

# Shallow water/gas

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## Challenges and solutions

Geir Smaaskjær AkerBP 13<sup>th</sup> Nov 2025

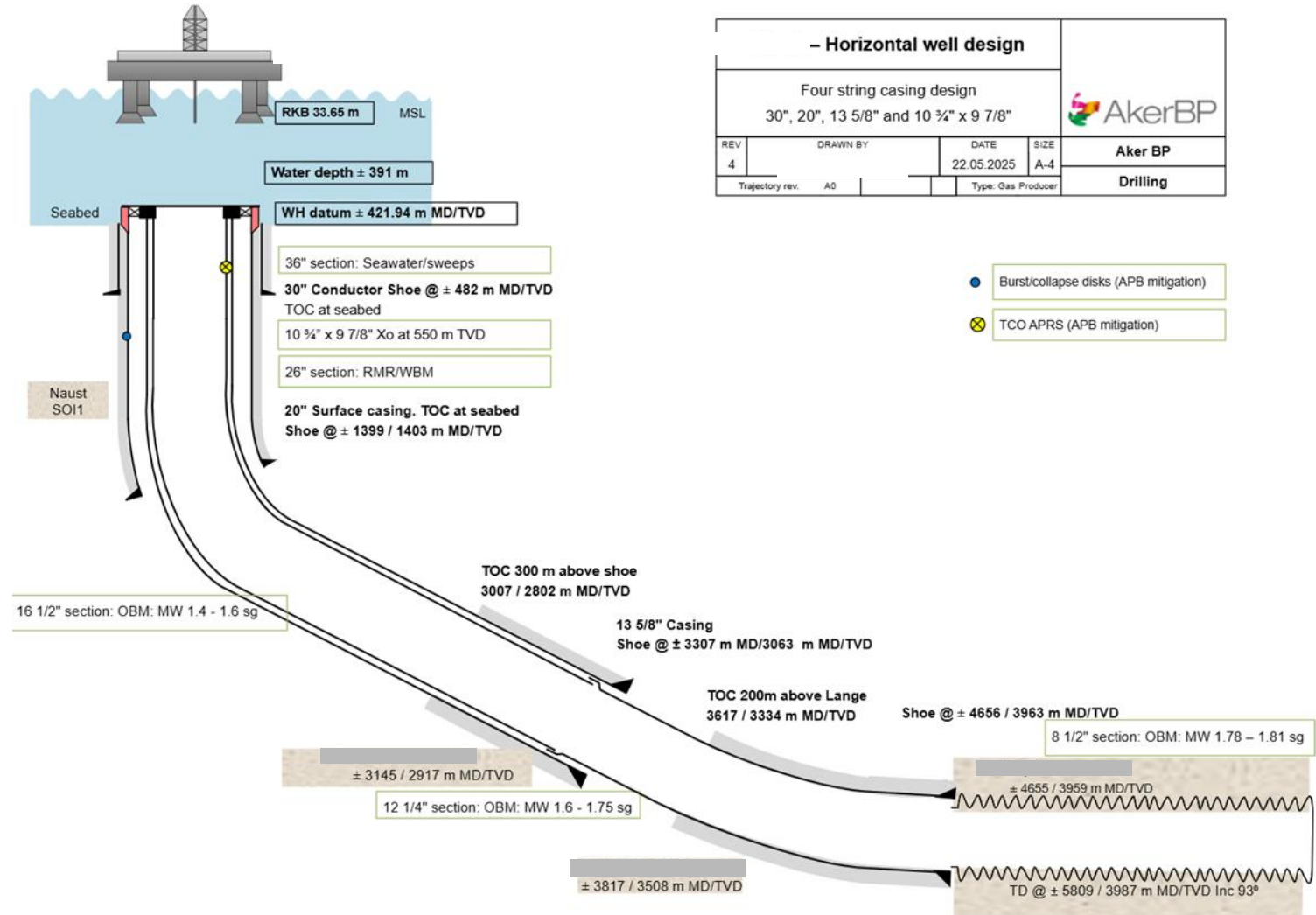


# What we have do deal with

## SHALLOW HAZARD IDENTIFICATION

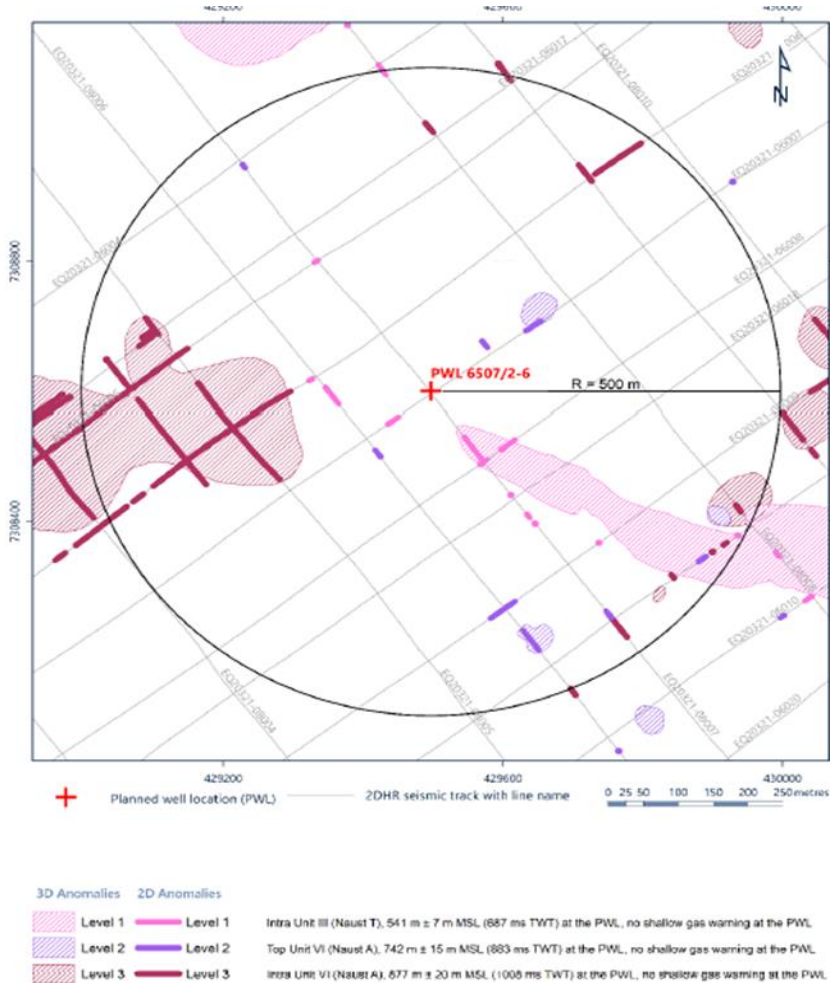
## Well Design with Deep set surface casing

- Well design with deep set surface casing
