Final Phase: Project Update

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IEA GHG
WEYBURN-MIDALE
CO_2 MONITORING
AND STORAGE PROJECT

Phase 1: 2000-2004

"To predict and verify the ability of an oil reservoir to securely and economically contain CO_2 (geologically) through a comprehensive analysis of various process factors as well as monitoring and modeling methods intended to address the long-term migration and fate of CO_2 in a specific environment (EnCana's Weyburn, Saskatchewan EOR operation)"

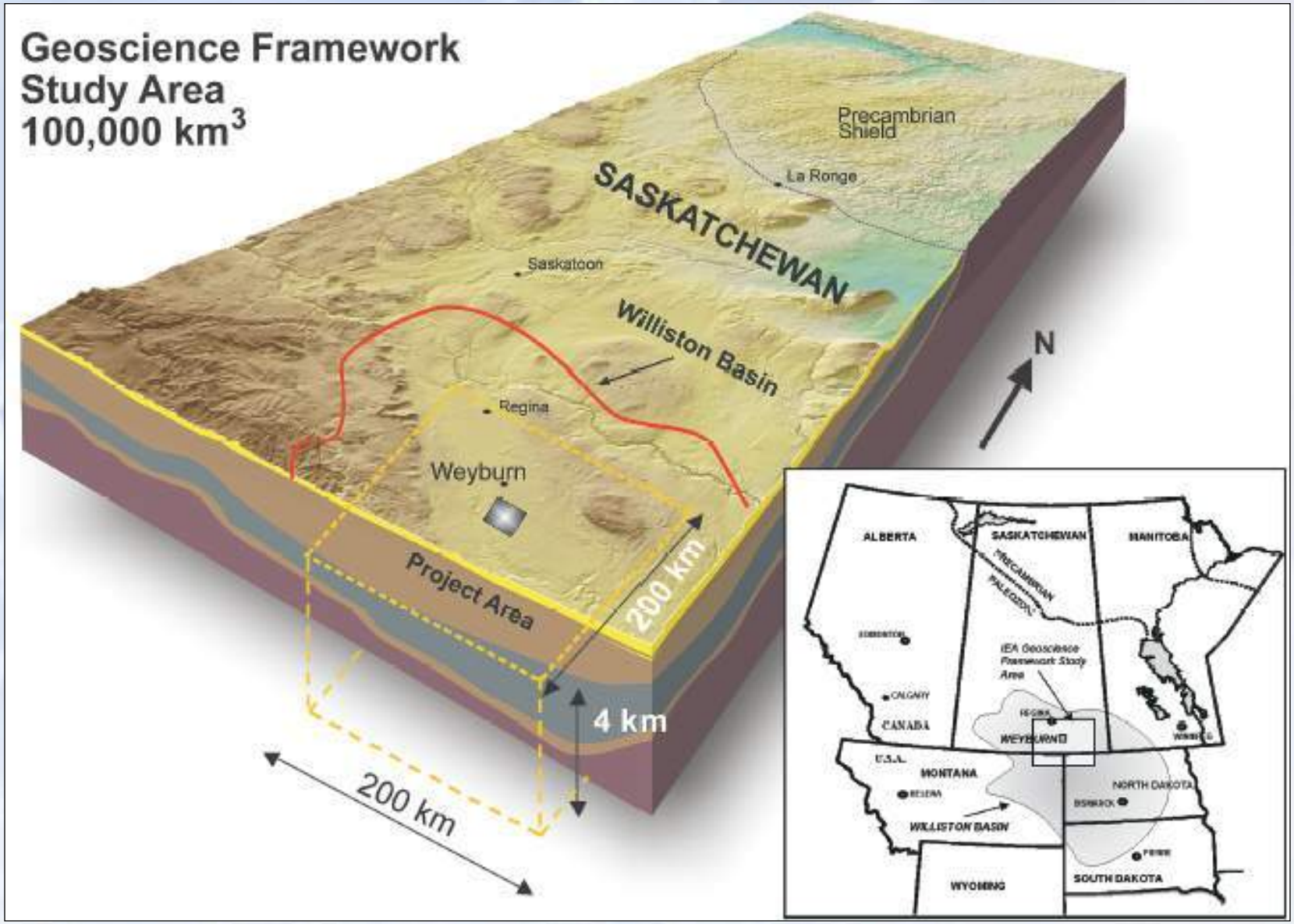
Sponsors:

- 5 governments (NRCan, US DOE, SIR, AERI, EU)
- 10 industry sponsors (Canada, USA, EU, Japan) – energy-based
- endorsed by IEA GHG R&D Programme
- $42 million (50:50 cash : in-kind)

Research Management:

- overall project management by PTRC, based in Regina, SK
- 22 S&T organizations in 6 countries
- 80+ researchers

Where is the CO_2 stored?



