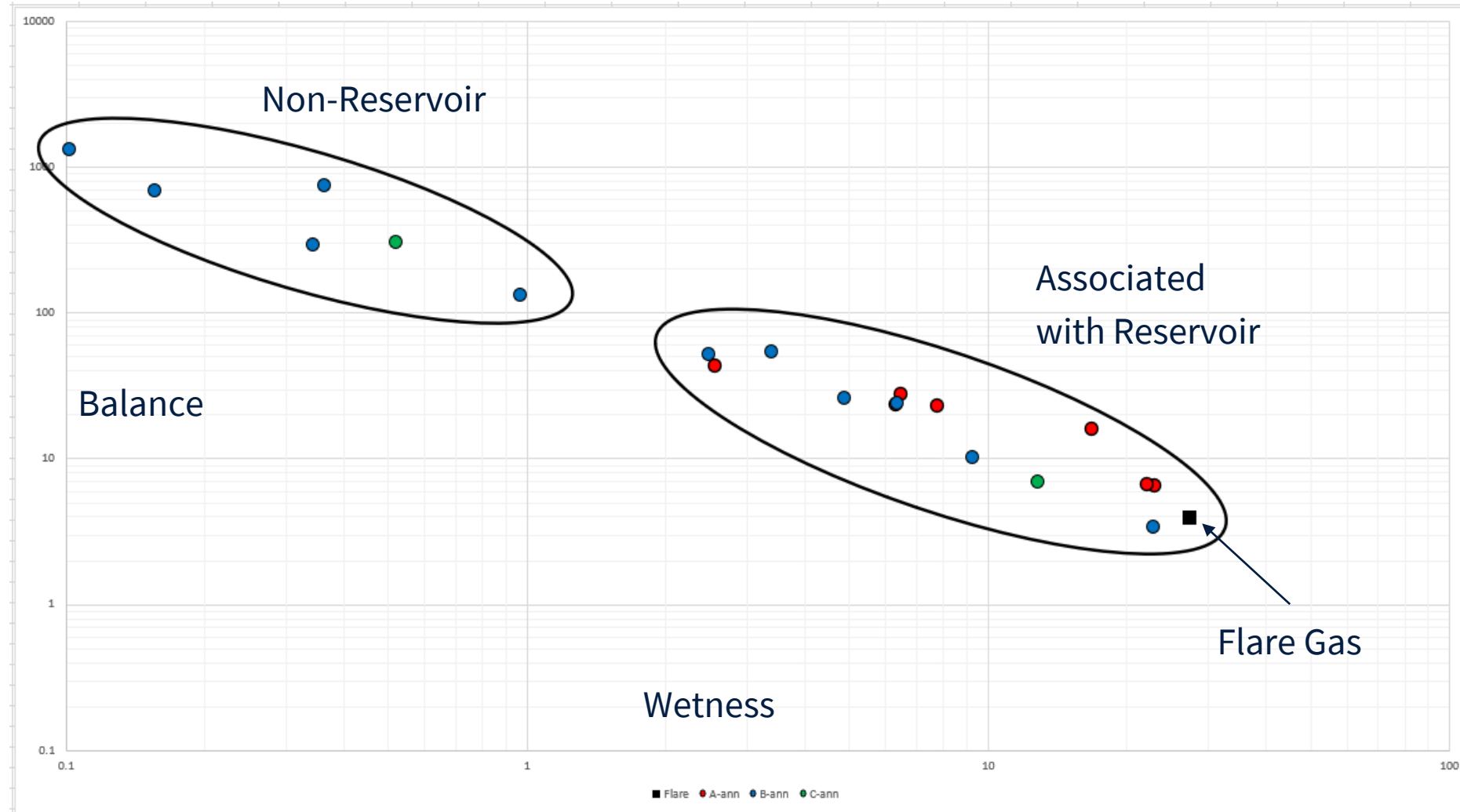
- Wetness:  

$$\left[ \frac{C_2 + C_3 + \dots + C_{10}}{C_1 + C_2 + \dots + C_{10}} \right] \times 100$$
- Balance:  

