Offshore CO_2: Monitoring, Detection, Attribution, and Assurance

Direct detection + attribution for offshore MMV

June 2026

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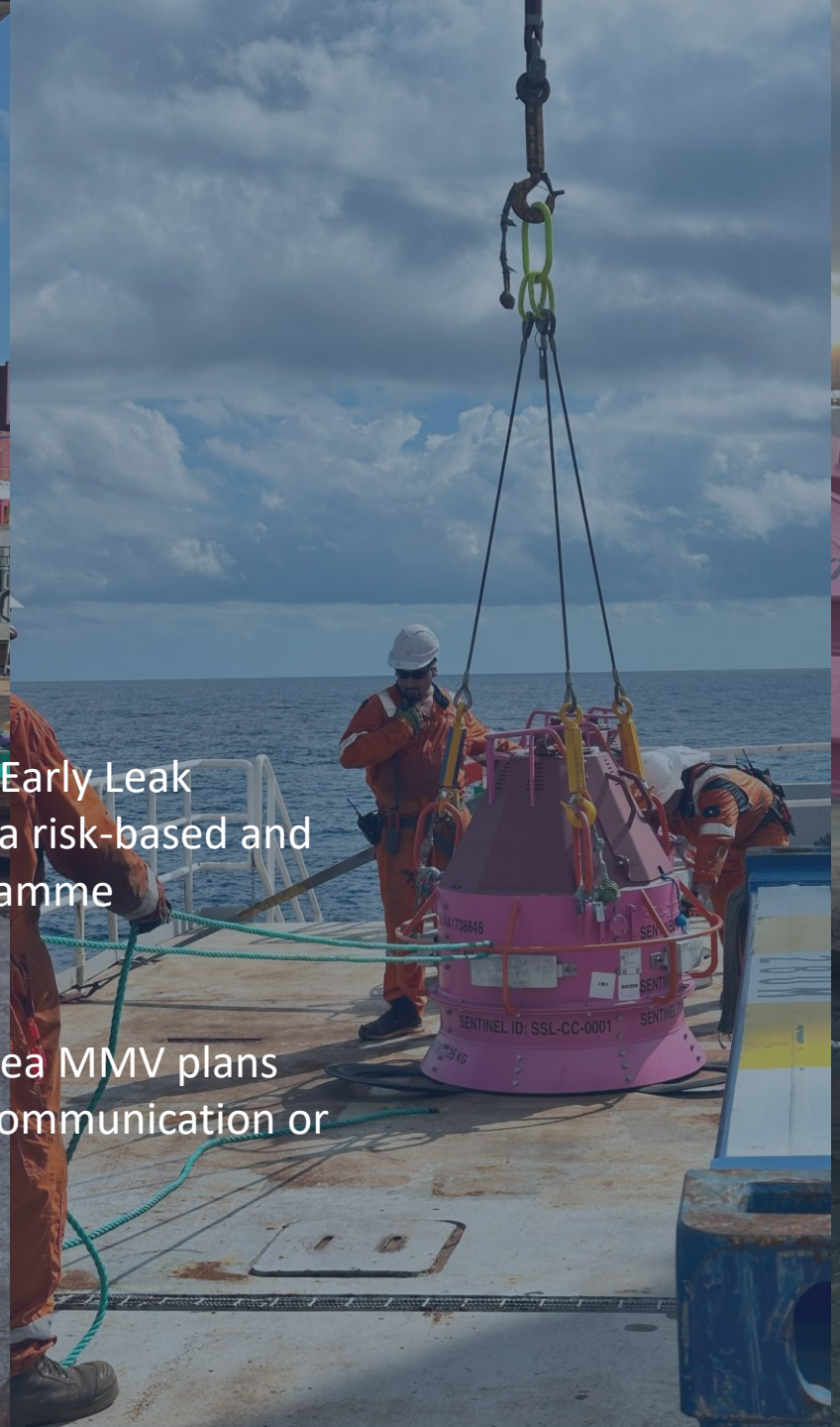
Sentinel

WellSentinel™

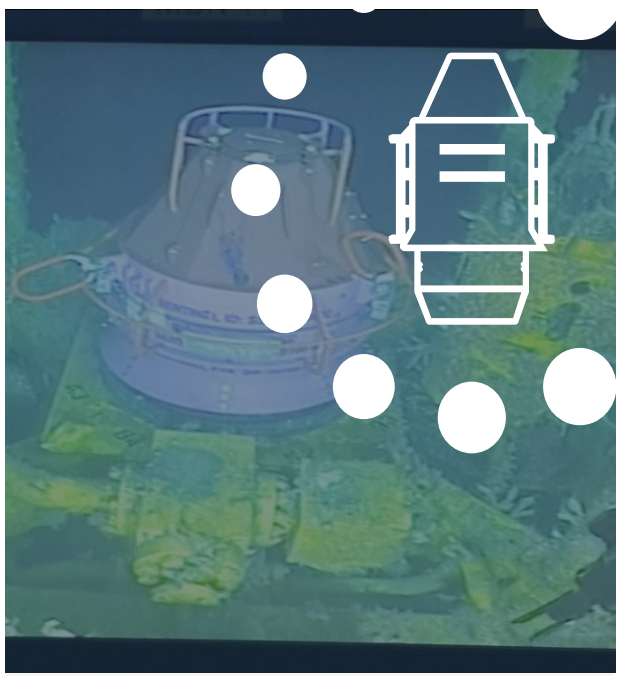
Continuous Integrity Monitoring and Early Leak Detection for Legacy Wells as part of a risk-based and cost effective CCUS monitoring programme

Remote monitoring approach to subsea MMV plans without active power, ongoing data communication or complex intervention



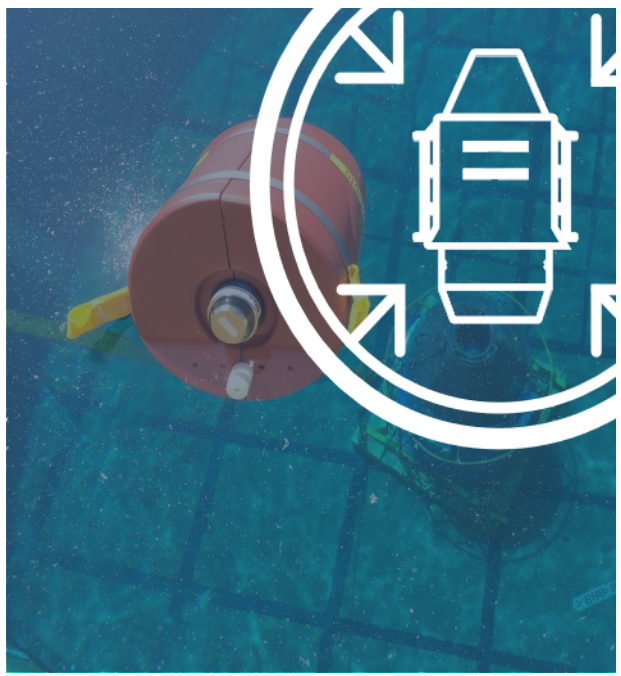
Deploy onto the Subsea Well

Deploy a system onto an asset designed to capture emissions in the subsea environment



Continuous Asset Monitoring

Provides long-term continuous asset monitoring for up to 20 years without intervention



