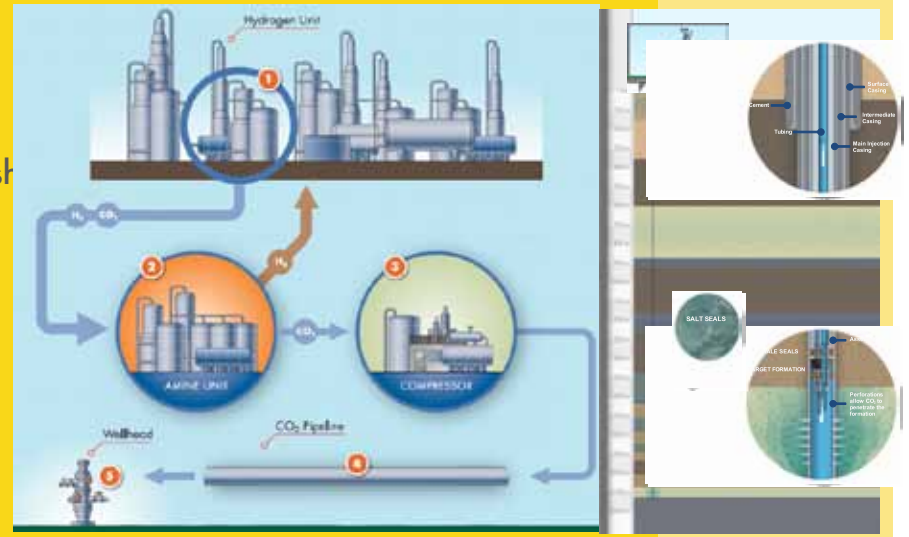
QUEST Carbon Capture and Storage

Risk-Based Measurement, Monitoring & Verification

MVA/MMV Knowledge Sharing Worksh
Mobile Alabama
May 16-17, 2012



Shell Canada Energy
Quest Subsurface Team

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The United States Securities and Exchange Commission (SEC) permits oil and gas companies, in their filings with the SEC, to disclose only proved reserves that a company has demonstrated by actual production or conclusive formation tests to be economically and legally producible under existing economic and operating conditions. We use certain terms in this presentation, such as resources and oil in place, that SEC's guidelines strictly prohibit us from including in filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.

Definitions and Cautionary Note

Reserves: Our use of the term "reserves" in this presentation means SEC proved oil and gas reserves for all 2009 and 2010 data, and includes both SEC proved oil and gas reserves and SEC proven mining reserves for 2008 data.
Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves or SEC proven mining reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.
Organic: Our use of the term Organic includes SEC proved oil and gas reserves and SEC proven mining reserves (for 2008) excluding changes resulting from acquisitions, divestments and year-average pricing impact.
To facilitate a better understanding of underlying business performance, the financial results are also presented on an estimated current cost of supplies (CCS) basis as applied for the Oil Products and Chemicals segment earnings. Earnings on an estimated current cost of supplies basis provides useful information concerning the effect of changes in the cost of supplies on Royal Dutch Shell's results of operations and is a measure to manage the performance of the Oil Products and Chemicals segments but is not a measure of financial performance under IFRS.

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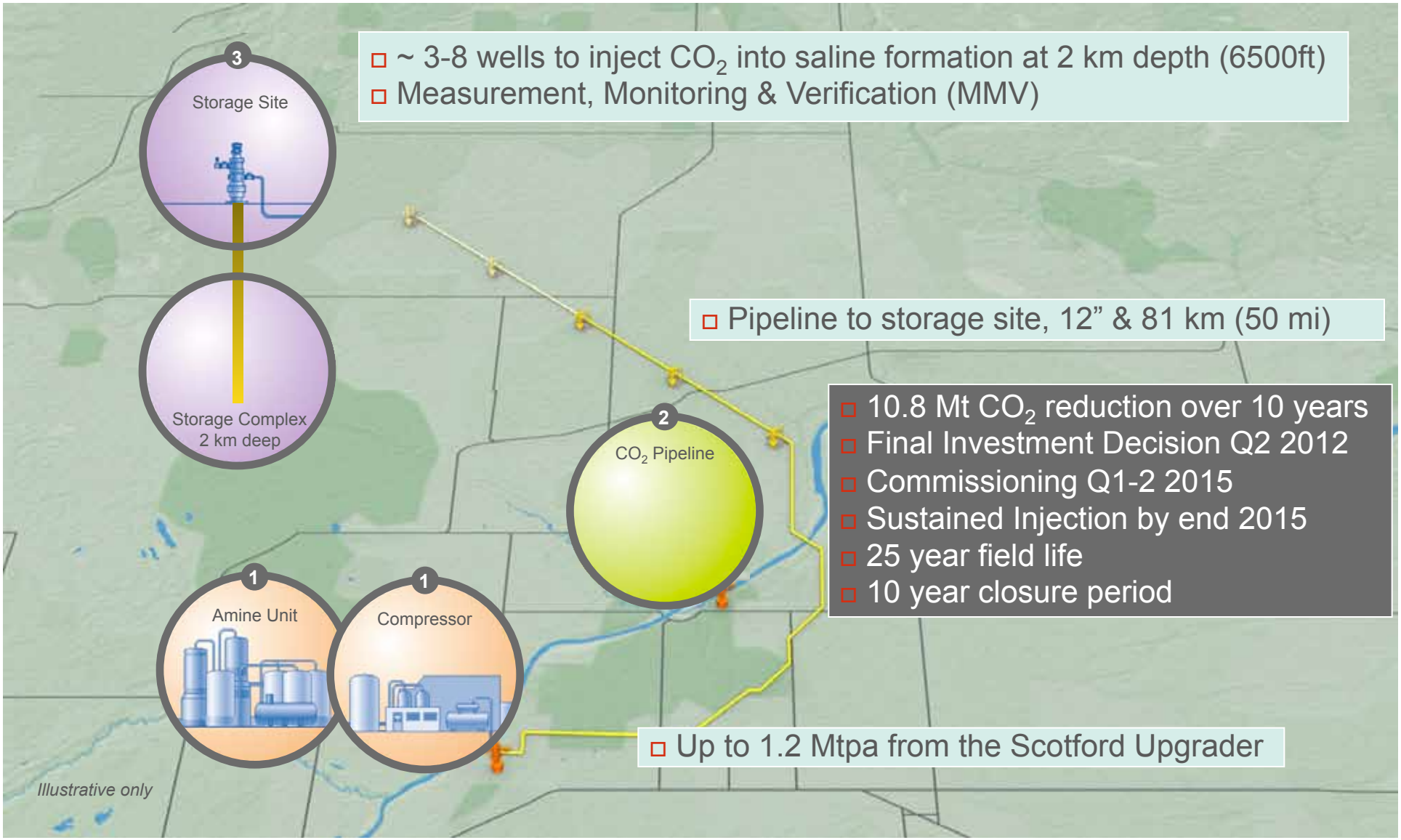
Quest CCS Project

- JV:
  - Shell (60%)
  - Chevron (20%)
  - Marathon (20%)
- GoA = $745 mln
- GoC = $120 mln