Weyburn Unit Statistics

Field size
- 70 square miles

Original oil in place:
- 1.4 billion barrels

Oil recovery (pre-CO_2-EOR):
- 370 million barrels

Projected CO_2 IOR:
- 155 million barrels

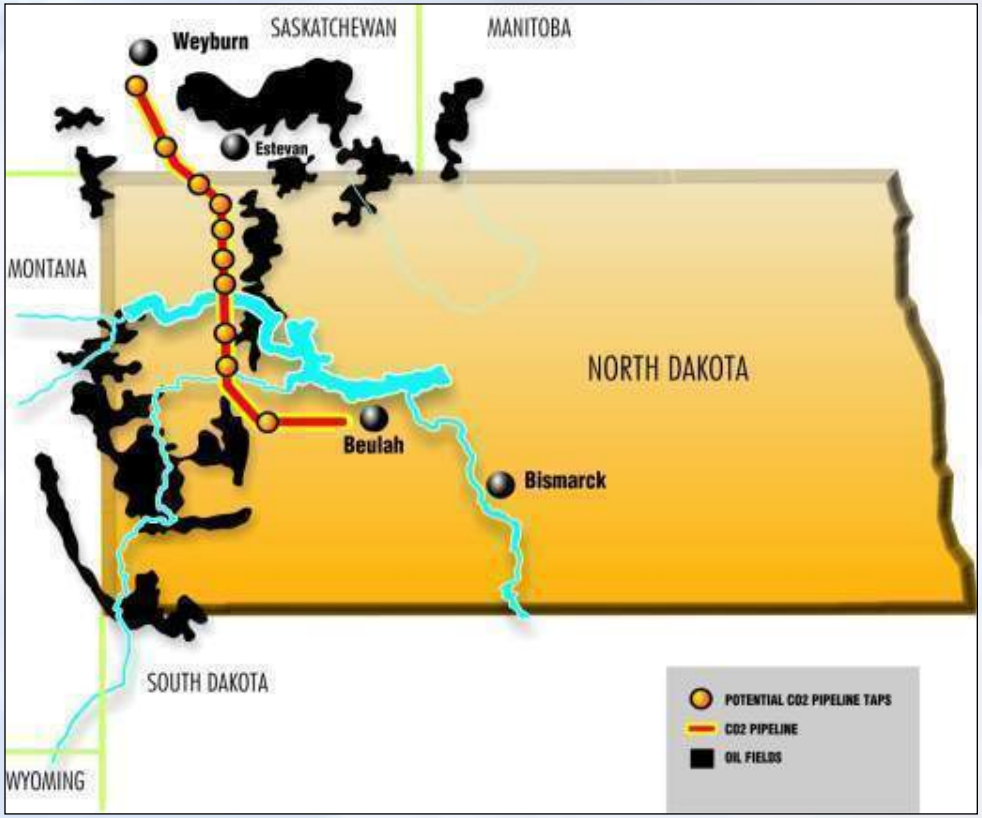
Projected CO_2 stored:
- 30+ million tonnes* (gross)
- 26+ million tonnes (net)

