OIL & GAS

# Risk-based abandonment of offshore wells

## Examples and applications

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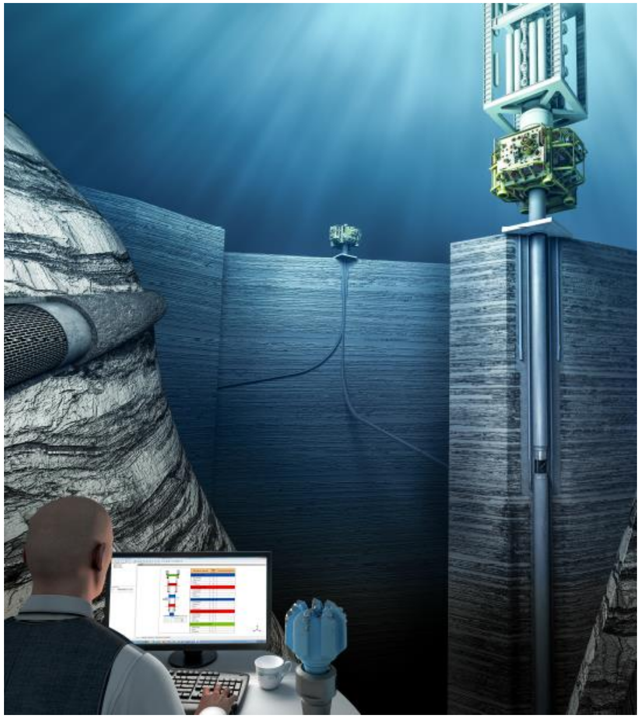
# Content

- Re-introduction to DNV GL RP-E103

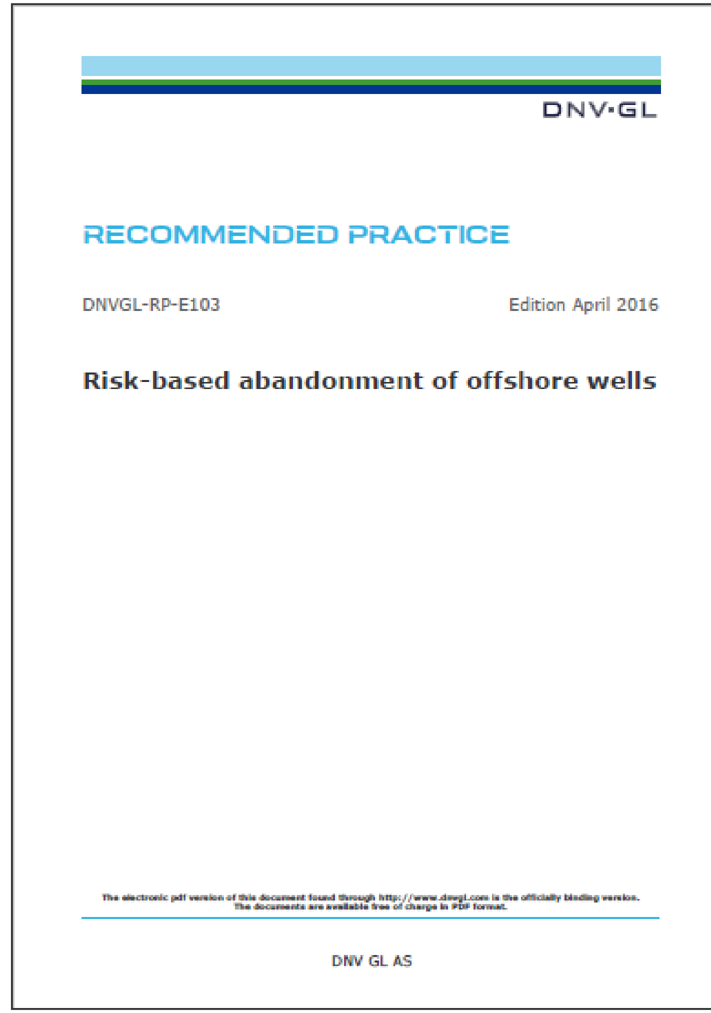
  "Risk based Abandonment of offshore wells"
- Case examples of alternative P&A designs
- Reflections on current use



