Decommissioning and Restoration – Fostering Excellence through Regulations, Innovation, and Sustainable Practices

30–31 JULY 2024 | BANDAR SERI BEGAWAN, BRUNEI

TOP HAT APPROACH FOR SUBSURFACE ISOLATION STRATEGY

Martin Tjioe, Sakamrin Abdul Rahman, Syazwani Haji Durajid

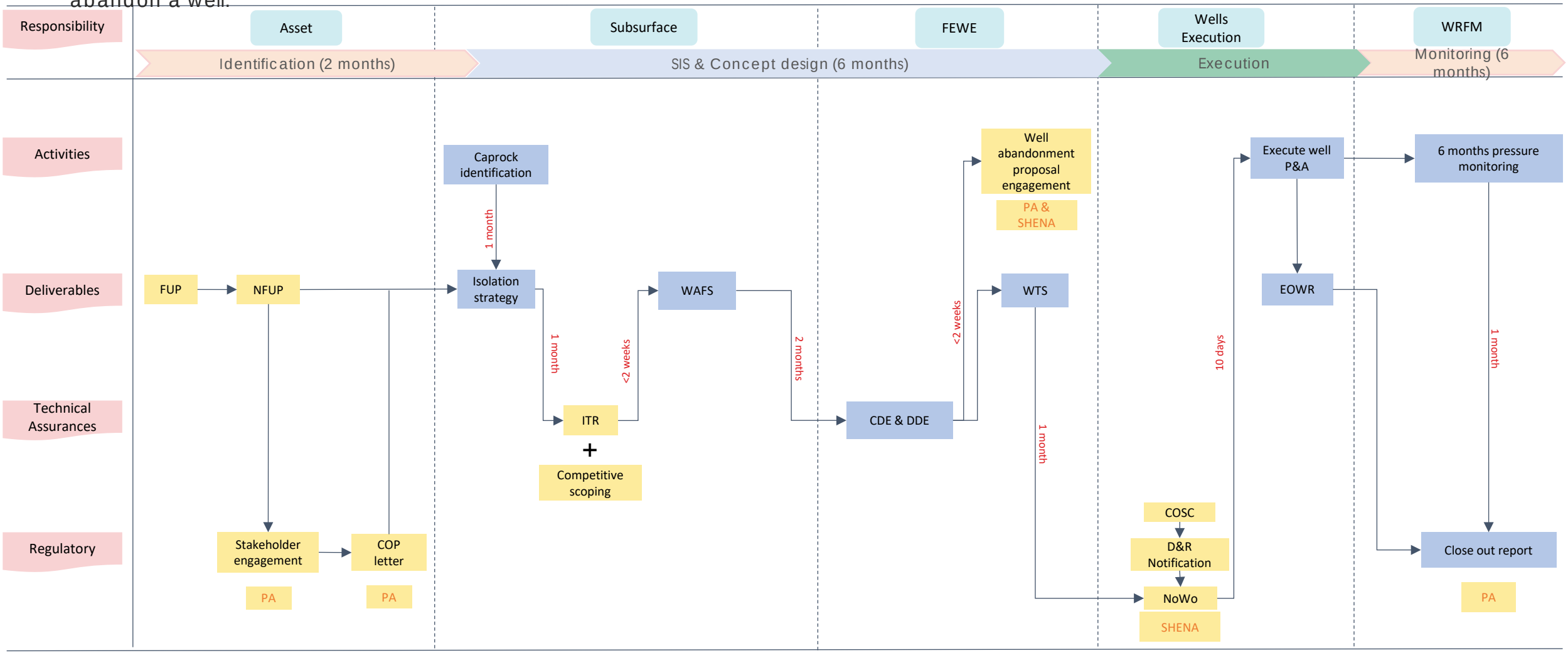
Brunei Shell Petroleum

Content

- Case Study Background
- ALARP Demonstration
- Economic Value
- Path Forward: End-to-End Map for Well P&A

