Heartland Area Redwater Project
HARP

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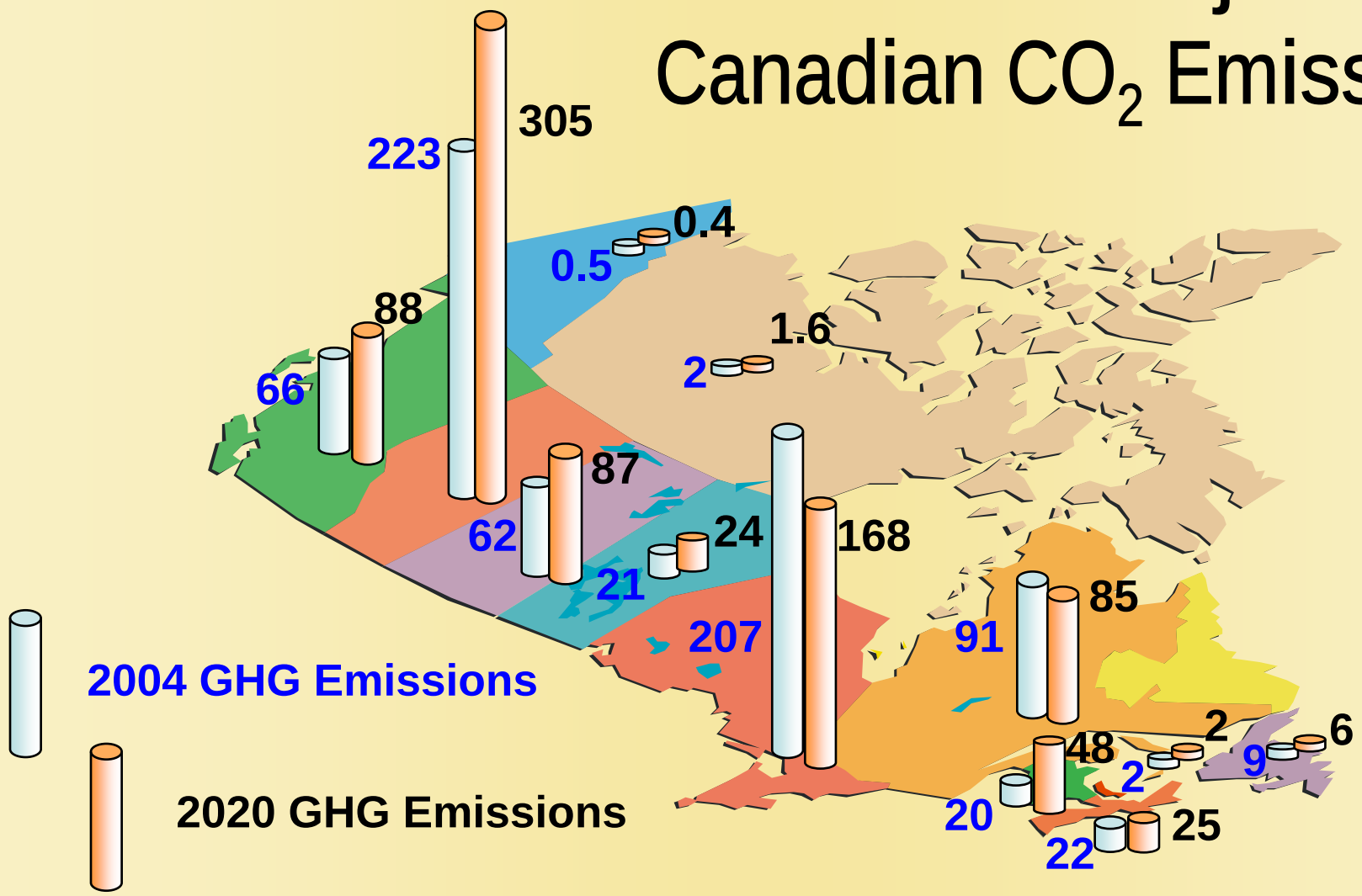
Alberta Research Council

CSLF Technical Group Meeting
London, UK, October 11, 2009

Current and Projected Canadian CO_2 Emissions



Current CCS Projects in Western Canada

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Project Goal and Objectives

Goal: Implement a commercial-scale CO_2 storage operation in a brine-saturated carbonate reef located in the Alberta Industrial Heartland, in a farmland area close to industrial CO_2 sources