  - Conventional 4 string casing design
  - Source of Inflow (SOI) in all section limits the design
  - Ensure 8 ½ section through reservoir



## SHALLOW HAZARD IDENTIFICATION

# Typical 2-D 3-D seismic map on Haltenbanken



Seismic Anomaly map and Planned well location (PWL)

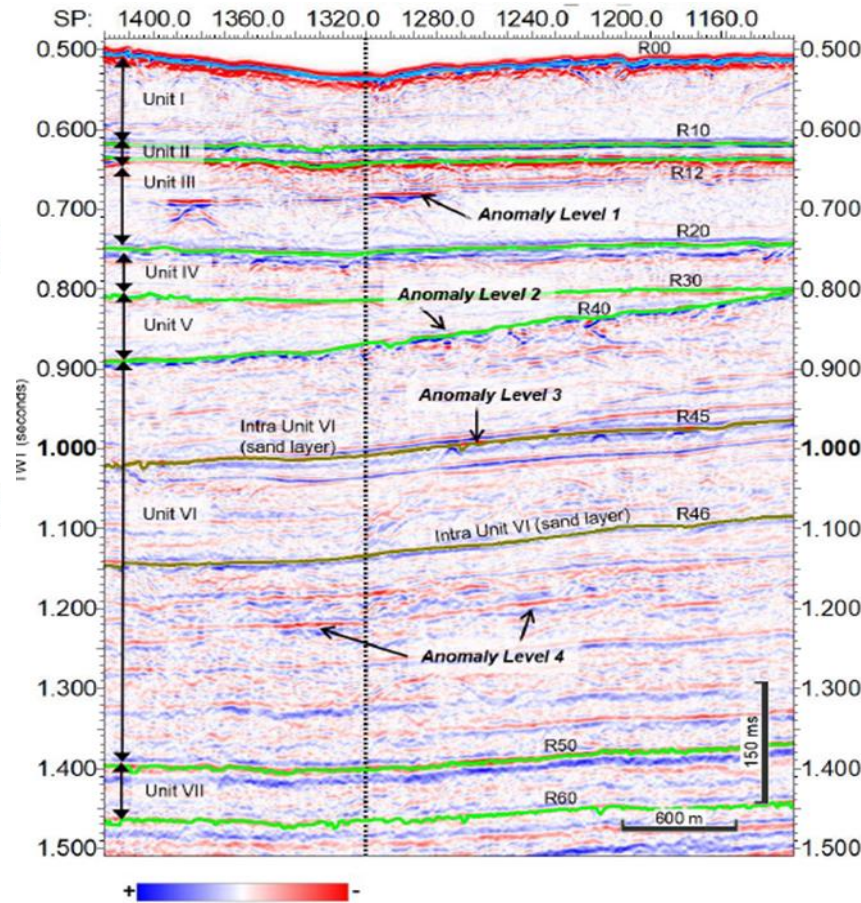
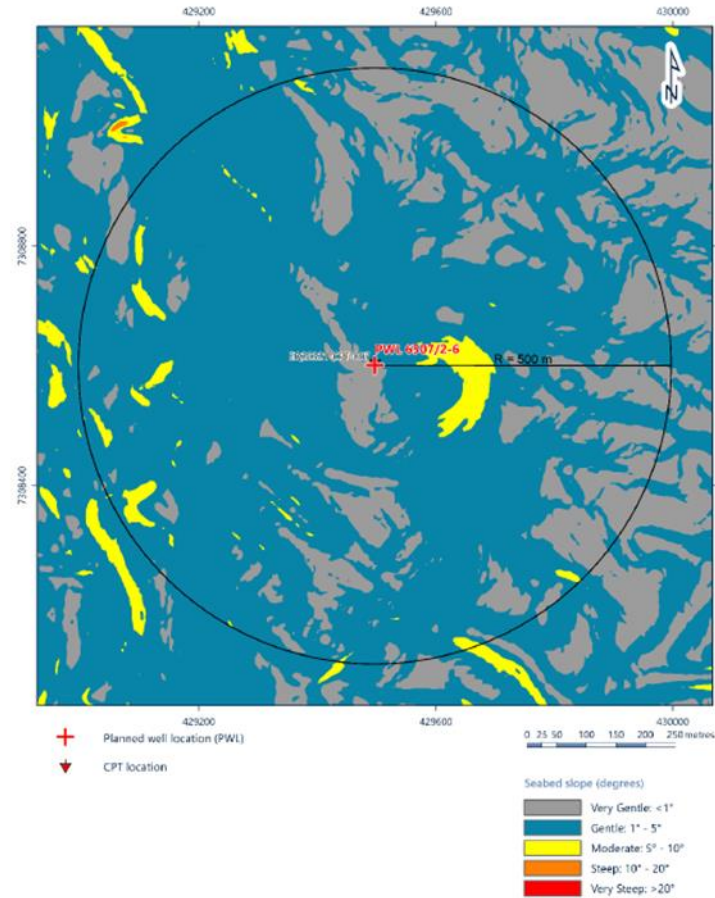