# Background of Knowledge

- DNV GL developed DNV GL RP-E103

  “Risk based Abandonment of offshore wells
- Based on industry feedback through a first revision Guideline
- 2 OTC papers and presentations
- A large number of industry presentations
- Both high-level and detail dialogs ongoing with operators in the North Sea and worldwide
- Ongoing discussions with regulators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RECOMMENDED PRACTICE

DNVGL-RP-E103 Edition April 2016

**Risk-based abandonment of offshore wells**

The electronic pdf version of this document found through http://www.dnvgl.com is the officially binding version. The documents are available free of charge in PDF format.

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# Rules and Regulations perspective

Norway's regulations for petroleum operations offshore and on land are risk-based (ref. ptil.no)

UK Verification Scheme

- Performance standards
- ALARP principles

Netherlands

- "Goal setting" intention
- NOGEPA initiatives

ISO 16530 Well integrity series
-> risk based P&A

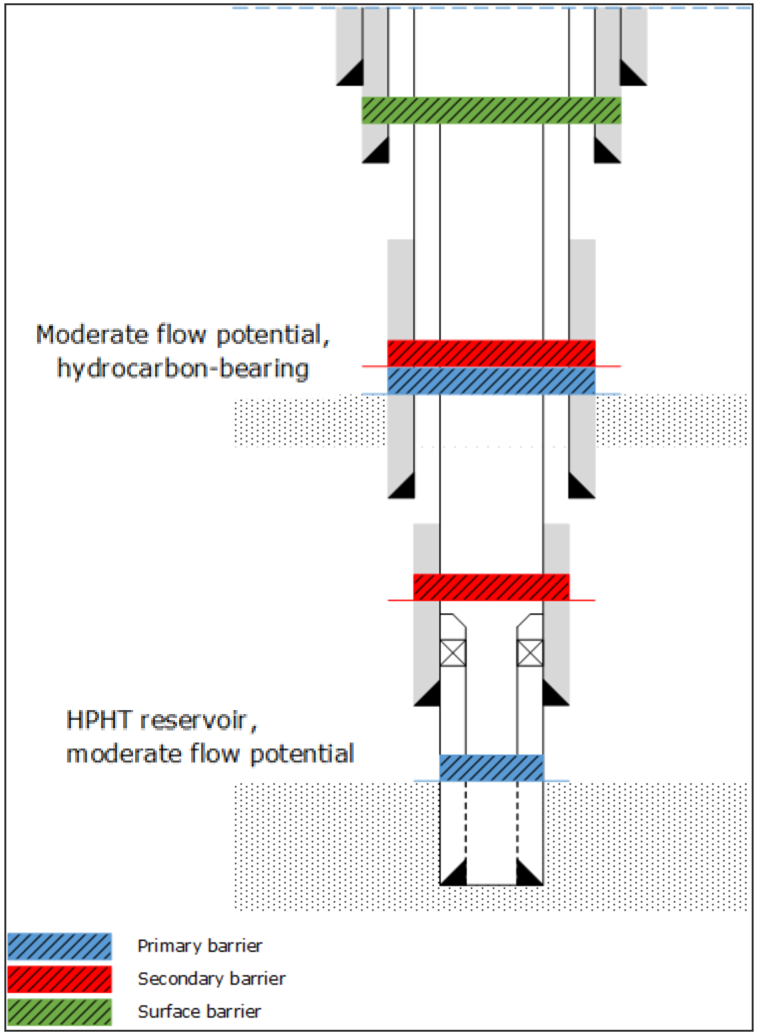
- Industry standards, throughout the world, prescribe the **number**, **type** and **size** of the permanent well barriers.
- The standards differ throughout the North Sea alone.