Objectives:

- Demonstrate feasibility of CO_2 storage in onshore consolidated carbonate rocks with characteristics representative of North America
- Implement a pilot operation that will inject 100 kt CO_2 by 2012
- Scale up by 2015 to a fully-commercial operation that will store 1 Mt CO_2/year

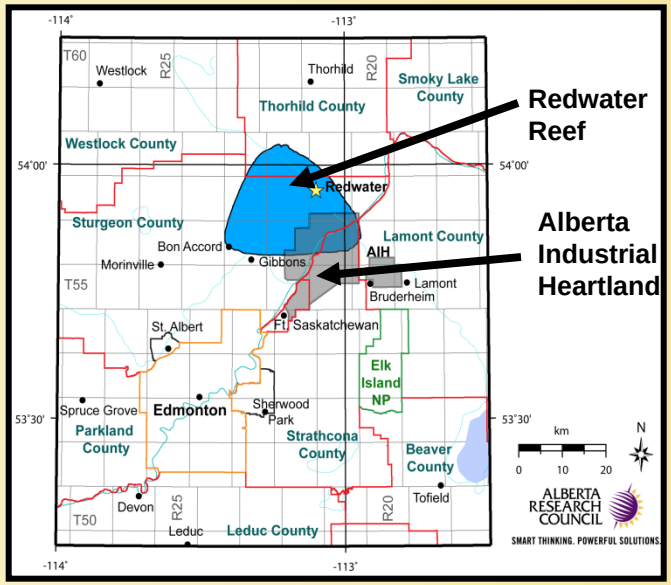
Multiple CO_2 Sources in Alberta's Heartland Area Northeast of Edmonton

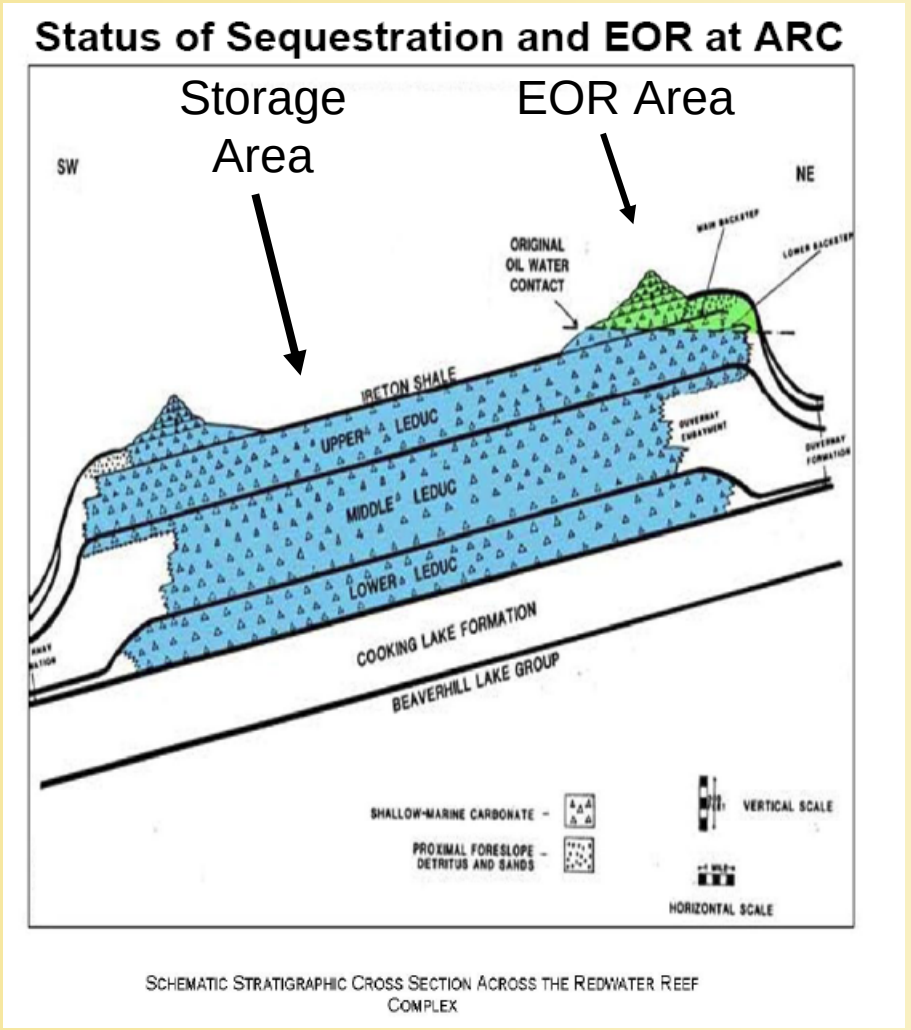
- CO_2-rich stream (80%+) from processing feed ethane and ethylene oxide production
- CO_2-rich stream from K_2CO_3 absorption in hydrogen production in ammonia plants
- Pressure Swing Adsorption (PSA) off-gas stream from hydrogen production
- Exhaust combustion gas from ethane cracker furnace and from natural-gas fired co-generation units