**equivalent to removing > 5 million cars off the road for a year!*

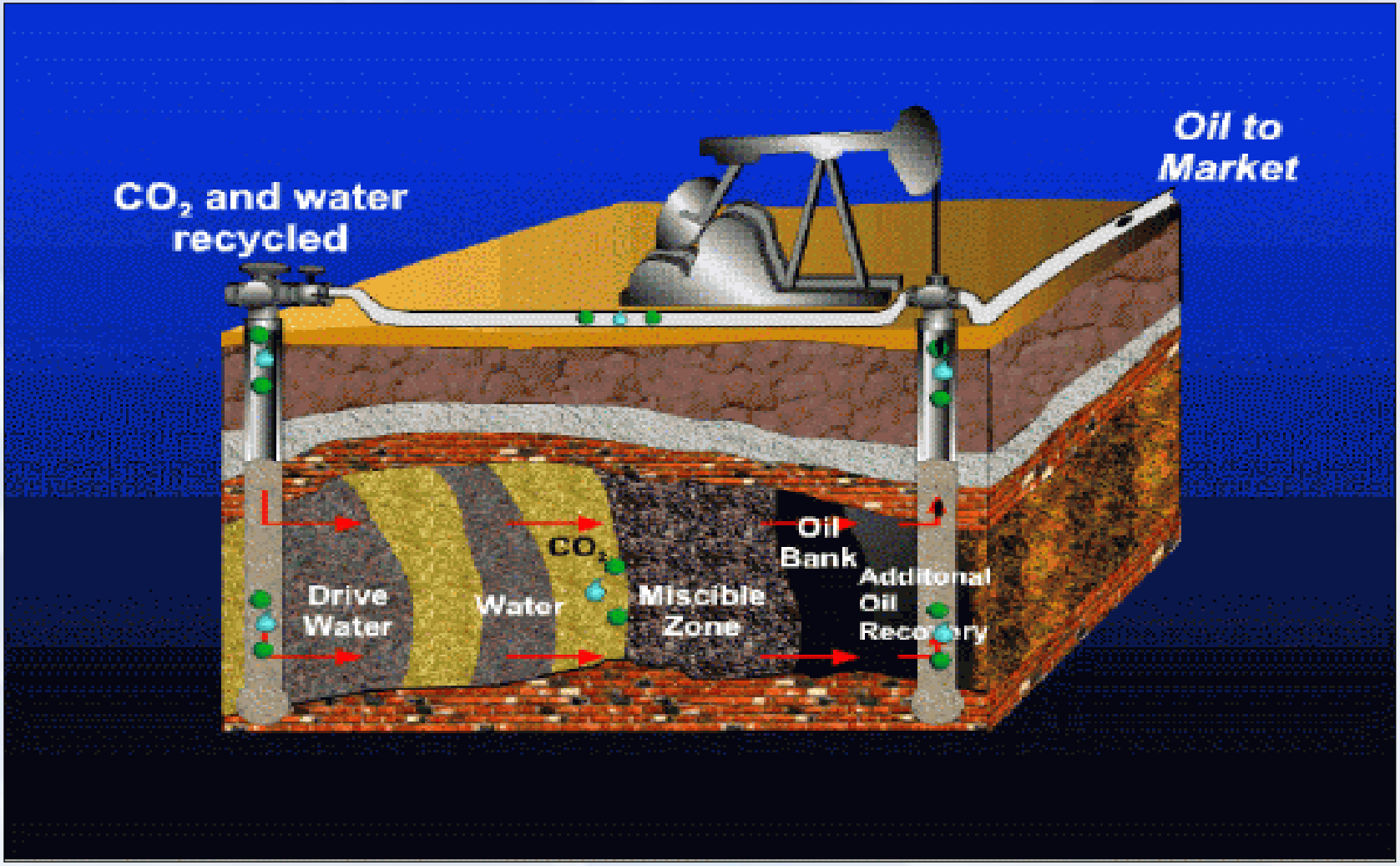
The Source of CO_2

Dakota Gasification Company

- 250 mmscfd CO_2 by-product of coal (lignite) gasification of which approx. 8000 tonnes/day suitable for EOR
- CO_2 purity 95% (less than 2% H_2S) ; trace mercaptans
- 95 mmscfd (5000 tonnes/day) contracted and injected at Weyburn
- EnCana injects 150 mmscfd (33% recycle) as of December 2005
- Apache began injection at Midale in October 2005, injecting 5-10 mmscfd; by Q3 2006 injection will be 26 mmscfd or 1368 tonnes/day to recover an additional 45-60 million barrels over project life