Detect LoC with Passive Triggers

Passively detect a Loss of Containment (LoC) without active electronics and release an alert beacon to surface

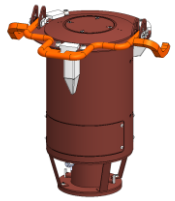
Receive Alert via Satellite

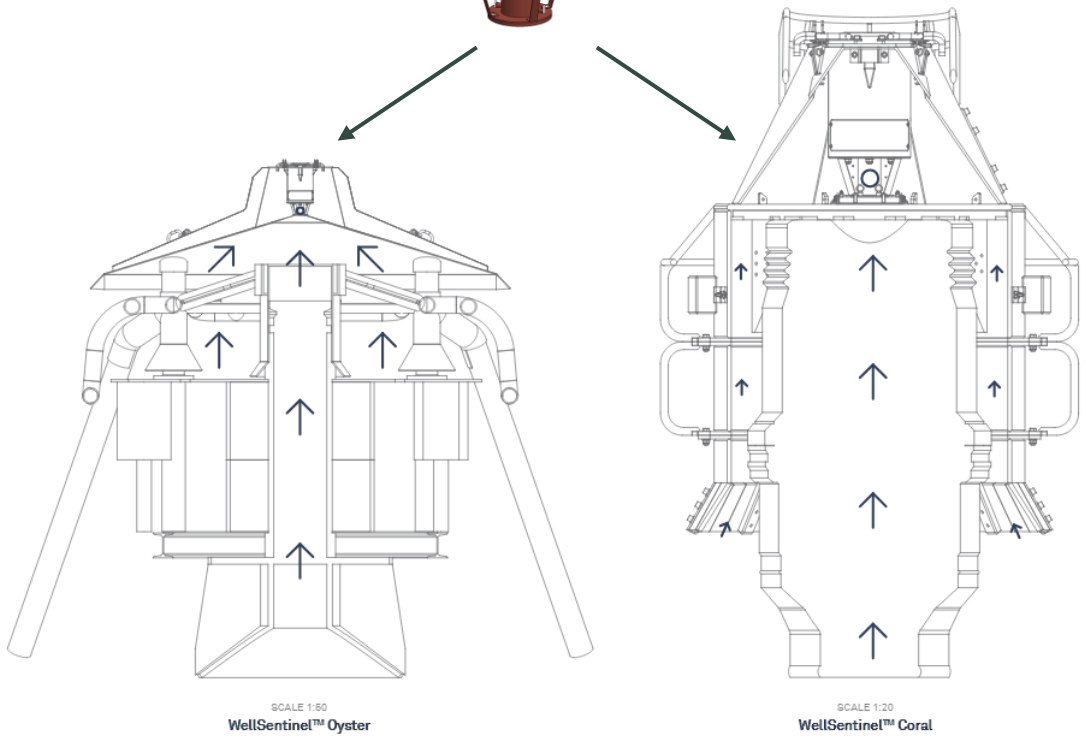
Rapidly sends an alert to the asset owner including the Well ID and allows a rapid and coordinated response

Deploy onto the Subsea Well

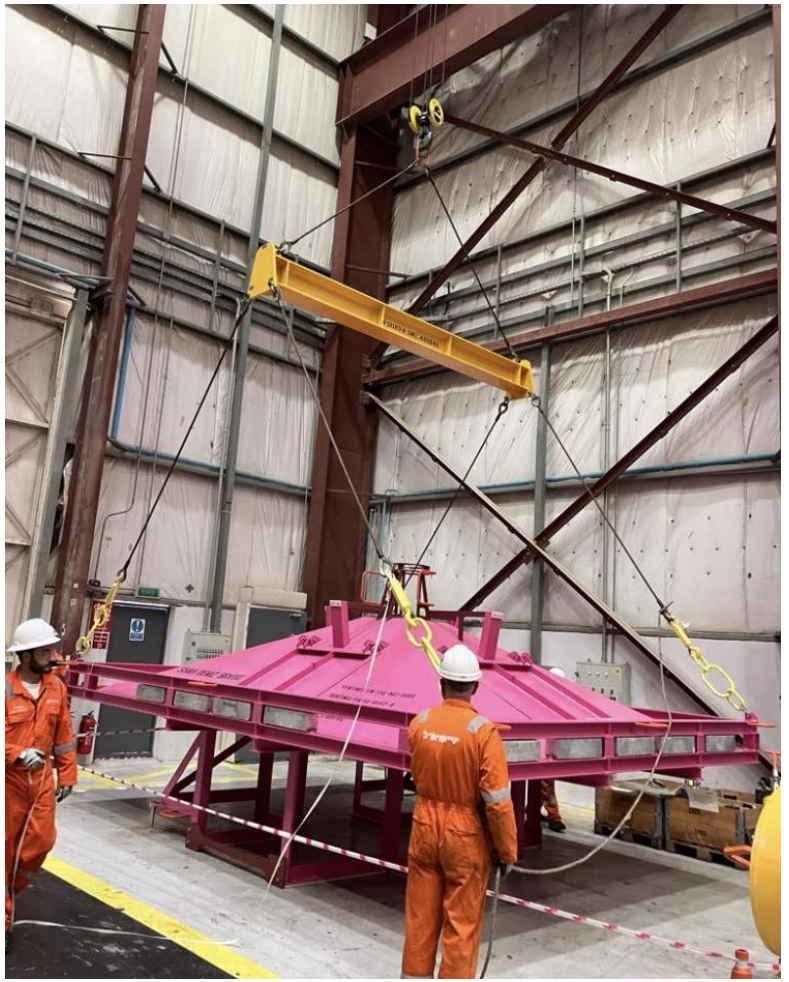
Deploy a system onto an asset designed to capture emissions in the subsea environment.

