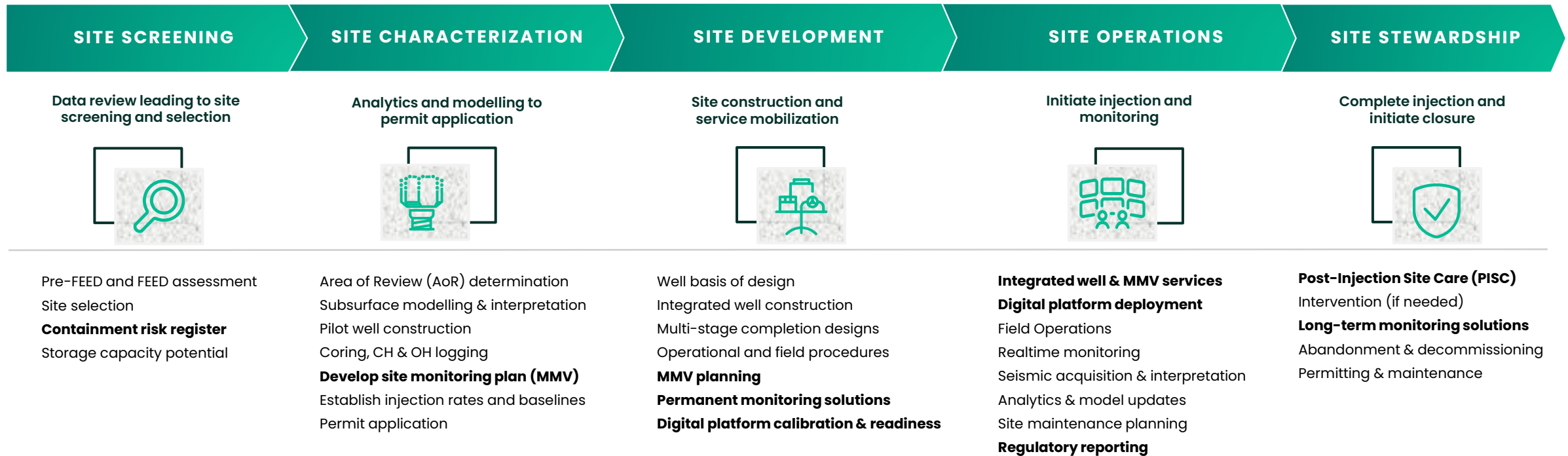


# An Integrated Workflow for CCS Characterization, Geomechanics, Dynamic Modelling, and Model- Driven Monitoring

**Gaffney Cline Energy Advisory**

8 June 2026

# CO<sub>2</sub> sequestration: from screening to project execution



# Why Integrated Assurance Matters

## The Challenge

Many CCS projects develop subsurface characterization, geomechanics, reservoir simulation, monitoring, and verification activities in parallel, but these workstreams often remain only partially connected.

### As a result:

- Monitoring programs are designed without a direct link to key storage risks.
- Geomechanical and containment risks are not continuously updated as new monitoring data becomes available.
- Predicted reservoir behaviour and observed field performance diverge over time.
- Verification and regulatory reporting become reactive rather than predictive.
- Project teams struggle to demonstrate long-term storage integrity and containment assurance with confidence.