Figure 4.7: 2DHR Seismic Line EQ20321-08007 showing lithostratigraphic units, interpreted horizons and amplitude anomaly levels

2DHR – Two-Dimensional High Resolution Seismic

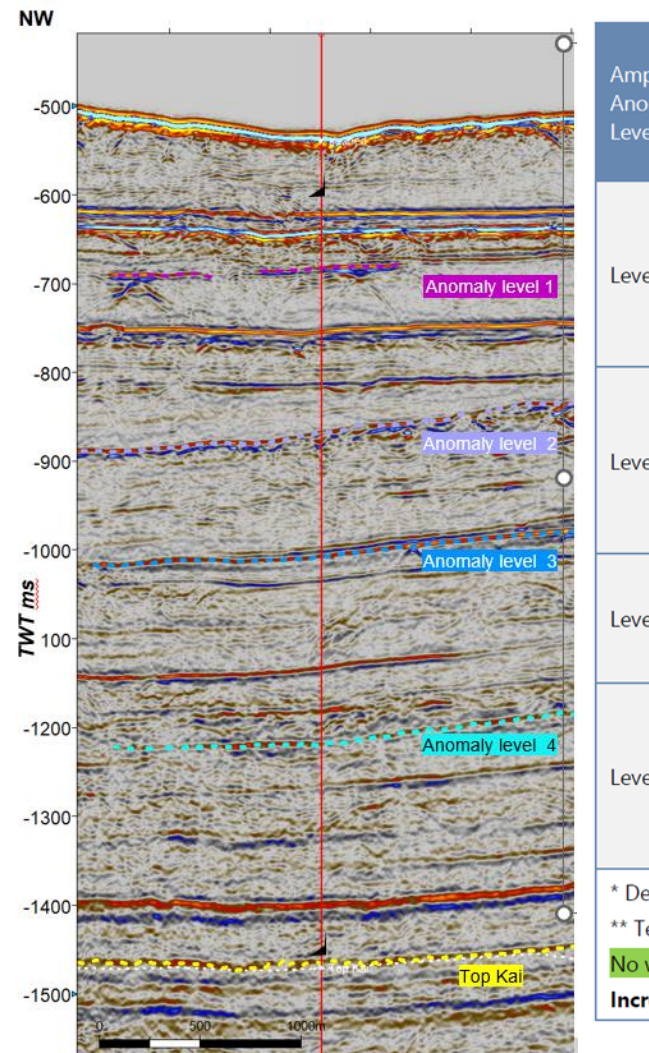


Seabed Bathymetry Map

## SHALLOW HAZARD IDENTIFICATION

## Shallow Hazard Assessment

For subsea wells where there is no potential for shallow hazard (Green) and a pilot hole is not drilled, a drilling facility impact assessment shall be performed with respect to shallow hazard influx in cases where the water depth is less than 100 m



## Requirements for drilling of pilot holes

Pilot holes shall be drilled to investigate for shallow gas according to this table:

	Green	Yellow 2	Red 1
Jack-up, exploration and appraisal wells	Yes	Yes	Yes
Semi-sub, exploration and appraisal wells	See footnote 6	Yes	Yes
Platform installation on seabed Footnote 1,2 & 3	Yes	Yes	Yes
Templates Footnote 4	Yes	Yes	Yes
Production wells Footnote 5	Yes	Yes	Yes

The shallow gas warning classifications (green, yellow, red) are according to *Define shallow gas potential* (see below).

## Notes

1. Rigs, templates and platforms shall not be placed in a red zone. The only exception is when there is no alternative, a pilot hole has been drilled, and a full risk assessment has been performed.
2. Rigs, templates and platforms should not be placed in a yellow zone, unless there are no alternatives. A risk assessment shall be performed.

