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Risked-based Framework for Developing an Integrity Management Strategy for Legacy Wells

Yakubu Wagaja, Prince Innocent, Dr Ruissein Mahon

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A Mature Basin at a Crossroad

7,800+

Wells drilled on the UKCS to date

Delivered 47.7 bn boe 2024 end

£44 bn

Forecast cost of fully decommissioning

£3 bn up from 2021 prices

500+

P&A wells backlog

Excess of 1,000 wells due for P&A (2026 to 2030)

- A record **£2.4 billion** on decommissioning in **2024**; yet deeply behind on well P&A targets
- Regulator has opened formal investigations and is considering fines of up to **£1 million** per operator for non-compliance
- A risk-based integrity strategy is no longer optional – it is a regulatory imperative

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What Makes UKCS Legacy Wells Uniquely Risky

Pre-modern Well Integrity Standards

Wells drilled before **API RP 90 / NORSOK D-010** became standard practice – sustained casing pressure found in **11 to 12%** of offshore wells in the Gulf of Mexico (Al-Shehri, 2019); similar legacy conditions apply to early UKCS fields drilled from the 1970s onward

Incomplete & Inaccessible Records

Decades of operator changes, mergers, and asset transfers mean many UKCS wells have fragmented construction, completion, and abandonment records - a key driver of data uncertainty in the DCI component of this framework

Cement & Casing Degradation

Degradation driven by CO_2 exposure, pressure changes, and brine corrosion – creates micro-annuli and pathways that compromise long-term zonal isolation and structural integrity

Harsh North Sea Subsurface Conditions

HPHT reservoirs in the CNS and WoS; cyclic tidal and wave-induced loading on subsea wellheads; corrosive seawater ingress – all compound long-term integrity risk

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New Demands on UKCS Legacy Wells

UKCS legacy wells sit directly inside a basin now targeted for UK low-carbon infrastructure:

Carbon Capture & Storage (CCS)

→ 21 NSTA carbon storage licences awarded in 2023 across **~12,000 km²** - area equivalent to Yorkshire

→ UK government committed **£21.7bn** to CCS; HyNet (Liverpool Bay) targets **4.5 Mt CO_2/yr** rising to **10 Mt** by **2030**

→ Acorn Project (NE Scotland) repurposes existing North Sea gas field infrastructure for CO_2 storage

→ NZTC/DNV CCS Wells Tech Roadmap (2025): legacy well remediation is one of 4 key focus areas across 60+ technologies

Underground Hydrogen Storage (UHS)

→ UKCS has a total potential hydrogen storage capacity of 3,454 TWh across 96 fields (Peecock et al., 2022)

→ H_2 diffuses far faster than CH_4 through micro-annuli – existing cement sheaths face unprecedented pressure cycles

→ Aquaterra Energy: new RAF technology targets **80%** cost reduction and **50%** time saving for legacy well re-abandonment

→ Northern Endurance Partnership selected RAF for UK's first approved offshore CCS project (2025)

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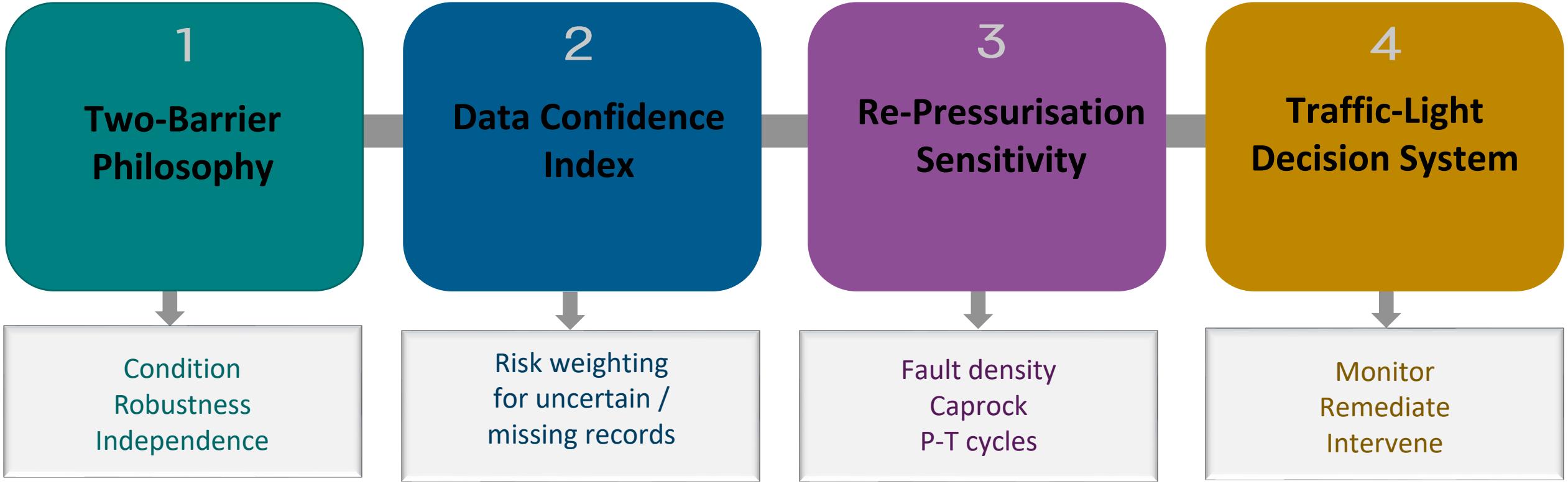
Risk-based Framework Overview