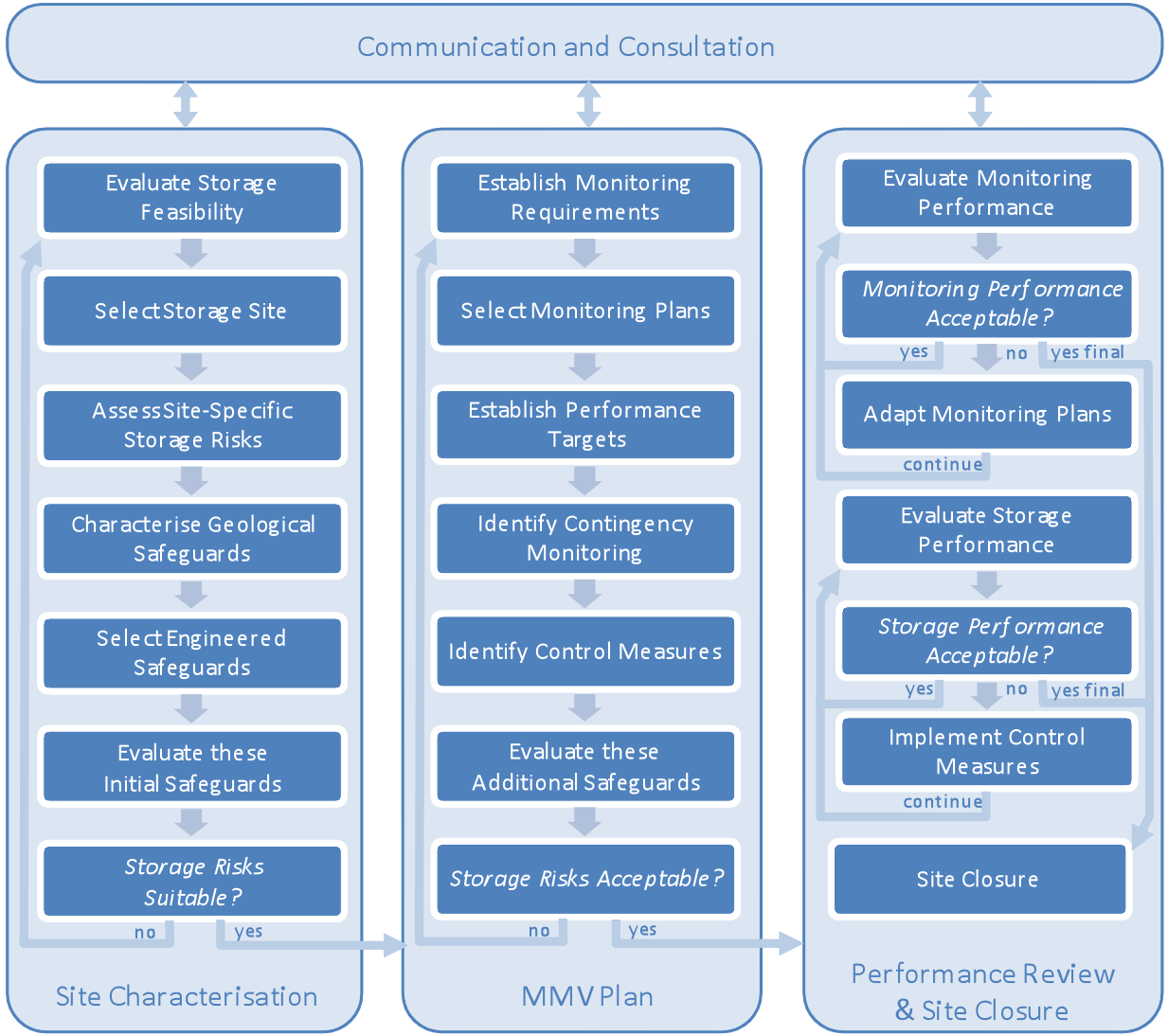
Integrated CCS Project



- ~ 3-8 wells to inject CO_2 into saline formation at 2 km depth (6500ft)
- Measurement, Monitoring & Verification (MMV)
- Pipeline to storage site, 12” & 81 km (50 mi)
- 10.8 Mt CO_2 reduction over 10 years
- Final Investment Decision Q2 2012
- Commissioning Q1-2 2015
- Sustained Injection by end 2015
- 25 year field life
- 10 year closure period
- Up to 1.2 Mtpa from the Scotford Upgrader

MMV is Central to Storage Risk Management Framework

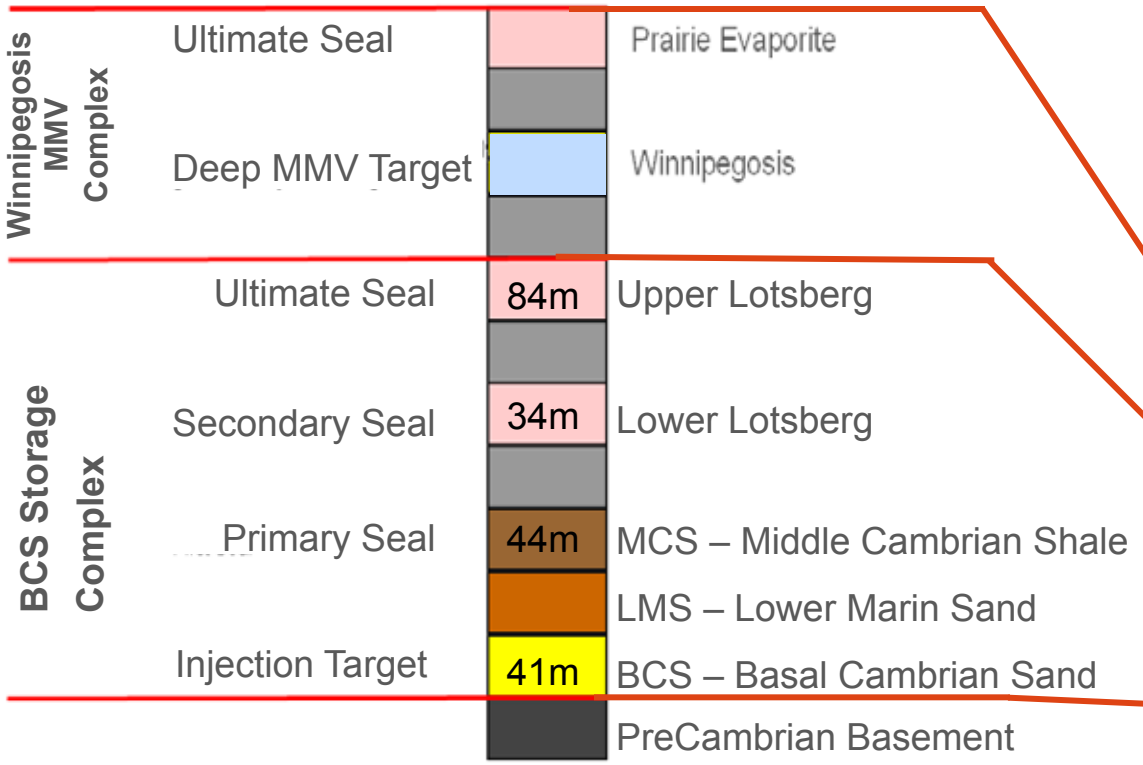
- Site Characterisation
  - Initial risk assessment
    - Site Selection
    - Appraisal
    - Engineering concept selection
- MMV Plan
  - Additional risk assessment
  - Additional safeguards
    - Monitoring
- Performance and Closure
  - Continuation of risk management
  - Injection and closure periods
  - Support transfer of liability