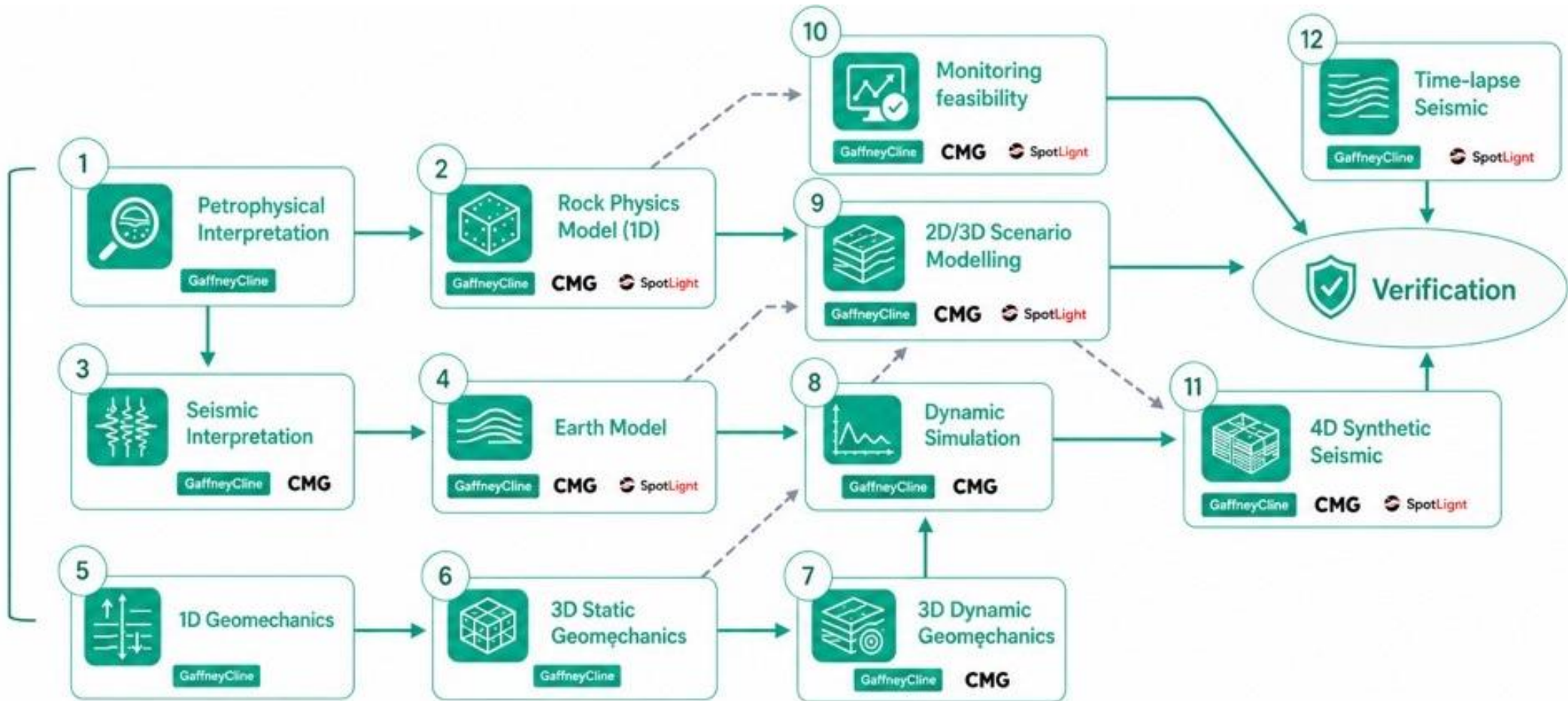
## Consequences of Fragmented Workflows

Challenge	Impact
Disconnected models and datasets	Increased uncertainty
Generic MMV programs	Higher monitoring costs
Limited integration of monitoring data	Delayed detection of anomalies
Manual reporting processes	Increased regulatory burden
Separate technical workstreams	Reduced confidence in storage performance



Integrated CCS Assurance transforms monitoring from a compliance activity into a **risk-informed decision-making tool**, improving storage confidence, reducing uncertainty, and supporting successful long-term CO<sub>2</sub> containment

# Integrated CCUS Workflow (End-to-End View)



# Risk Driven MMV Design

Monitoring is tailored to specific risk and decision needs

Risk	Monitoring Objective	Example Technology
Caprock breach / Containment failure	Detect pressure anomalies and caprock leakage	Pressure gauges, DAS, 4D seismic, geochemistry
Fault Reactivation / induced seismicity	Detect deformation and seismic events	Microseismic, DAS, geomechanics
Plume migration outside target zone	Track plume extent and migration pathways	4D seismic, EM, geomechanics
Legacy well leakage	Detect leakage through abandoned well	Fiber optic, pressure, soil and gas monitoring, tracer
Injectivity / Conformance Issues	Monitor injectivity and conformance	Pressure, temperature, PLT, DAS