➢ Future streams: bitumen upgraders, hydrogen plants, gasification of coal, petcoke, bitumen residue

The CO_2 Storage Site: The Redwater Reef

- Approximately 600 km^2 in area and more than 250 m thick, located at 1000 m depth at its shallowest
- The third largest oil reservoir in Canada is located at the updip rim of the reef (1.3 BBL OOIP)





SCHEMATIC STRATIGRAPHIC CROSS SECTION ACROSS THE REDWATER REEF COMPLEX

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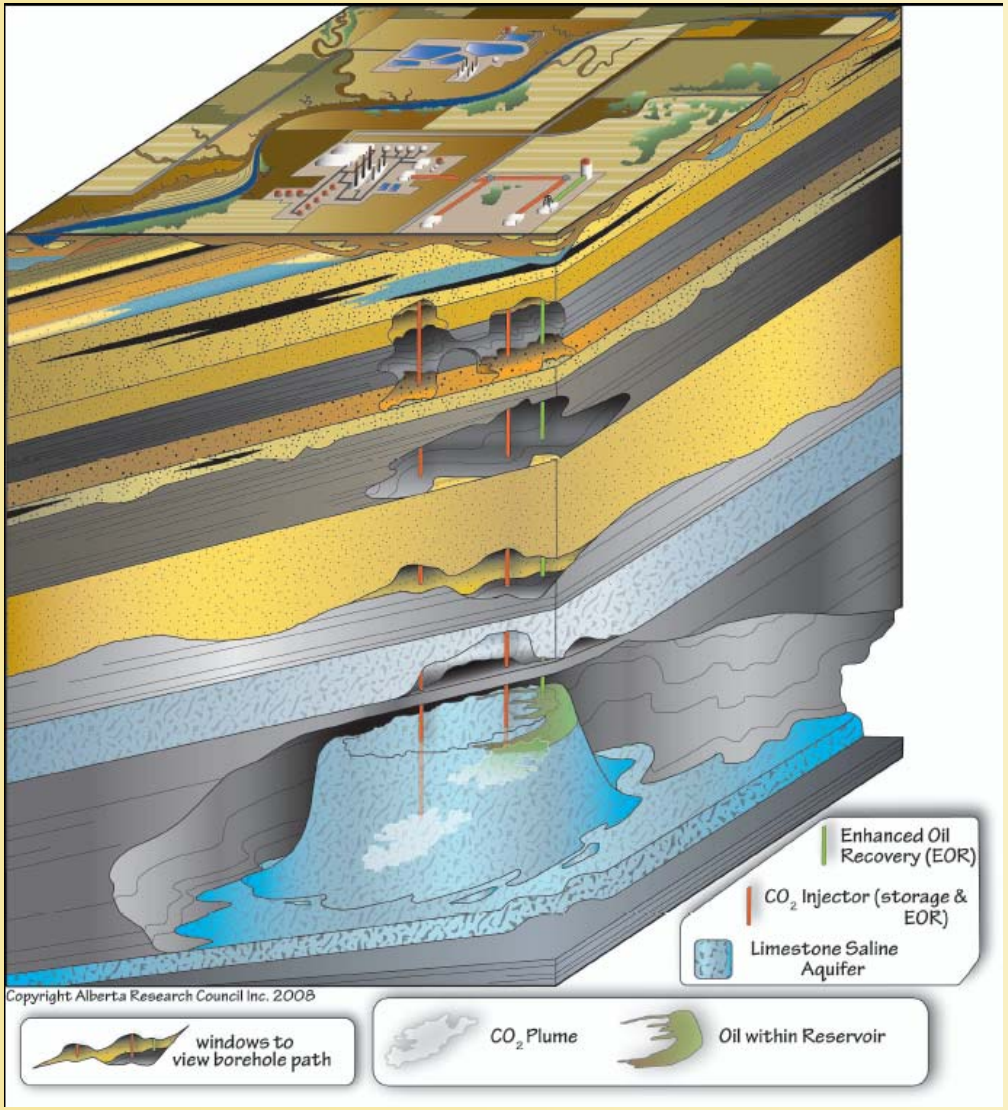
HARP Starting Point

