Isometric Project Design Document

Version 1.10

This PDD template follows the Isometric Standard. Please refer to the Standard for more information on how PDDs are used as part of the procedures of the Isometric Registry.

Section A – Key Project Data

A.1 Title

Please provide the title of your Project. This will be displayed as your Project's name on the Isometric Registry and all related documentation.

Deep Sky Alpha

A.2 Description

Please provide a brief description (50-100 words) of your carbon removal Project. A more detailed written technical description must be provided later.

Deep Sky Alpha ("Alpha") is a [redacted] facility that evaluates the energy consumption, operability, and reliability of various direct air capture technologies under real-world conditions. The project encompasses the capture, liquefaction, transport, and sequestration of CO_2. CO_2 captured at Alpha is transported by road and sequestered off-site.

A.3 Project Location(s)

- *Please submit at least one Address and/or specific geo-coordinates for the project.*
- *You may submit multiple Project locations – please specify what role each location plays in the Project.*

Deep Sky Alpha (Capture): 6015 35th Street, Innisfail, AB T4G 1V9
Storage Location: [redacted]

A.4 Project Participants

Please provide a complete list of organizations participating in the project, with a contact person for each organization.
(*Please duplicate the below rows for each additional organization you wish to add)*

Company Registration Number (*Unique business identification number in your country of registration*): 1298990-5
Organization Name: Deep Sky Corporation
Organization Address: 690 Hartland Ave, Outremont, QC H2V 1S2
Contact Person: Alexandra Petre
Contact Email Address: alex@deepskyclimate.com
Contact Phone Number: [redacted]
Organization Role in Project: Project developer and operator
Organization Name: [redacted]
Organization Address: [redacted]
Contact Person: [redacted]
Contact Email Address: [redacted]
Contact Phone Number: [redacted]
Organization Role in Project: CO_2 storage provider

A.5 Legal ownership of carbon removal claims

Please provide reasoning and evidence for legal ownership over the rights to all removals that will be claimed from the Project and refer to Section 3.1 “Ownership” of the Isometric Standard.

Deep Sky is the only Project Participant that will have ownership of the carbon removal claims resulting from this project. Our relationship with all other organizations involved in the project is limited to contracting for specific goods and/or services required to complete the project. All our agreements with such partners include provisions confirming Deep Sky’s ownership of the removals.

A.6 Technical description of Project activity

Please provide a brief technical description of your carbon removal Project activity in accessible language. This should include information on facilities and equipment, the age and average lifespan of equipment, and all further information essential to understanding how carbon removal is achieved by the Project.

Direct air capture (DAC) technology captures CO_2 directly from the atmosphere, providing a solution to offset emissions from hard-to-decarbonize sectors. Deep Sky Alpha is a dedicated facility designed to evaluate multiple DAC technologies under real-world operating conditions. DAC systems tested at Alpha will be rigorously assessed on their energy consumption, operability, and reliability, with the objective of identifying optimal solutions that can be scaled commercially across Canada. CO_2 captured from Alpha is then transported by road tanker to a deep saline aquifer injection facility.

The Project is structured into three distinct phases: **DAC Process, CO_2 Transport, and CO_2 Storage & Monitoring**.

DAC Process
At the Deep Sky Alpha facility, located in Innisfail, Alberta, atmospheric CO_2 is captured using multiple pilot-scale DAC systems. These systems use renewable electricity sourced via a dedicated, long-term power purchase agreement (PPA) with a solar photovoltaic facility in Lethbridge, Alberta. No fossil fuels are consumed during routine facility operation.

Although multiple DAC system vendors are represented at Alpha, they are not project participants since Deep Sky is the owner and operator of the equipment and the facility. From a carbon credit perspective, CO_2 from all the DAC systems is blended together and treated as a single offtake, not multiple individual offtakes. As such, the process inputs and outputs are recorded on the facility level rather than at the DAC system level.

CO_2 captured from the DAC systems is combined and fed to a common liquefaction system at Deep Sky Alpha. The liquefaction system compresses, dries, and cools the CO_2 stream prior to injecting it into a temporary refrigerated storage tank. There is additional shared process equipment at Deep Sky Alpha that is accessible by all DAC systems should they require it:

- Water treatment system
- Wastewater treatment system
- Air compressor system

Equipment deployed at Alpha is primarily new and state-of-the-art, with an anticipated operational lifespan ranging from 20 to 30 years, depending on the specific components.

Given the rapid evolution of DAC technology, it is important to note that individual DAC systems will be deployed for less than 20 to 30 years, with the exact duration depending on their technology readiness level, performance under field conditions, and the specific goals of each testing campaign. The modular nature of Alpha allows for the rotation and integration of new DAC systems over time, enabling continuous innovation and technology benchmarking.

CO_2 Transport

The liquid CO_2 is then transferred to specialized tanker trucks for transportation to a permanent storage location. The tanker truck will arrive at Alpha empty and travel to the storage provider without any additional loading or unloading stops in between. Transportation logistics are carefully managed to minimize environmental impacts.
As part of the standard operating procedure, the tanker truck will stop at a weigh station before arriving at Alpha and again after loading at Alpha on route to the storage location. These weigh scale recordings serve as backup measurements for the mass of CO_2 loaded onto the truck.

CO_2 Storage & Monitoring

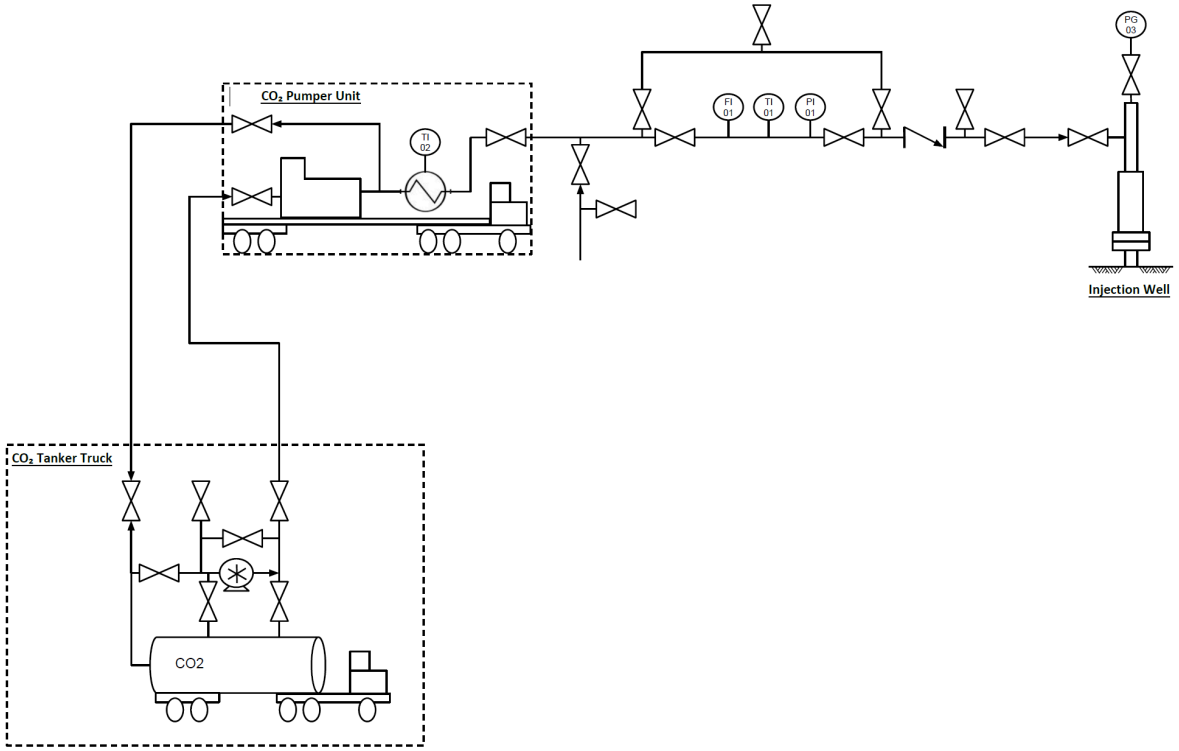
To ensure continuous, secure storage for all captured CO_2, Deep Sky Alpha has partnered with the [redacted] in Alberta. [redacted], CO_2 will be permanently injected into deep saline aquifer formations under the oversight of the Alberta Energy Regulator (AER).