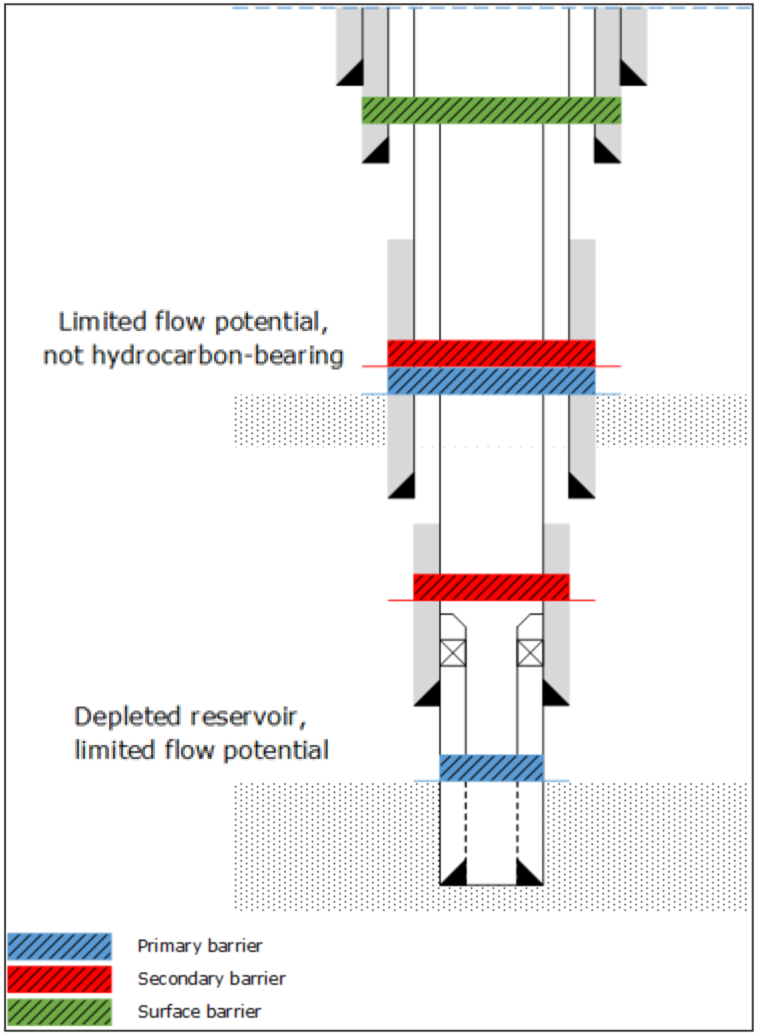
# Parallels to highway design code


- US highways are designed based prescriptive methods, such as xx” of cement.

- German highways are designed to withstand a certain number of years of service.