Estimated CO_2 Storage Capacity of the Redwater Reef

- In the Redwater oil reservoir: 50 Mt CO_2; A vertical flood CO_2-EOR Pilot operation is underway
- Storage capacity in the water-saturated reef is estimated at several hundreds Mt CO_2



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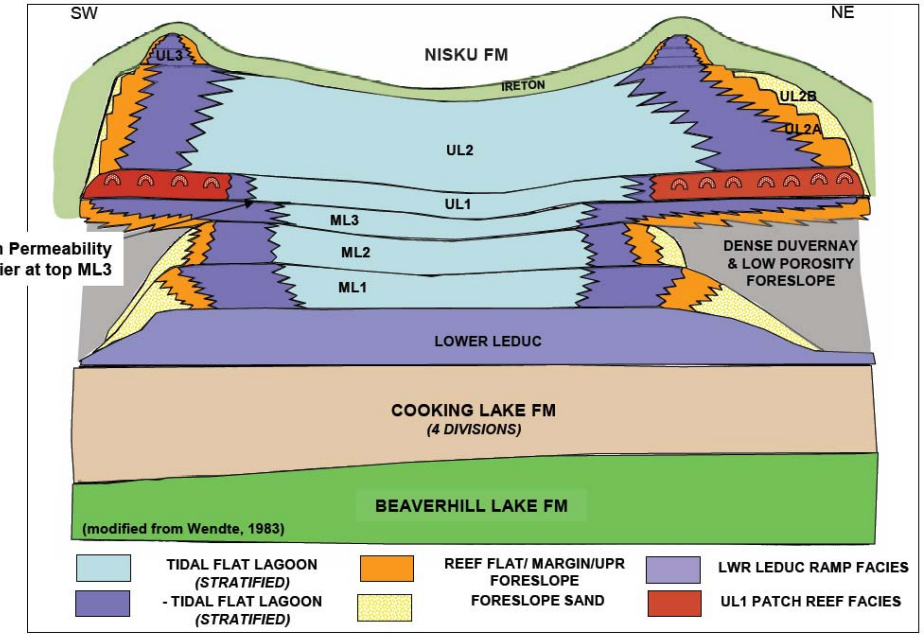
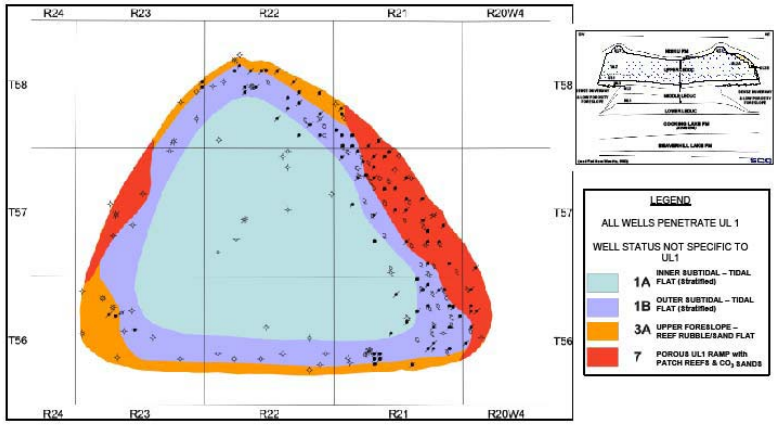
Reef Architecture

- Multiple facies identified
- Rocks characterized
- Reef model constructed



Facies Map of Upper Leduc 1 (UL1)



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Project Stages – HARP Project