To align with project timelines and de-risk deliveries, the [redacted] injection facility has been designed in two phases: an immediate [redacted] **Interim Solution** followed by a [redacted] **Permanent Solution**. Both solutions utilize the same well and storage complex; the difference is how CO_2 is transferred from the CO_2 tanker truck to the wellhead.

At injection, the CO_2 is in dense phase (liquid) at the wellhead and rapidly transitions to a dense/supercritical phase within the wellbore as pressure and temperature increase with depth; storage occurs in deep saline aquifer formations under conditions safely above the CO_2 critical point. The scheme operates under AER Approval [redacted] (Class III sequestration), which sets injectant composition and pressure limits, requires monthly composition sampling, continuous annulus monitoring, and annual packer isolation tests, and links monitoring to closure through an AER-approved plan.

[redacted]***Interim Solution***

Under the Interim Solution, [redacted] mobilizes the required surface equipment per injection: a CO_2 pumper unit (high-pressure pump, heating, and wellhead hookups) is dispatched from a nearby service provider and connected to the well; [redacted] provides the required wellhead monitoring (flow, pressure, temperature) immediately upstream of the well. All roles, hand-offs, and on-site procedures, from truck arrival and offloading through injection and post-job checks, are defined in a standard operating procedures document. A diagram of the injection setup can be found below. The interim solution does not make any concentration measurements at the wellhead. The concentration of the liquid CO_2 in the storage tank at the capture facility will be used for the calculation of CO_2 stored. The capture facility uses a mass spectrometer to quantify at least the following compounds: CO_2, oxygen, and nitrogen.



[redacted]***Permanent Solution***

The Permanent Solution is [redacted]long-term, fit-for-purpose surface facility designed for continuous injection and multi-customer throughput. It will include permanent truck offloading infrastructure, on-site storage/conditioning and compression, and dedicated injection pumps tied into the existing injection well. Measurement and data systems will be fully integrated, with Coriolis mass flow (with in-line density), upstream/downstream pressure and temperature instrumentation, and composition sampling via NDIR sensor to support automated reconciliation and verifier access. Commissioning is targeted for end-2025. Upon commissioning, Deep Sky Alpha will transition from the Interim Solution to the Permanent Solution. During any brief overlap period, the applicable pathway for each Reporting Period will be clearly identified.

[redacted]employs a risk-based, site-specific Measurement, Monitoring, and Verification (MMV) program approved under Alberta's rigorous CCS regulations. All injection wells and surface facilities are engineered to exceed AER standards, with ongoing monitoring and maintenance that safeguard operational integrity and support a projected storage horizon of more than 1,000 years.

A.7 Declaration of exclusive registration

Please confirm that your Project may only claim credits for activities that are exclusively registered with the Isometric Registry.

Yes	Deep Sky confirms that the Project for which it aims to generate credits under the Isometric Standard is not registered with any other voluntary or compliance scheme.

A.8 Public funding

Please describe briefly whether your Project has received any public funding, e.g., grants or subsidies.

Deep Sky has secured a 40 million USD funding grant from the Breakthrough Energy Catalyst Foundation for the Deep Sky Alpha project. The project also received another 5 million CAD funding grant from Emissions Reduction Alberta.

Additional funding opportunities are in the pipeline but have yet to be confirmed. Deep Sky Alpha has applied for the federal government's Carbon Capture, Utilization, and Storage Investment Tax Credit (CCUS ITC). Upon receiving project approval, this ITC program would reimburse 60% of capital expenditures at Deep Sky Alpha. Another provincial government program, the Alberta Carbon Capture Incentive Program, could cover an additional 12% of capital expenditures.

A.9 Estimated carbon removal capacity

Please give an estimate of the net carbon removal capacity of this project in the coming years (metric tonnes)

The estimated carbon removal capacity for Deep Sky Alpha reflects the dynamic and iterative nature of the project, which is designed to host and evaluate multiple DAC technologies at varying stages of maturity. As units are commissioned, decommissioned, ramped up, or replaced throughout the testing lifecycle, annual removal volumes may fluctuate. The figures below represent reasonable projections based on current technology testing schedules and anticipated operational capacity.

Year	**Estimated carbon removal capacity (metric tonnes)**
2025	450-600
2026	1400-1800
2027	1800-2400
2028	2400-3000
2029	2400-3000
2030	2400-3000

Section B – Protocol and Monitoring Data

B.1 Selected Certified Protocol

Please select the Isometric Certified Protocol you wish to use for this Project.

Please note that, as per the Isometric Standard, you must use the latest available version of a Certified Protocol, unless a grace period has been explicitly specified by Isometric, whereby a former version of a Protocol may continue to be used for a defined time period.

Protocol Name: Direct Air Capture	
Protocol Version Number: v1.1.3	
Yes	Deep Sky confirms that it is using the most recent available Certified Protocol version, or that a grace period has been explicitly specified allowing the use of an earlier protocol version.

B.2 Project Eligibility

Please explain why this Project is eligible under the selected Protocol.

The Project meets the eligibility criteria for the Direct Air Capture protocol (§ 4.0):

- The Project has a zero emissions baseline and qualifies for this distinction by meeting the following condition: no capture facility existed at the capture facility location prior to the start of the project activity (greenfield capture facility).
- There are several light industrial facilities 500 m from Alpha. The CO_2 emitted by these facilities is expected to be very small and have no impact on local atmospheric CO_2 concentrations at the DAC facility. In accordance with the Direct Air Capture protocol, the Project will discount measured gross CO_2 removals in an amount corresponding to the relative difference between local atmospheric CO_2 concentrations, and background atmospheric CO_2 concentrations. This discounting will ensure that only the captured fraction corresponding to non-fossil emissions is included in claimed removals.
- Project boundaries and associated emissions are measured and calculated in compliance with the most recent and relevant Isometric modules.
- CO_2 captured from the Project adheres to the storage requirements in the CO_2 Storage in Saline Aquifers (v1.1.0) module.

B.3 Acknowledgement of responsibility for providing notification of changes to operations

Please confirm that you acknowledge responsibility for notifying Isometric of changes to operations which deviate from this submitted PDD

✅	Deep Sky acknowledges responsibility for notifying Isometric of any changes to operations.