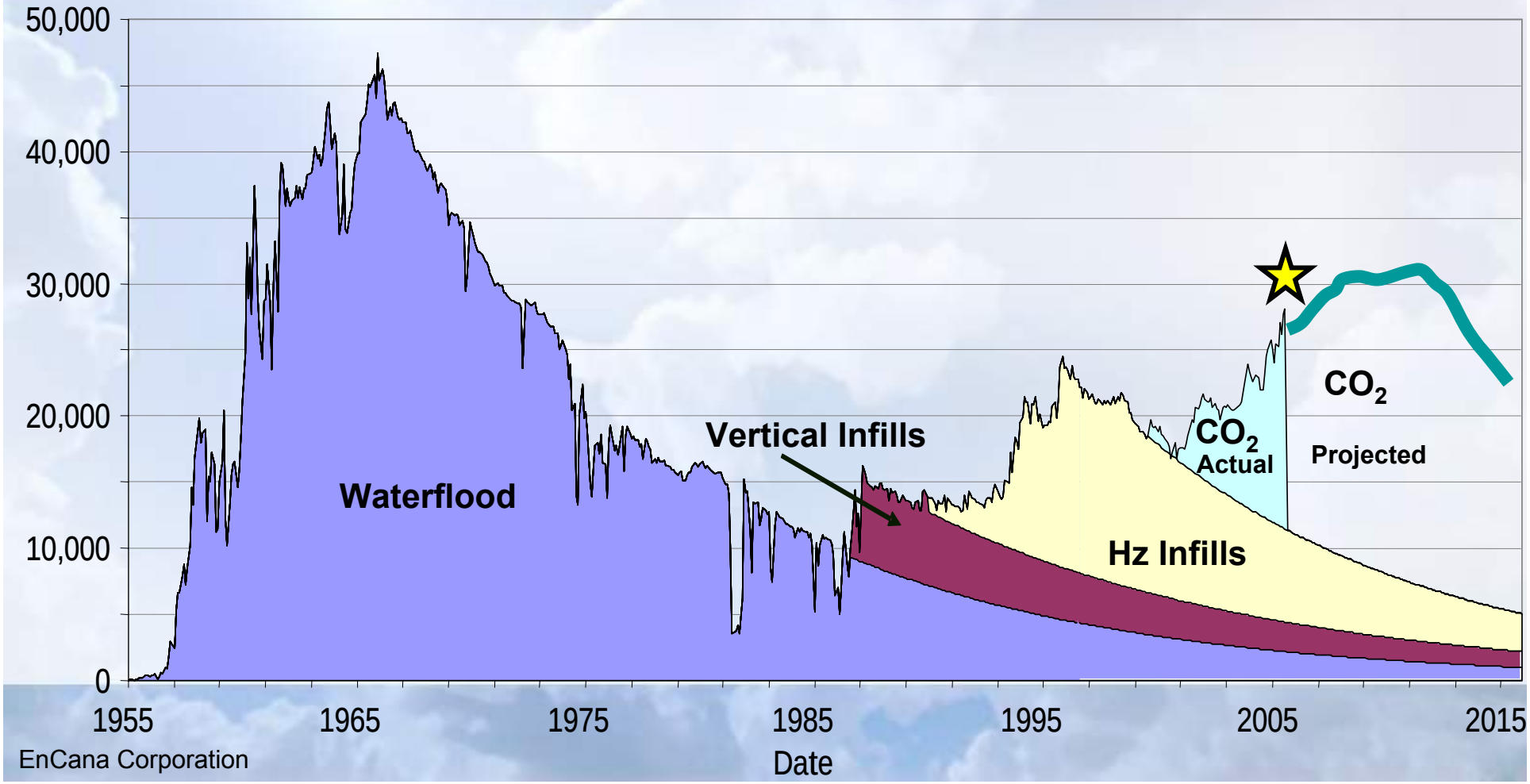


How does CO_2 Enhanced Oil Recovery (EOR) work?



EnCana's Weyburn Unit Production Data

- 7 million tonnes (net) of CO_2 injected by end of 2005
- 26+ million tonnes (net) will be geologically stored by 2035
- 18,000 incremental bopd (30,000 bopd total unit prod'n)
- world's largest, full-scale, in-field MMV study with CO_2-EOR