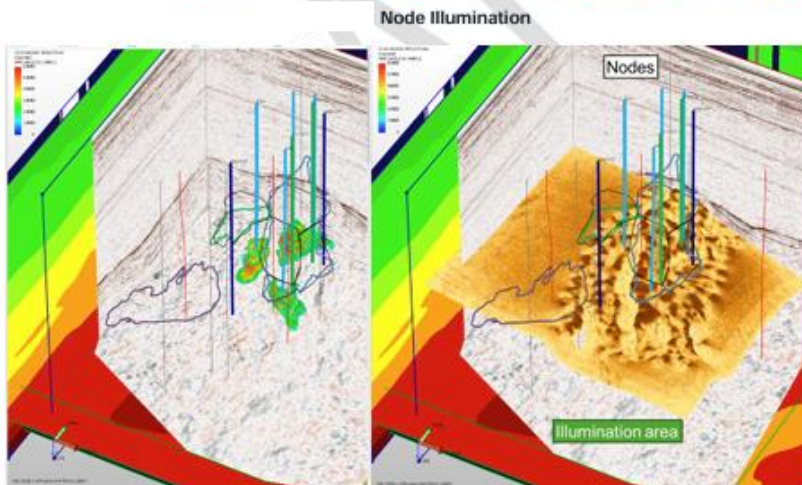
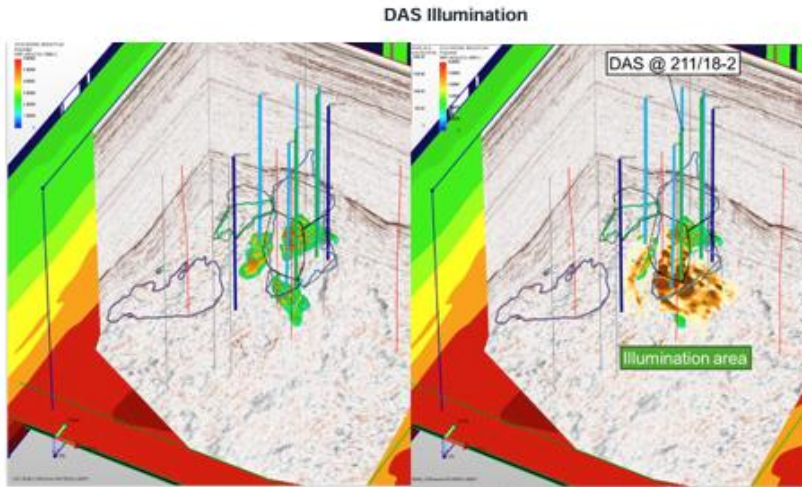


## Why Risk Driven?

- Focus monitoring investment where it matters most
- Optimize cost by avoiding unnecessary data
- Enable timely decision and response
- Strengthen regulatory confidence and demonstrate due diligence

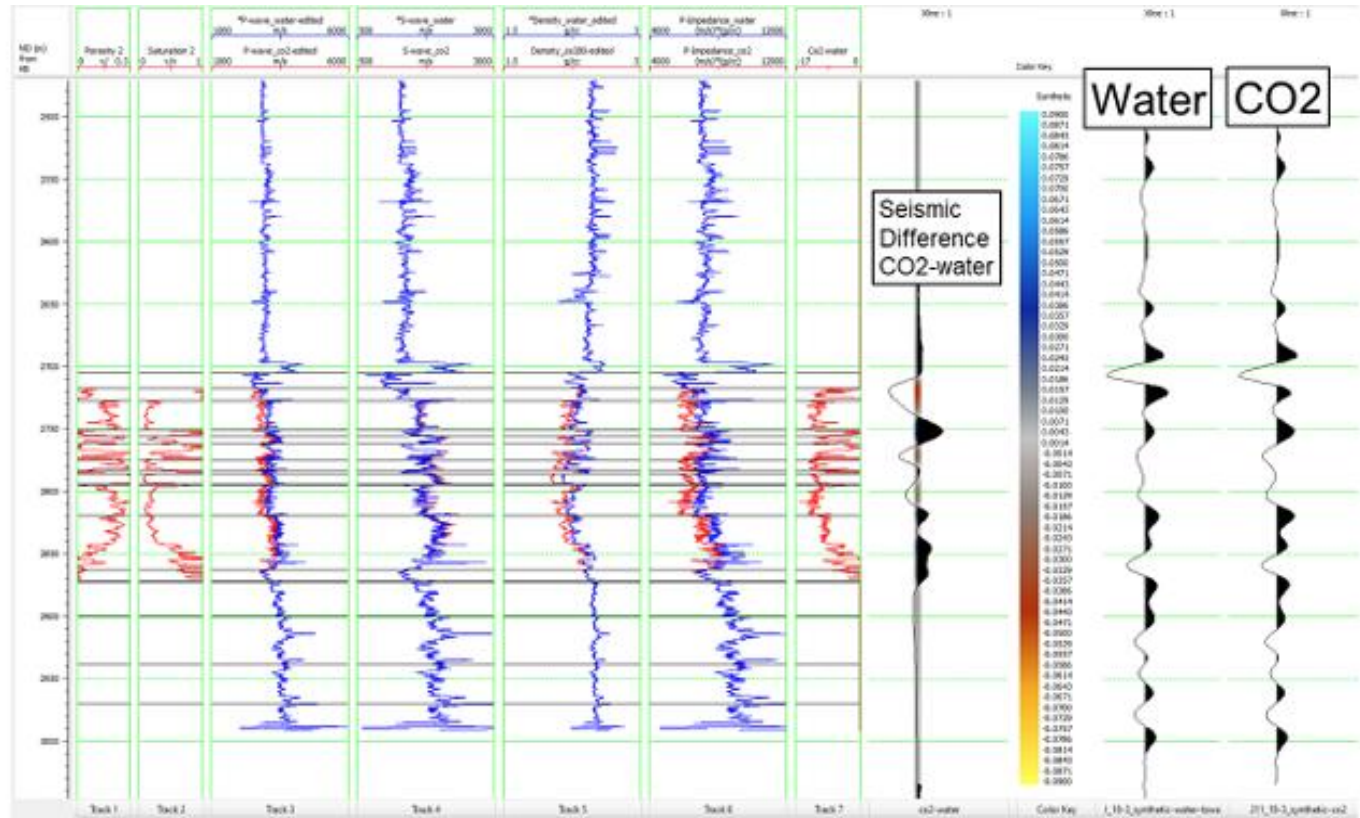
# Rock physics and Monitoring Feasibility