B.4 Project Boundary

Please provide a description of the project boundary and complete the below table, including all GHGs considered across all Sources, Sinks and Reservoirs (SSRs) in both the Project and Baseline scenario. An appropriate level of detail on the scope of each individual GHG SSR that was studied should be clearly set out. Robust justification and appropriate evidence must be provided for any GHG SSRs that have been excluded from the project boundary. Evidence may be documented here or appended to the GHG Statement or PDD separately.

Additionally, you may also provide a diagram of the project boundary.

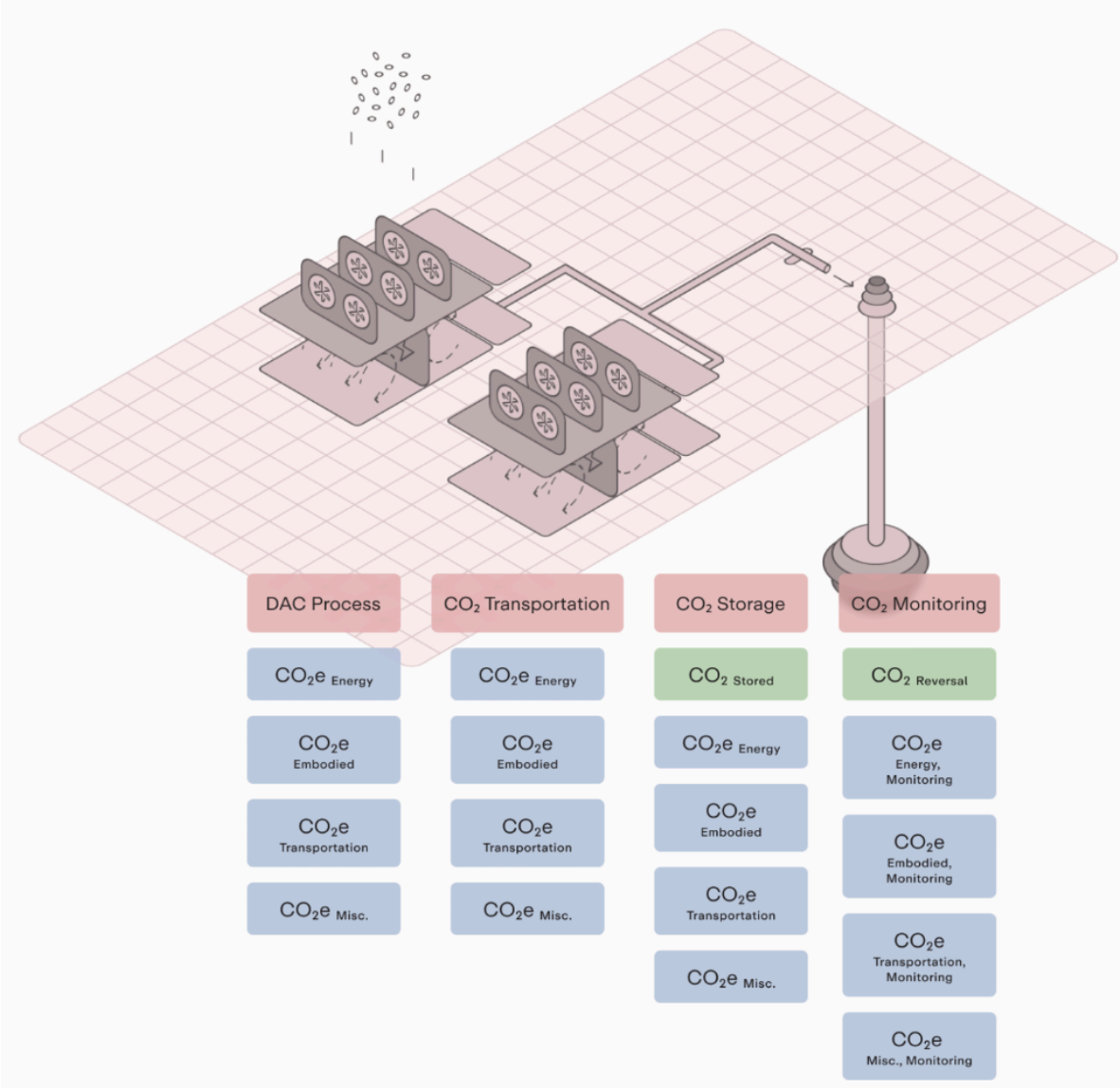
Description of Project boundary:

The Deep Sky Alpha ("Alpha") system boundary is defined in strict accordance with the Isometric Direct Air Capture protocol (§ 7.1 System Boundary and GHG-Emission Scope) and the boundary principles laid out in the Isometric Standard (§ 2.5.1). All material Greenhouse-Gas Sources, Sinks and Reservoirs (SSRs) that occur from the first dedicated project input through long-term geologic monitoring are therefore captured and mapped into the five accounting buckets mandated by the protocol - CO_2e_{Stored}, CO_2e_{Energy}, $CO_2e_{Transportation}$, $CO_2e_{Embodied}$, and CO_2e_{Misc}. The boundary opens the moment renewable electricity from PPA with the Lethbridge solar-PV plant or any project-specific material (e.g., sorbent, refrigerant) is directed towards Alpha, and it closes only after the captured CO_2 has been injected by a regulatory-approved storage partner, shown to be durably contained under a site-specific MMV program, and all post-injection monitoring obligations have been discharged.

Spatially, the boundary encompasses several locations in Alberta, Canada. These include (i) the Alpha DAC and liquefaction installation in Innisfail, Alberta, (ii) on-site refrigerated CO_2 storage tanks, (iii) intra-provincial road transport of CO_2 to the AER-approved storage site, (iv) the storage site's surface facilities - including unloading pumps, transfer lines, wellheads and measurement skid - and (v) the subsurface reservoir together with its Area-of-Review. Energy consumed by MMV instrumentation during the post-injection period, replacement sorbent manufacture, and any fugitives (e.g. refrigerant make-up, vacuum pump oil aerosol, well-pad venting) are all inside the project envelope. Temporally, the boundary stretches from the first project input through the entire capture, transport, injection and monitoring sequence and thus spans the full life-cycle crediting horizon. Durability is safeguarded by adherence to the Isometric Saline-Aquifer Storage Module, § 3 Monitoring & Risk of Reversal, which requires continuous pressure/plume surveillance, leak quantification and automatic deduction of any verified reversal.

The counterfactual (baseline) condition is the absence of any removal activity: no DAC plant, no transport, no injection, and hence zero gross CO_2e removals. Because the project is additional to regional grid and freight operations, only project-side emissions are counted against credited tonnes, in line with § 7.2 of the DAC Protocol.