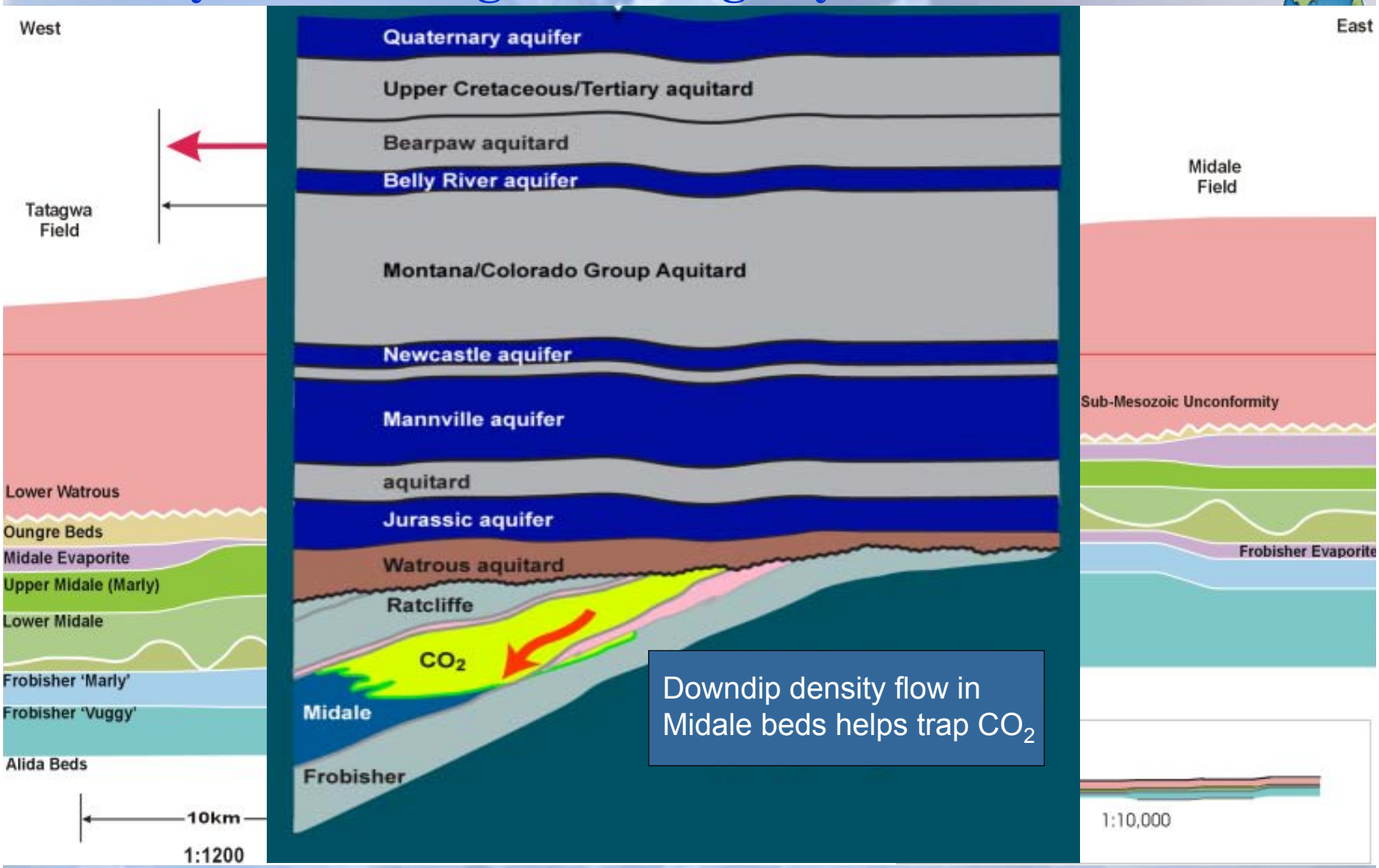


A comprehensive, internationally peer-reviewed data set

- Baseline monitoring survey (geophysical, geochemical, surface) in July 2000 (pre-injection)
- CO_2 injection began in September 2000 in 19 of 75 planned patterns
- R&D program focused on the first 19 patterns (Phase 1a)
- Regular monitoring surveys completed (quarterly, annually)
- Expert review led by IEA GHG in mid-2003 to make course adjustments and plan for Final Phase
- Expert review of Final Phase Technical Program led by IEA GHG in early 2006

Facility where main CO_2 pipeline enters Weyburn field from Beulah, ND

Weyburn Geological Storage System – Phase 1



Saskatchewan Geological Survey; University of Alberta

Summary of Phase 1 Results

- **Geological "container" at Weyburn is effective:**
  - Primary carbonate and secondary shale seals are highly competent
  - Sluggish hydrogeological flow in Midale beds
  - Hydraulic separation between adjacent aquifers
  - No fluid flow connecting all aquifers (including flow along fractures, discontinuities)

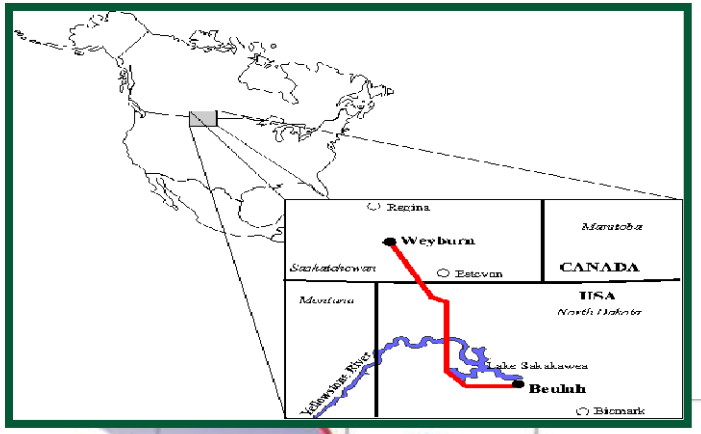
- **Migration of CO_2 outside the EOR area at 5000 years post-injection:**
  - 26.8% (7 million tonnes) moves outside the EOR area but remains within the geological region or "system under study":
    - **18.2% migrates to geosphere below reservoir via water phase but is confined within EOR perimeter**
    - **8.6% migrates laterally within reservoir but outside 75 EOR patterns (moving updip or northeast)**
    - **0.02% goes above reservoir but confined within EOR perimeter**
    - **0.14% leaks via aging, abandoned wells**
    - **0.0% enters potable aquifers near the surface**