Four integrated components feed a decision-support traffic-light system for UKCS legacy well management:



↕ Framework aligns with NSTA Well Decommissioning Strategy, NORSOK D-010, and the UK's North Sea Transition Deal Net Zero commitments

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C1: Evaluation Criteria for UKCS Wells

CONDITION

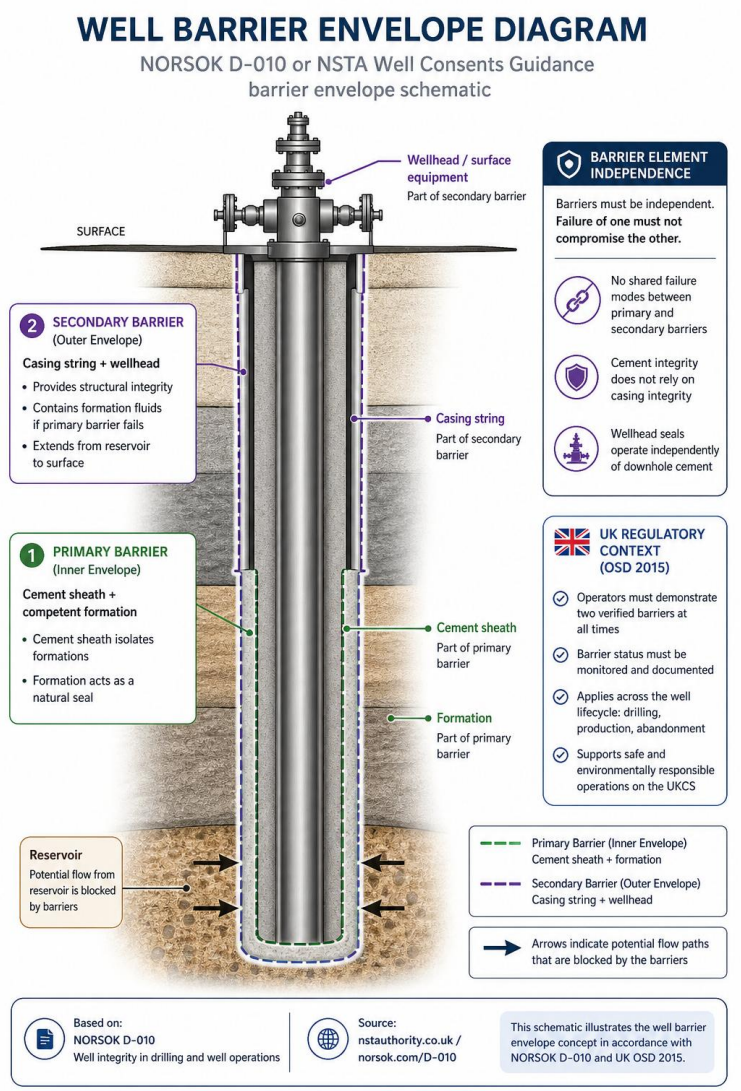
Physical state of casing, cement sheath, and wellhead — assessed from WONS records, cement bond logs, and ultrasonic logging data. North Sea wells with shut-in status: 795 as of 2023, an all-time high of 31% of active well stock

INDEPENDENCE

Are the primary barrier (cement sheath) and secondary barrier (casing/tubing) genuinely independent? North Sea super-emitter offshore wells highlight cases where both barriers have degraded simultaneously (Pullen et al., 2025)

ROBUSTNESS

Ability to withstand CCS/UHS re-pressurisation cycles – NZTC/DNV CCS Wells Roadmap (2025) flags pressure cycling and extreme temperature fluctuation as primary technical challenges for UKCS storage wells



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C 2: Data Confidence Index (DCI)

UKCS well records span 50+ years and multiple operators. The DCI assigns explicit risk weighting to data gaps:

Data Category	Available & Verified	Partial / Estimated	Missing / Unknown
Construction records	Low risk weight	Moderate risk weight	High risk weight
Cement bond logs	Low risk weight	Moderate risk weight	High risk weight
Abandonment certificate	Low risk weight	Moderate risk weight	High risk weight
Casing inspection log	Low risk weight	Moderate risk weight	High risk weight

UKCS context: NSTA's Well Operations and Notifications System (WONS) holds operator-submitted data, but older wells pre-date digital records. Operator M&A activity can sometimes fragment record continuity. A high DCI score on missing data must trigger elevated risk classification.