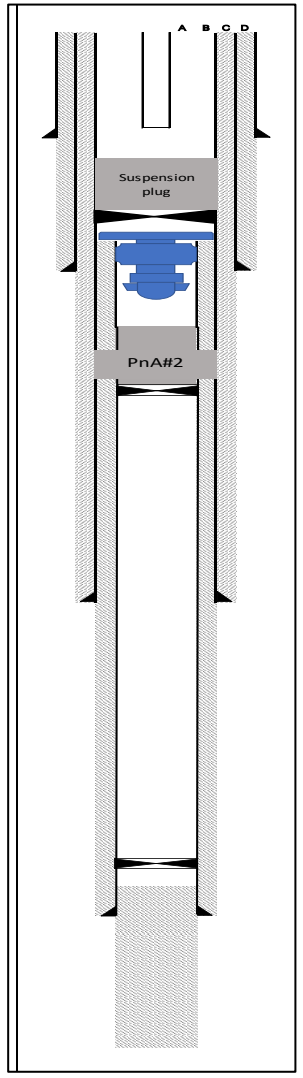
End-to-End Map for Well P&A

- Decommissioning and Restoration (D&R) projects need to be performed in a cost-effective manner while also ensuring that risks are reduced to as low as reasonably practicable (ALARP). To that end, a Top Hat approach is an effective method to abandon a well.