[Optional] Project boundary diagram:



Baseline / Project	Carbon Flux / Emission Source	Included/ excluded from project boundary?	Greenhouse Gas(es)	Justification/description
DAC Process				
Project	DAC Process - CO_2e_{Energy}	Included	CO_2, CH_4, NO_2	Energy-related emissions for the DAC process as outlined in the Direct Air Capture protocol (§ 7.4.3.2). Alpha is considered a non-intensive facility under the Energy Use Accounting module (§ 5.1). Alpha is powered by a low-carbon solar photovoltaic facility and meets all eligibility criteria outlined in the Energy Use Accounting module (§ 5.3). During regular operation there will be no fuel combustion on site. Combustion of diesel fuel will only take place if the backup generator is run. The fuel consumption, if any, will be recorded. The backup generator will only be run only to initiate a safe shutdown of the equipment and will not be used to power the DAC process.
Project	DAC Process - $CO_2e_{Embodied}$	Included	CO_2, CH_4, NO_2	Embodied emissions associated with the production, construction, use, and end of life of materials at Alpha as outlined in the Direct Air Capture protocol (§ 7.4.3.4). Materials at Alpha will include equipment (e.g., DAC systems, CO_2 liquefaction system), facilities (e.g., process building), and consumables (e.g., solvents and sorbents) used in the DAC in compliance with the Embodied Emissions Accounting Module.
CO_2 Transportation				
Project	CO_2 Transportation - $CO_2e_{Transportation}$	Included	CO_2, CH_4, NO_2	Emissions associated with the transportation of CO_2 from the DAC facility to the injection site. Emissions are calculated using the Energy Usage Method whenever possible or, when data is not sufficient, the Distance-Based method. Both methods are outlined in the Isometric

				Transportation Emissions Accounting Module. Embodied emissions related to transportation vehicles and infrastructure explicitly utilized for the project are accounted for within CO_2eTransportation, as specified in the Transportation Emissions Accounting Module (§ 3.4).
CO_2 Storage				
Project	CO_2 Storage - CO_2 Stored	Included	CO_2	Total quantity of CO_2 physically stored underground, measured according to the Isometric DAC Protocol (§ 7.4.1).
Project	CO_2 Storage - CO_2e_{Energy}	Included	CO_2, CH_4, NO_2	Energy-related emissions for the injection and storage of CO_2 as outlined in § 7.4.3.2 of the Isometric DAC Protocol and the Energy Use Accounting Module.
Project	CO_2 Storage - $CO_2e_{Embodied}$	Included	CO_2, CH_4, NO_2	Embodied emissions associated with the manufacturing, delivery, and installation of all equipment and consumables used in the CO_2 Storage process as outlined in § 7.4.3.4 of the Isometric DAC Protocol and the Embodied Emissions Accounting Module.
CO_2 Monitoring				
Project	CO_2 Monitoring - CO_2 Reversal	Included	CO_2	Potential emissions from the reversal of previously stored CO_2, accounted for according to the Isometric DAC Protocol and applicable monitoring module requirements.
Project	CO_2 Monitoring - $CO_2e_{Energy, Monitoring}$	Included	CO_2, CH_4, NO_2	Energy-related emissions for the monitoring of CO_2 as outlined in § 7.4.3.2 of the Isometric DAC Protocol and the Energy Use Accounting Module.
Project	CO_2 Monitoring - $CO_2e_{Embodied, Monitoring}$	Included	CO_2, CH_4, NO_2	Embodied emissions associated with the manufacturing, delivery, and installation of all equipment and consumables used in the CO_2 Monitoring process as outlined in § 7.4.3.4 of the Isometric DAC Protocol and the Embodied Emissions Accounting Module.

B.5 Baseline scenario

Please describe the baseline scenario of what would have happened if your Project did not take place (refer to Section 2.5.2 "Baselines" of the Isometric Standard and the requirements outlined in the relevant Protocol). Projects will only be credited for Removals above this counterfactual baseline.

The baseline scenario assumes that activities associated with the Project do not take place and no associated infrastructure is built. The counterfactual for the Project is considered to be zero given that CO_2 would not be captured from ambient air and stored in the absence of this project. These claims are consistent with the Isometric Direct Air Capture protocol (§ 7.2).

B.6 Market Leakage Assessment

Please give a robust assessment of how you have considered potential increases in GHG emissions outside the defined Project boundary that occur as a result of the Project activity. Where the potential for such Market Leakage is identified, it must be quantified and deducted from the CO_2 Removals in accordance with the relevant Protocol. Please refer to Section 2.5.4 "Leakage" of the Isometric Standard.

Deep Sky has considered leakage across each stage of the Project:

- **Feedstock and Consumables**: The DAC systems tested at Deep Sky Alpha utilize materials and equipment specifically produced or procured for this project. Their consumption is incremental compared to the size of the market and does not reduce availability for other industries or cause shifts in production elsewhere that could increase emissions. Leakage will be validated individually for each DAC system that comes to Alpha.
- **Energy Consumption**: Energy for DAC systems at Deep Sky Alpha is supplied exclusively through a dedicated, long-term Power Purchase Agreement (PPA) from a grid-connected renewable energy (solar PV) facility in Lethbridge, Alberta. As per the Isometric Energy Use Accounting Module, v1.2, Deep Sky Alpha is considered a non-intensive facility based on the low electricity consumption. Therefore, the energy demand from the project will not displace renewable energy availability or lead to increased fossil fuel generation elsewhere in the market.
- **CO_2 Transportation**: CO_2 is transported using mobile tanker trucks contracted specifically for this project. The use of these vehicles does not influence market dynamics in a way that would lead to increased emissions outside the boundary, given the relatively small scale and defined contractual usage.
- **CO_2 Storage:** The Alberta Energy Regulator (AER)–approved [redacted] CO_2 Storage Hub is not solely reserved for Deep Sky Alpha; it maintains ample, regulator-certified capacity to accept CO_2 from multiple clients concurrently. Deep Sky Alpha's injections will neither displace nor limit storage opportunities for other projects and therefore will not drive emission increases elsewhere.

Given this assessment, the potential for market leakage has been evaluated as negligible. Therefore, no market leakage adjustments are deemed necessary for the Deep Sky Alpha

project under the Isometric DAC Protocol.

B.7 Demonstration of Additionality

B.7.1 Demonstration of Additionality: Financial Additionality
Please describe and provide evidence for how your Project is financially additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.
The Project is financially additional because the removals are the main purpose of and the only source of revenue for the Project. The Project meets the requirements for financial additionality outlined in the Isometric Standard (§ 2.5.3). The Carbon Capture, Utilization, and Storage (CCUS) Investment Tax Credit (ITC) and the Alberta Carbon Capture Incentive Program (ACCIP) offer opportunities to reduce the capital cost of the facility but do not make the Project non-additional.

B.7.2 Demonstration of Additionality: Environmental Additionality
Please describe and provide evidence for how your Project is environmentally additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.
The Project demonstrates environmental additionality by achieving net-negative greenhouse gas (GHG) emissions, thereby directly contributing to atmospheric CO_2 reduction. In the baseline scenario, as clearly defined by the Isometric Direct Air Capture protocol (§ 7.2), no atmospheric CO_2 would be removed.

B.7.3 Demonstration of Additionality: Regulatory Additionality
Please describe and provide evidence for how your Project is regulatorily additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.
The Project demonstrates regulatory additionality, as carbon removals are not required by any existing laws, regulations, or policies. Currently, there are no regulatory requirements at the municipal, provincial, or federal levels mandating the implementation of direct air capture (DAC) projects or the specific activities undertaken in the Project.

B.8 Durability

Please confirm the Project Durability Threshold for this Project, based on an acceptable Durability Threshold from the Protocol which this Project is using, and provide justification for how the Project adheres to the durability requirements outlined in the selected Protocol.

If using the Reforestation Protocol, please note that the Project Durability Threshold is equal to the length of the Ongoing Monitoring Period, as per Section 10.1 Durability, and the minimum is 40 years.

If using Biochar Storage in Agricultural Soils, please note that you may choose between a 200 and 1000 year option, as per Section 4.0 Durability of Biochar in Surface Soil.