$$\frac{C_1 + C_2}{C_3 + C_4 + \dots + C_{10}}$$

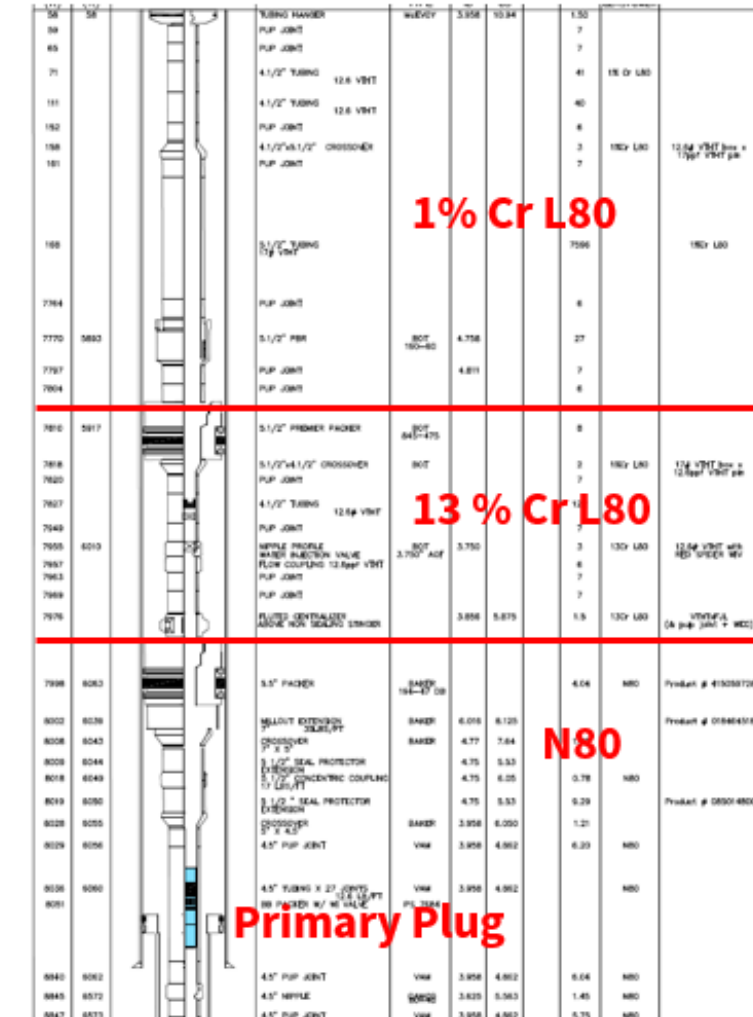
▶ Key to markers:

- Red – A-ann
- Blue – B-ann
- Green – C-ann
- Black – Flare Gas



# Plug Monitoring / Remediation

- ▶ All wells plugged by summer 2018 ahead of down-manning in Q4
- ▶ First plug failures were recorded in 2019
- ▶ Currently have 16 wells with failed plugs
- ▶ The plugs comprise a wide range of makes & models and include cement. In some cases the well has been plugged several times with repeated failures
- ▶ It is believed that the common failure mechanism may be related to the tubing condition rather than the plug
- ▶ During the initial field development phase, the reservoir was sweet and the wells were completed with N80 tubing
- ▶ By late field life, the recommended metallurgy was 13Cr due to reservoir souring
- ▶ All passing plugs to date have been set in low alloy tubulars
- ▶ New plug monitoring procedure implemented
  - Record CITHP when UMV is opened
  - One hour inflow test recorded on a digital gauge