Well-A: An Overview

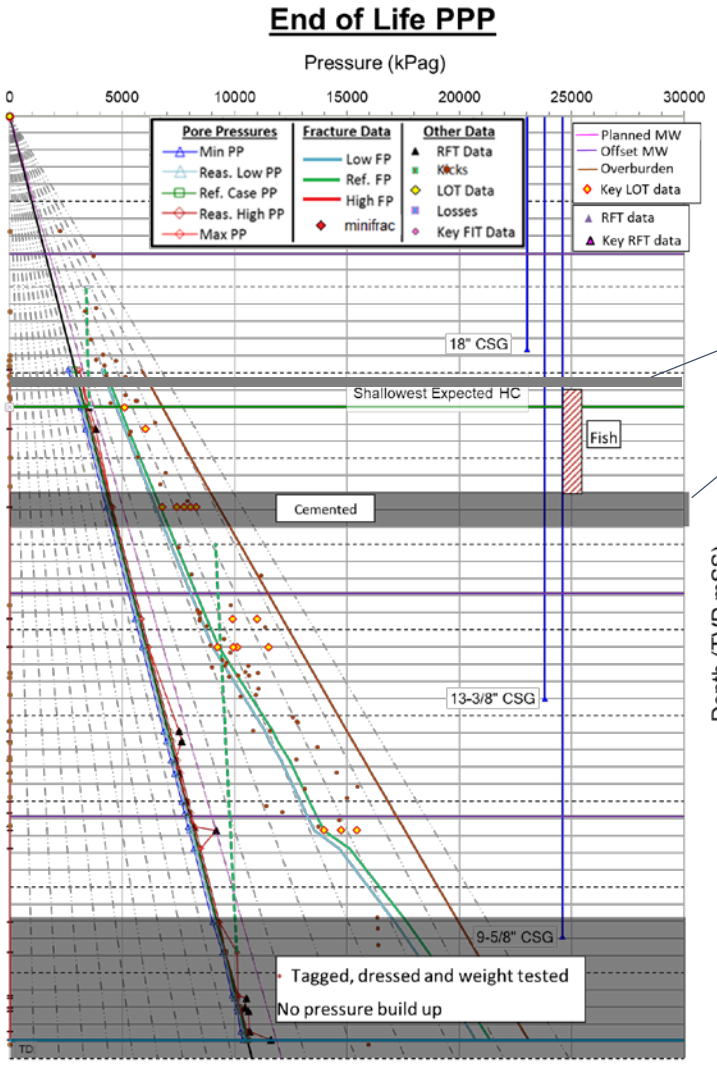
Well History



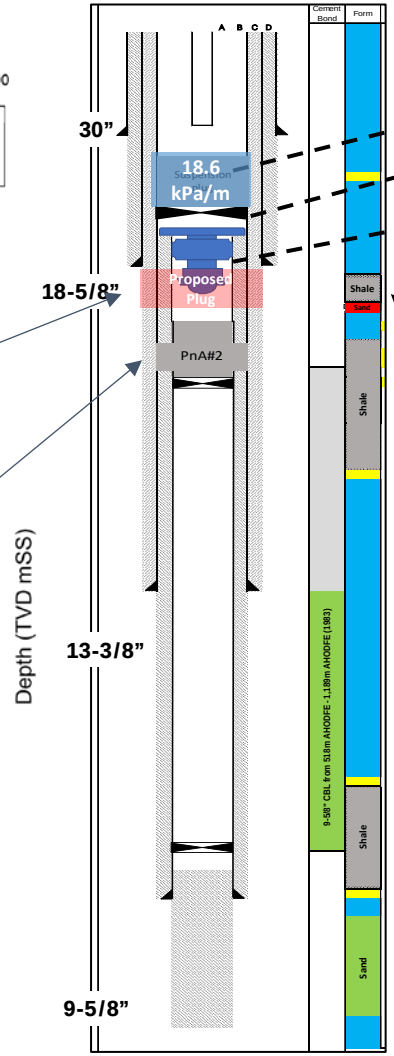
- An appraisal well, drilled in 1983 and has been suspended.
- In Feb 2021, attempted for caprock restoration:
  - Caprock restoration: **cut and pull 90m FP (Free Pipe)** and pilot mill 280m (planned)
  - BHA parted while attempting to pull casing free.
  - Set cement plug above fish, install kill string and suspended well.
- No sustain pressure in tubing and annulus.
- H2S has been zero.
- Behind casing cement and CBL Availability:

CBL Availability		
Cap Rock	CBL across shale	Quality of cement
Plug #1	Yes (behind 9-5/8" casing). Double casing environment.	Poor behind 9-5/8" casing. No clear indication behind 13-3/8".

Isolation Strategy



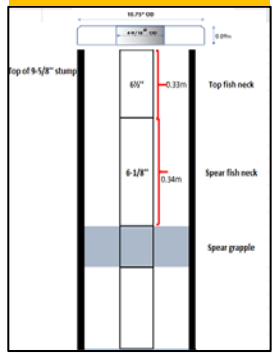
Well Status



- Suspension plug
  - Tagged & P/T to 500psi
- Bridge plug
  - P/T to 500psi
- Fish in hole ~ 2.54m

Proposed caprock

Fish



ALARP Approach: Top-hat Design Abandonment

- Allows team to deal with routine (as per abandonment philosophy) and complex wells (where conservatisms can be explored to ensure the balance between cost and risk are achieved) across the field.
- Enables planning for contingent operations if issues are encountered when setting plugs in difficult wells (prevents suspending work and coming back to wells).

Technical assessment and ALARP approach:

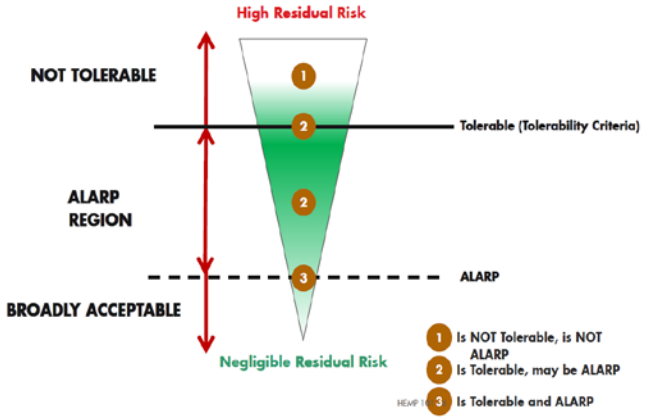
1) Different possible well options were reviewed and technically assessed based on rate of success, whereby it is analyzed by 10%, 50% and 90% ratio– 90% being the worst-case scenario.

2) In the well of interest (Well A), final outcome of the technical assessment produced a rate of success of 1%. Which means it has a 99% rate of failure to reenter the well and successfully abandoning caprock of interest

3) This early assessment allowed the team to decide whether to pursue with well re-enter and attempt to restore caprock, or alternatively close out the well's abandonment with a top-hat abandonment design

4) End result from this technical assessment and ALARP approach gives a better prediction of well execution's outcome.