You may further expand on the Monitoring approach used to support the claimed Durability in the "Monitoring Plan" question.

Project Durability Threshold:	*Please state the Project Durability Threshold here.* Deep Sky Alpha confirms the Project Durability Threshold aligns with the Isometric DAC Protocol, meeting the required minimum durability period of **greater than 1000 years** for captured and stored CO_2.
Assessment:	*Please provide justification for how the Project adheres to the durability requirements outlined in the selected Protocol.* Durability of CO_2 storage at Deep Sky Alpha is ensured through strict compliance with the Isometric DAC Protocol (v1.1.3) and Isometric CO_2 Storage in Saline Aquifers Module (v1.1.0). The captured CO_2 is injected into deep saline aquifer formations managed by the storage provider [redacted], regulated under the AER's Directive 065. Comprehensive geological characterization, reservoir modelling, and risk analysis for [redacted] demonstrate an extremely low probability of CO_2 migration or leakage. Long-term integrity is further safeguarded by [redacted] site-specific MMV plan, which provides continuous oversight of injection performance, reservoir pressure, and seal effectiveness throughout the project life.

B.9 Monitoring Plan

Please specify whether this Project will follow the default Monitoring Plan, following the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules (Option A), or whether a Monitoring Plan will be submitted which may contain additional or modified monitored parameters (Option B).

Additionally, please give an overview of how monitored parameters and/or models will be used to support the assessment of durability. You may also provide any additional information here about how Project monitoring will be conducted.

	A – I confirm this Project will follow the default Monitoring Plan, following the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules.
✅	B – I have submitted a Monitoring Plan, which meets the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules, and which describes any additional or modified parameters monitored which deviate from the default Monitoring Plan.

Overview of how monitored parameters or models will be used to support assessment of durability. If Option B was selected, please give details of how the monitoring plan adds to or differs from the default monitoring requirements outlined in the Protocol:

A site-specific monitoring plan has been developed for the [redacted] storage location and is detailed in the accompanying documents:
Deep Sky Alpha Subsurface Injection PDD Appendix.
Appendix G - MMV Requirements and Deviations

B.10 Use of Models

Please describe your use of models (if any) for quantification, monitoring, and meeting specified Protocol requirements. Describe the specific model and simulations used, with enough detail so that the work could be replicated.

Please provide model validation results to demonstrate model accuracy, and include an assessment of model uncertainty.

If the use of models are described elsewhere in the PDD, i.e. in a Protocol-specific appendix, then it can be omitted from here. Please list the relevant sections where models are further described instead.

Subsurface modelling was performed by our third-party storage provider as part of their regulatory submissions to the AER. These models are used to inform plume migration, pressure response, injectivity forecasts, and overall containment risk in alignment with Isometric's durability and monitoring requirements.

Details of the modelling approaches, input parameters, validation methods, and uncertainty assessments are provided in the following appendix:

- *Appendix A - [redacted] Reservoir Modelling*

B.11 Data collection and storage

Please describe the data collection and storage approach taken, including:

- *How data is transmitted and collected.*
- *How data is stored.*
- *Length of time for which records are archived.*
- *Backup procedures and strategies for identifying and coping with lost or poor-quality data.*
- *Person(s) / organization(s) responsible for measurement and data collection.*

Deep Sky's [redacted] ("the cloud") serves as the central database for the Project. All raw data collected during the Project will be stored in the cloud for a period no less than three years. Raw data is stored to a S3 data lake in the cloud and, from there, Deep Sky supplies the aggregated data products for verification. For details on the selection of emission factors used throughout the Project, please see B.13 below.

DAC Process

Each of the commercial equipment packages at Deep Sky Alpha, such as the DAC systems and the CO_2 liquefaction system, are controlled by independent programmable logic controllers (PLCs). The "balance of plant" (BOP) equipment not covered within any commercial equipment package will include [redacted] and an [redacted] server for supervisory control and data acquisition (SCADA). Other examples of such "balance of plant" (BOP) equipment include: power meters on the electrical distribution network, pumps and control valves for the water distribution systems, CO_2 measurements made between packages, and basic measurements (of flow, electrical power, density, temperature, pressure). The SCADA will perform the supervisory control and data acquisition (SCADA) functions for all the PLCs and sensors, and transfer the data to the cloud using[redacted].

A power meter on the primary switchgear will measure the power consumption of the entire Alpha facility. Similarly, an electromagnetic flow transmitter on the primary water line will measure the water consumption of the Alpha facility. The wastewater production of the Alpha facility will be calculated based on the wastewater production of the DAC systems (measured with individual variable area flow transmitters) and the water rejection from the water purification unit. The water rejection from the water purification unit over a period of time will be calculated based on the water supplied to the water purification unit (measured with an electromagnetic flow transmitter), the change in level of the purified water holding tank (measured with a radar level transmitter), the change in level of the feed tank for the water purification unit (measured with a radar level transmitter), and the amount of purified water dispensed to the DAC systems (measured with individual variable area flow transmitters). Each of the three primary measurements (electricity consumption, water consumption, and wastewater production) will be cross-referenced against meter readings from the local municipality for validation.

Some data critical to the quantification process will be collected in the field using equipment disjointed from any PLC (e.g., sorbent replacement, diesel fuel top-up for the backup generator, chemical waste disposal). These readings will be collected as part of work orders in Deep Sky's resource management software (e.g., DAC system scheduled maintenance). Data from [redacted], Deep Sky's resource management software, will then be transferred to the cloud.

CO_2 Transportation

Data related to CO_2 transportation will be transmitted from the transportation provider in spreadsheet format via email, reflecting the relatively small volume of shipments per month. These datasets originate from onboard vehicle tracking systems, which automatically capture trip distances and fuel consumption. Backup data collection protocols will supplement this primary dataset to ensure complete data integrity and compliance with the Isometric Transportation Emissions Accounting Module. All received data will be manually uploaded and securely stored in the cloud to ensure consistent record-keeping, transparency, and ease of auditing.

CO_2 Storage & Monitoring

Data generated at the storage facility is captured in a phased manner that aligns with the [redacted]**Interim Solution** and, subsequently, the [redacted]**Permanent Solution**. In both phases, all received files are ingested to Deep Sky's[redacted]("the cloud") [redacted], validated, versioned, and retained for no less than three years.

[redacted]***Interim Solution***

For each injection job, the [redacted]field representative transmits a data package via email to Deep Sky's Operations Lead. The package includes: (i) time-series from the wellhead turbine meter (volumetric flow), (ii) time-series wellhead pressure (P) and temperature (T), and (iii) job metadata (start/stop timestamps, pumper/lineup identifiers). Deep Sky then processes the dataset, converting volumetric flow to injected mass using the Helmholtz Equation of State (HEOS implementation in CoolProp). As part of this processing, Deep Sky performs a "phase check" guardrail: if the measured pressure/temperature conditions fall below the CO_2 bubble-point at operating composition, the affected interval is flagged as potentially multiphase. In such cases, the recorded flow values are conservatively set to zero and excluded from credited CO_2 storage. This ensures that only periods with unambiguous dense-phase flow contribute to the net injected mass. In practice, normal operations are expected to remain well within stable liquid conditions due to process control, so data exclusions should be rare. Deep Sky then uploads these source files to the cloud, assigns them to the unique load/injection ID, and performs QA/QC (format checks, timestamp sanity, monotonic totals, sensor range checks).