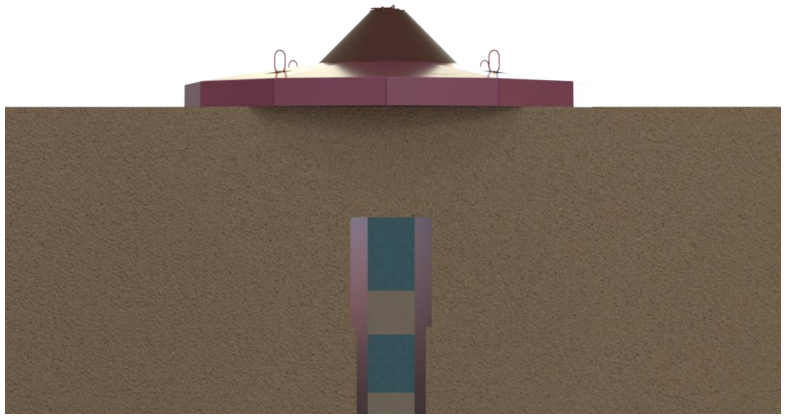
Monitoring Module

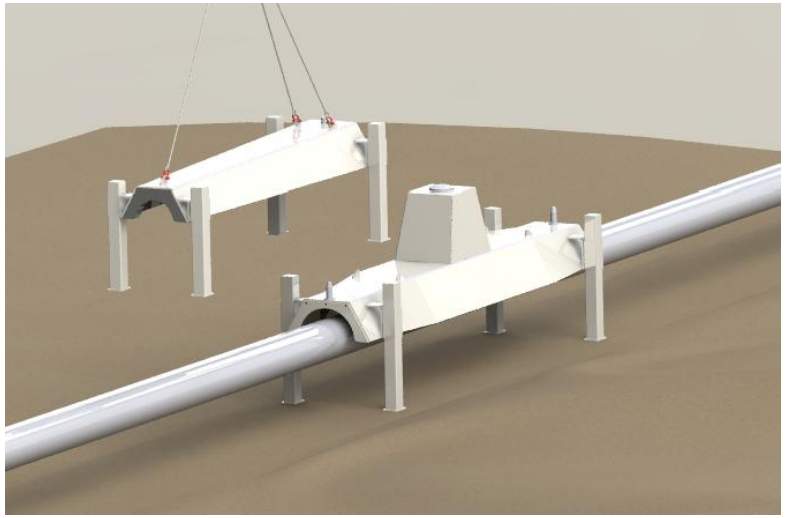




Designed to Monitor your Subsea Well







Set System with Passive Triggers

The system monitors passively by inserting the appropriate Triggers to secure an Alert Beacon in place in the Monitoring Module

See our detection capabilities

Gas	Reacts to thermogenic (reservoir) gas
Oil	Reacts to liquid hydrocarbons (HC)
Tracer	Reacts to tracer fluid (SWIFT)
CO2	Reacts to the presence of CO2
Mixed	Multiple Triggers can be fitted in one system

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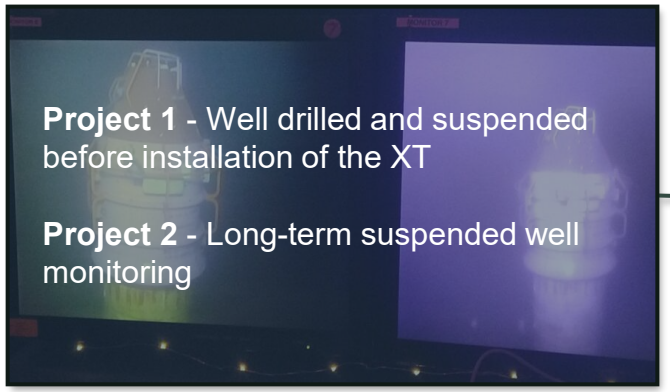
Detection and Alert Beacon Release

Should the system detect an emission, this mechanically releases the Alert Beacon to the ocean surface

Receive an Alert via Satellite

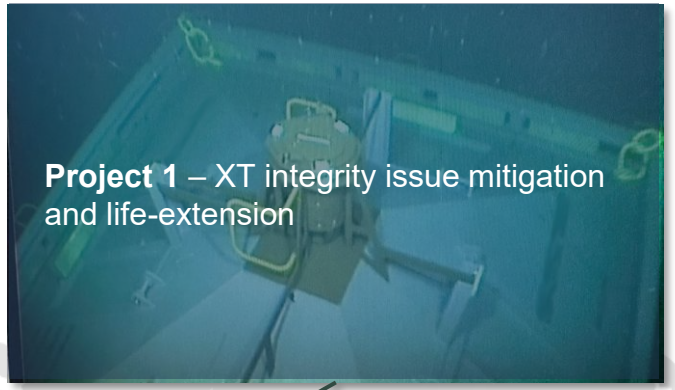
Once reaching the surface the coded Alert Beacon activates and automatically alerts operator's response teams

Real-World Global Applications

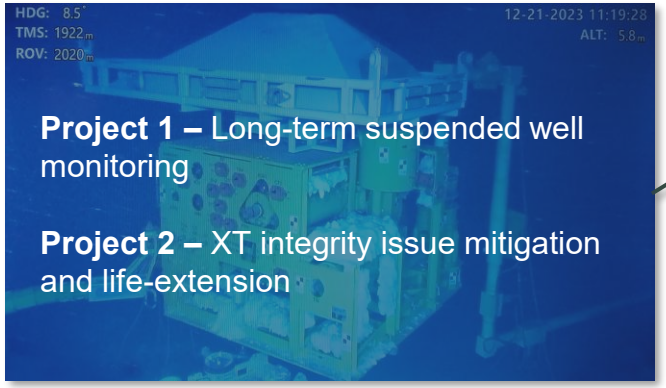


Project 1 - Well drilled and suspended before installation of the XT

Project 2 - Long-term suspended well monitoring



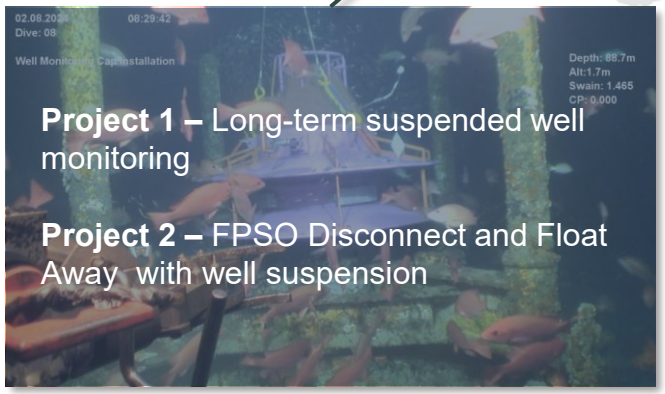
Project 1 – XT integrity issue mitigation and life-extension