Residual risk, Tolerability and ALARP



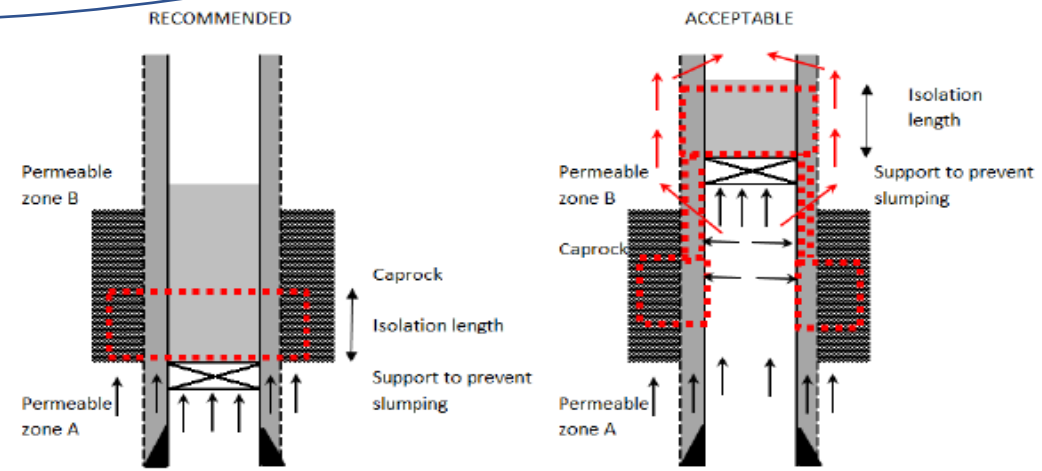
- We make the proposal as safe as possible until the point where additional risk reduction is very small compared to the effort / costs that needs to be invested.
- The risk in this case includes the probability of this happening times the worst-case outcome.
- A combination of qualitative and quantitative techniques are commensurate with the novelty, complexity and the levels of risk. These include:
  - Relevant legislation;
  - Codes and standards;
  - Industry good practice; and
  - Quantitative risk profile.

Top Hat Isolation Design

- Following Company's standard practice and guideline, top hat abandonment is recognized and accepted.
- Well of interest (Well A) has clearly demonstrated Guide-Lines are followed and in compliance with Company's standard.

The requirement is normally easily met by placing the isolation across a suitable caprock, which is often referred to as the "cap rock restoration" principle (see figure below). This is considered 'best practice" and for some areas it is a regulatory requirement. A suitable caprock is an impermeable rock without natural or induced fractures that is continuous over the field. The caprock may be immediately above the permeable zone to be isolated or shallower. One caprock can be suitable to isolate more than one permeable zone.

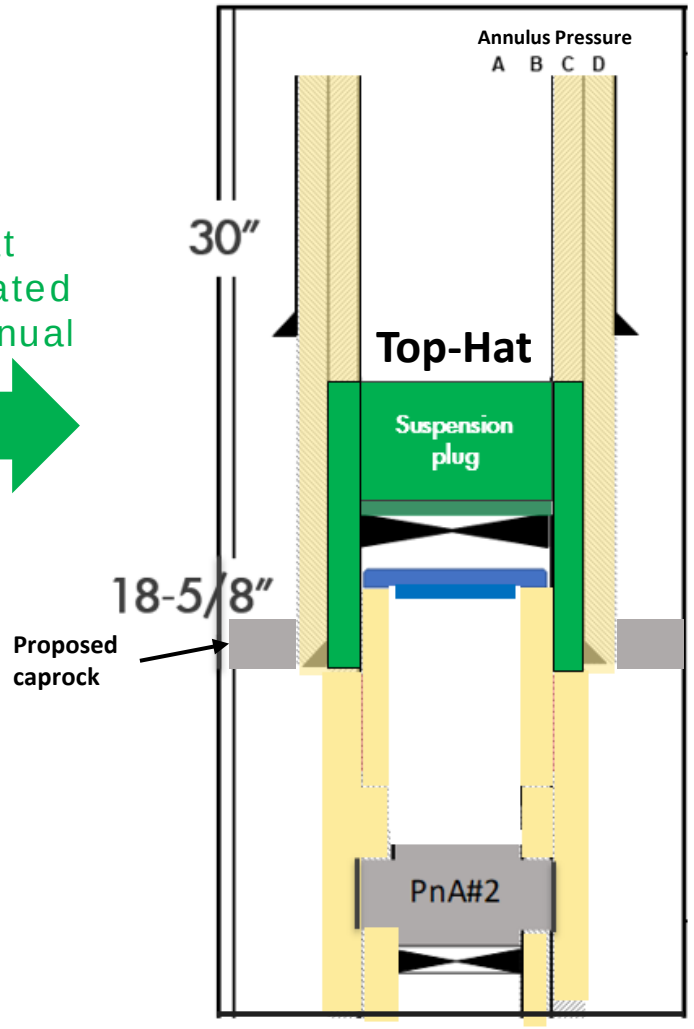
Shell, however, recognises that in some areas, there is long term experience with indirect cap-rock restoration where the formation has permeability or lacks strength. In this case, the seal will rely on the casing to be durable and/or the risk on fluids by-passing the isolation through the surrounding hazard is considered unlikely or have limited consequences.