\* De 3. For platform installations in yellow and red zones, a pilot hole shall be drilled no later than the project Select phase.

\*\* Te 4. Only one pilot hole required per template

5. For field developments where a pilot hole has been drilled, it shall be evaluated whether gas migration to shallow formations may have occurred since last pilot hole was drilled based on recent or new seismic interpretations

Incr 6. Deviation can be applied for , if water depth is over 100m.

## SHALLOW HAZARD IDENTIFICATION

# Pilot Hole Regulatory Requirements

## NORSOK D-010 6.7.2.3 Operational constraints

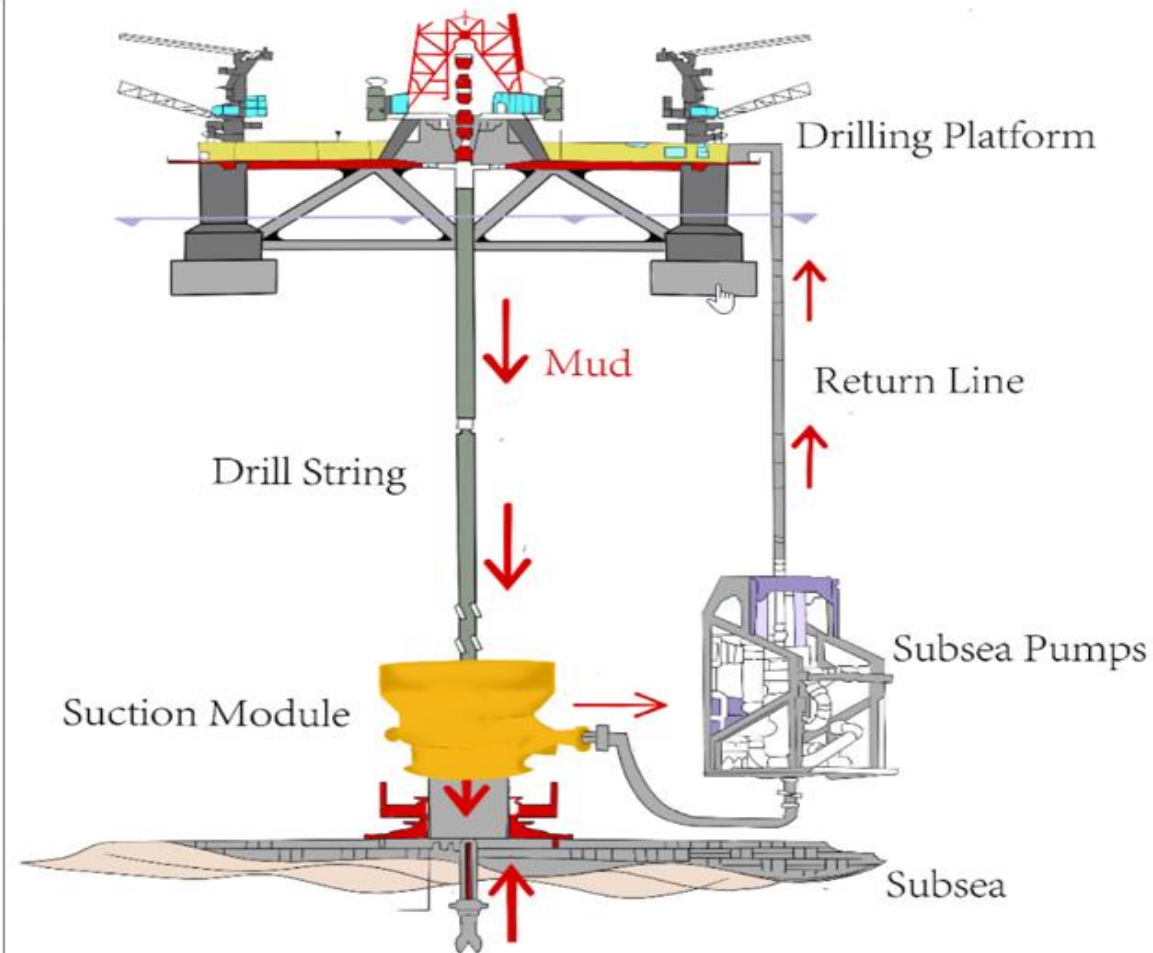
It is an acceptable method to **de-risk shallow hazards by drilling a pilot hole**. If over-pressured gas is confirmed, re-drilling of these intervals shall be performed with two barriers in place, ref. Table 1. If normal pressured gas or over-pressured water is encountered, setting surface casing through these zones may be acceptable pending a specific risk assessment considering well/template/rig/installation integrity

## NORSOK D-010 6.7.2.3 Operational constraints

Potential shallow gas zones where **abnormal pressure cannot be ruled out** may be drilled with a pilot hole of maximum 12 ¼" hole size and **weighted drilling fluid**. Each anomaly shall independently be inflow tested with seawater

As we will see later- the challenge is not to drill through these anomalies, but to run and cement the surface casing with cement to seabed