# Are all P&A wells the same?

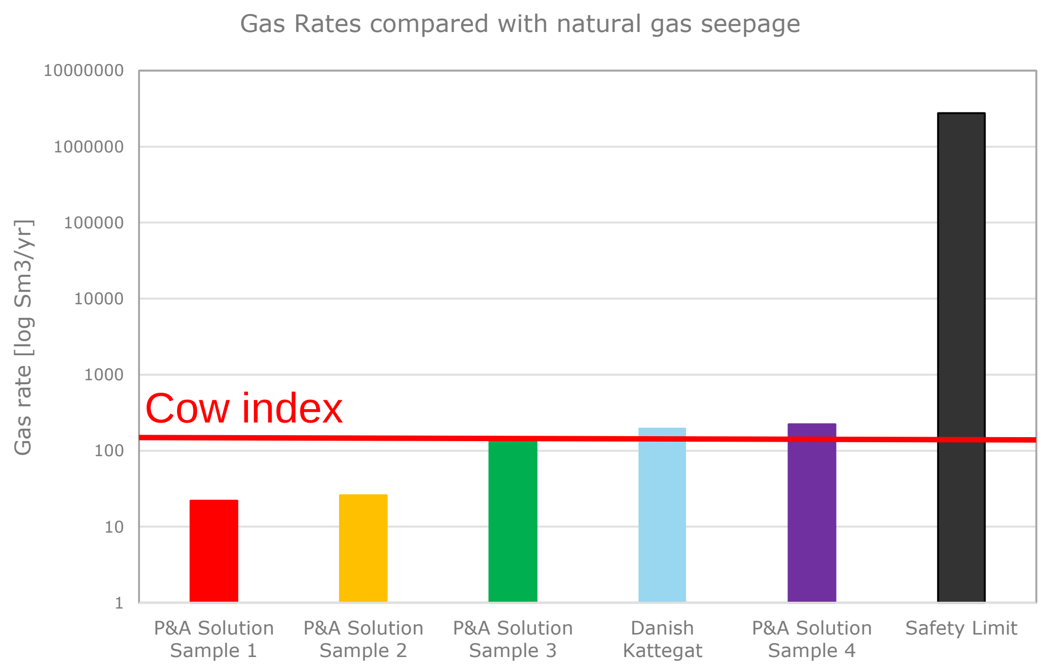


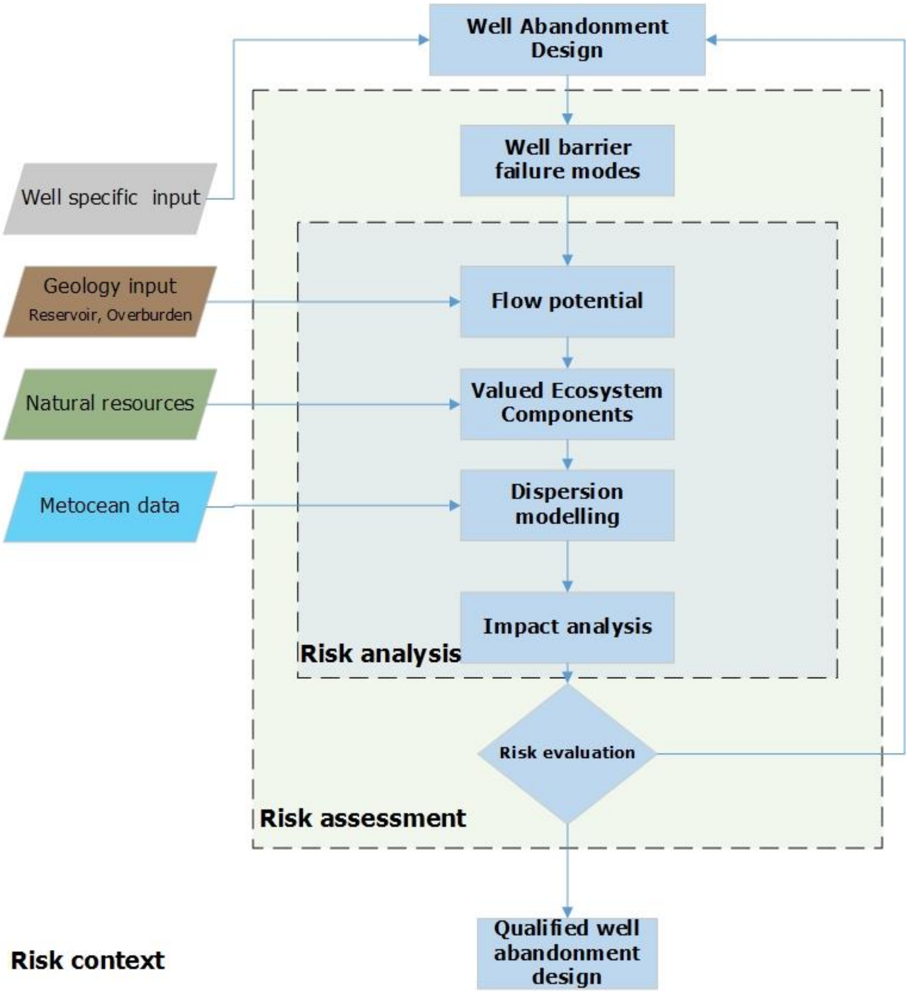
# Environmental perspective reflections

- Oil from produced water released to the Norwegian Se North Sea – 1800 tc as a benchmark
  - Leak rates from ca are significantly lc