Permanent isolation depth relative to the caprock. The direct cap rock restoration (left) is preferred, the indirect cap rock restoration is acceptable as long as the risk on leak paths is deemed ALARP

If flow between neighbouring wells is likely, it is important that zones with flow potential are isolated consistently across the field to prevent undesired crossflow. A so-called "plumbing diagram" (see figure below) helps to identify inconsistencies in isolation depths between wells and is normally part of the sub-surface isolation strategy.

Similar Top Hat Design as annotated in Guideline/ Manual

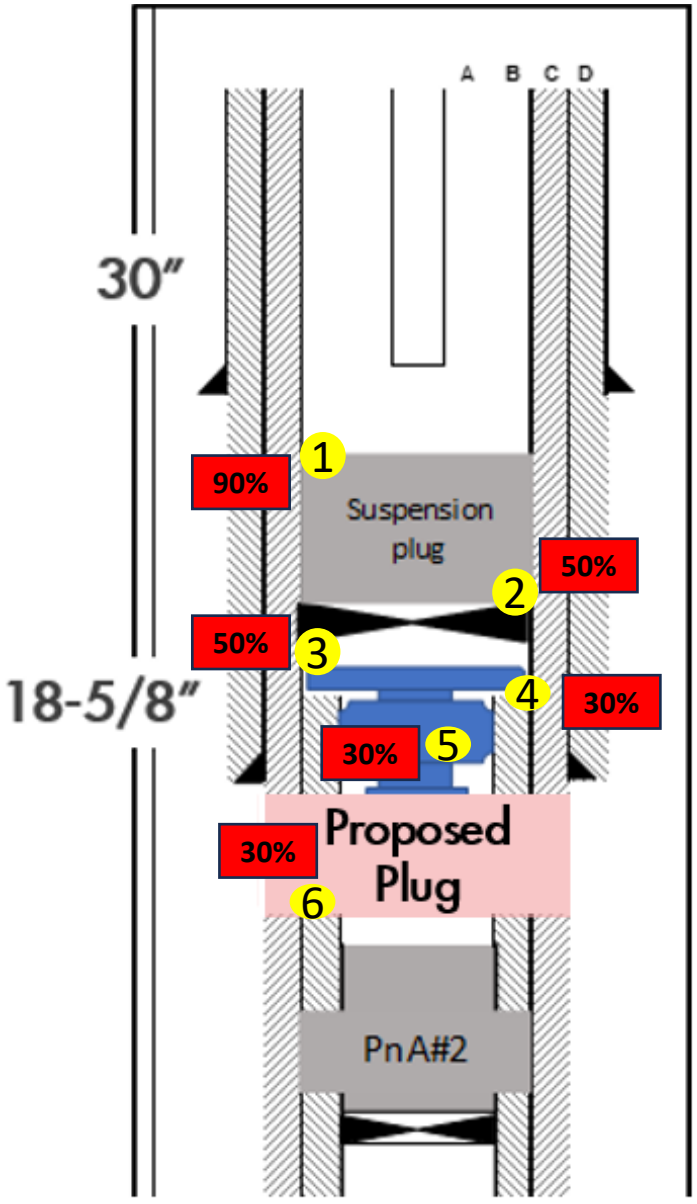


ALARP Demonstration

- Compliance in accordance with Standard Guidelines: Integrated discussion with each discipline Technical Assurances, includes:
  - Indication of the recoverable volume of fluid leaking Post abandonment scenario
  - The severity of any failure of the cement (or if the cement in the open hole part of that section is not there)
  - Assessment of well status using Alternative Annulus Verification (AAV) Process:
    - No Cement logging acquired behind 18 5/8” and 13 3/8”, however there is no annulus pressure observed.
    - Theoretical TOC to surface based on reports and returns observed behind both casing scheme.
    - The routine annulus investigation reported showing no sustained annulus pressure. Because this is hydrostatic pressure, if current well status is not abandoned properly and the suspension plug is not holding, we would have seen an sustain annulus pressure at A and B side.
  - The fact that there are no annulus pressures and pressures above the cement plug gives indeed confidence that the well has been properly abandoned from the inside.
- Comparison of quantitative risk with tolerability criteria to determine that calculated risks are within tolerable limit and further reduced to ALARP with the Technical Risk on well complexity and Fishes recovery