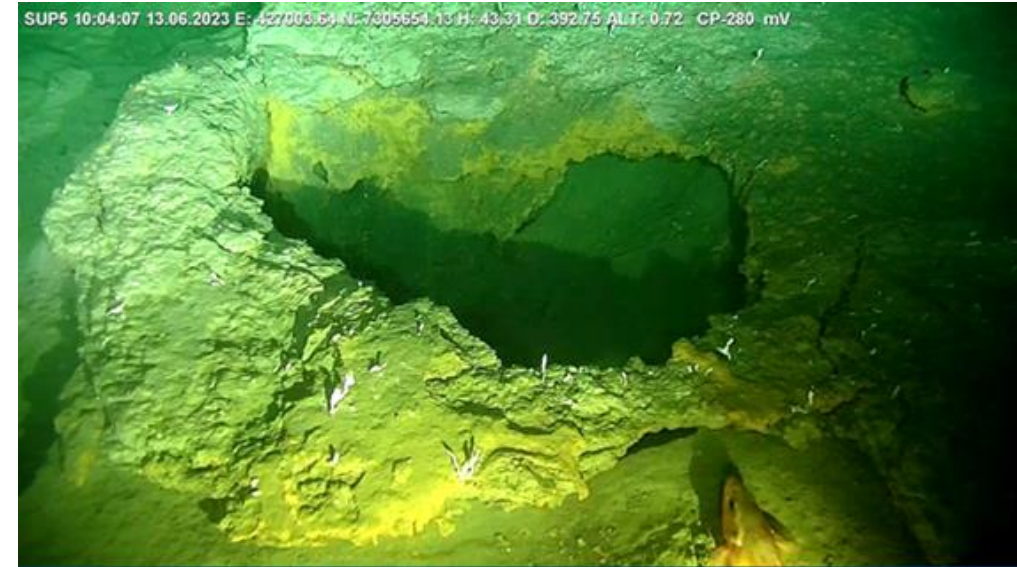
## Riserless Mud Recovery System (RMR)



# Experience from Drilled Pilot holes

## SHALLOW GAS PILOT HOLES

## Shallow Gas Pilot from Template location close by

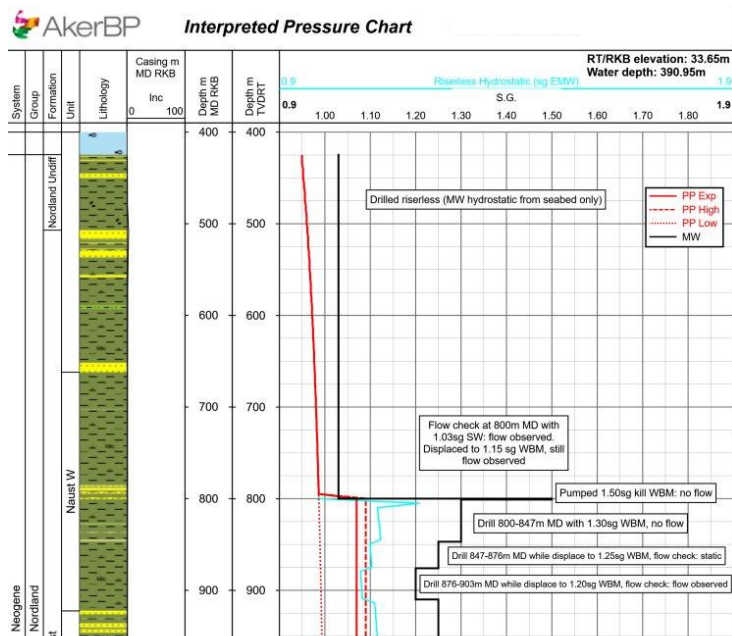


- Well reached a total depth of 871 m MD, well short of the planned TD of 1415 m MD
- Initially spotted flow on sonar and crew interpreted flow to be water.
- Moved ROV closer for better video coverage and still interpreted the flow to be water.

- Image of abandoned pilot hole, 6 days after abandonment

## SHALLOW GAS PILOT HOLES

## Shallow Gas Pilot at template location (second pilot hole)



Increased attention should be paid to **Anomaly Level 2** (742 m  $\pm$  15 m MSL, 883 ms TWT, at the PWL), as this level occurs within an interval where shallow water flow and associated gas was experienced in the shallow gas pilots XXXX/X-U-3 and XXXX/X-U-5 (located 3.87 km southwest of the PWL).

Potential Sources of Inflow

Formation	Interval m MD	Interval m TVD RKB	Thickness m TVD	Source of Inflow ID	Fluid	Lithology	Max PP sg	Fracture Pressure sg	Data Source	Temp o C
Intra-Naust (Fugro anomaly level 1)*	567-581	567-581	14	SOI 1	Water / Gas ?	Thin sandstones	0.97	1.246	PPFG	10
Intra-Naust (Fugro anomaly level 2)*	760-790	760-790	30	SOI 2	Water / Gas ?	Thin sandstones	0.985	1.43	PPFG	16