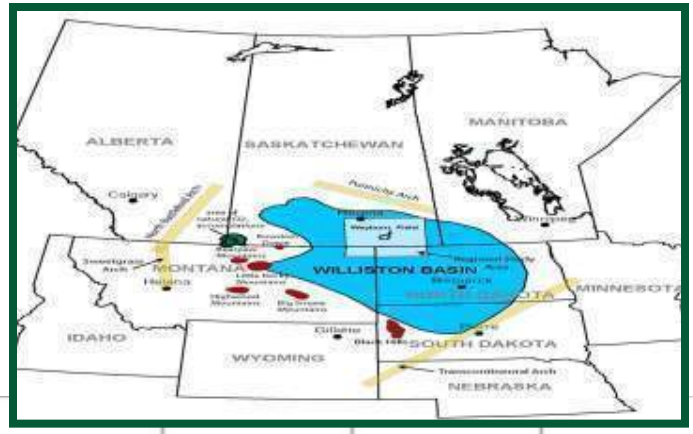
Why pursue a Final Phase (2005-2008) project?

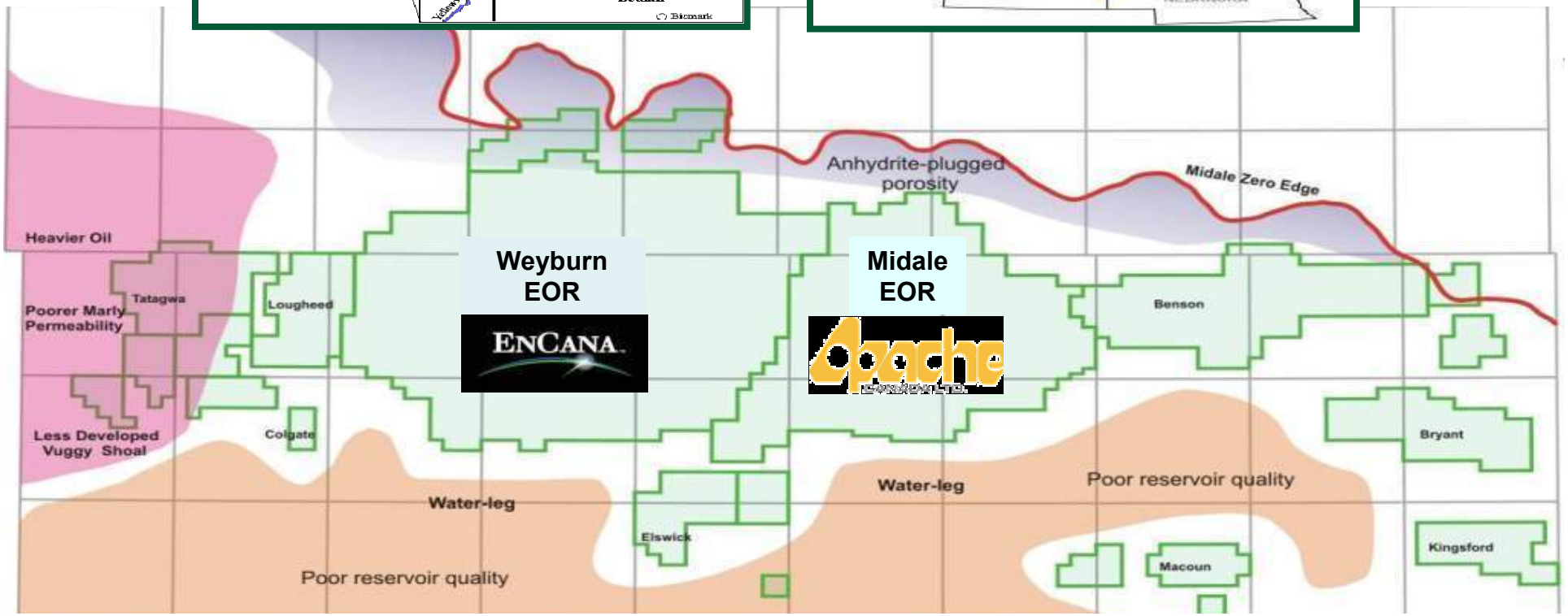
"Encourage the widespread use of technologies required for the design, implementation, monitoring and verification of a significant number of CO_2 geological storage projects in Canada and the USA"