Evaluate detectability before field deployment to optimize MMV

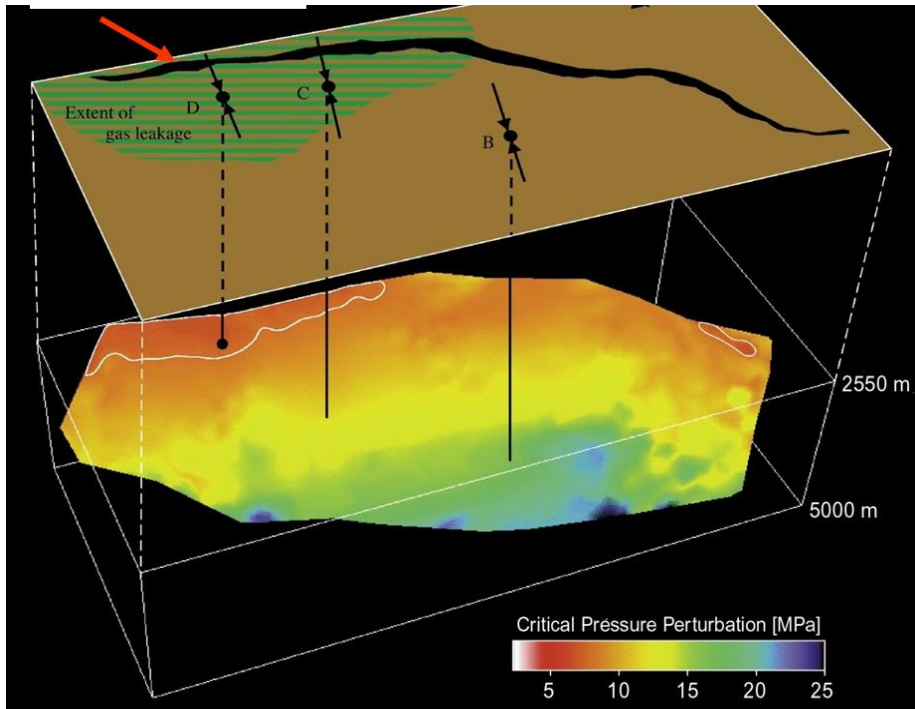


Not limited to:

- Assessing expected effect of CO2 on velocity / 4D seismic
- Identifying alternative method to monitor plume migration