Deep Sky then converts volumetric flow to injected mass as follows:

1. **Windowing & cleaning:** align the time window to the confirmed injection interval; remove spool-up/out-of-range points; flag gaps.
2. **Density from EOS:** compute $\rho(P,T,\text{composition})$ using the Helmholtz Equation of State and evaluated at the wellhead P/T time series and stream composition result.
3. **Mass calculation:** integrate $\dot{m}(t) = \rho(P,T,\text{comp}) \times q_v(t)$ over the injection interval to obtain total mass injected; store intermediate arrays ($\rho(t)$, $q_v(t)$, $\dot{m}(t)$) for auditability.

4. **Heel-gas deduction:** calculate trailer heel gas from the transporter's pre-/post-job tanker pressures and deduct this mass so that the reported "CO_2 Stored" reflects net injected CO_2 only; record the deduction in the job ledger.
5. **Reconciliation:** cross-check the injected mass against (a) Alpha load ticket/weigh-tickets and (b) transporter logs; document any variances > threshold with rationale and corrective action.

This interim method (turbine + EOS) and its uncertainty budget are documented in the project's metering and uncertainty assessments.

[redacted]***Permanent Solution***

Upon transition to [redacted] permanent surface facility, data transmission becomes system-to-system: [redacted] will publish near-real-time and batch time-series from their historian/SCADA (including Coriolis mass flow with in-line density, upstream/downstream P/T, and composition results) to the cloud via a secure interface. Deep Sky will treat the Coriolis mass flow as the primary injected-mass signal, while maintaining the EOS-based calculation as a QA cross-check and for diagnostics (e.g., density comparisons, anomaly detection). Data will arrive with instrument IDs, calibration certificates, and health/status flags to support automated validation, reconciliation, and verifier access.

B.12 Reversals

Please complete a reversal risk assessment for your Project, including consideration of the guidance in the Risk of Reversal Questionnaire below.

Overall risk of reversal (based on risk reversal questionnaire score; please select one option by **bolding** the relevant risk of reversal category):

0: Very Low Risk
1-2: Low Risk
3-4: Medium Risk
5+: High Risk

[Optional] Additional details/assessment of reversal risk mechanisms:
Because the project's Risk-of-Reversal score is 1 (Low), 5 % of every issuance of verified CDR credits will be automatically withheld by the Registry and credited to the project's Buffer-Pool. These Buffer-Pool credits are non-transferable and may not be sold, delivered, or retired; they serve as insurance against any future reversals for as long as reversal risk exists.

#	Question	If answered “Yes”	If answered “No”	Response
1	Is a reversal directly observable with a physical or chemical measurement as opposed to a modeled result?	Proceed to questions 2-9	Proceed to questions 8-9	**Yes**
2	Is the carbon being stored in an impermeable geologic system? (e.g., salt cavern)	Proceed to questions 8-9	Add 1 to Risk Score and proceed to questions 3-9	No
3	Is the carbon being stored organic?	Add 1 to Risk Score		**No**
4	Are conditions for methane production present (anaerobic conditions, lignin content)? storage reservoir has a less than 10,000 year durability?	Add 1 to Risk Score		**No**
5	Does this approach have a material risk of reversal due to natural disasters including, but not limited to, floods, storms, earthquakes, fires, etc.?	Add 1 to Risk Score		**No**
6	Does this approach have a material risk of reversal due to human-induced events from outside actors, such as change in farming practices, change in ownership and management of Project sites, or similar?	Add up to 2 to Risk Score		**No**
7	[Applicable only for subsurface storage] Is the carbon being stored with trapping mechanisms preventing reversals? (e.g., multiple confining layers, CO_2 dissolves or solidifies)	Minus 1 to risk (unless 0)		**Yes**

8	Is there 10+ years of monitoring and/or lab data demonstrating low project risk?	Minus 2 to risk (unless 0)		**No**
9	Does this pathway have a documented history of reversals?	Please consider the frequency and severity of previous reversals, and the shared characteristics between documented reversals and the present project. For pathways with no documented history of reversals, add 0 to the Risk Score. For pathways with a history of frequent reversal, add 2 to Risk Score. For pathways with a limited history of reversals, add 1 to Risk Score.		**Yes - expect limited history of reversals**
10	Is there one or more Project-specific factors that merit a high risk level?	Please consider the number and severity of risks identified. If one low or medium severity risk is identified, add 1 to Risk Score. If multiple risks are identified, or if any high severity risks are identified, add 2 to Risk Score		**No**
Total Risk Score				**1**

B.13 GHG Statement Calculations

Provide information on the GHG Statement approach and methodology in relation to calculations.

This should include the following information as a minimum:

- *General description of the methodology, criteria and procedures used as a basis for the assessment, including reference to any documentation (including Isometric protocols and modules), guidance, industry standards and best practice that were*

followed
- *Information on calculation procedures followed*
- *Information on any tools used as part of the assessment*
- *Procedure for selecting emission factors including how age (age of data, and the period over which they have been collected), geography (the region or country from where the data have originated), technology (whether the data are specific to a particular technology or mix of many), methodology (the approach applied to gather or calculate the data) and competency (proficiency of entity that developed the data) were considered.*
- *Assumptions and limitations - provide full transparency in terms of value-choices, rationales and expert judgements*

GHG emissions will be calculated in accordance with the Project boundary outlined above and the calculation methods outlined in the Direct Air Capture protocol (§ 7.4).

A general discussion on the sources of the emission factors are listed below:

- **Energy - Electricity:** The emissions factor is taken from an engineering study performed by [redacted] for the Lethbridge 1 solar project (see Appendix H - Solar Facility Emissions Study). Lethbridge 1 is the facility that the Project has a PPA with. This study accounts for the lifecycle emissions associated with the PV modules, supports, and inverters. The emission factor accounts for a decay in system electricity output over the system lifetime (see Appendix I - Electricity Emission Factor Calculation). A transmission loss factor is assumed based on average data from the provincial electric system operator [1]. The loss factor will be revisited on an annual basis as data is published. The emission factor complies with the requirements outlined in the Energy Use Accounting Module (§ 5.5).
    - The emissions factor from this facility is benchmarked against those in academic literature. For a system matching the description of the Lethbridge 1 facility (south-facing, 1-axis backtracking, located near Lethbridge, Alberta), the annual solar irradiance is 1840 kWh/m^2 [3]. One academic publication developed an emissions estimate for a facility based on harmonized performance metrics across 13 different LCA studies. This study predicted that a facility with a solar irradiance of 1700 kWh/m^2 will have a median emissions factor of 45 an emissions factor IQR of 39 to 49 gCO2e/kWh [4]. Although the emissions factor from Lethbridge 1 report is slightly less than this range, it is understandable because the facility receives ~8% more solar irradiance than the harmonized facility (1840 vs. 1700 kWh/m^2).
    - The renewable energy certificates (RECs) issued under the Deep Sky PPA will be immediately retired by Deep Sky to avoid double-counting of RECs.
- **Energy/Transportation - Fuel combustion:** The emissions factor for diesel combustion is taken from the open source LCA software, GHGenius [2]. GHGenius will also be used to account for the embodied emissions of the CO_2 transportation vehicle. The transportation emission factor complies with the requirements outlined in the Transportation Emissions Accounting Module (§ 3.4).
- **Embodied:** Emissions factors will be taken from LCA databases, academic publications, vendor environmental product declarations (EPDs), or government databases as available. Wherever possible, values will be selected such that the Project region matches the applicable region of the database. In the event that the region cannot be matched, the next closest region will be selected. In a similar fashion, best efforts will be made to match the year of consumption with the applicable year of the database. Emissions factors will include those associated with supply, transport, manufacturing, and transport. To cover the embodied emissions at all these stages, data from multiple sources may need to be used in

conjunction.