Stage 1: Comprises 3 phases occurring in 2008-2011	**Phase I** Site & reef characterization (2008-2009)	☑ **COMPLETED – July 2009**
	Phase II Selection of pilot site, drilling of exploratory well (2009), prepare and design pilot facilities (2010)	☑ **STARTED August 2009**
	Phase III Construct facilities & CCS Pilot operation injecting 200-300 tonne CO_2/day (~100,000 t/year) by truck in (2011-2012)	
Stage 2: Comprises 4 phases occurring in 2012-2015	Scale up to commercial size	
	Inject 1 Mt minimum CO_2/year (2,700 tonne CO_2/day) by pipeline	

Key Criteria for Geological Storage

Capacity

Injectivity

Containment

Resource Protection

Economics

Location

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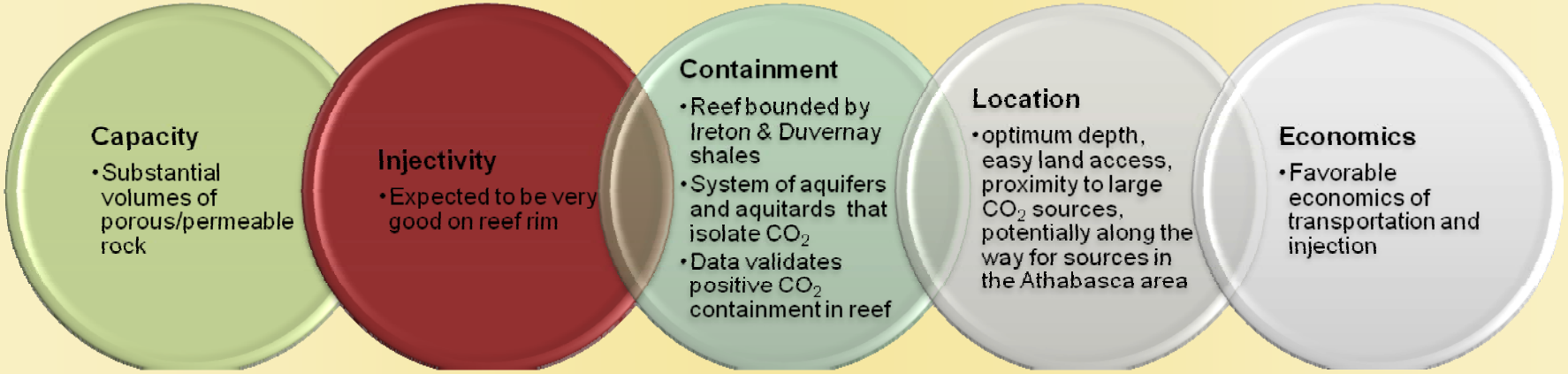
HARP Project – Stage 1, Phase I

Phase I focused on the characterization and evaluation of the Redwater reef as a potential CO_2 saline aquifer storage site based on available data:

- Internal and external architecture of the Redwater Leduc reef
- Evaluation of hydraulic communication with adjacent aquifers
- Geomechanical characterization of the reef and overlying strata
- Evaluation of wellbore integrity of wells penetrating the reef
- Preliminary modeling of various processes
- Preparatory work:
  - Baseline data collection and monitoring plans for the storage unit
  - Baseline data collection and monitoring plans for shallow groundwater, soil, vegetation and air
  - Site selection for investigative well
  - Public communication with the local community

HARP and Key Criteria for CO_2 Storage

Key geological storage criteria fulfilled by work completed in Phase I



as supported by oil field operations

HARP is strategically located, is one of the best and most advanced projects, and will be one of, if not the most economic CO_2 storage projects

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HARP Project – Stage 1, Phase II

Phase II will focus on collection of new field and laboratory data, additional site characterization and design of the CO_2 injection pilot:

Identification of CO_2 source for Phase III piloting

- Drilling and coring of an investigative well (site has been selected), to be converted into a CO_2 injection well
- Collection of additional geological, geophysical, hydrogeological, geochemical and geomechanical data (storage unit, caprock, adjacent strata, shallow groundwater aquifers, soil, vegetation and air)
- Simulation of various CO_2 storage scenarios
- Site facility design and application for permitting
- Continuing public and stakeholder communication
- Initiation of the dialogue for tenure and permitting

HARP Project – Stage 1, Phase III

Phase III will focus on site development, injection of up to 100,000 t CO_2 by March 2012, and monitoring:

- Drilling of monitoring wells
- Construction & development of surface facilities (CO_2 will be trucked in)
- Monitoring of the storage unit and of the injected CO_2
- Assurance monitoring of shallow groundwater, soil, vegetation and air
- Continuing public and stakeholder communication