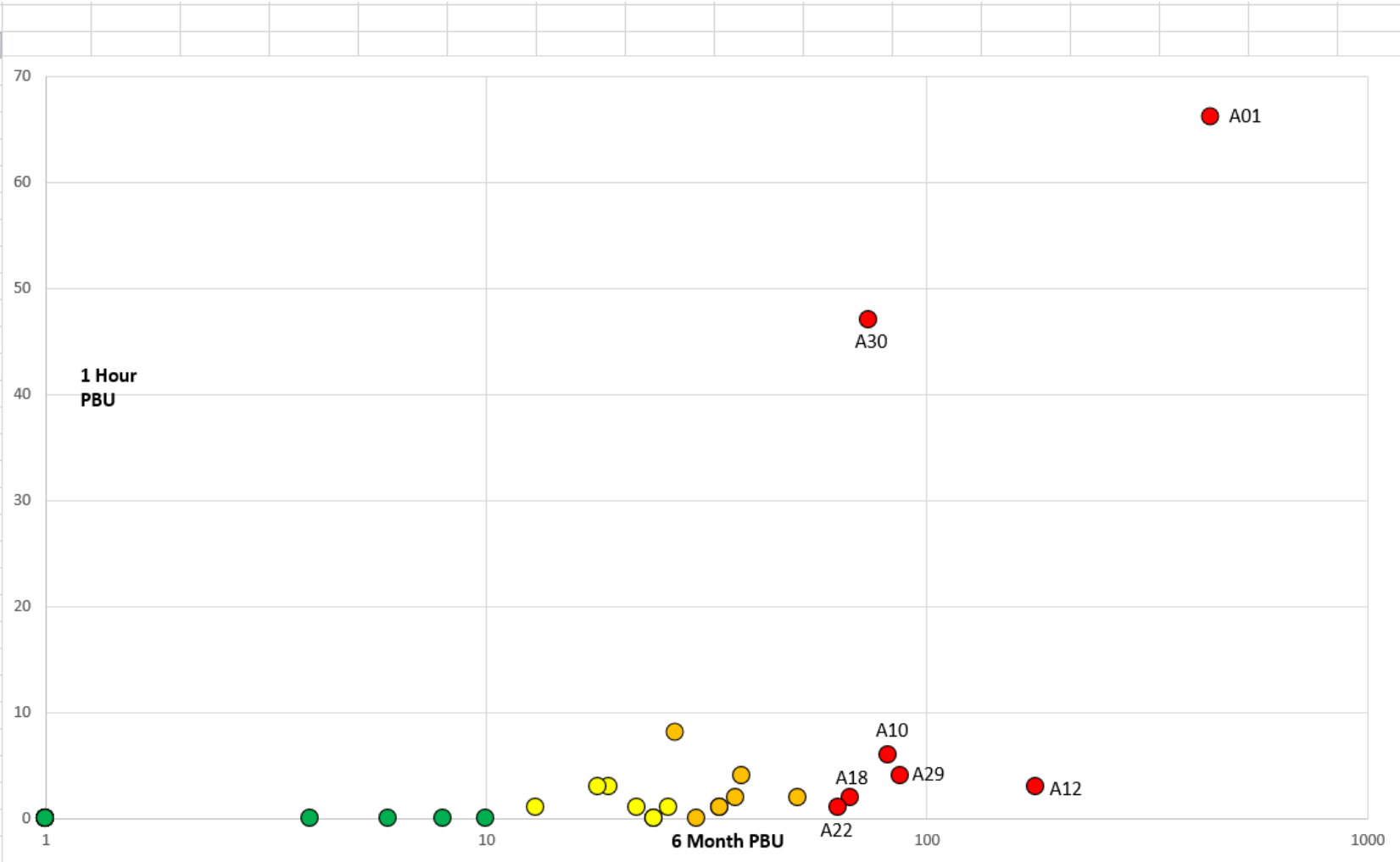


# Plug Evaluation

Wells divided into four categories based on leak rate characteristics

- ▶ Cat.1 – minimal pressure as found, no PBU
- ▶ Cat.2 – low pressure as found, definite PBU
- ▶ Cat.3 higher as-found pressure no PBU
- ▶ Cat.4 higher as-found pressure

Well	GM psi	PBU psi/h
A01/07	443	66
A12/27	177	3
A29/02	87	4
A10/31	82	6
A30/08	74	47
A18/13	67	2
A22/32	63	1
A14/28	51	2
A04/06	38	4
A20/16	37	2
A19/15	34	1
A16/30	30	0
A25/14	27	8
A27/24	26	1
A02/05	24	0
A11/22	24	0
A17/19	22	1
A27/25	19	3
A02/05	18	3
A11/23	13	1
A09/11	10	0
A32/26	8	0
A28/18	6	0
A03/03	4	0
A15/21	1	0
A21/17	1	0
A33z/20	1	0
A06/04	1	0
A13/29	1	0
A31/10	1	0