Project 1 – Long-term suspended well monitoring

Project 2 – XT integrity issue mitigation and life-extension

Project 1 – Long-term suspended well monitoring



Project 1 – Long-term suspended well monitoring

Project 2 – FPSO Disconnect and Float Away with well suspension

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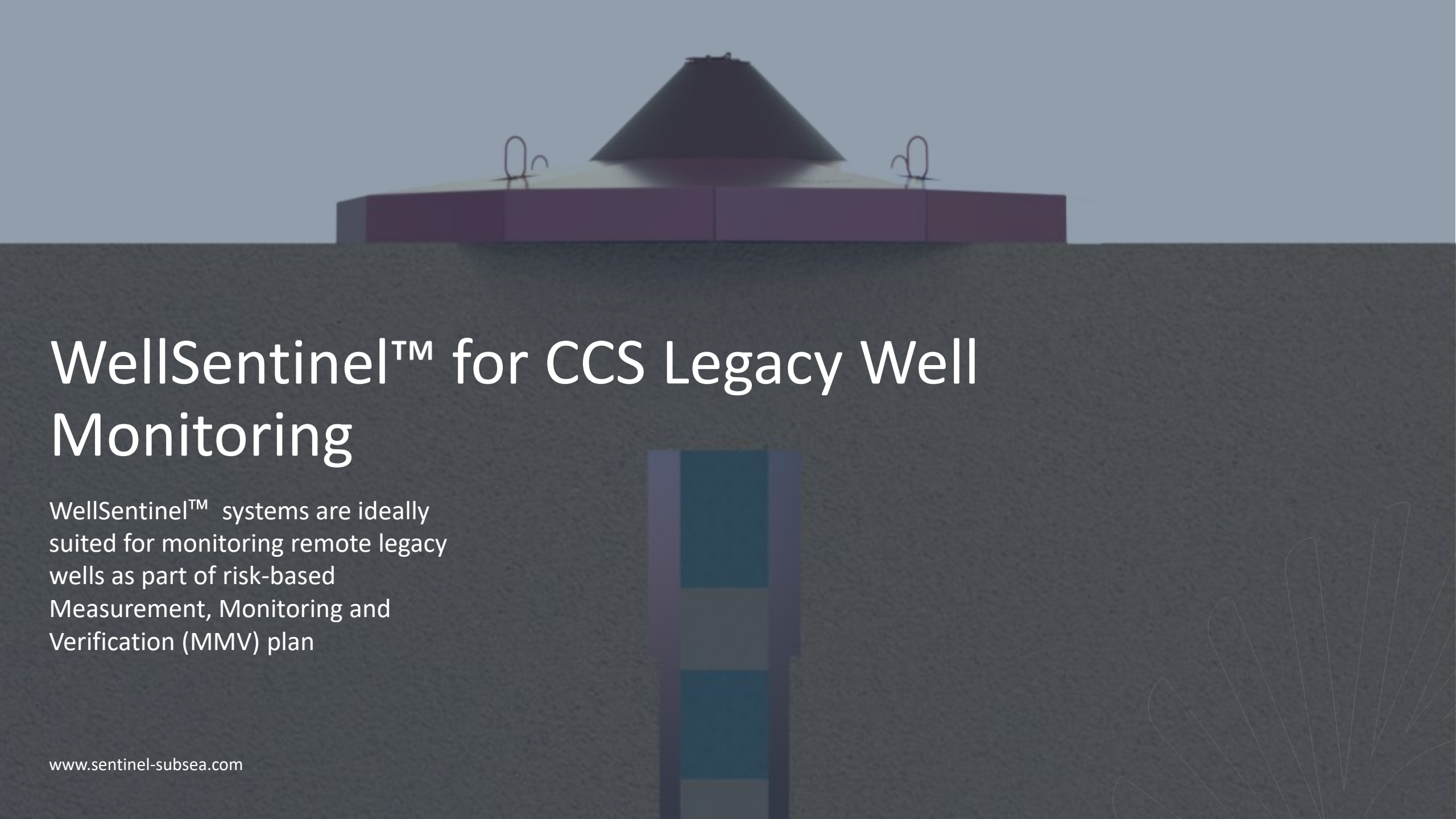
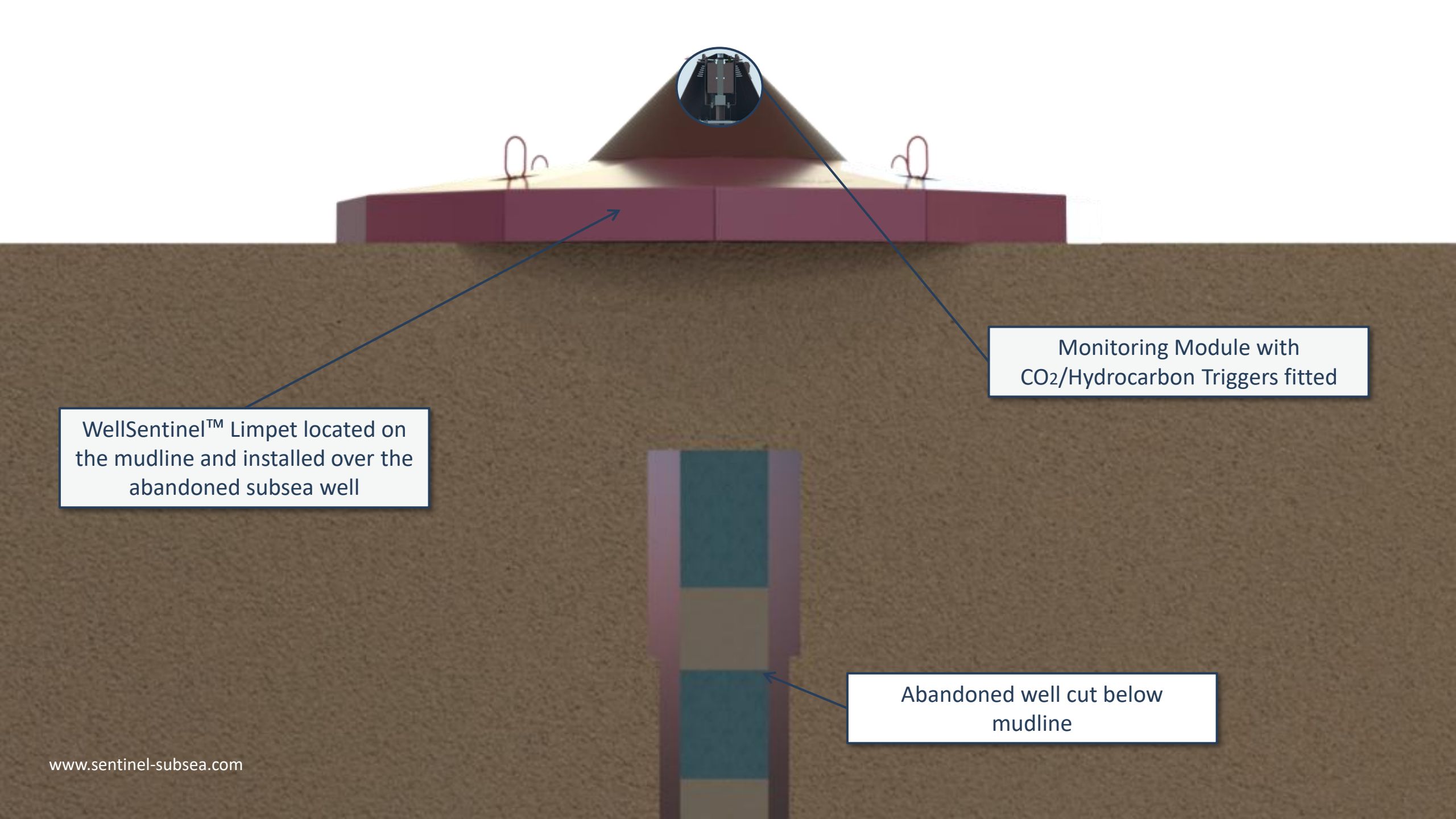


WellSentinel™ for CCS Legacy Well Monitoring

WellSentinel™ systems are ideally suited for monitoring remote legacy wells as part of risk-based Measurement, Monitoring and Verification (MMV) plan