Well Technical Risks

Step no.	Execution Steps	Probability of Success	Challenges
1	Drill through suspension plug	0.9	-
2	Drill through bridge plug	0.5	• Debris from bridge plug landed on TOF
3	Fish out section of bridge plug on TOF	0.5	• Complexity in retrieving section of bridge plug • Challenge in milling • Unknown condition of TOF • Small clearance between casing and tool
4	Fish out stop plate	0.3	• Challenge in engaging onto stop plate due to its weight & well profile • Multiple BHAs and change out of BHAs
5	Retrieve spear and grapple	0.4	• Lengthy time to mill casing • Metal swarves causing potential of getting stuck
6	Remove casing	0.3	• Lengthy time to mill casing • Metal swarves causing potential of getting stuck

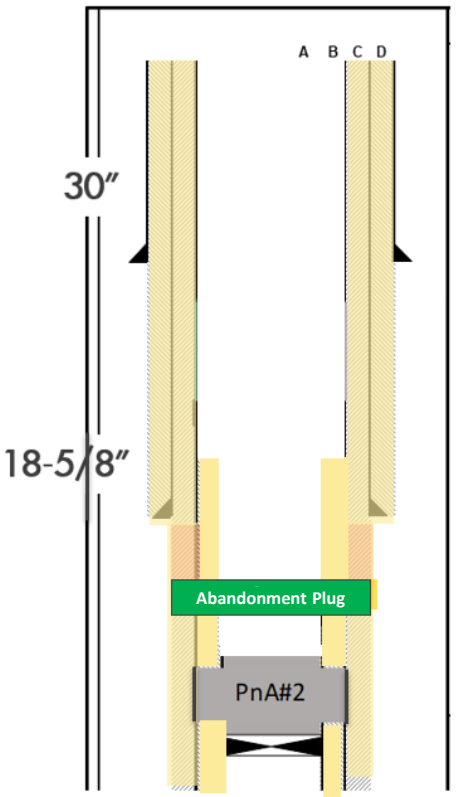


Outcome from technical assessment

1% Success rate
99% Failure

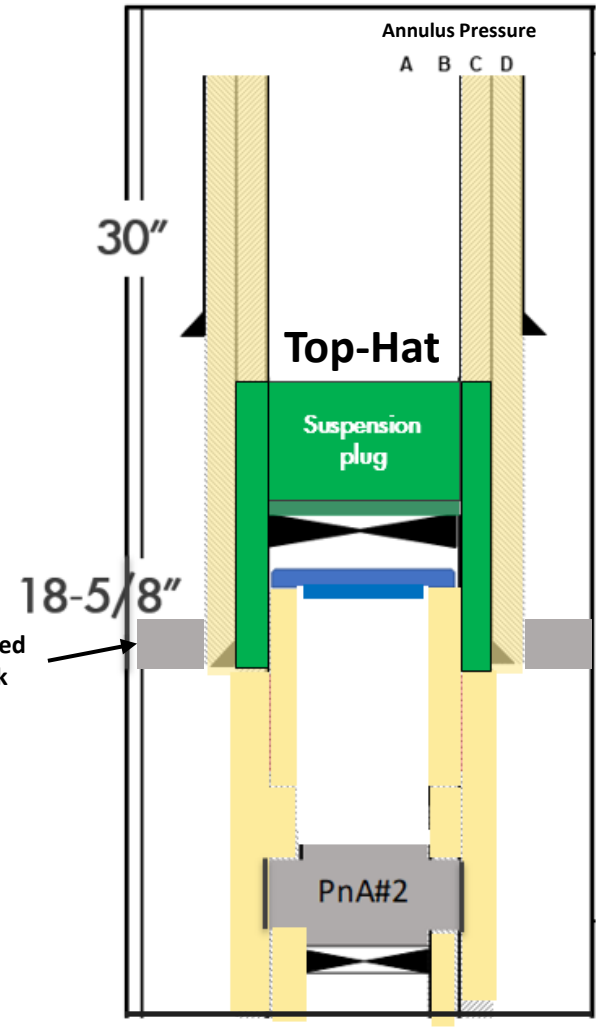
Well Technical Assessment

Base Case



Base Case – Abandon & Restore Caprock	ALARP Approach – Accepted Top Hat Design
Attempt to restore Caprock to best endeavor. Follow flowchart and probability tree.	Accept abandonment top hat design **ALARP approach**