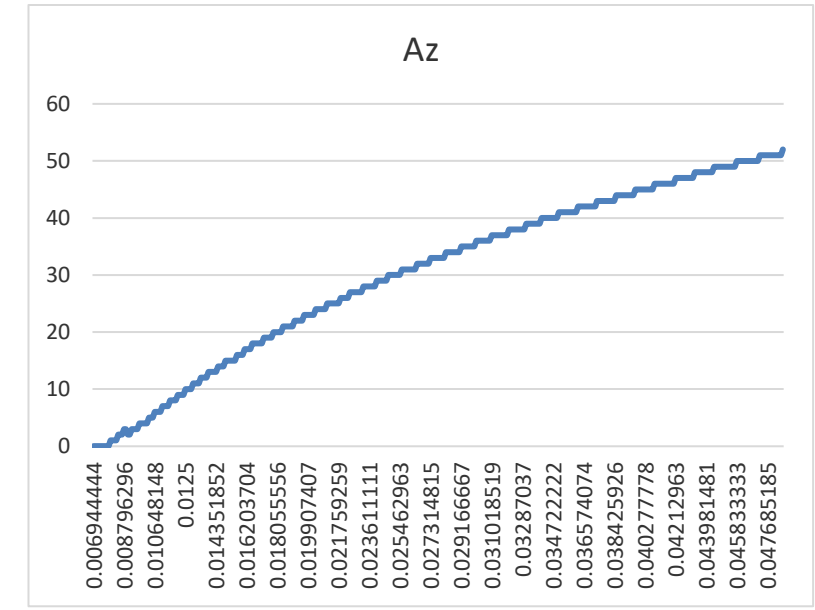
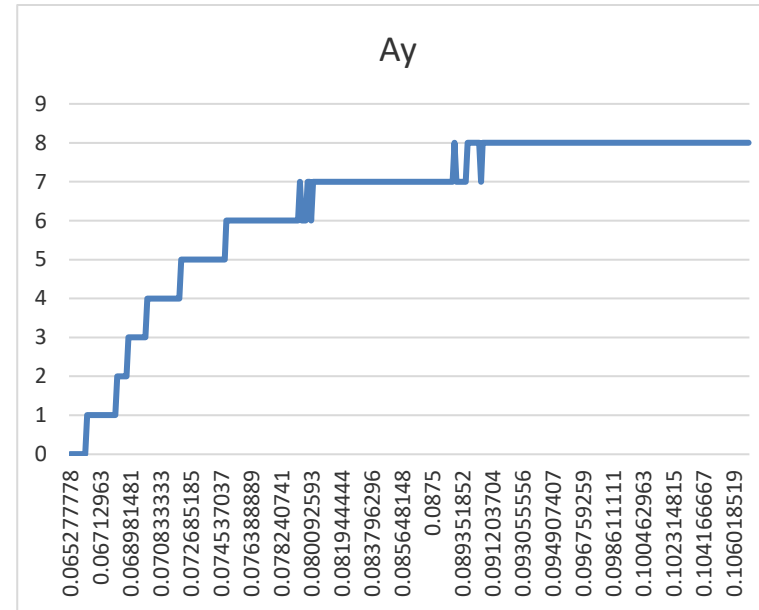
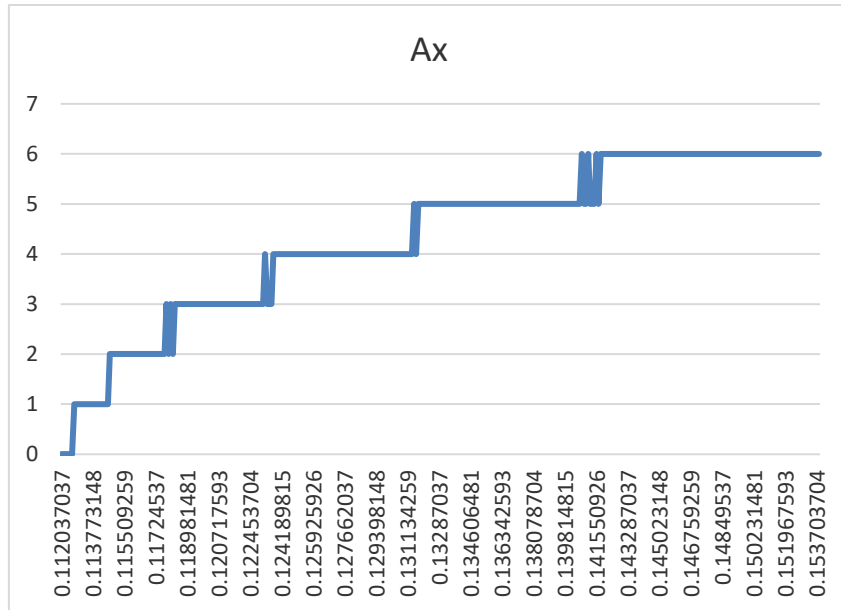


# Plug Leak Rates Compared

Oil Release Tonnage			
<b>4.5</b>	litres/day		<b>Oil Density</b>
<b>0.005</b>	cu.m/d		0.844 sg
<b>0.004</b>	tonnes/day		

Oil Release Tonnage			
<b>73.6</b>	litres/day		<b>Oil Density</b>
<b>0.074</b>	cu.m/d		0.844 sg
<b>0.062</b>	tonnes/day		

Oil Release Tonnage			
<b>301.7</b>	litres/day		<b>Oil Density</b>
<b>0.302</b>	cu.m/d		0.844 sg
<b>0.255</b>	tonnes/day		