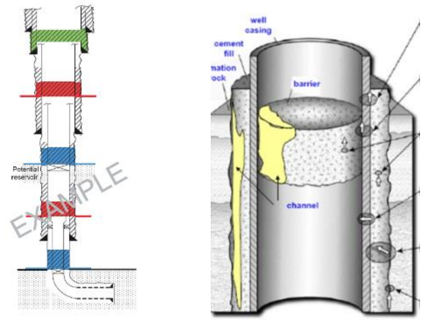

- Natural seepage of g North is a known ph comparison with cas
  - Methane release - for NCS (2014)
  - Natural Methane Release
    - Scanner pockmark 50 Sm3/yr
    - Danish Kattegat 200 Sm3/yr



# Elements in well abandonment risk assessment

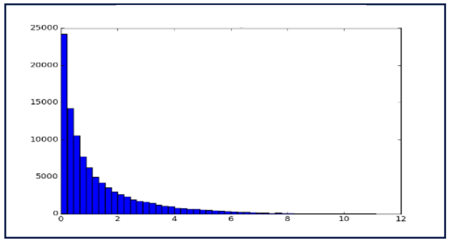


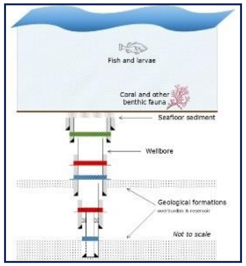

Identify failure modes for pathways




Potential rate with probabilistic modelling

Probabilities in the order of 10-4



# Risk Evaluation Tool – Risk Matrix

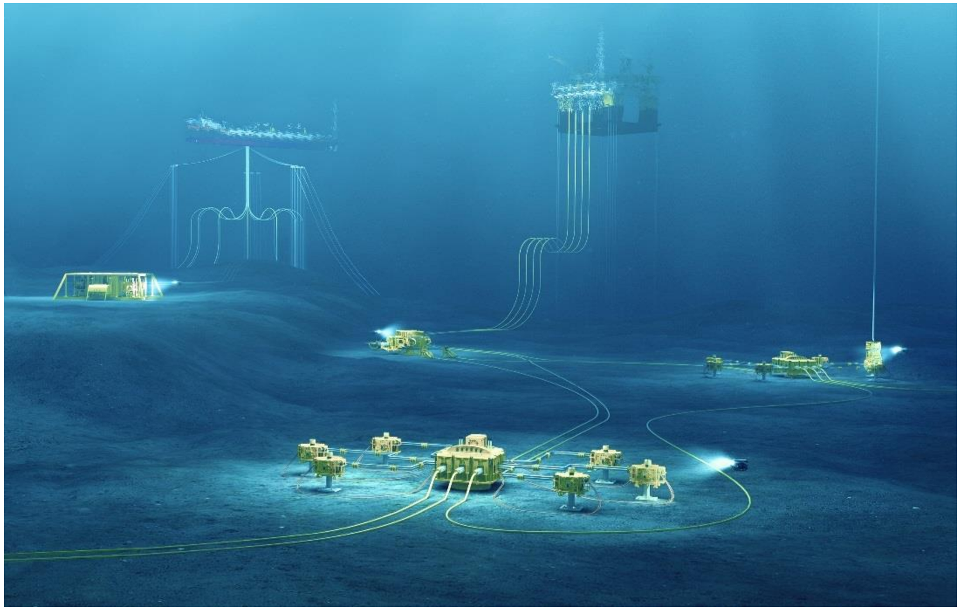
| | Reputation | Platform Safety Risk | Time & Cost | Long-term Environment | Operational Risk | Increasing probability | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $1x10^{-4}$ | $1x10^{-3}$ | $1x10^{-2}$ | $5x10^{-2}$ | $1x10^{-1}$ |
| | | | | | | P1 | P2 | P3 | P4 | P5 |
| I5 | Operator specific | > 1 kg/s hydrocarbons on platform | Operator & Region specific | Region specific | Loss of both barriers [2] | | | | | |
| I4 | | > 0.1 kg/s hydrocarbons on platform [1] | | | Loss of one barrier [2] | | | | | |
| I3 | | > 0.01 kg/s hydrocarbons on platform | | | Uncertain well barrier condition | | | | | |
| I2 | | Undetectable hydrocarbons on platform | | | Negligible well integrity situation | | | | | |
| I1 | | No hydrocarbons on platform | | No flow | No impact | | | | | |

[1] Ref. NORSOK Z-013 [2] Ref. NORSOK D-010

- The proposed risk matrix is aligned with industry codes and operator best practice.