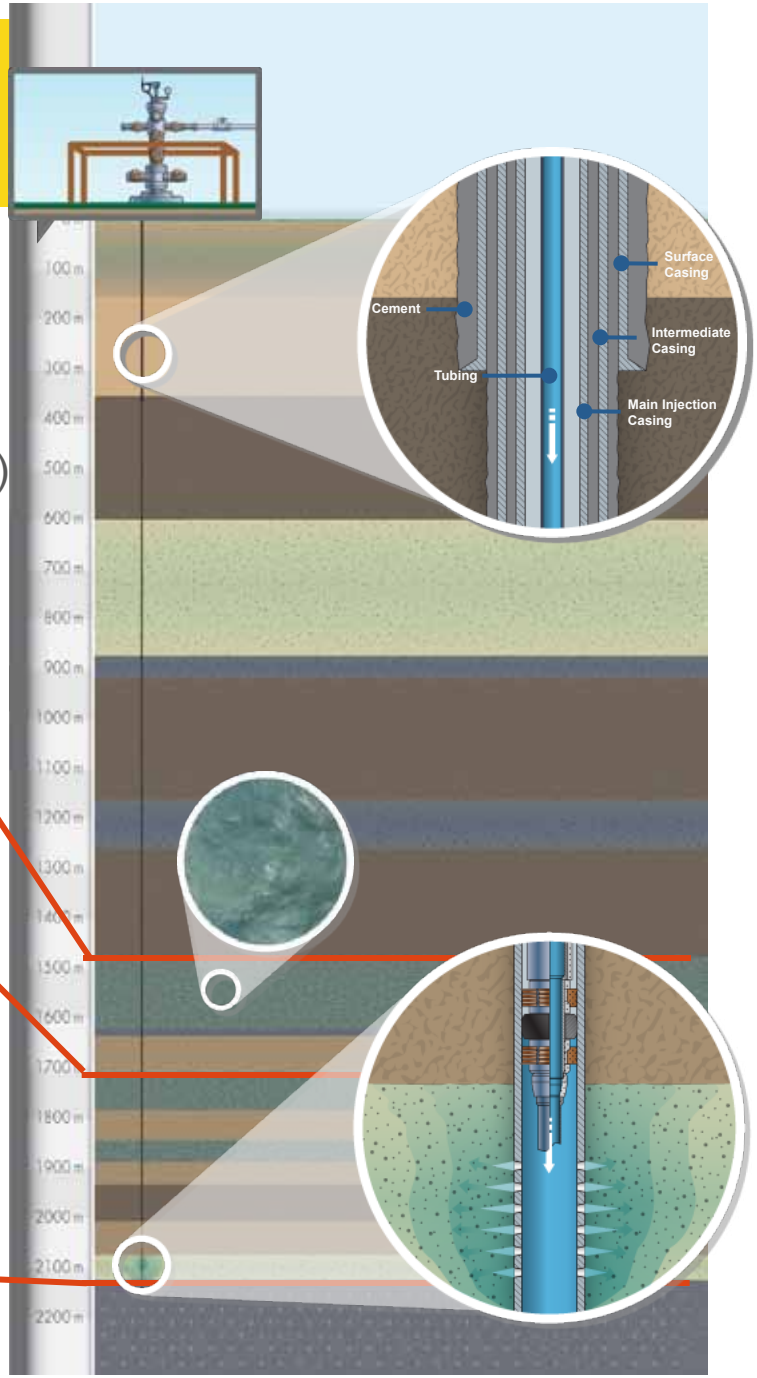


Injection Target De-risks Site Selection

Storage Geology – Basal Cambrian Sand

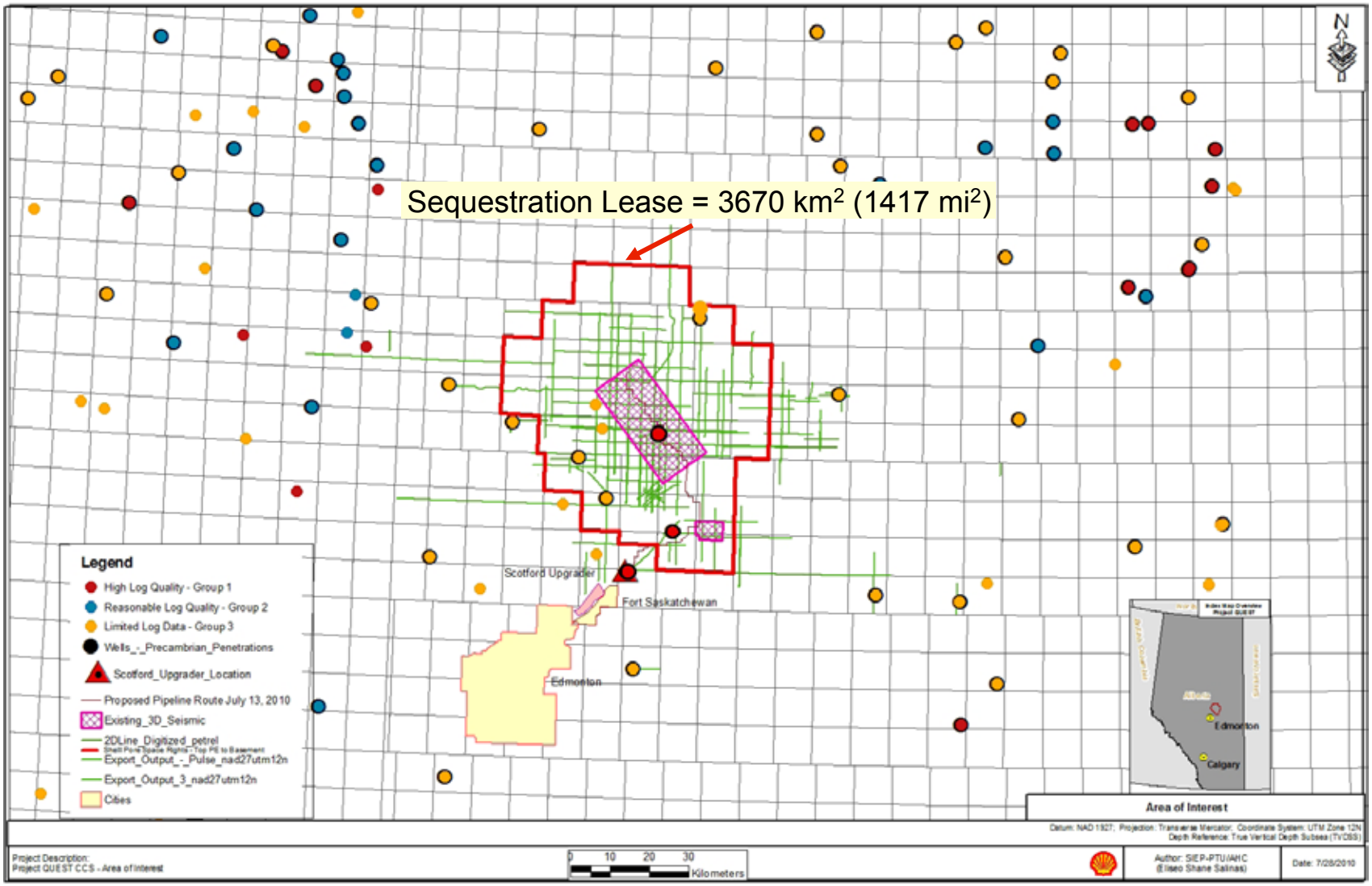
- Deep saline aquifer (~2 km or 6500ft)
- Porous sandstone rock (Por~16%, K~300mD)
- Multiple seals minimize containment risk
- Well below hydrocarbon bearing formations(<1200m) and potable water zones (<200m)