www.sentinel-subsea.com



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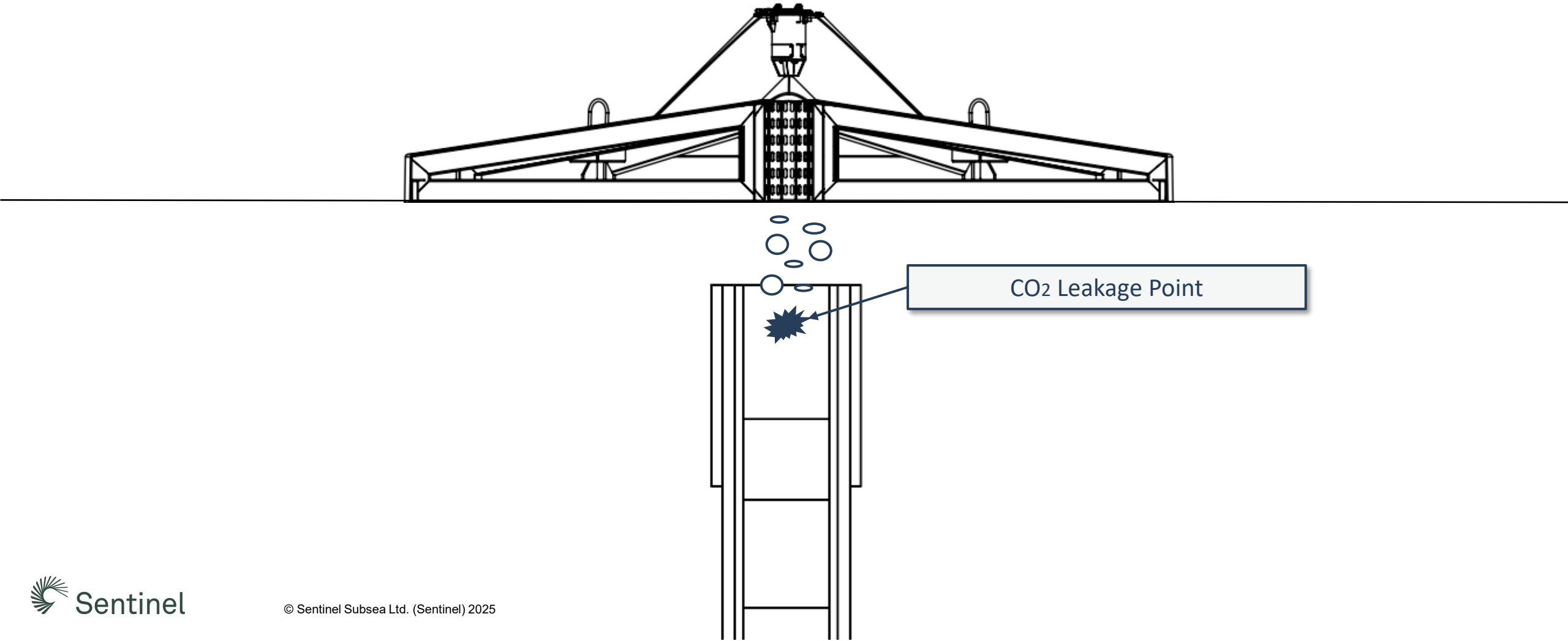
Vertical Capture



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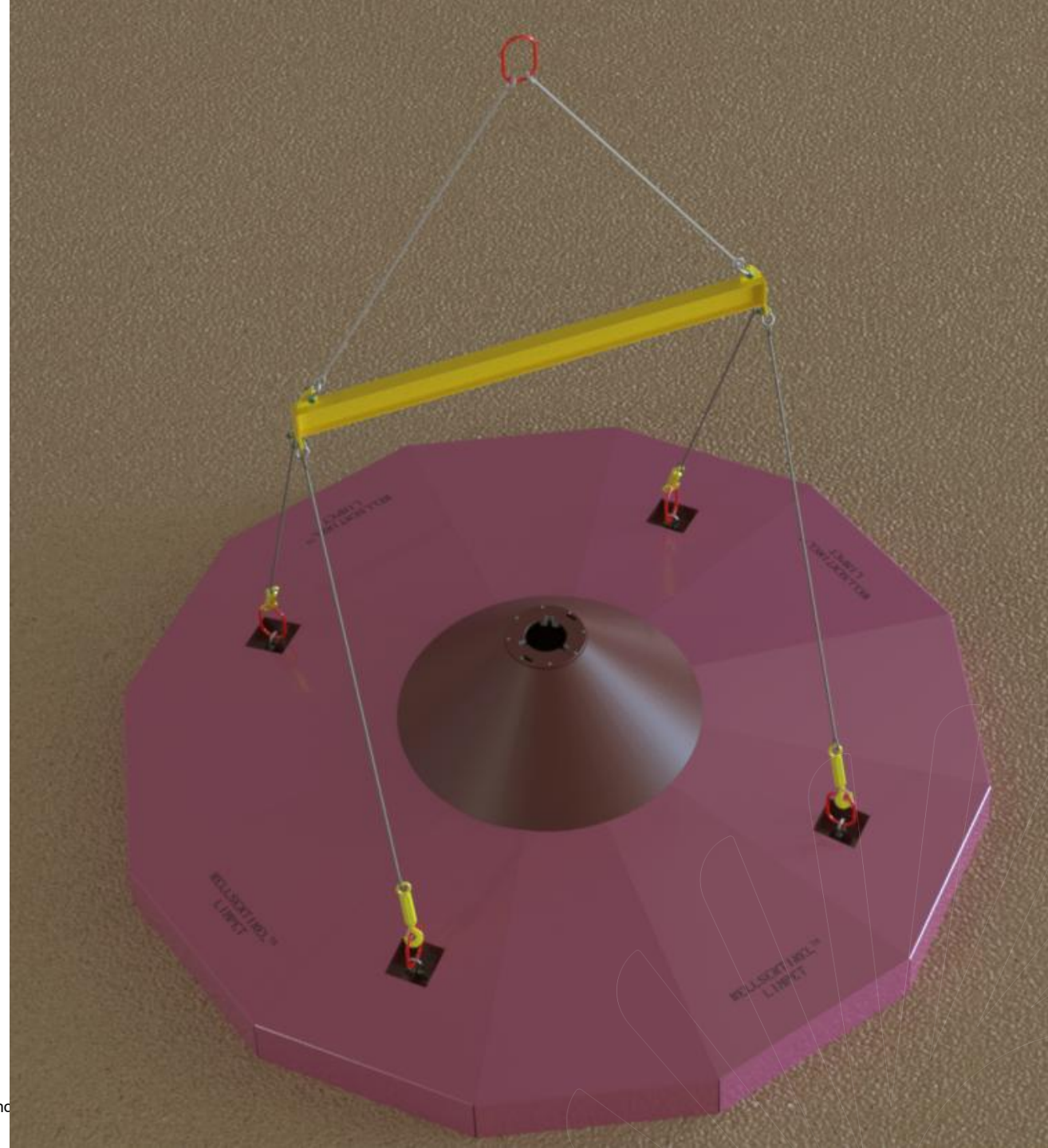
WellSentinel™ Limpet

A risk-based and cost-effective approach to legacy well monitoring

- Continuous long-term monitoring for 20 years +
- No-in well intervention
- Remote monitoring with no active infrastructure
- Early detection of issues
- Optimised MMV and a risk-based approach to legacy well monitoring, reducing cost and GHG emissions
- Fishing Friendly

WellSentinel™ systems are already the part of two monitoring plans for major CCS projects