# Case A

- Subsea Template, 360m water depth
- Oil production with two reservoir zones, where the lower completion is exposed
- 180 – 200 bar pressures for P&A
- Two overburden zones (gas, oil)
- Overburden pressure profiles were normal, but volume uncertain
- No significant annulus leakages were observed and recorded
- No migration of overburden fluids and no hydrocarbons observed in environment



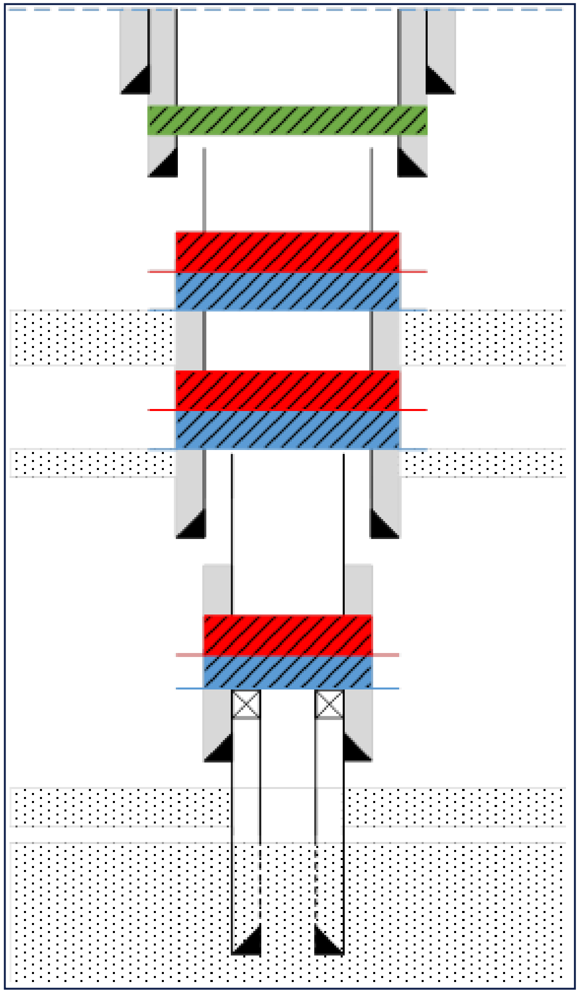
# Case A

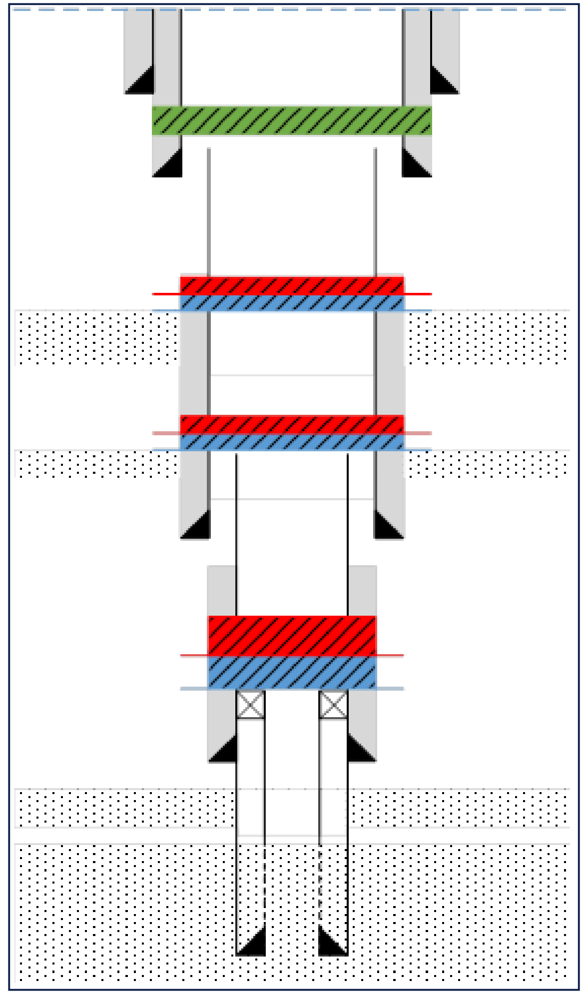
- Analyses was run to identify and optimize the required minimum permanent well barrier length