Site Selection Further De-Risked by Extensive Appraisal Data

- Location and Subsurface Characteristics



Comprehensive Area of Review

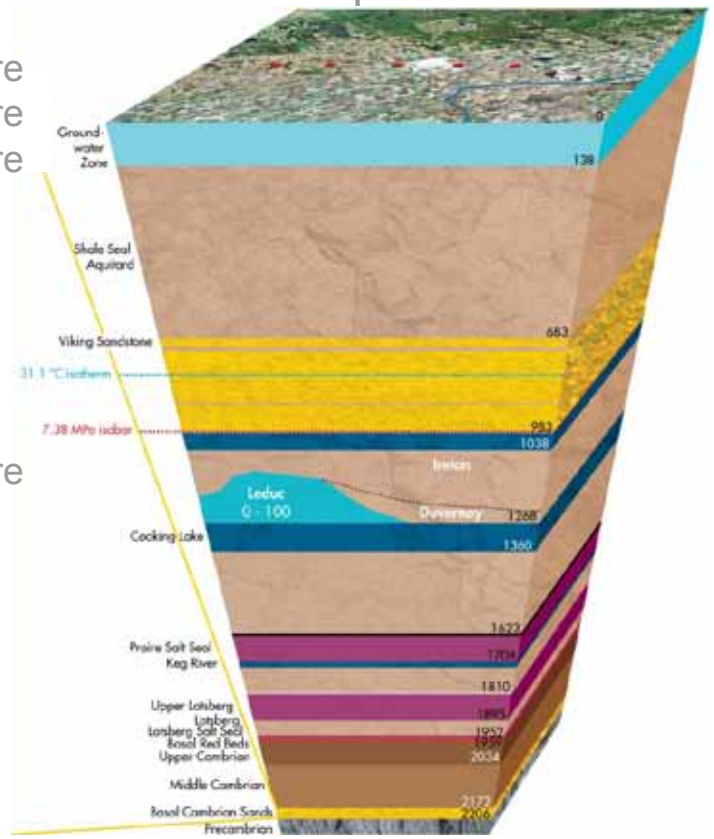
- MMV needs to be of sufficient extent to include any potential impacts due to CO2 storage including the displacement of brine

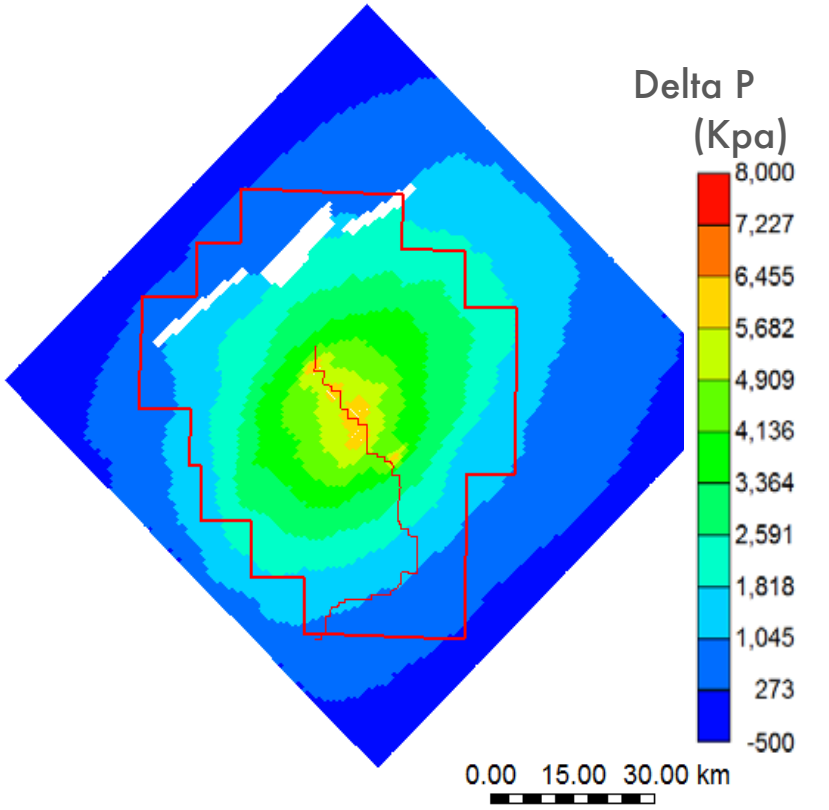
Depth Extent

Areal Extent

Atmosphere
Biosphere
Hydrosphere

Geosphere





MMV Designed to Verify Safe CO2 Storage

- Ensure Conformance *to indicate long-term security of storage*
  - Validate, calibrate, update performance predictions
  - Adapt injection & monitoring to optimise performance
  - CO2 inventory reporting

- Ensure Containment *to demonstrate current security of storage*
  - Verify absence of environmental effects
  - Detect early warning signs of any unexpected loss of containment
  - If necessary, activate additional safeguards

MMV Iterative Design Process Reduces Risks

Source: Adapted from CO2Qualstore Report (DNV, 2009)

- Risk-Based
  - Verifies geological & engineered safeguards
  - Reduces containment risk to ALARP
- Site-Specific
  - Tailor-made monitoring
  - Informed by appraisal data
- Diversified
  - Multiple independent monitoring systems
  - Multiple independent safeguards
- Adaptive
  - Responds to observed performance
  - Contingency plans in place

Conformance vs. Containment

Conformance is *not* a safety-critical risk:

- Cost of additional monitoring, delayed site closure, loss of storage efficiency
- Single monitoring system for each aspect of conformance (CO2 Plume and Pressure)
- Multiple effective control measures
- Unexpected monitoring failure mitigated by contingency plans
- Residual likelihood of conformance loss is *low* (5-20%)

Containment *is* a safety-critical risk:

- Multiple effective monitoring systems for each aspect of containment
- Multiple effective control measures
- Unexpected monitoring failure mitigated by contingency plans
- Residual likelihood of containment loss is *very low* and ALARP