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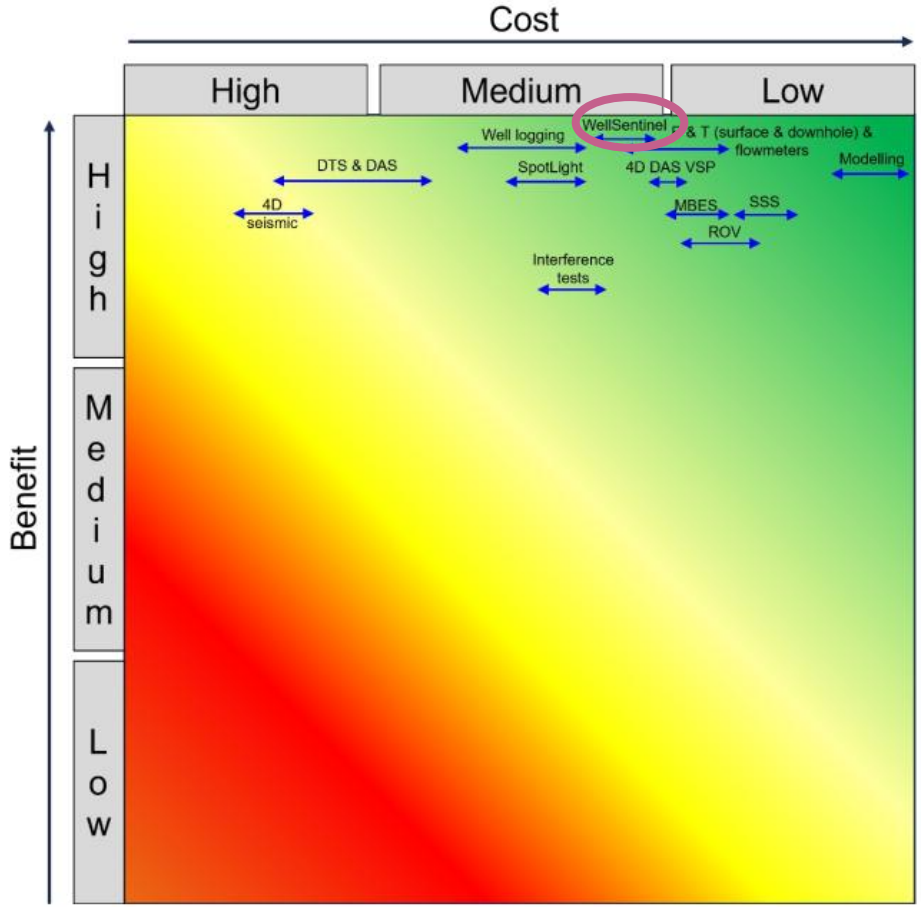
MMV Cost Benefit Analysis

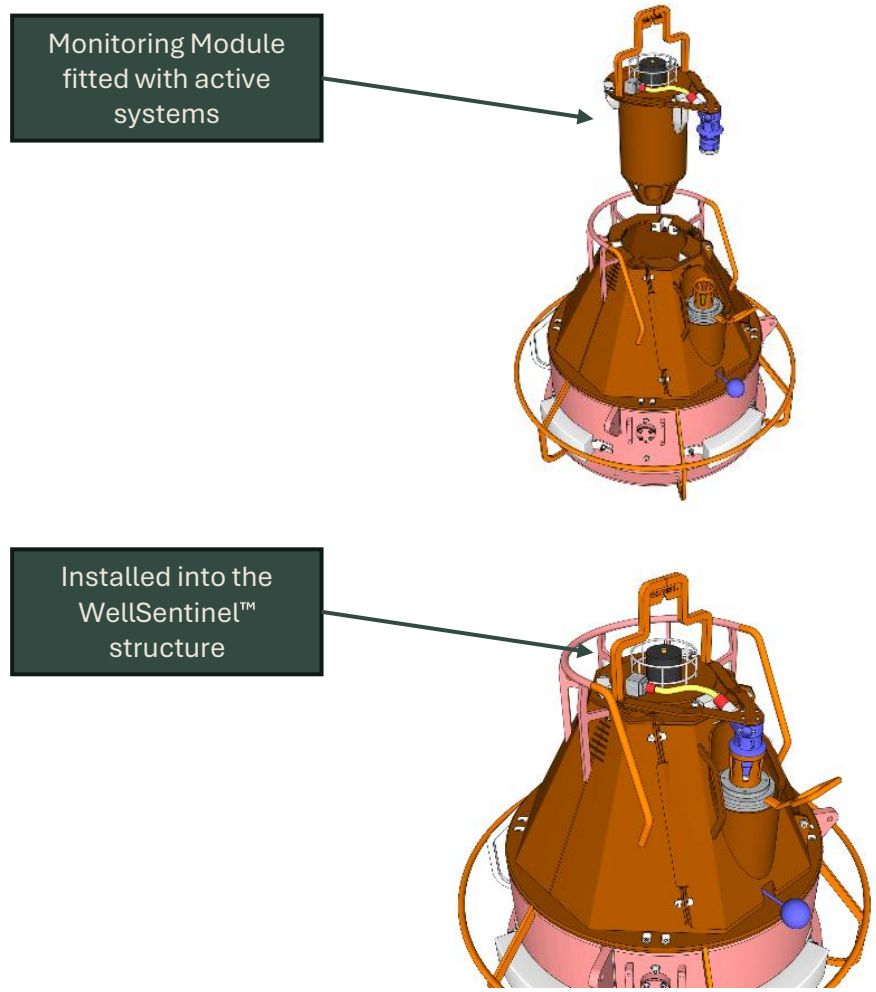
A major European CCS project technology screening concluded that continuous autonomous monitoring offers significant advantages

- WellSentinel™ requires no re-entry into legacy wells for installation of fibre optics or downhole P/T gauges for leak detection
- WellSentinel™ also avoids repeated vessel mobilisation for monitoring campaigns such as Echo Sounder, Side Scan Sonar and ROV GVI surveys.
- The screening identified that many seismic MMV tools are primarily CCS plume-monitoring technologies and may be disproportionate for targeted legacy well integrity surveillance