- A strong desire to keep original well design pushed for drilling a second pilot hole with weighted mud to see if planned surface casing depth could be reached
- Shallow water flow was seen on this second Shallow Gas Pilot well during a flow check at 800 m MD prior to planned weight-up to 1.15 sg for drilling ahead.
- Attempted to kill the well with 1.15 sg – unsuccessful.
- Well killed with 1.50 sg.
- Reduced mud weight to 1.30 sg and well stable.
- Reduced mud weight to 1.25 sg while drilling ahead and well stable.
- Reduced mud weight to 1.20 sg while drilling ahead and well showed indications of flow.
- Increased MW to 1.25 sg and drilled to planned section TD, well stable throughout.
- Estimated pore pressure in the Naust to between 1.07 sg and 1.09 sg based on draw-down tests performed.
- Pressure point attempted at 799.7 m MD – Lost seal.
  - No further pressure points were attempted due to operational constraints

# Potential Solutions for Keeper wells

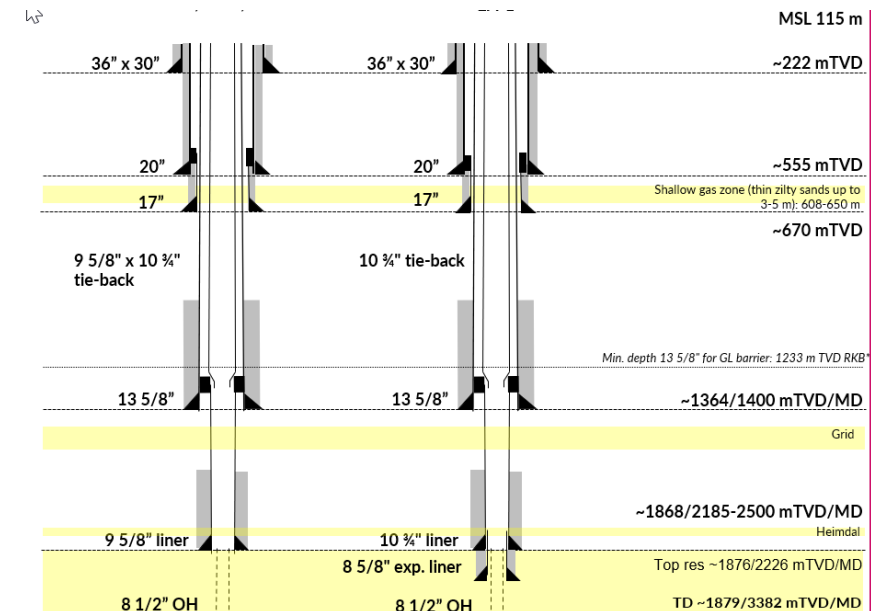
## SHALLOW GAS PILOT HOLES

## Solutions for Keeper wells

- As proven in second Shallow gas pilot, the well could be drilled in as safe manner to intended surface setting depth
- Regulatory it is an opening for setting the surface casing through such zones;
- Or setting the surface casing above and introduction a liner past shallow zone to isolate shallow hazard zone (SOI)
  - Should be considered If it is not possible to get within an acceptable risk for deep set surface casing
  - Must be done if shallow gas in proven (D-010 Table 1)

## NORSOK D-010 6.7.2.3 Operational constraints

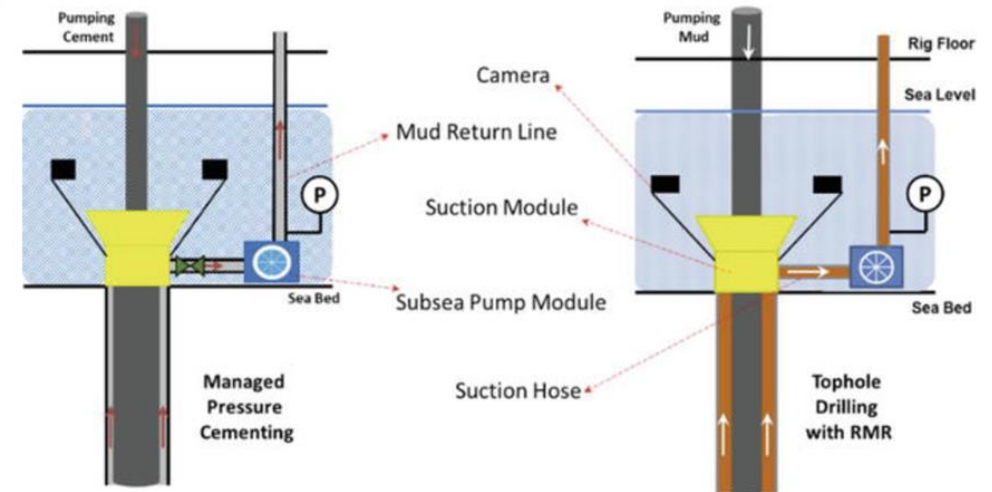
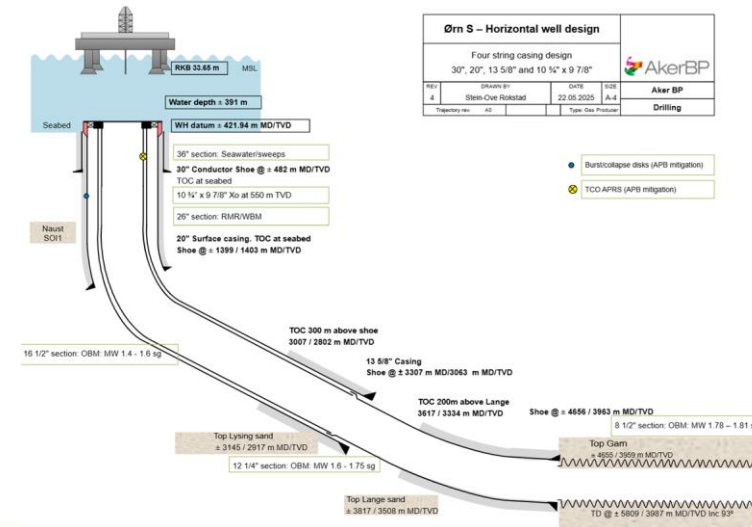
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## SHALLOW GAS PILOT HOLES