- Build a Best Practices Manual (BPM) as a practical, technical guide for design and implementation for CO_2 storage associated with EOR
- Influence the development of clear, workable regulations for CO_2 storage, building upon existing, effective regulatory framework
- Influence the development of an effective public consultation process
- Influence the development of effective public policy to seed the development of a large, economic CO_2 supply and infrastructure, and a mechanism for monetizing credits for CO_2 storage

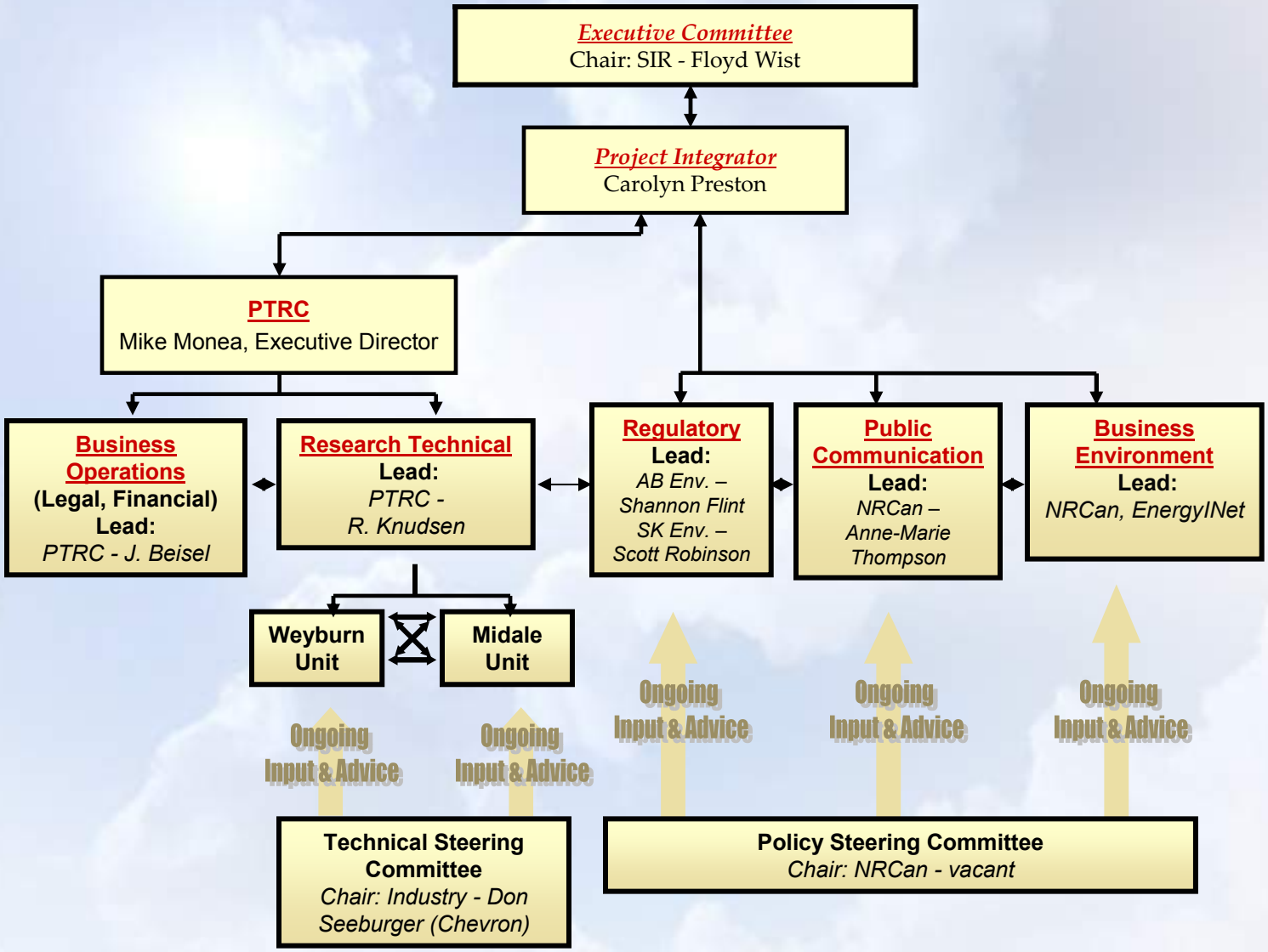
Apache Canada includes its Midale CO_2-EOR operation in the Project