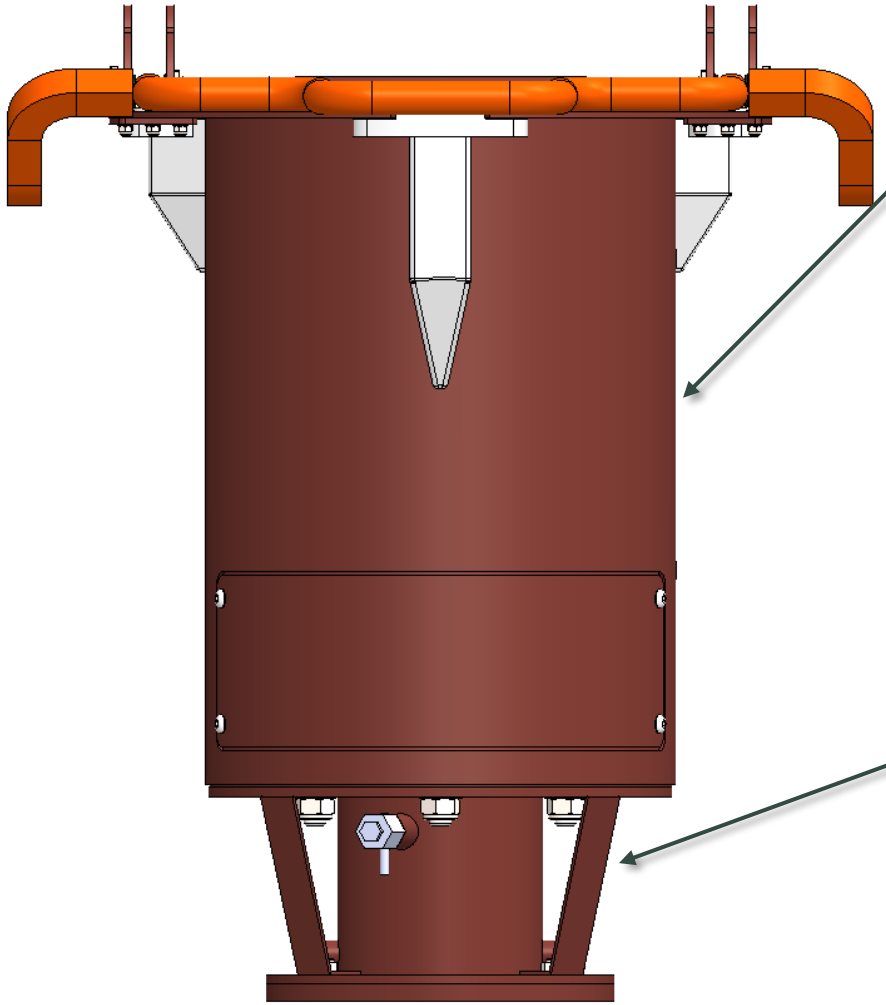


Post-Detection

- Following detection, proportionate action can be implemented through active monitoring and targeted intervention strategies
- Active monitoring systems can be installed within the Monitoring Module without disturbing the primary structure
- Modular deployment enables enhanced surveillance capability while minimising operational impact and offshore intervention
- Supports a staged, risk-based response approach aligned with ongoing assurance and well integrity management



Sample Capture Unit



Monitoring Module

Interchangeable extension on base of Silo

Additional Capability

- **Sample Capturing Unit** with capacity to capture approx. 150ml sample of Fluid of Interest.
- **Flow Diverting and Measuring Unit** that only passes fluid to reaction chamber when in-flow exceeds chosen threshold value

Tracerco

Insight through innovation

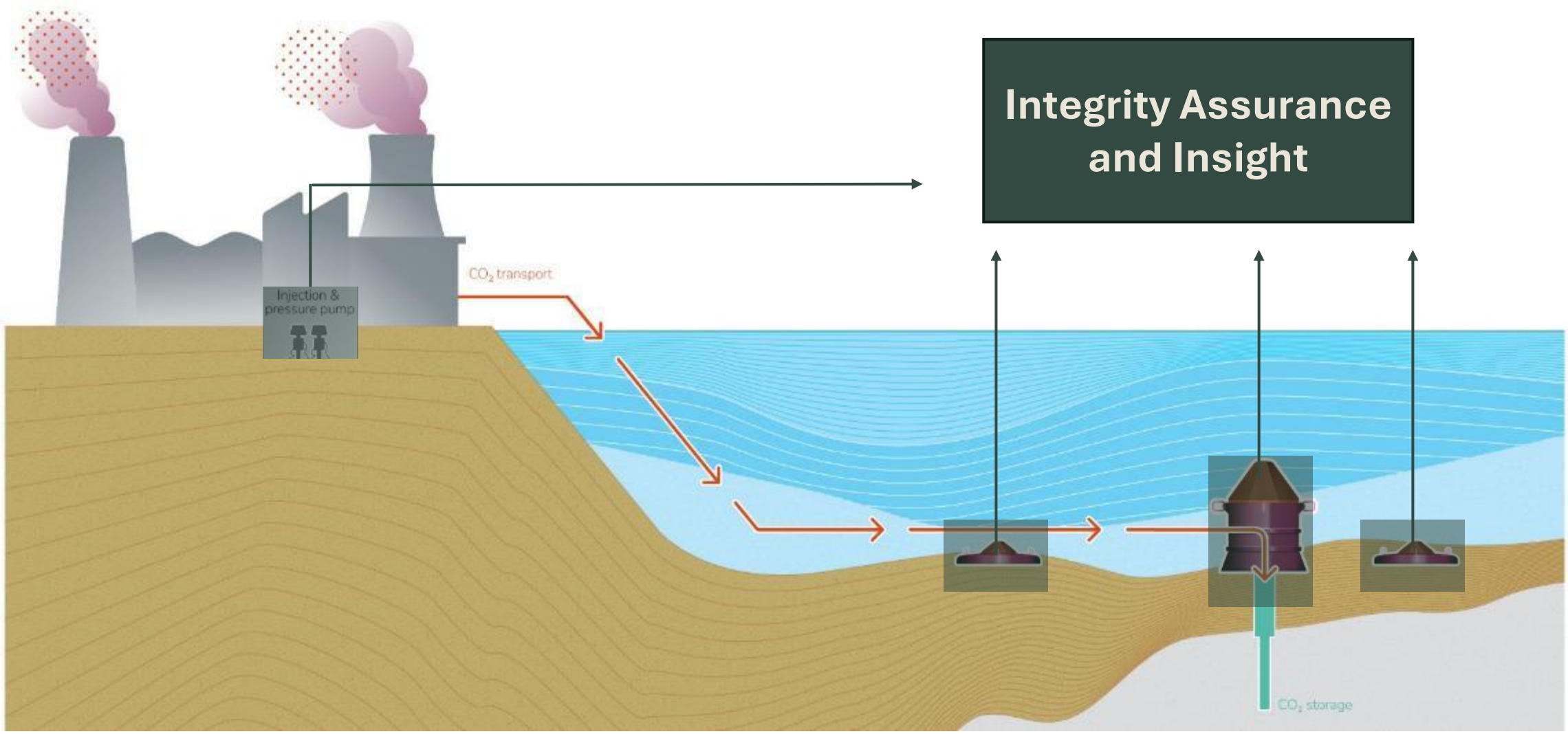
Continuous CO_2 Monitoring, Measurement & Verification for onshore and offshore operations

Over ***400,000 metric tons*** of permanently stored CO_2 independently authenticated through continuous tracer monitoring and analytical verification.

The Attribution Advantage:

Tracerco's continuous tracer technology is the only solution capable of definitively identifying the source of CO_2, providing unmatched accountability across capture, transport, and permanent storage.

Sentinel + Tracerco



Continuous leak detection and source attribution provide independent verification of CO_2 containment and permanent storage integrity

Why Continuous Tracer Monitoring?

Customer Challenge

Traditional monitoring methods provided limited subsurface visibility due to the low porosity carbonate limestone reservoir, making it difficult to confidently track CO_2 movement using seismic and pressure data alone.

The Solution

Tracerco designed a continuous CO_2 tracer injection program, creating a permanent monitoring signal within the CO_2 stream rather than relying on periodic measurements or snapshots.