## Solutions for Keeper wells, Cement Considerations

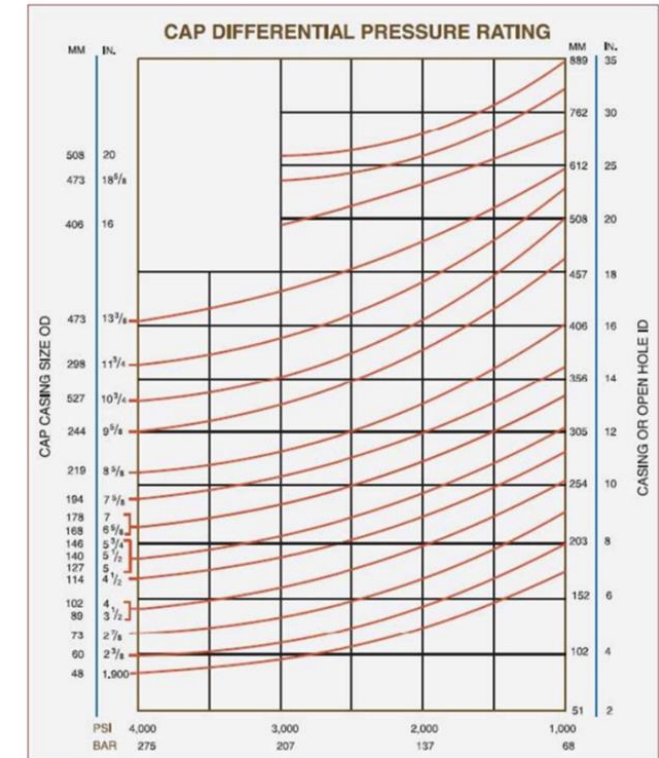
- For deep set surface casing a general rule for the slurry design where shallow formation fluid can affect the slurry
  - Slurry should have a very fast “transition times” (transition liquid to solid)
  - Slurry to have no free water, be very stable and exhibit low fluid loss (<50ml API)
  - Contain Gas migration mitigation agents that “block” formation fluid (gas or water) entering slurry
  - The cement blend should have a high Solids Volume Fraction (SVF), as this reduces its permeability (ex: Tuned Light from HAL, Lite CRETE / Deep CRETE from SLB)
  
- Or Special Cement Systems such as foam cement
  - where the internal Pore Pressure inside the cement matrix coming from the N2 bubbles slows down formation fluid entering the slurry during the “transition period”.
  
- And one need to consider if Managed Pressure Cementing (MPC) will assist in ensuring the cement column stays in place
  - 5-6 bars additional annulus pressure to assist the hydrostatic pressure loss of the cement in the transition period.



## SHALLOW GAS PILOT HOLES

## Solutions for Keeper wells, Cement Considerations

- Or an alternative to include an integrated 20" casing annulus packer in the surface casing to be set just above the SWF zone
  - Mitigate shallow water flow while cement is gelling and setting up by isolating annulus above Shallow Water Flow zone
  - The packer is set by pressure- depended on plug bump
  - New to Norwegian Continental Shelf- used a lot elsewhere