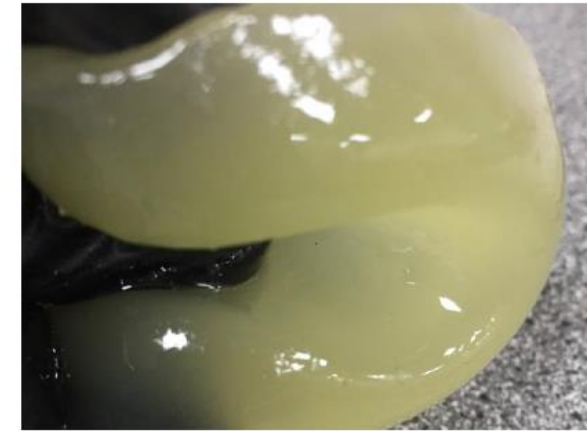


# Plug Remediation

- ▶ Eight wells identified for plug remediation through intervention
- ▶ Two technologies have been selected
  - Alloy / Thermite Plugs deployed on wireline
  - Gel plug spotted on depth using CoilHose with brine above
- ▶ Crew and equipment mobilised mid May for a 56 day campaign
- ▶ Day-time operations only, daily transfer by boat
- ▶ Well abandonment to commence Q2, 2024 with a planned completion of Q4, 2026 (from a jack-up)
- ▶ To avoid potential complications to abandonment, Alloy / Thermite plugs will only be run in wells where sufficient depth can be achieved



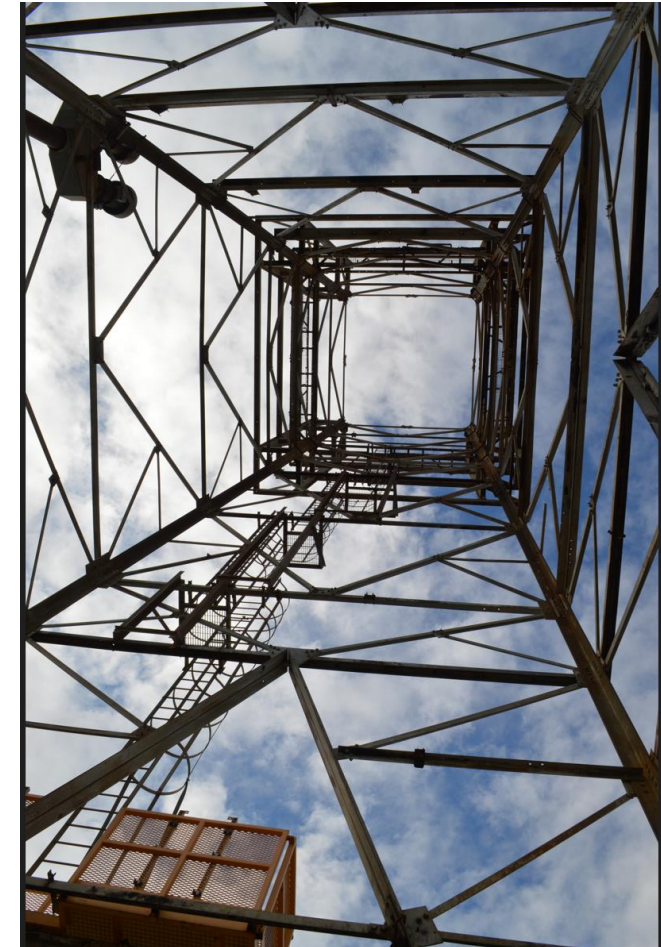
Cured gel, upright & tilted



Plug removed from jar and deformed by hand

# Re-Cap

- ▶ Beatrice is an old field, all wells plugged, platform in NNA status since 2018
- ▶ The crude is high wax and would beach in the event of a release
- ▶ The wells are subject to 6 month and 12 month verification to the same level of scrutiny as wells still in operation
- ▶ KP4 inspections are conducted every six months. Any component in poor condition is subject to a secondary inspection by FIE and may result in replacement or FM
- ▶ A wireless gauge system was installed prior to NNA and allows remote monitoring via PI with email alerts
- ▶ Annulus reviews based on gauge data were used to identify candidates for sampling. Sample analysis has provided input to well abandonment design
- ▶ A number of plugs have been identified as passing based on as-found CITHP and 1-hour inflow tests. The plugs have been categorised by leak rate
- ▶ A plug remediation campaign is currently in progress (Q2, 2023). The objectives are to restore reservoir isolation on a number of key wells until final well abandonment operations are completed in Q4, 2026





# Thank You