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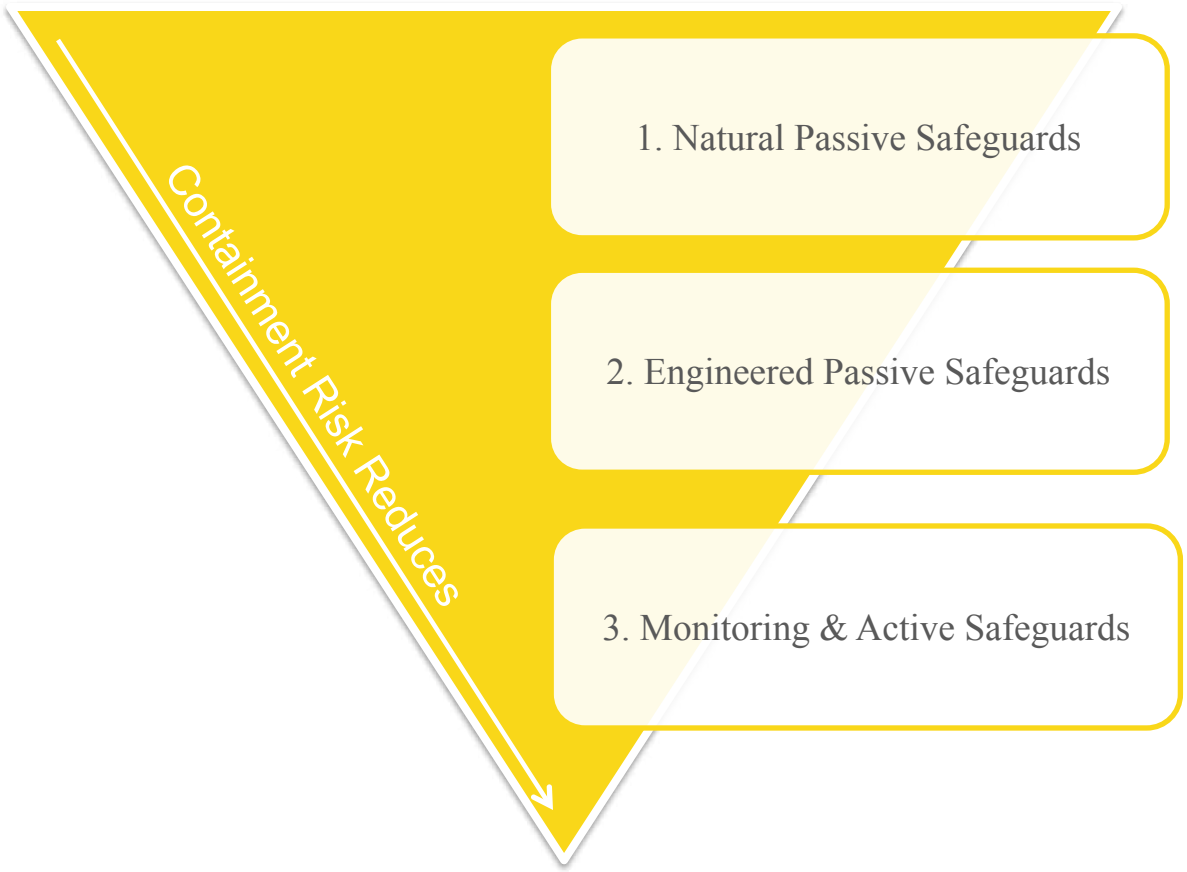
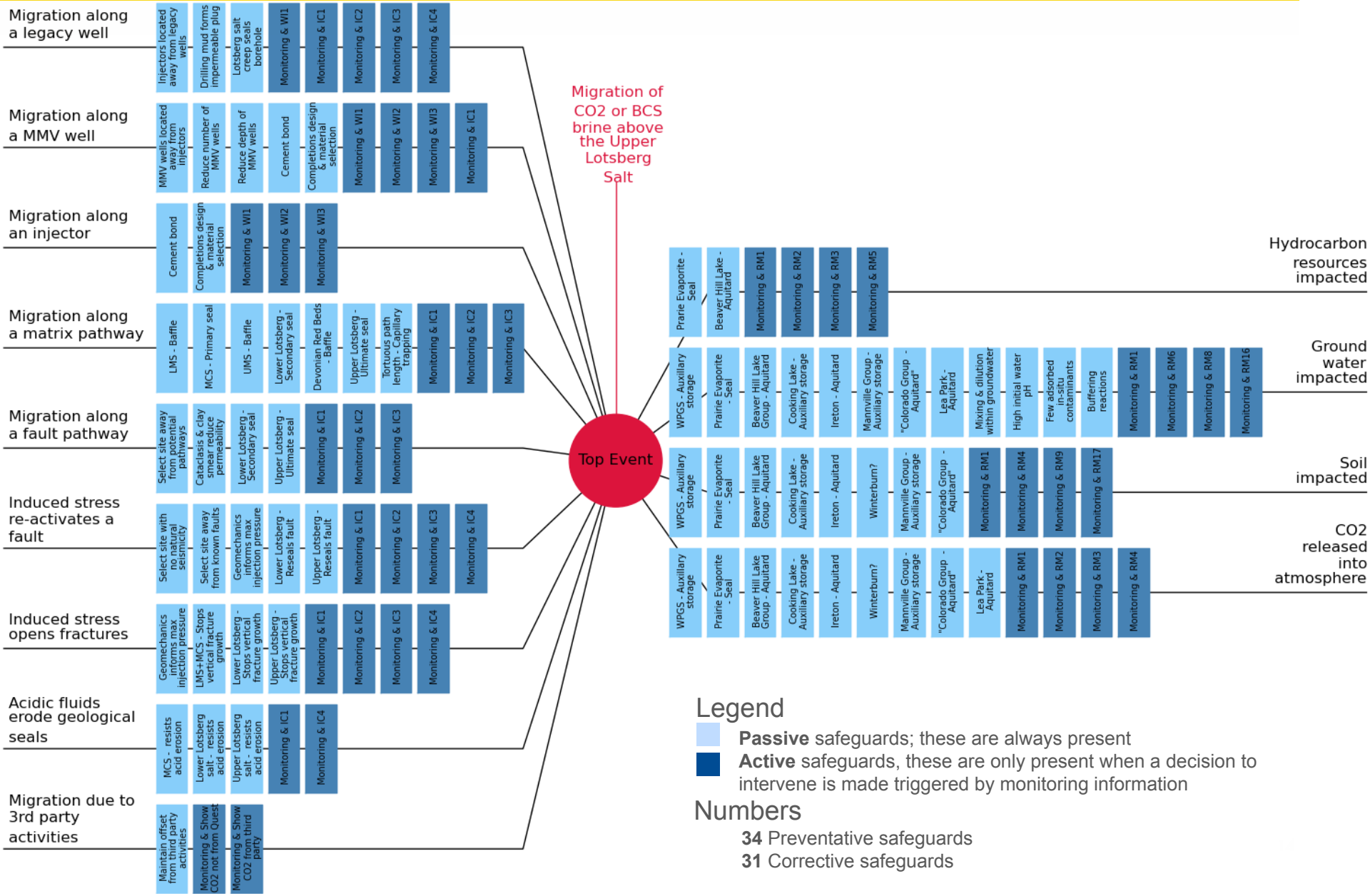
Three Types of Safeguards Reduce Containment Risks



Multiple Independent Containment Safeguards In-Place



Systematic Evaluation of Passive Safeguards

- Evidence based using collective expert judgement
- Informed by appraisal data and site characterization studies
- Three value logic: 1 - True – False = Uncertainty
- Subject to independent expert review

	Threat		Safeguard	Evidence For	Evidence Against	EF	EA
T6	Induced stress re-activates a fault	B6.1	Select site with no natural seismicity	1. No recorded seismicity within AOR 2. Central Alberta is tectonically stable 3. No faults seen in overburden 4. Faults not critically stressed before injection	1. Past may not indicate future seismicity	0.6	0.2
		B6.2	Select site away from known faults	1. No faults through seals on 2D/3D seismic	1. Not all faults (offsets<20m) identified 2. Widespread basement faults; offsets<20m 3. Reactivated fault may grow upwards	0.3	0.3
		B6.3	Select max injection pressure using geomechanics	1. Inject at >14MPa below BCS fracture pressure 2. Fault-normal stresses remain compressive 3. Compressor & pipeline rated to 14.5MPa	1. Injection induces shear stress on faults	0.6	0.2
		B6.4	Lower Lotsberg - Reseals fault	1. Salt creep re-seals fault after slippage 2. Expected salt thickness is 2-36 m	1. Pinches out beyond the SW edge of AOI 2. Salt creep may take years to re-seal fault	0.2	0.4
		B6.5	Upper Lotsberg - Reseals fault	1. Salt creep re-seals fault after slippage 2. Expected salt thickness is 53-91 m	1. Salt creep may take years to re-seal fault	0.3	0.3

How to Build an Active Safeguard

A sensor capable of detecting changes with sufficient sensitivity and reliability to provide an early warning	**Decision logic** to interpret the sensor data and select the most appropriate form of intervention	**A control response** to ensure continuing containment or to control any potential loss of containment

Is it fast enough, precise enough and big enough?