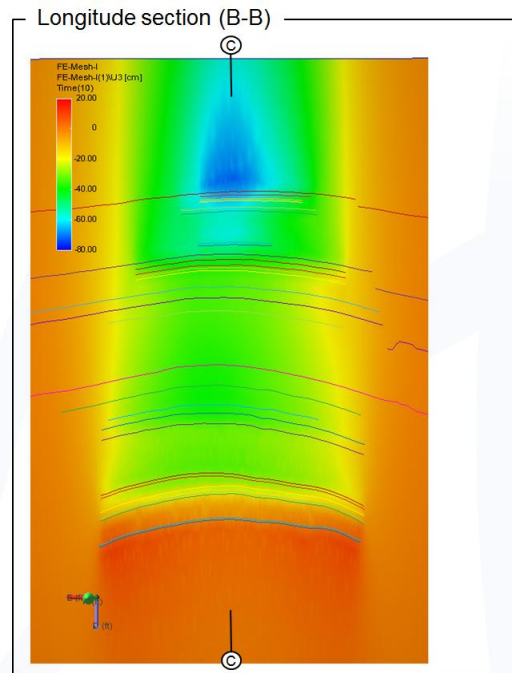


# Role of geomechanics in CCS Assurance

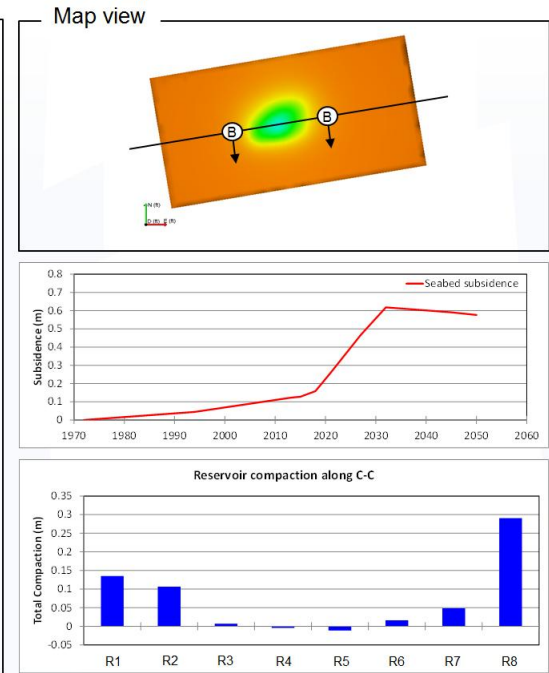


**Ensure storage integrity and containment**

**Quantify risk and reduce uncertainty**



**Support injection operations and optimization**



**Enable confident decision-making and regulatory compliance**

# Verification & Model Calibration Loop

## Better match between predicted and observed behavior

- Improved model reliability

## Early detection of deviations and anomalies

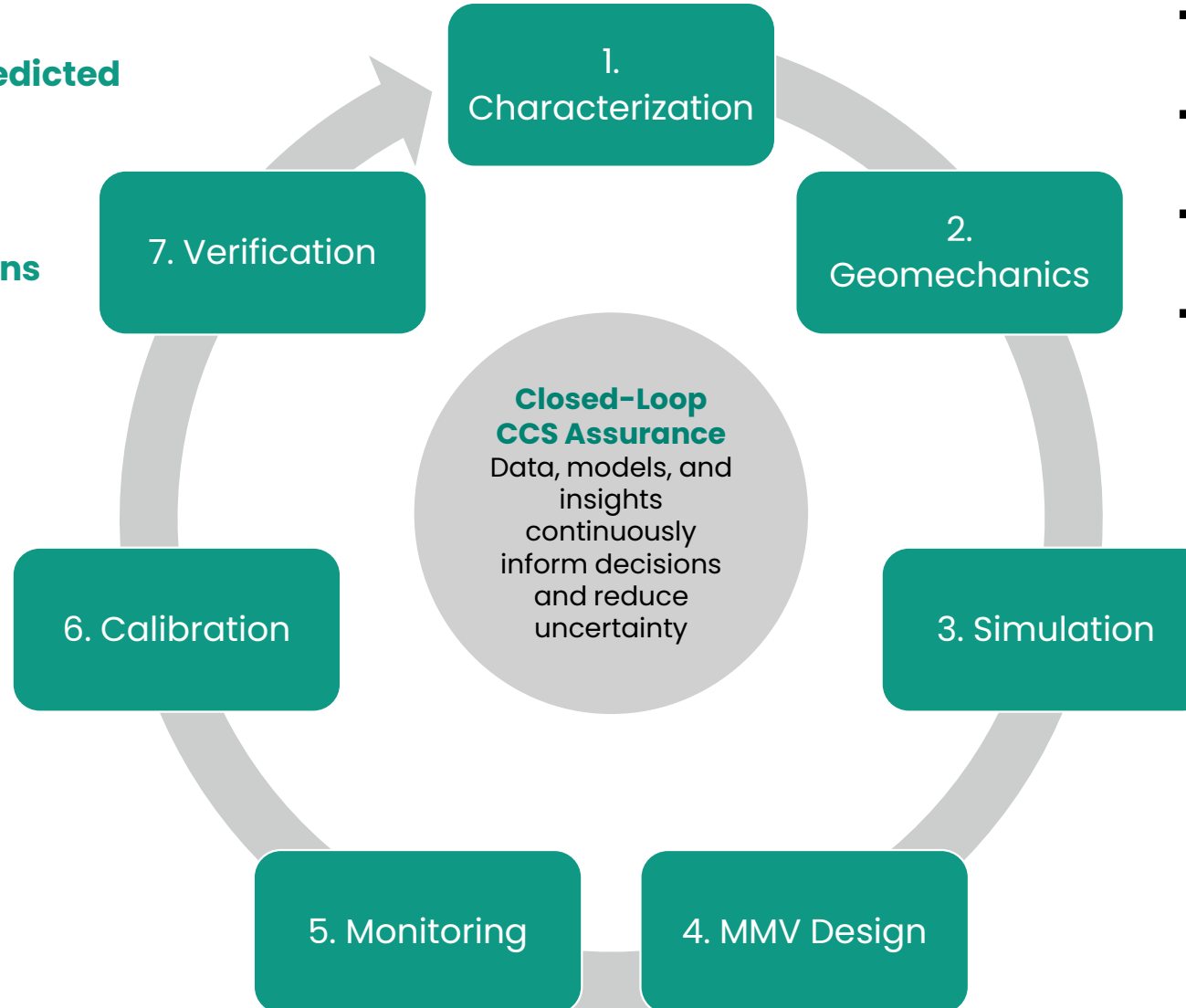
- Enable timely response

## Adaptive monitoring optimization

- Focus on what matters

## Defensible technical basis for decisions and reporting

- Support regulatory confidence



## Outputs

- Updated forecast and scenarios
- Reduced uncertainty
- Improved assurance
- Regulatory confidence

# CarbonEdge™ MMV solutions

Enabling the Digital Backbone of the CCS Assurance



## Connect

### Single pane of glass to the entire CCUS value chain

- Integrated asset model
- Connecting sub-surface to surface
- Visualization of data from sensors and sources



## Mitigate

### Identify and mitigate project risks

- Implementation of risk catalog & risk register
- Customizable alarms based on sensor data
- Advanced analytics to detect anomalies