The following assumptions are in force for the GHG calculations:

- A lifetime of 25 years is assumed for all capture facility equipment. This does not apply to the individual DAC systems wherein a lifetime of 10 years is assumed initially. A shorter lifetime is assumed for the individual DAC systems because the DAC systems will be replaced once sufficient learnings have been realized and new DAC systems are available. If any equipment is run for less time, then the embodied emissions will be amortized over the actual lifespan so that the embodied emissions are always fully accounted for in the LCA.
- Building materials for Alpha are assumed to to be transported 150 km by road from the vendor to the site. Calgary (120 km from Alpha) and Edmonton (180 km from Alpha) are the two largest cities in the province and account for ~50% of the provincial population. It was assumed that all building materials would originate from either of these two locations (or closer) so the average distance was taken. Building materials include elements such as cabling, piping, and structural steel but does not apply to equipment or consumables where the origin of the shipment is otherwise specified.

References:
[1] AESO. “Loss factors.” Accessed Jun 7, 2025. [Online.] Available: https://www.aeso.ca/grid/grid-related-initiatives/loss-factors

[2] S&T Squared. “GHGenius.” Accessed Jun 7, 2025. [Online.] Available: https://www.ghgenius.ca/index.php

[3] NREL. “PVWatts Calculator.” Accessed Jun 17, 2025. [Online.] Available: https://pvwatts.nrel.gov/

[4] Hsu, D.D. et al. (2012) ‘Life cycle greenhouse gas emissions of crystalline silicon photovoltaic electricity generation’, Journal of Industrial Ecology, 16(S122-S135). doi:10.1111/j.1530-9290.2011.00439.x.

B.14 Uncertainty assessment

Specify how uncertainty is considered, and how removals are to be conservatively estimated, in accordance with Section 2.5.7 “Uncertainty” of the Isometric Standard.

Please specify which option(s) were used in consideration of uncertainty (*one or multiple options*).

✅	Conservative estimate of input parameters
✅	Variance propagation
	Monte Carlo Simulations

Please provide a sensitivity analysis.

•	I have uploaded a sensitivity analysis in accordance with the guidance in the Isometric Standard

Provide details of a sensitivity analysis, how parameters were assessed and details of any evidence used.

A sensitivity analysis was performed based on conservative estimates of the Project behaviour given that the Project is not yet in operation. The estimate is based on data collected from conversations with vendors, engineering documentation, equipment datasheets, and other sources. The sensitivity analysis is uploaded as a separate document.

Emission sources which constitute >1% of the gross removal capacity of the Project will be carried over to the uncertainty analysis as per § 6.5.1 of the Direct Air Capture protocol. The gross removal capacity of the Project is that which is attained if all DAC systems operate at their nameplate capacity. The five emission sources which warranted further analysis in the uncertainty analysis include:

- DAC Process - CO_2e_{Energy} (Electricity consumption)
- DAC Process - $CO_2e_{Embodied}$ (DAC systems)
- DAC Process - $CO_2e_{Embodied}$ (Facility)
- CO_2 Transport - $CO_2e_{Transportation}$
- CO_2 Storage - CO_2e_{Energy}

All other variables were deemed to have an insignificant impact on the net removals of the project. As new data is made available, the sensitivity analysis will be revisited to validate the selection of significant and insignificant variables. An automated sensitivity analysis will be completed in Certify at the first verification using real-world LCA inputs.

Provide details of uncertainty analysis and any uncertainty adjustments (e.g. %) applied in instances of high uncertainty. Include justification for your choice of uncertainty approach.

DAC Process - CO_2e_{Energy} (Electricity consumption): This emission source has significance to the net removals but the uncertainty is relatively low. The electricity consumption for the entire Alpha facility is metered by a [redacted] power monitoring device installed in the primary switchgear. When measuring active energy, this device conforms to error limits defined by Class 0.5S in accordance with IEC 62053-22:2003-01. The accuracy prescribed by this standard varies subject to the power factor and the current but the most error permitted is ±1.0%.

DAC Process - $CO_2e_{Embodied}$ (DAC systems): The dead weight of the systems is well known to a high degree of accuracy from engineering documentation. The key source of uncertainty is in determining the materials of construction. A review of common materials of construction used in these DAC systems suggests that the embodied emissions can vary ±50% between materials. To reduce this uncertainty, Deep Sky will use the equipment lists from individual DAC systems to develop a detailed breakdown of the construction materials.

DAC Process - $CO_2e_{Embodied}$ (Facility): This emission source has significance to the net removals but the uncertainty is relatively low. The amount of concrete poured is well known to a high degree of accuracy from engineering and construction documentation. The engineering drawings specify a tolerance of [redacted] in all dimensions. The thinnest concrete dimension, the vertical dimension, has a thickness of approximately [redacted] typically. The uncertainty associated with the thickness tolerance is then 1.5%. Assuming that the length, width, and depth all have 1.5% uncertainty (a conservative estimate given that the length and width of the foundation are much larger dimensions) then the overall uncertainty on the volume poured will be 2.6%.

CO_2 Transport - $CO_2e_{Transportation}$: This emission source has significance to the net removals but the uncertainty is relatively low. For this analysis, it is considered that the distance-based method is being used to calculate transportation emissions. Fleet management software can typically have trip length errors of 0.5-5%. If the truck odometer is the source of the trip mileage, then the error can be in the range of 4-7%. To reduce this uncertainty, Deep Sky will work with transport companies that have accurate fleet management software.

CO_2 Storage - CO_2e_{Energy}: This emission source has significance to the net removals but the uncertainty is relatively low. Diesel consumption may be measured based on flow or level instruments. Pressure and ultrasonic level transmitters can have accuracies between 0.2 and 3% depending on the application. Similarly, Coriolis and mechanical flow meters can have accuracies between 0.2% and 2% depending on the application.

Section C – Duration & Crediting Period

C.1 Project timeline

Please indicate the projected start date of your Project and, if applicable, its expected operational closure date.

Start date of Project: August 1, 2025

[Optional] Expected operational closure date of Project: N/A

C.2 Project closure

Please describe the conditions under which the Project will be considered closed, and describe the Project Closure Plan – outlining any post-cessation actions that will be undertaken upon Closure of the Project.

Definition of Project cessation: The Project will be considered closed when no additional carbon dioxide removal activities are occurring at Deep Sky Alpha.

Closure Plan: Deep Sky Alpha will be decommissioned and the waste disposed of in accordance with local regulations. The CO_2 storage & monitoring facilities will likely continue operation well past the close of Deep Sky Alpha.

C.3 Crediting Period

Please indicate the planned start date and duration of your crediting period. The crediting start date may either be your Project's start date or up to two years prior to design submission, whichever is later. Unless otherwise specified in the relevant Protocol, the maximum crediting period is 5 years.
Start date of crediting period: August 1, 2025
Total length of crediting period: 5 years

Section D – Environmental and social impacts

D.1 Analysis of environmental and social impacts

Please provide an assessment of the environmental and social impacts of the Project, in accordance with Section 3.7 "Environmental and Social Impacts" of the Isometric Standard.