Many Independent Control Response Options Exist

Preventative Controls

Injection Controls

IC1 Re-distribute injection across existing wells

IC2 Drill new vertical or horizontal injectors

IC3 Extract reservoir fluids to reduce pressure

IC4 Stop injection

Well Interventions

WI1 Repair leaking well by re-plugging with cement

WI2 Repair leaking injector by replacing completion

WI3 Plug and abandon leaking wells that cannot be repaired

Corrective Controls

Well Interventions

RM1 Repair leaking well by re-plugging with cement

RM2 Repair leaking injector by replacing completion

RM3 Plug and abandon leaking wells that cannot be repaired

Exposure Controls

RM4 Inject fluids to increase pressure above leak

RM5 Inject chemical sealant to block leak

RM6 Contain contaminated groundwater with hydraulic barriers

RM7 Replacement of potable water supplies

Remediation Measures

RM8 Pump and Treat

RM9 Air Sparging or Vapour Extraction

RM10 Multi-phase Extraction

RM11 Chemical Oxidation

RM12 Bioremediation

RM13 Electrokinetic Remediation

RM14 Phytoremediation

RM15 Monitored Natural Attenuation

RM16 Permeable Reactive Barriers

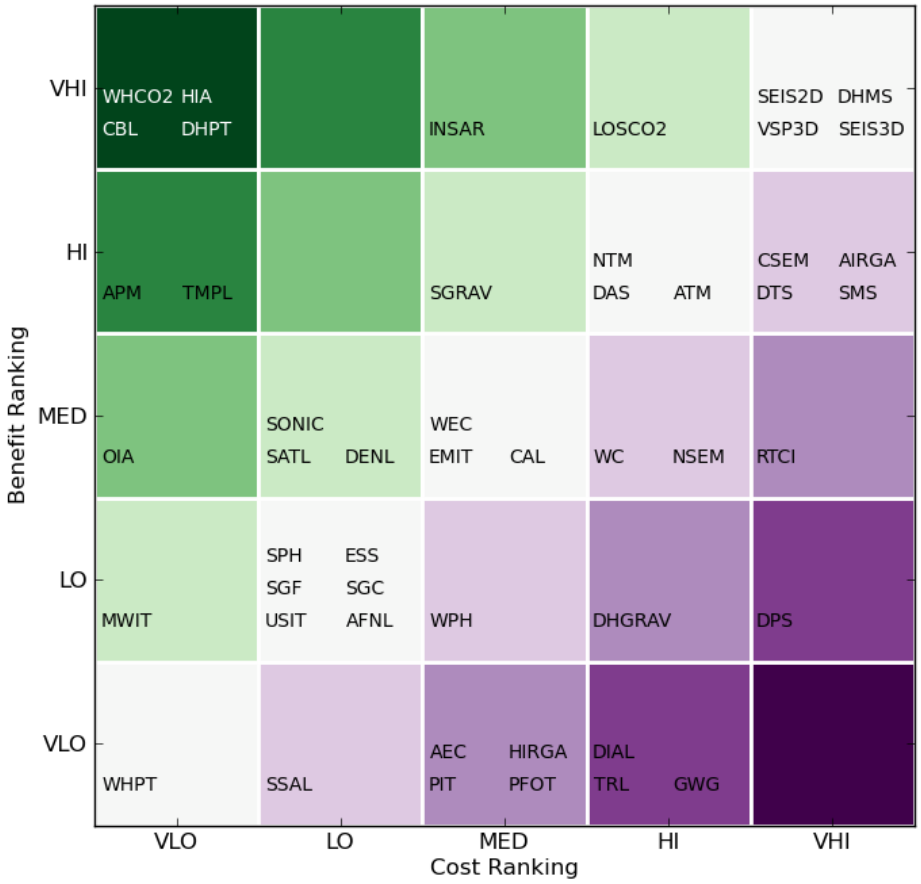
RM17 Treat acidified soils with alkaline supplements

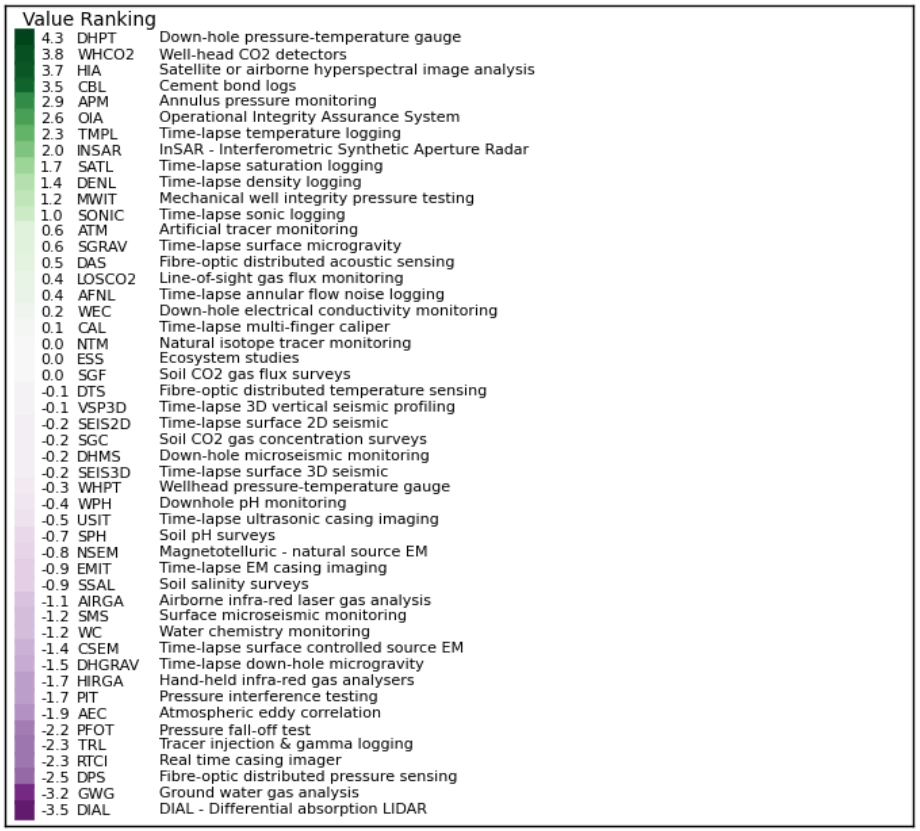
Systematic Evaluation of Monitoring Technologies

- Effectiveness of each monitoring technology to monitor tasks is evaluated
- Monitoring tasks are risked-based and designed to
  - verify effectiveness of passive safe guards and
  - trigger timely deployment of active control measures
- Evidence-based using collective expert judgement and independently reviewed

Task	Technology	Indicator	Evidence For	Evidence Against	EF	EA
6 Detect fault reactivation						
DHPT	Down-hole pressure-temperature gauge in a WPGS observation well	Sustained Winnipegosis pressure increase detected by down hole pressure gauge	1. Industry standard technology 2. Continuous monitoring 3. Early warning before brine or CO2 arrives 4. Sensitive to low flux rates (1 ppm) 5. Detection within 1-6 months	1. Gauge drift may mask indicator 2. Natural changes may mask indicator 3. WPGS pressure barriers may mask indicator 4. WPGS permeability may be insufficient	0.8	0.1
DHMS	Down-hole microseismic monitoring	A sustained cluster of microseismic events located above the primary seal that migrates upwards with time	1. Industry standard technology 2. Continuous monitoring 3. Detect magnitude -3 events up to 600m away 4. Event location error c. 10-20 m	1. Not all fault slip creates microseismic events 2. Not all microseismic events are detectable	0.7	0.2
INSAR	InSAR - Interferometric Synthetic Aperture Radar	Short spatial wavelength surface uplift anomaly around a potential fault	1. Detects dilation of any shallow formation 2. Sensitive to uplifts >1mm/year 3. Monthly monitoring over entire AOR	1. Natural monitoring targets maybe limited 2. Cannot monitor through snow cover	0.6	0.2
SEIS3D	Time-lapse surface 3D seismic	Appearance of an amplitude anomaly above the primary seal around a potential fault	1. Areal coverage over entire CO2 plume 2. Expect to image the CO2 plume 3. Lateral resolution c. 25 m 4. Vertical resolution c. 10 m	1. No sensitivity expected to brine migration 2. Acquisition noise may mask indicator 3. Only monitor every few years 4. Leak may go undetected for years 5. Unable to detect CO2 leaks <10-60 ktonnes	0.3	0.3