## Optimize

### Improve Operational Efficiency

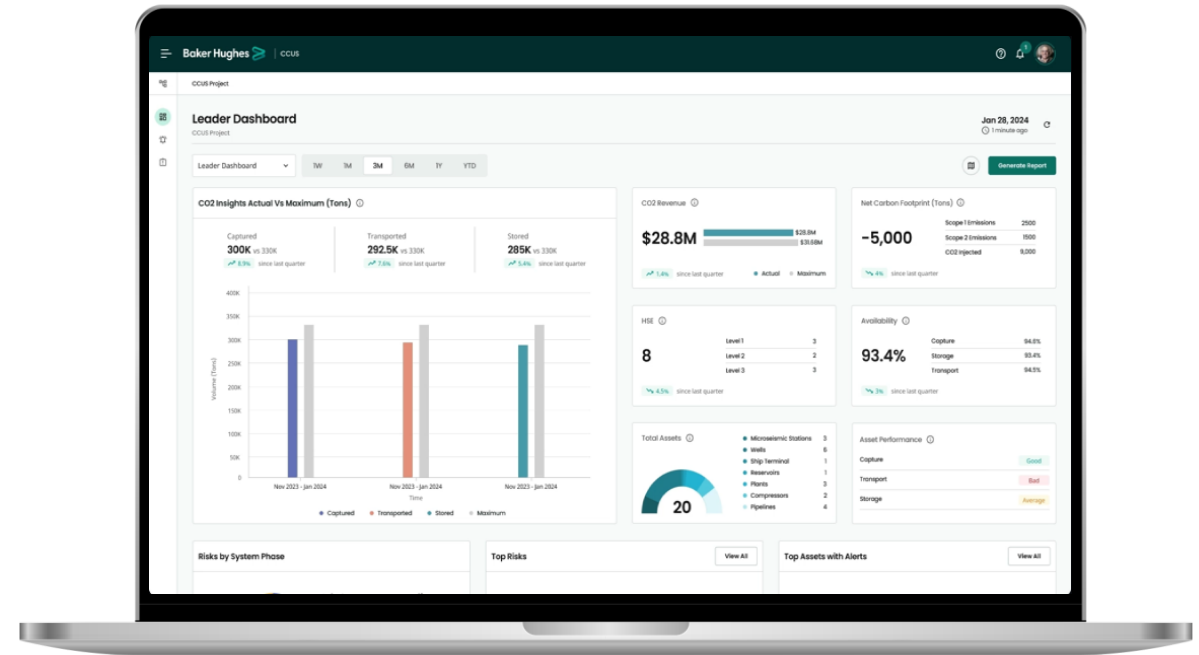
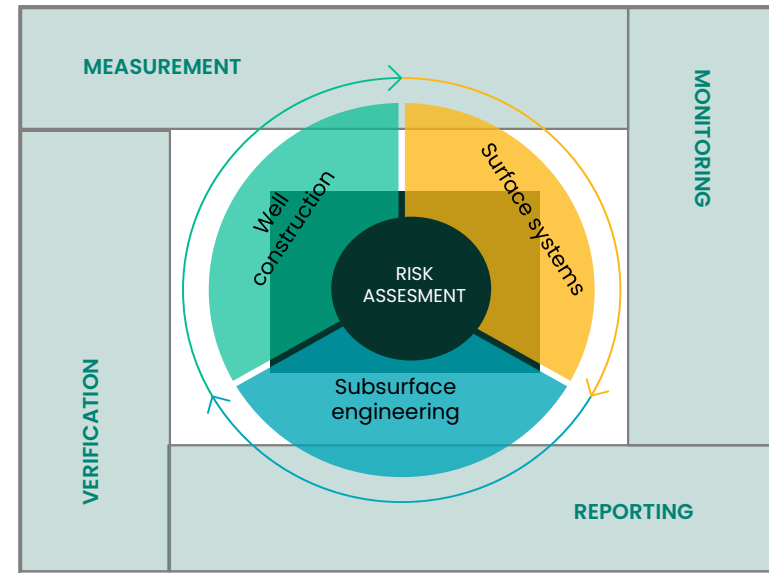
- Reduction of non-productive time
- Proactive preventive measurements insights
- Continuous process optimization along lifecycle



## Report

### Simplify and expedite reporting

- Enabling compliance and regulatory reporting
- CO2 accounting for multi tenant assets



# Benefits of Model-Driven Monitoring

## Technical Benefits

- Reduced uncertainty in plume migration forecast
- Improved pressure history matching
- Earlier anomaly detection
- Better containment assurance
- Optimized MMV deployment

## Operational Benefits

- Reduced monitoring cost
- Faster permitting support
- Improved regulatory confidence
- Reduced false alarms
- Adaptive monitoring

## Quantified Impact



**Reduced Uncertainty**  
20–35% improvement in plume extent forecasting



**Improved Calibration**  
30–50% reduction in pressure and plume mismatch



**Faster Permitting**  
Shorter preparation time while maintaining risk rigor

Model-driven monitoring turns data into actionable insights, reducing uncertainty and improving confidence in long-term CO<sub>2</sub> storage performance

# Key Takeaways

## An integrated workflow ensures that:



Integrated workflows connect characterization, geomechanics, simulation, MMV and verification across the full CCS lifecycle.



Monitoring objectives are explicitly linked to identified risks and performance criteria.



Model-driven monitoring with closed-loop calibration reduces uncertainty and improves prediction reliability



Uncertainty is progressively reduced throughout the project lifecycle.



Storage performance, containment, and conformance can be demonstrated with greater confidence.



Regulatory reporting is supported by a transparent and auditable technical framework.



Advanced technologies (4D seismic, Sparse Nodal Seismic, DAS, fiber optic, microseismic, etc.) are optimally selected and deployed



**Baker Hughes** 