The Result

- 24/7 CO_2 monitoring
- Continuous leak detection
- Definitive CO_2 attribution
- Regulator-Ready Reporting & Compliance Documentation
- Digital reporting and compliance dashboards

Tracerco
Insight through innovation

From Injection to Verified CO_2 Storage

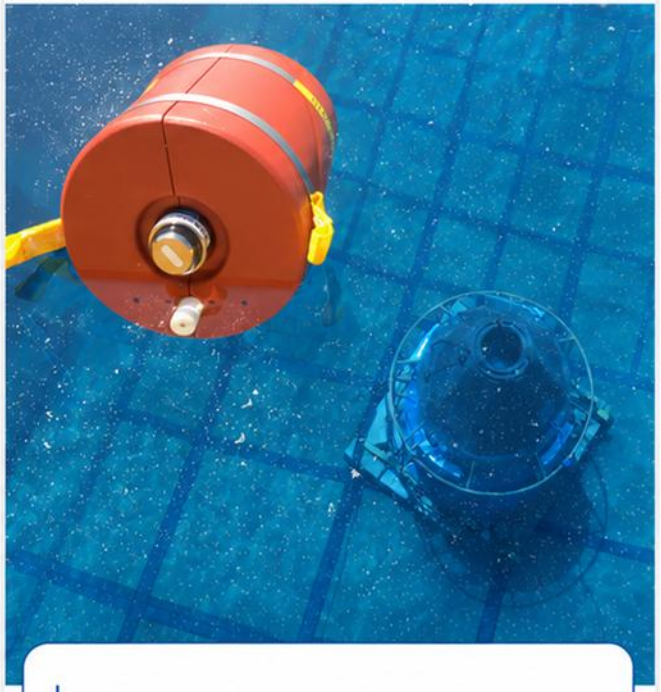
1 Inject & Tag

Tracer injected with CO_2.

DATA: Known tracer injection rate & ID

2 Detect & Sample

Tracer detected and quantified in monitoring samples.



DATA: Tracer concentration, plume movement, leak detection

3 Verify & Report

Independent verification and regulatory reporting.

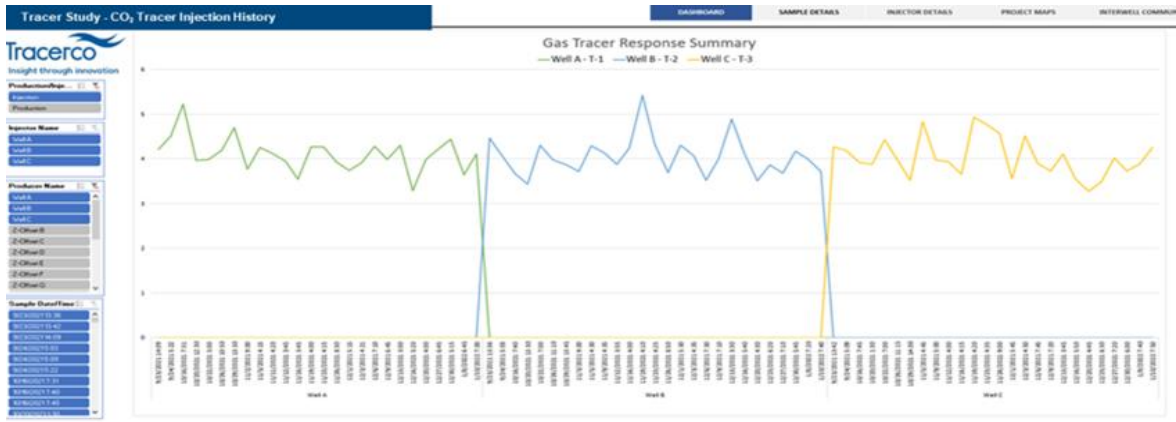
DATA: Attribution confirmation, storage verification, audit-ready reports

Sampling, Analysis & Digital Verification

- **Trusted Data. Defensible Results.**
- **ppb–ppt Detection** using advanced tracer analysis
- **Certified GC-MS Laboratories** with controlled QA/QC procedures
- **Direct Digital Upload** eliminating manual data handling
- **Source Attribution** identifying the emitter, well, and CO_2 owner
- **Water Monitoring** for environmental verification
- **Real-Time Dashboards** tracking wells, tracers, and results
- **Audit-Ready Reporting** for regulators and carbon credit programs
- **Outcome**

Sample → Analyze → Attribute → Report

Verified CO_2 storage backed by laboratory-proven data.



Safe Offshore Operations Backed by 60+ Years of Tracer Expertise

A proven offshore foundation enabling safe, scalable monitoring and verification of CO_2 storage

Category	Region / Location	Applications / Use
Tracerco Experience	North Sea (UK / Norway)	Interwell communication, Reservoir flow tracking, Production optimization
	Brazil (Santos Basin)	Flow assurance diagnostics, Subsea system monitoring, Deepwater operations
	Middle East Offshore	Waterflood surveillance, Injector–producer connectivity, Breakthrough analysis
CCS / Industry Use	North Sea (Norway)	Tracers (SF_6, isotopes) in studies, CO_2 flow pathway understanding
	Barents Sea	Tracers used in CCS monitoring context
	General CCS Use	Confirm leak source, Track flow paths / rates, Assess CO_2 behavior (gas vs dissolved)

Lower Cost. Lower Risk. Greater Storage Confidence.

Continuous MRV delivers measurable commercial and regulatory advantages throughout the CCS project lifecycle.

Benefit	Value
Reduce Risk	Early leak detection
Lower Insurance Costs	Reduced exposure
Improve Bankability	Greater lender confidence
Attract Investment	Increased investor confidence
Lower MMV Costs	Continuous monitoring
Support Compliance	Defensible records
Protect Asset Value	Storage assurance
Enable Multi-Emitter Hubs	Source attribution
Verify Storage	Independent containment proof

Lower cost *Scales cleanly* *Repeatable* *No operational impact*

Legacy Wells: The Leading Risk to Long-Term CO_2 Storage Integrity

Legacy wells are a leading leakage risk; continuous monitoring and attribution strengthen storage assurance and compliance.

Study	Key Finding	Tracerco + Sentinel Solution	Reference
Carbon Dioxide Plumes, Pressure Space and Legacy Well Risk (Southern North Sea, 2025)	Legacy wells are a key CCS risk.	Detect migration early and verify CO_2 source.	https://www.sciencedirect.com/science/article/pii/S2666759225000964
Screening, Monitoring and Remediation of Legacy Wells (Norwegian Continental Shelf, 2022)	Historic wells may threaten containment.	Monitor well integrity and attribute detected CO_2.	https://www.frontiersin.org/journals/energy-research/articles/10.3389/fenrg.2022.826100/full
CO_2 Storage Liabilities in the North Sea (UK Government)	Well leakage is a major long-term liability concern.	Provide defensible containment and leak evidence.	https://www.gov.uk/government/publications/co2-storage-liabilities-in-the-north-sea-an-assessment-of-risks-and-financial-consequences-summary-report-for-decc-may-2012
Legacy Wells Along the Norwegian Continental Shelf	Thousands of legacy wells require monitoring.	Continuous surveillance around high-risk wells.	https://nva.sikt.no/registration/0198cc57b8b9-61cc3998-d668-4fec-a11c-5880c515d576
CO_2 Storage Safety in the North Sea (ZEP)	Monitoring is critical for storage assurance.	Continuous MRV, attribution, and leak detection.	https://carbonmanagementeurope.org/wp-content/uploads/2019/11/ZEP-report-CO2-Storage-Safety-in-the-North-Sea.pdf
TOPHOLE Project (SINTEF, Norway)	Focused on legacy well monitoring technologies.	Early warning and confirmation of storage-related CO_2.	https://www.sintef.no/en/events/archive/2022/non-invasive-well-integrity-monitoring-findings-from-the-tophole-project/

Are you developing your MMV plan?

Please visit us at stand 11 with any further questions

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