DCI Score → feeds directly into the Traffic-Light System as an uncertainty penalty on overall well risk classification

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Well Screening & CCS Site Selection

Well Screening

Objective: Identify and evaluate legacy wells for potential reuse in CO_2 or H_2 storage projects

Data: Well datasets sourced from UKCS

Criteria: Well age · type · deviation · cement condition · abandonment method · architecture

Risk Scoring Framework

Low Risk	Moderate Risk	High Risk
< 0.3	0.3 to 0.6	> 0.6

Risk Scoring Criteria (Sample)

Criterion	Description	Score
Well Age	Unknown / pre–1975 / 1975–1985 / 1986–1997 / post-1997	5→1
Cement Top	Unknown / Extremely low / Low / Moderate / Above surface casing	5→1

Scores aggregated into composite risk index (0 to 5 scale)

CCS/UHS Site Selection

Objective: Determine the most promising offshore CO_2 or H_2 storage site

Data: Field datasets from UKCS (NNS · CNS · SNS)

Criteria: Beneficial: storage capacity, leakage risks, proximity to shore | Non-beneficial: development cost

Field Ranking Method — TOPSIS

1. Matrix normalisation
2. + / – Ideal solution
3. Euclidean distance
4. Ranking

Five-Point Scoring Scale

1	2	3	4	5
Low	Below Average	Average	Good	Excellent

Criteria Categories

✓ Beneficial Criteria	✕ Non-Beneficial
Storage capacity · Leakage risk · Proximity to shore	Development cost

TOPSIS ranks NNS · CNS · SNS fields by composite closeness coefficient

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C 3: Re-pressurisation Sensitivity Analysis

Basin-scale geological screening — 4 key factors

Fault Density

High fault density elevates seismic risk from injection and creates preferential fluid migration pathways – H_2 diffuses orders of magnitude faster than CH_4 along fractures (Zheng et al., 2025)

Shallow Gas Occurrence

Shallow gas increases blowout risk during well intervention; particularly relevant for North Sea legacy wells where 'super-emitter' wells have been identified in the past (Böttner et al., 2020; Vielstädte et al., 2017)

Caprock Strength

Caprock permeability and mechanical strength determine long-term containment; critical for CCS sites where CO_2 must be stored for 1,000+ years

Historical P-T Cycles

Prior pressure and/or temperature fluctuations which damage cement microstructure; wells near depleted reservoirs show higher sustained casing pressure rates (Ibukun et al., 2024)

Four geological factors: fault density, shallow gas, caprock strength, and P-T history – collectively determine whether a legacy well is safe to repurpose

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C 4: Traffic Decision System

Combined DCI Score + Barrier Assessment + Sensitivity Analysis → Structured Action

GREEN

→ MONITOR

Criteria: Both barriers verified · High data confidence · Low re-pressurisation sensitivity

Action: Routine surveillance programme · Annual integrity verification · Baseline monitoring

AMBER

→ REMEDIATE

Criteria: Single barrier concern OR moderate DCI score OR intermediate geological sensitivity

Action: Targeted cement squeeze / repair · Enhanced logging campaign · Increased monitoring frequency

RED

→ INTERVENE

Criteria: Both barriers compromised OR very low DCI score OR high geological sensitivity (fault proximity, shallow gas)

Action: Full well workover or P&A · Regulatory notification · Exclusion from CCS/UHS repurposing scope

This framework mirrors risk-based methodologies in NORSOK D-010, API RP 100 (CCS), and emerging UHS regulatory guidance

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UK Regulatory Alignment & Sustainability

NSTA Well Decommissioning Strategy	Targets 300 wells P&A per year; backlog of 500+ wells past target dates; operator league table forthcoming	UK / UKCS
NORSOK D-010 Revision 5	Two-barrier philosophy for well integrity across entire lifecycle – basis of Component 1 of proposed framework	Norway / International
UK OSD Regulations 2015	Offshore Safety Directive: operators must be formally appointed; all well operations require NSTA consent via WONS	UK
NSTA Wells Consents Guidance	Governs suspension (max 2 to 5 yrs), abandonment strategy, and P&A standards for UKCS wells	UK
EU CCS Directive (UK-retained)	Long-term CO_2 storage safety, 30+ yr post-closure monitoring required – directly relevant to CCS licence wells	UK (retained EU law)

Commercial reality: NSTA estimates operators will commit £27 bn to decommissioning (2023 to 2032). Well P&A alone accounts for ~50% of total decommissioning spend. A risk-based approach avoids costly, unplanned interventions and protects the UKCS supply chain.

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Key Takeaways

1

The UKCS P&A backlog is a systemic integrity risk

A real risk potential of unmanaged integrity deterioration – particularly in wells now adjacent to CCS and UHS licence areas

2

A structured, risk-based framework enables smarter prioritisation

Combining two-barrier evaluation, a data confidence index, UKCS-specific geological screening, and a traffic-light system allows operators to triage the backlog efficiently – directing scarce rig capacity where risk is highest

3

Acting now protects the UK's low-carbon subsurface investment

The UK government has committed £21.7bn to CCS. Legacy well integrity failures in the same basins could undermine containment credibility, expose operators to NSTA enforcement, and jeopardise Net Zero milestones

The North Sea built the UK's energy security. Responsible stewardship of its legacy will define the UK’s Net Zero future.