Pros: 1) Confirm the TOF and complexity to fish. 2) Able to confirm TOC and cement quality behind 13-3/8" casing. 3) Achieve wall to wall isolation in the Caprock in the case of successful fishing **Cons:** 1) Potential stuck during fishing/milling. 2) Low possibility of success (1.0% success)	**Pros:** 1) Low complexity. 2) Well re-entry not required. 3) Save CAPEX/ABEX to re-enter well.
D10: 14 days **D50:** 23 days **D90:** ➢ i) 33 days - Success fishing ➢ ii) 27 days - Unsuccessful fishing & reinstate back top hat design	**ALARP Approach** – rig entry not required. **D10:** 0 **D50:** 0 **D90:** 0

ALARP



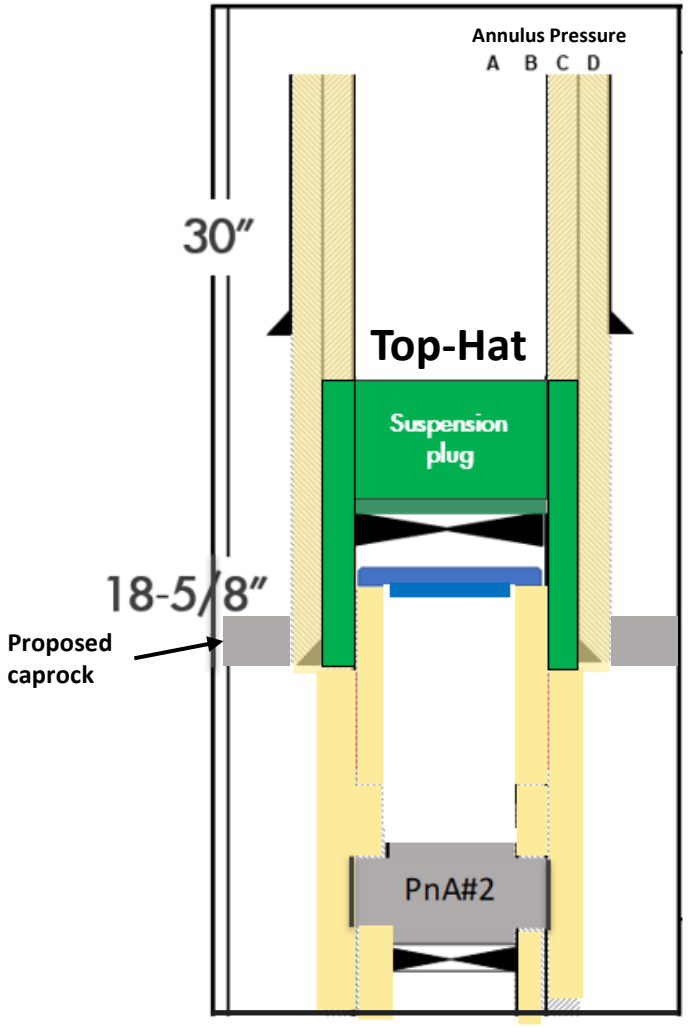
Value of Top-Hat Approach

- Not only does the top-hat approach reduce safety risks, it is also expected to provide economic value to BSP and the country in general
- The well is a candidate for slot recovery. Failure to properly abandon the well if we proceed with well entry could result in significant cost due to unsuccessful abandonment and loss of value from future production