# Recommendation

## SHALLOW GAS PILOT HOLES

# Recommendation

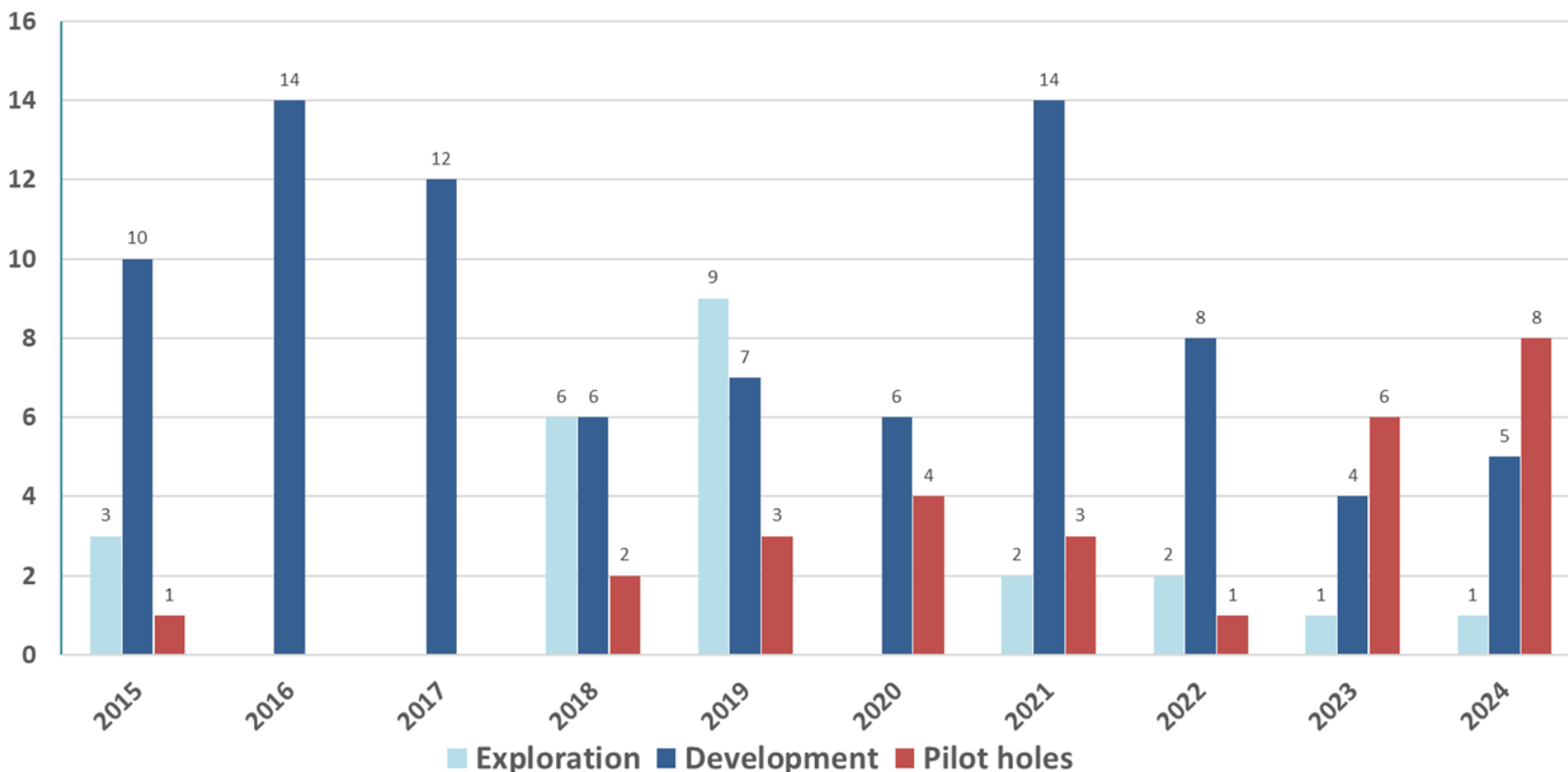
- As shown, even if all “Green” on the Shallow hazard prognoses;
  - For subsea Template location it is essential that shallow pilot holes are drilled.
  - They should be drilled in good time prior to template installation in order to assess potential move of template location.
  - Depending what the pilot hole discovers, the intended well design can be kept with high attention on cementing of the surface casing- drilling is not an issue.
  - Or alternative well design will have to considered.



You do not want this to happen- here drilling a 17 ½” hole with seawater and sweeps, no pilot hole drilled,. Only option to close diverter, pump kill mud and hope kill well before diverter washes out.

# Regulatory update

# INCIDENTS PER WELL TYPE 2015-2024

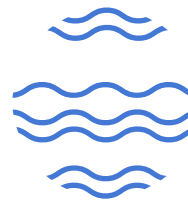


Significant Increase in Shallow Pilot hole incident over the last year  
- and probably more to come as the number of subsea infill projects are increasing



OFFSHORE NORGE

# REVISION GUIDELINE 135 – DRILLING AND COMPLETION INTERVENTION



# SHALLOW HAZARD INCIDENTS

Today's classification:

- Green- not reflecting that pilot hole are drilled to de-risk location(ALARP)
- Green- included in "Risikonivå i norsk petroleumsvirksomhet" (RNNP)

New classification:

- Handled according to plan, no escalation
- Grey and not included in RNNP

NEW OLF Guideline 135 to be

Published start of 2026

Will better reflect actual well control risk level on NCS

Level 3 - Green Regular well control incidents	1. <b>Low HC or water influx volume/rate</b>	1. Influx volume below design criteria for kick margin, and successfully regained barrier with standard kill procedure without degrading well integrity.
	2. <b>Low-rate shallow gas flow</b>	2. Shallow gas incident with kill operations. No gas handled on installation (riser-less operation)
Level 4 - Well control experiences for learning	1. <b>Non-continuous gas/water migration in well - with all barriers in place</b>	1. Release of a barrier element with contained volume of gas/water trapped below or behind casing.
	2. <b>Loss of primary or secondary barrier without influx into the well</b>	2. Incidents where a barrier is compromised but no influx has occurred.
	3. <b>Low rate shallow gas/water flow from riser-less pilot hole drilled with floating unit</b>	3. Shallow gas/water flow when de-risking planned well location with small-size pilot hole. Handled according to plan, without escalation.

Tan = Alert to PSA according to management regulation

Blue = Notification to PSA according to management regulation

Grey = Alert or Notification to PSA depending in potential in accordance with Management Regulations § 29

Well control experiences for learning	
D4.3 - 01	Shallow gas/water incident when drilling riser-less pilot hole from floating drilling unit. Operation according to ALARP principle to de-risk location. Handled according to plan, no escalation.



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