Final Phase Organization



IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project

Best Practices Manual – Final Phase

Protocols for:

- ***Storage site selection***
- ***Monitoring and verification of stored CO_2***
- ***Well-bore integrity monitoring and remediation***
- ***Long-term risk assessment and risk management***
- ***Maximizing economic CO_2 storage capacity***

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Technical Priorities – Final Phase

1. Geological Integrity (Site Selection)

- develop firm protocols for site selection
- minimum data set required for successful site selection and full RA
- integrate hydrogeological, geophysical, geological data sets vis à vis seal integrity
- impact of CO_2 on geochemical and geomechanical processes and regional seals/geology

2. Well-bore Integrity

- essential parameters to define well-bore integrity
- impact of current well abandonment practices on long-term CO_2 storage and proposed future abandonment/remediation requirements
- conduct cased-hole dynamic testing (pressures and mobile fluids that signal CO_2 migration out of zone)
- document safe practices and impact on well-bore integrity and geomechanics

Technical Priorities – Final Phase

3. Storage Monitoring Methods (Geophysics, Geochemistry)

- are multi-year 4D seismic programs an appropriate monitoring and verification requirement?
- quantitative prediction of CO_2 location and volume
- determine CO_2 distribution through in-situ, time-lapse well logging; spinner surveys; selective drilling, coring and logging of slim holes
- continue to explore passive seismic monitoring

4. Risk Assessment; Storage and Trapping Mechanisms; Remediation Measures; Environment, Health and Safety

- complete full-field risk assessment from Phase 1
- determine risk levels for various storage optimization scenarios
- study natural analogues vis à vis well-bore and storage integrity
- ultimate fate of CO_2 , relative volumes in each trapping mechanism, time lapse to trapping, and factors affecting these
- determine methods for stimulating/accelerating CO_2 mineral fixation at reservoir conditions

Regulatory Policy Research – Final Phase

- Use existing national and provincial regulations as a basis for developing a generic "Straw Dog" regulatory application suitable for use in many different jurisdictions, addressing long-term storage issues and gas-credit accounting

- Work with regulatory bodies to develop fit-for-purpose, science-based, multi-jurisdictional regulations and outline an effective two-way public communication process

- Based on the foregoing, and feedback from stakeholders, revisit and accordingly revise the Best Practices Manual to make it universally applicable

Public Communications and Outreach (Policy) – Final Phase

- With stakeholders, develop a Communication Plan based on the Weyburn experience and other major international CO_2 geological storage projects:
  - *Identify and focus on issues (and metrics) of key interest to policy makers, regulators, investors and (national and local) public*
  - *Appropriately communicate the Best Practices Manual and other relevant technical information to these essentially non-technical audiences*
  - *Launch the public communication process early*
- Based on issues/feedback from these stakeholders, revisit and accordingly revise the Best Practices Manual

Overall Status of Final Phase

- Continued financial support of Governments confirmed: NRCan, US DOE/NETL, SIR and AERI (EU application under review)
- Sponsorship from industry: enhanced to include new participants from different sectors
- Agreements close to finalization (sponsorship and research provider)
- Budget envelopes approved (90% technical; 10% policy)
- Expert Review of technical program completed and initial monitoring work is underway
- Policy Program is lagging Technical Program by ~ 10 months but is making rapid progress to drive the Technical Program through the Best Practices Manual

Conclusions (for now)

- Based on preliminary results, the natural geological setting appears to be highly suitable for long-term CO_2 geological storage
- The Project has arguably the most complete, comprehensive, peer-reviewed data set in the world for CO_2 geological storage
- An effective, international team of culturally diverse, high-quality researchers has been established
- Strong international leadership has been demonstrated by Canada and the USA in CO_2 geological storage R&D through continued financial and managerial support
- International credibility and recognition have been achieved through recognition by the IEA GHG R&D Programme and the Carbon Sequestration Leadership Forum
- Best Practices Manual development will assure integration across the Technical and Policy Programs during the Final Phase