HARP Project – Stage 2

Scaling up by 2015 to a fully commercial facility that will inject

1 Mt CO_2/year pipelined in from major CO_2 sources

in the Edmonton and Heartland areas

HARP Project – Future

Increase the scale of the operation to inject several Mt CO_2/year by 2020

HARP Leadership and Partners

ARC Resources
Project Operator

Permitting
Well drilling
Site development & facilities
Operations

Alberta Research Council
Research Manager

Site characterization
Development and implementation of monitoring plan
Collection, analysis, processing and interpretation of existing and new data

Capital Power Corp, Shell, StatoilHydro, Suncor
Joint Industry Partners
Phase I

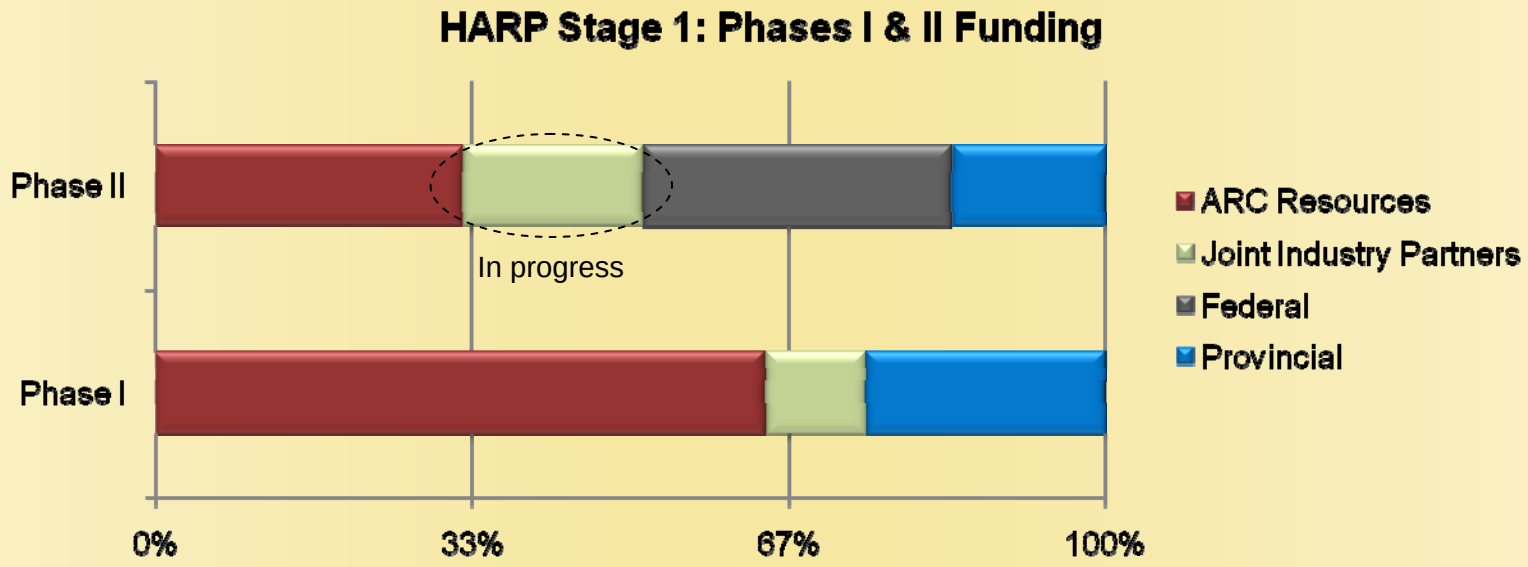
Input and advice to project management team
Receive project results through presentations and reports

Natural Resources Canada, Alberta Energy Research Institute
Government Supporters
Phase I

Input and advice to project management team
Receive project results through presentations and reports

Project Funding

Partnership funding between Industry, Federal and Provincial governments for Stage I (secured) and hopefully Stage II



Relevance to CSLF Gaps Analysis

Completely different storage environment from all other current CO_2 storage projects from the points of view of:

- Geology and structure (carbonate reef)
- Injectivity and storage strategies
- Surface facilities co-optimization with a CO_2-EOR operation
- Surface land use
- Climate
- Population proximity
- CO_2 sources
- Monitoring in a farmland region with four seasons
- Public communication and outreach