ALARP approach – accepted top hat design

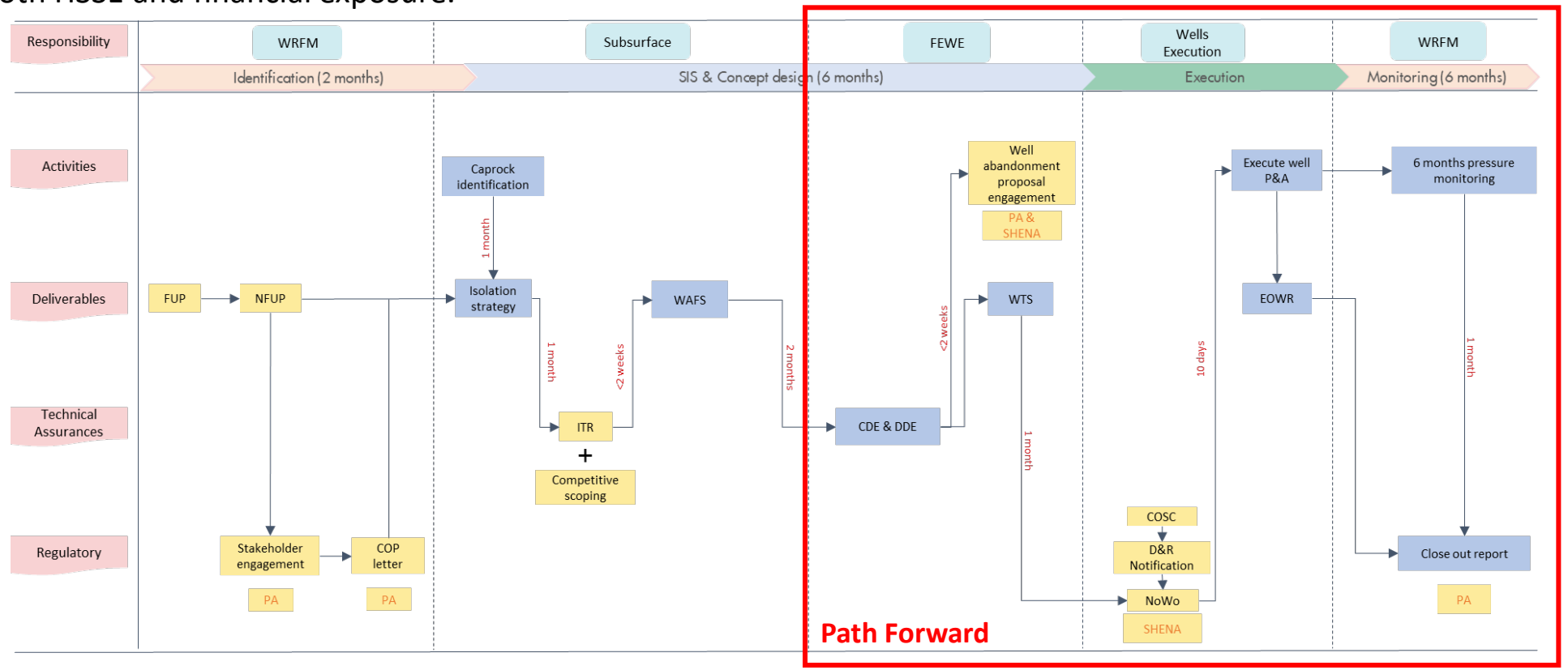
Reduced HSSE risks:
- Low complexity.
- Well re-entry not required.

Economic value:
- Save CAPEX/ABEX to re-enter well
- Successful slot recovery for future production



Conclusion and Path Forward

- With the ALARP (As Low As Reasonably Practicable) design approach, BSP is proceeding with Detailed Design Endorsement (DDE) with top-hat approach for well abandonment and utilizing the well as a slot recovery candidate.
- The approach used in this well can serve as case study for continuous improvement in abandonment standard, reducing both HSSE and financial exposure.



Acknowledgements

- The authors acknowledge the contributions made by the following people to this case study and the top-hat design approach:
  - Afnan Adam
  - Agnes van Loevezijn
  - Haji Muhammad Zulfadhli Putra Haji Ya’akub
  - Saiful Ibrahim
  - Siti Bazlina Awang Mohidin

Decommissioning and Restoration – Fostering Excellence through Regulations, Innovation, and Sustainable Practices

30–31 JULY 2024 | BANDAR SERI BEGAWAN, BRUNEI