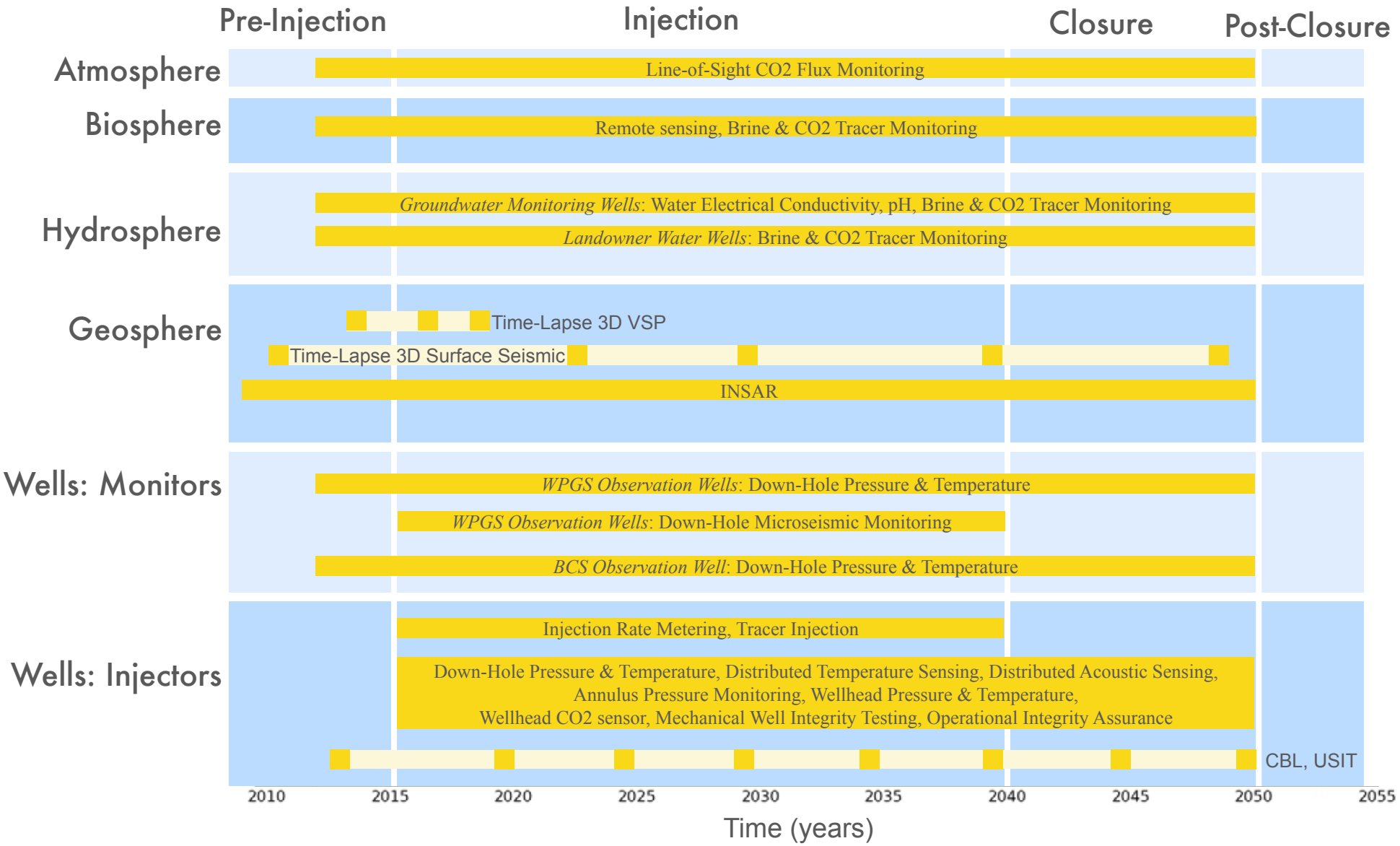
Technology Selection Based on Cost-Benefit Ranking





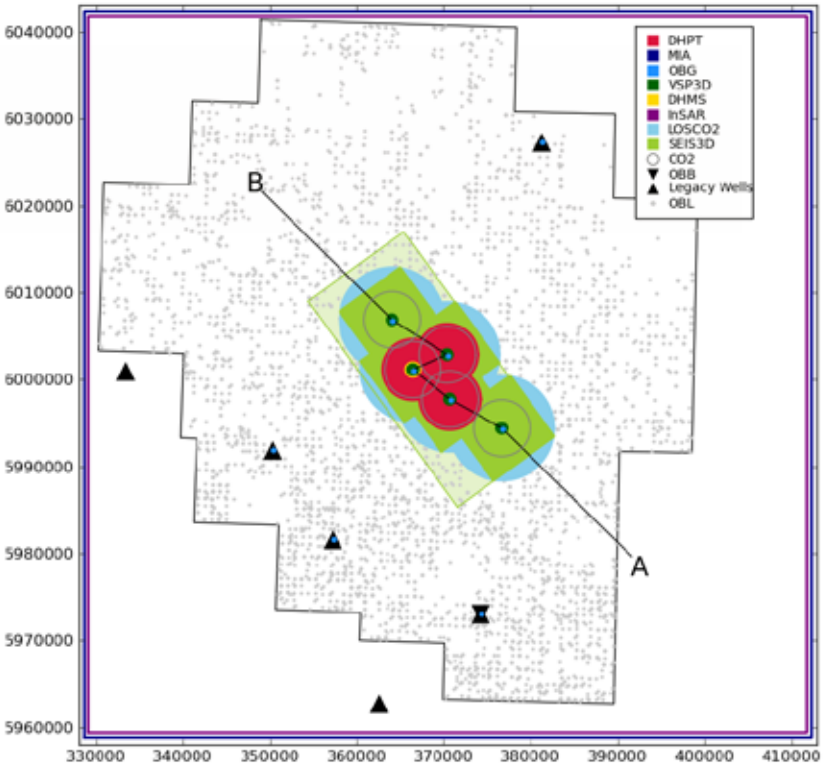
- Cost ranking based on estimated unit costs and schedule of monitoring
- Benefits ranking based on number of tasks supported weighted by the expected success rates
- Subject to regular re-evaluation based on performance

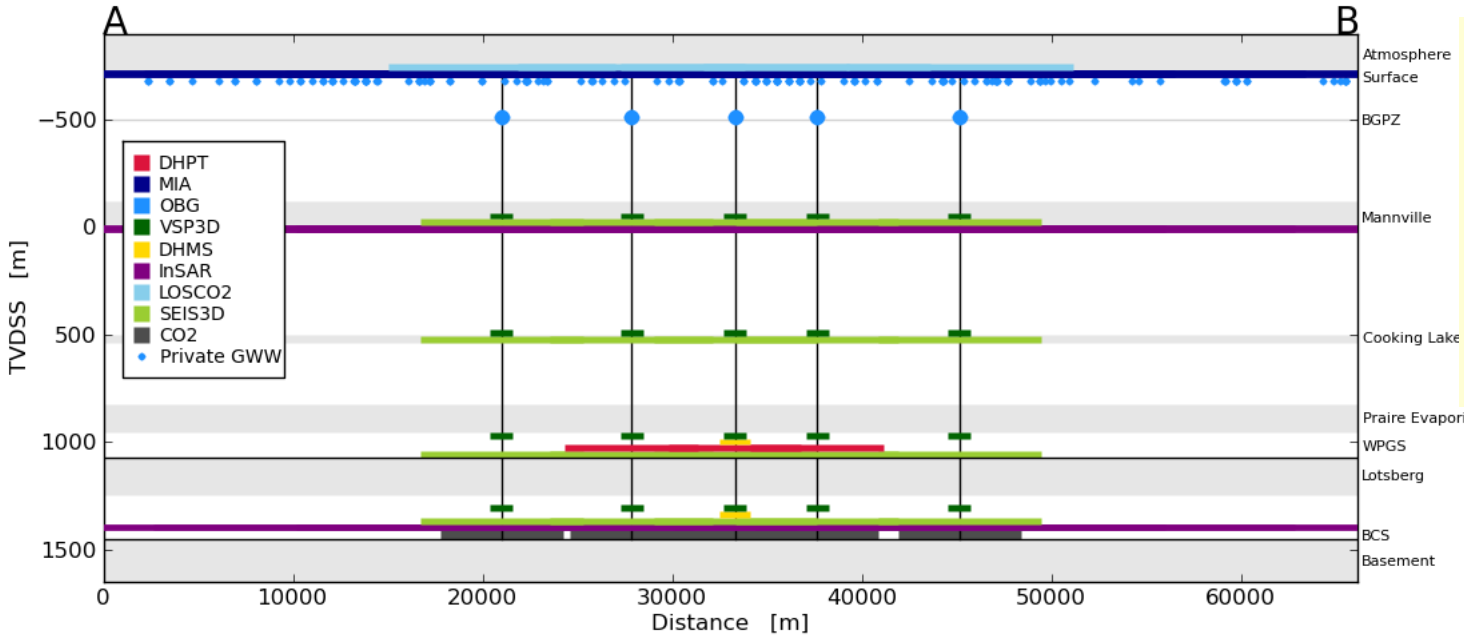
Diversified Monitoring Program Eliminates Dependence on any Single Technology