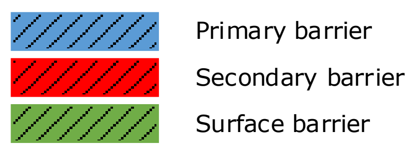
Results

- Lowermost permanent barriers towards the reservoir should remain the same as regulations prescribed, minimum of 30m interval with acceptable bonding and casing cement verified by logging and a 50m interval of formation integrity, ref NORSOK D-010, rev 4.
- Lower overburden zone was analyzed to give a minimum of 15m interval with acceptable bonding and casing cement verified by logging (including safety factors and uncertainty in the analysis).
- Upper overburden zone the result was a minimum of 18m interval with acceptable bonding and casing cement verified by logging.

# Case A







## Case A

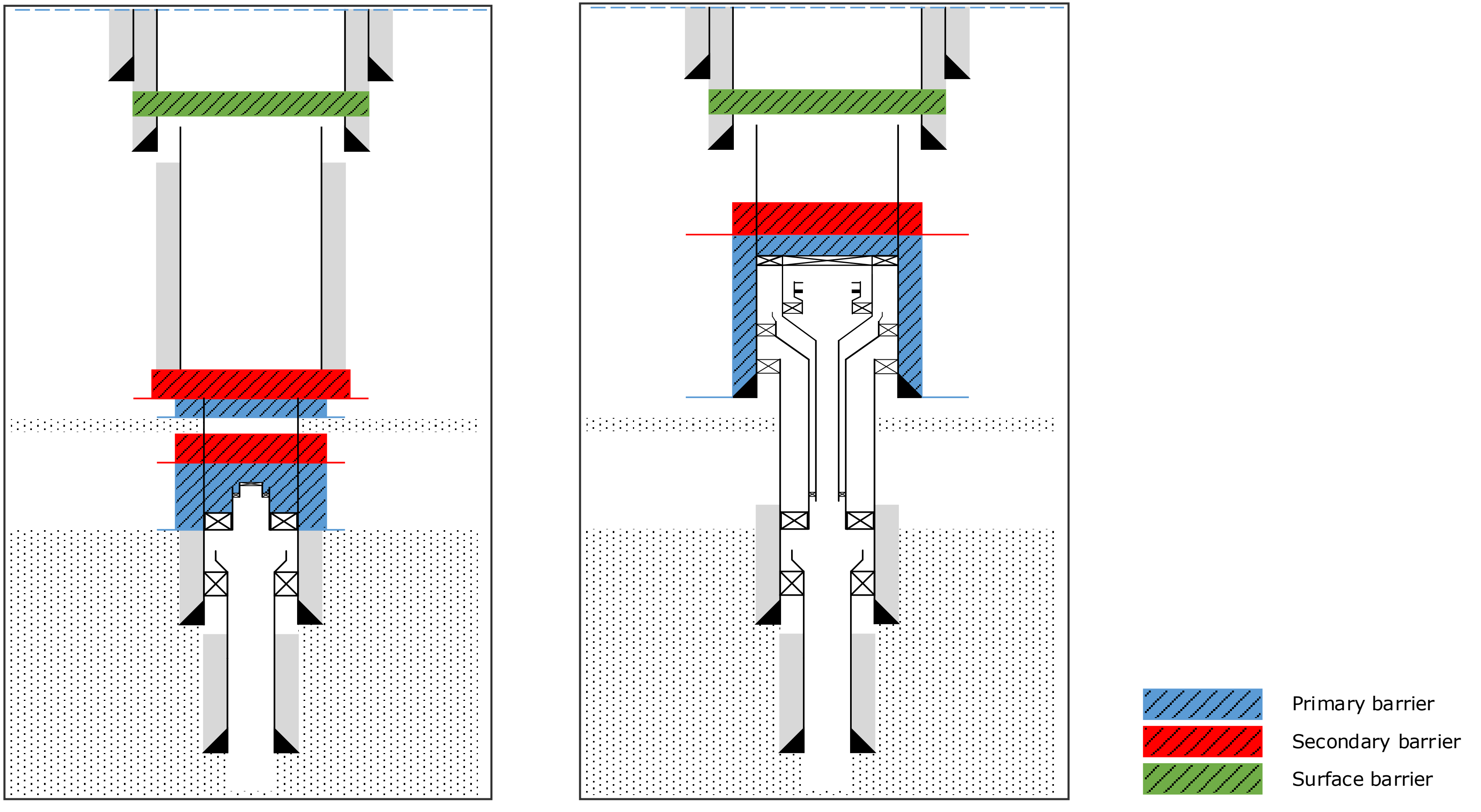
| | Base Case | Alternative |
|---|---|---|
| Reputation | Low | Low |
| Platform Safety | N/A | N/A |
| Time & Cost | Medium | Low |
| Long Term Environment | Low | Low |
| Operational | Low | Low |

- The alternative P&A design was selected as the required permanent barrier lengths, which could be used operationally to simplify decision making and to potentially lower operational costs and well P&A time.

# Case B

- Fixed platform (160m water depth), dry XT
- Injection well in oil reservoir, the well slot will be re-used and sidetracked
- Two potential reservoirs with high production indexes
- Annulus pressure buildup observed, signs of leakage in the lower scab pack liners
- Setting permanent barriers in the base is a challenge, straight forward for the alternative case

# Case B



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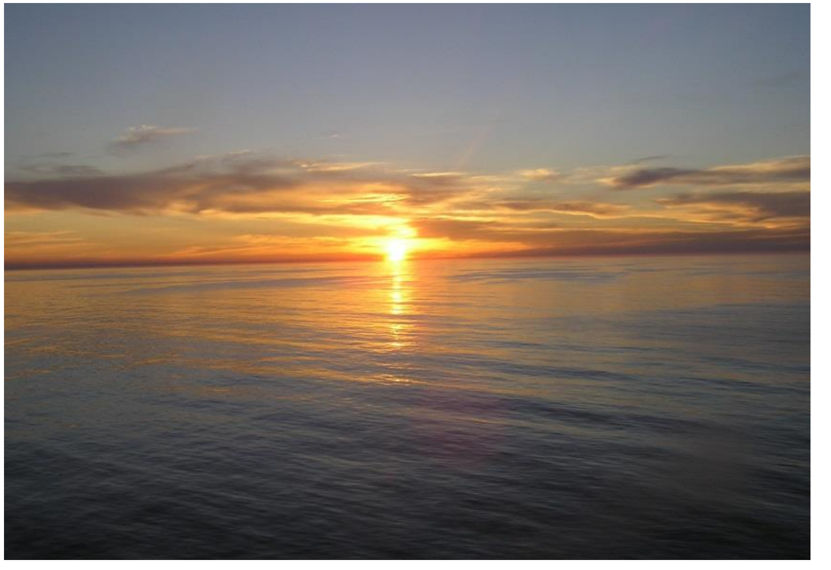
# Case B

| | Base Case | Alternative |
|---|---|---|
| Reputation | Low | Medium |
| Platform Safety | Low | Low |
| Time & Cost | Medium | Low |
| Long Term Environment | Low | Low |
| Operational | High | Low |

- In this table, ALARP principles have been included to show the time & cost perspective.
- The most advantageous solution can then be selected, implemented and approved according to DNV GL-RP-E103.

# Summary

- The methodology is in-use in the industry.
- Examples show that considerable savings can be achieved.
- DNV GL can assist in evaluating well abandonment design for optimization.
- “Fit-for-purpose ” designs can be used rather than “one size fits all.”



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