Depth and Spatial Coverage

- Injection Wells: 3 – 8; Base Case of 5
- Observation Wells:
  - 1 BCS well
  - 3 Deep Monitoring Wells (WPGS)
  - 3 shallow Groundwater Wells per injection well
    - 1 at each Injection Well
    - 1 in close proximity to each BCS Legacy Well
  - All private GW wells within 3.2 km of injection well
  - 1 private GW well per township in AOI



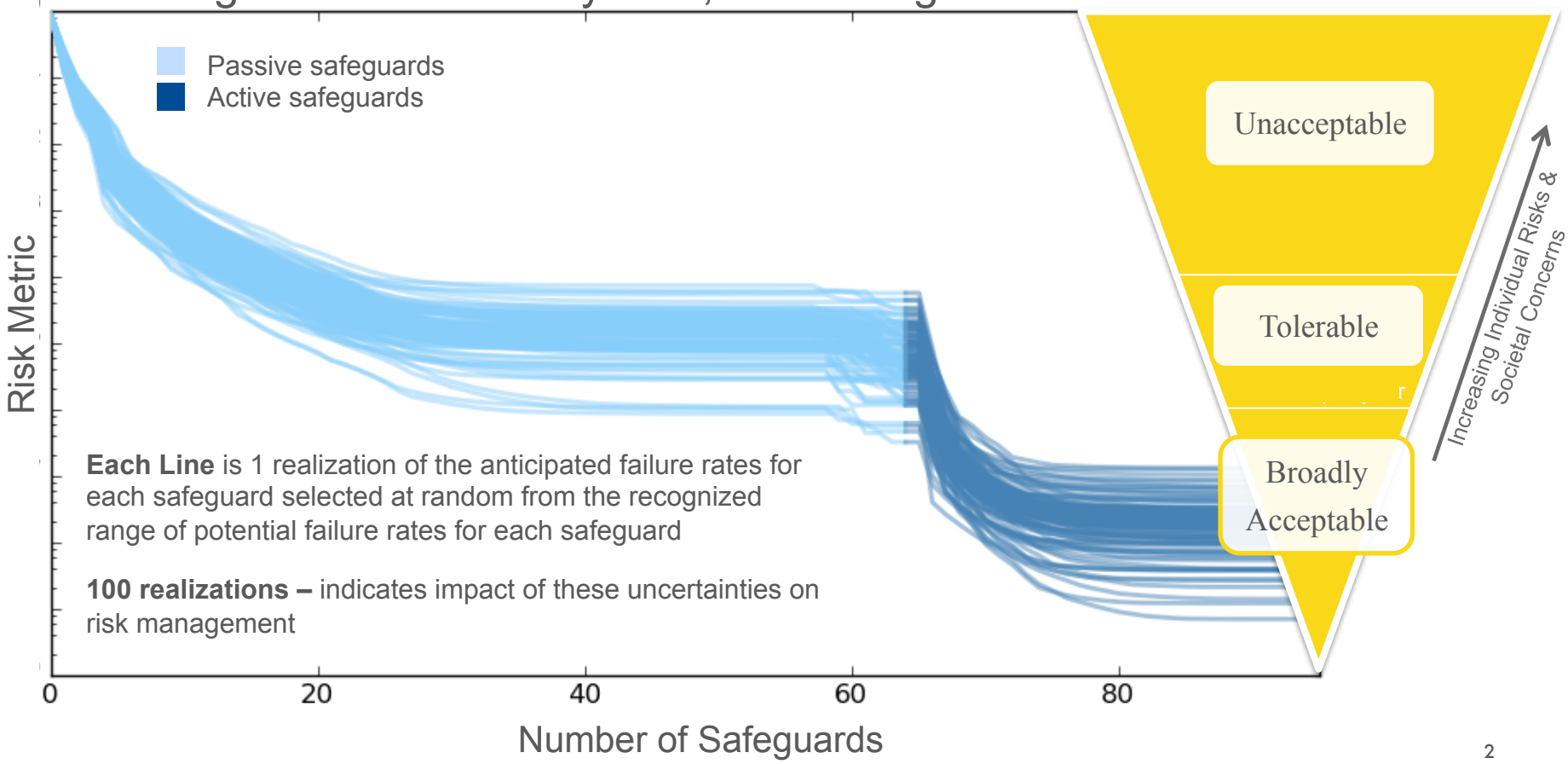


Legend

DHPT: Down-hole pressure temperature
MIA: Multi-spectral image analysis
OBG: Groundwater observation well
VSP3D: Time-lapse 3D vertical seismic profiles
DHMS: Down-hole microseismic monitoring
InSAR: Interferometric Synthetic Aperture Radar
LOSCO2: Optical path remote gas flux mapping
SEIS3D: Time-lapse 3D surface seismic
CO2: Maximum expected CO2 plume
Private GWW: Landowner groundwater wells
OBG: Project groundwater monitoring wells
OBB: Project BCS monitoring well
Legacy Wells: Legacy wells through BCS
OBL: Landowner wells

MMV Contributes to Risk Acceptance

- Based on collective expert judgement
- Informed by appraisal data and feasibility studies
- Storage site is inherently safe; Monitoring is for verification



Continuous Adaptation and Regular Updates

- MMV Plan continuously adapted in response to new information
  - Site-specific technical feasibility assessments
  - Baseline measurements during the pre-injection period
  - Monitoring during the injection and closure periods
- Performance Report submitted to the ERCB every year
- Updated MMV & Closure Plans published every 3 years

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Quest MMV Summary

- MMV designed to demonstrate secure CO2 storage
  - Risk-based Adaptive
  - Site-specific Diversified
- Regulatory review ongoing
  - Public Hearing (March 2012)
  - Awaiting decision and associated conditions prior to June 9
- Independent expert reviews completed
  - DNV-led Independent Project Review (September 2010, September 2011)
  - World's first certification of an MMV Plan by DNV (November 2011)

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Lessons Learned to Date

- Clear, agreed, site specific definitions for containment and conformance early in the site characterisation phase to inform the risk assessment and associated appraisal strategy appropriately to ensure fit for purpose MMV plan.

- Project Transparency has been an enabler on multiple fronts:
  - Project acceptance from Internal and External stakeholders
  - Provided guidance to researchers on existing technology gaps
  - Dialogue between industry and Government for policy discussions

- Regulations currently under development. Agreement that MMV is a performance driven, risk based and adaptive allows for program change over time as both regulatory and subsurface uncertainties are reduced.

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Acknowledgements

- Partners – Chevron Canada Limited & Marathon Oil Canada
- Government of Alberta, Department of Energy (DOE)
- Government of Canada, Natural Resources Canada (NRCan)
- Government of Alberta, Alberta Innovates