For each aspect of the assessment, demonstrate how the risks have been assessed and if applicable, what mitigation plan is in place to prevent them. If some aspects are not applicable to your project, justify how you determined it.

A full Environmental and/or Social Impact Assessment (EIA and/or SIA) is only required if impacts are considered significant and/or if required by the host jurisdiction.

	[Optional] I have attached a full EIA document.
	[Optional] I have attached a full SIA document.
✅	I acknowledge responsibility for reporting potential environmental and social impacts identified to Isometric and environmental regulators

DAC Process

The environmental and social aspects of the Alpha facility were documented in detail by Deep Sky's engineering firm in their project description document. The conclusion of that document was that the facility was not expected to lead to any significant impacts on air quality, water quality, or the natural environment. Deep Sky remains in communication with the provincial authorities and will ensure full compliance with the Environmental Protection and Enhancement Act and the Water Act.

CO_2 Transportation

The transportation phase involves the trucking of liquefied CO_2 from the capture facility to the injection sites. Environmental and social risks associated with transportation have been assessed by Deep Sky and include:

- **Emissions and Air Quality:** Trucks used are compliant with federal and provincial emission standards. Transportation emissions are carefully tracked using onboard measurement devices for fuel use and distances travelled, ensuring compliance with the Isometric Transportation Emissions Accounting Module. Backup procedures are also in place to maintain data reliability and accuracy.
- **Traffic and Safety:** Transportation routes were chosen to minimize interaction with densely populated areas, sensitive habitats, or regions of special environmental concern. Drivers are fully trained to handle compressed CO_2 and emergency procedures, ensuring minimal risk to public health and safety.

CO_2 Storage & Monitoring

The environmental and social impacts of CO_2 storage at the [redacted] storage site has been comprehensively evaluated through Alberta's rigorous regulatory processes. [redacted] has obtained approval from the Alberta Energy Regulator (AER) under:

- **Directive 065: Resources Applications for Conventional Oil and Gas Reservoirs**
- **Directive 051: Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements**

These directives represent stringent regulatory frameworks ensuring the protection of environmental quality, public safety, groundwater resources, and biodiversity. [redacted] conducted diligent risk assessments and environmental evaluations as required by AER directives, including:

- **Comprehensive geological and geophysical site characterization** to evaluate subsurface containment integrity and eliminate migration pathways.
- **Environmental assessments**, including impacts on groundwater, surface water, soil, air quality, wildlife habitats, and vegetation.
- **Induced seismicity risk assessment**, ensuring injection pressures remain within safe operational limits to prevent seismic disturbances.
- **Public consultation and stakeholder engagement**, consistent with Alberta's rigorous stakeholder involvement requirements to ensure transparency and address public and indigenous concerns.
- **Emergency response and containment plans** reviewed and approved by the AER to rapidly address any potential leaks or unforeseen environmental impacts.

The Alberta regulatory framework further mandates ongoing environmental monitoring and periodic reporting to the AER to verify continued compliance and containment integrity. Adherence to these rigorous provincial standards ensures that [redacted] storage operations meet or exceed all environmental protection requirements as outlined in the Isometric Standard.

Given the comprehensive nature of Alberta's approval processes and the ongoing regulatory oversight, Deep Sky concludes that the environmental and social risks associated with the transportation and storage phases are effectively mitigated.

D.2 Environmental Impacts

D.2.1 Resource efficiency and pollution prevention, including pollutant emissions to air, pollutant discharges to water, noise and vibration, generation of waste and release of hazardous materials, chemical pesticides and fertilizers.	
✅	Above risks are applicable to this Project
	Not applicable to this Project

The DAC process could produce pollutant emissions to air, noise, solid waste, and wastewater but all will be managed to minimize risk to the local environment:

- **Pollutant emissions to air:** Asides from ammonia and particulate matter, there is no indication that the Alpha facility will emit any substances that have a federal ambient air quality standard and/or Alberta Air Quality Objective (AAQO). It is not expected that ammonia and particulate matter concentrations will exceed AAQO limits. Air outfall samples will be taken during operation to validate pollutant levels and, if required, corrective actions will be taken to ensure compliance.
- **Noise:** The DAC systems have been designed in accordance with noise limits outlined by the Alberta Occupational Health and Safety Code. As such, the facility will be in compliance with the municipal Community Standards Bylaw. Noise measurements will be taken during operation for validation and, if required, corrective actions will be taken to ensure compliance.
- **Solid waste:** The primary source of solid waste from the Alpha facility will be spent sorbent. Deep Sky will contract waste management companies to ensure that this waste is disposed of in a safe manner.
- **Wastewater:** Alpha will produce wastewater from water treatment rejection and as a co-product from select DAC processes. The pH of this wastewater will be monitored and treated prior to discharge into the municipal drainage system. The treatment involves chemical dosing to make the wastewater less acidic. In most operational scenarios, this treatment will not be required. At the present, there is no indication that the treated wastewater will violate any element of the municipal Utilities Bylaw but ongoing monitoring will be performed to ensure compliance. Wastewater that cannot be treated with the installed water treatment system, such as post-capture solutions, will be collected by a waste management company and disposed of in accordance with local regulations.

In addition to the above mitigations, Alpha is on industrially zoned land and borders industrially zoned land on all sides. Locating Alpha in this industrial facility further lessens potential impacts on the local community.

D.2.2 Biodiversity conservation and sustainable management of living natural resources, including terrestrial & marine biodiversity and ecosystems, protecting habitats of rare and endangered species, avoiding conversion of natural forests, grasslands or wetlands, minimizing soil degradation or erosion, minimizing water consumption and stress.	
	Above risks are applicable to this Project
✅	Not applicable to this Project

The Deep Sky Alpha capture facility is located on previously developed, industrially zoned land in Innisfail, Alberta, and does not involve the disturbance or conversion of natural habitats such as forests, grasslands, wetlands, or other sensitive ecosystems. Therefore, no significant impacts on terrestrial biodiversity or habitats of rare and endangered species are anticipated from the capture operations.

The storage site operated by [redacted] underwent rigorous environmental assessments as part of their approval processes under the AER Directives (065 and 051). These comprehensive assessments specifically evaluated biodiversity, ecosystems, wildlife habitats, and risks to rare or endangered species. [redacted] has received regulatory approval, confirming no significant impacts to biodiversity or ecosystems are expected.

D.3 Social Impacts

D.3.1 Labor rights and working conditions, including providing safe & healthy working conditions for employees, fair treatment and equal opportunities in your organization; considerations of prevention of forced labor, child labour or trafficked persons protecting workers employed by third parties.

This is required for all Projects.

✅	Above risks are applicable to this Project

Deep Sky is committed to the highest standards of labor rights, workplace safety, and ethical employment practices across all of its operations. Our corporate policy is explicit on these matters and enforces a *zero-tolerance* approach to any violations.

Safe & Healthy Working Conditions

All Deep Sky projects in Alberta are executed in partnership with *Certificate of Recognition (COR)*-certified contractors and vendors. COR certification ensures adherence to a comprehensive occupational health and safety management system. This guarantees that all personnel operate in safe, well-regulated environments that meet or exceed industry safety standards.

Prevailing Wage Compliance

All Deep Sky project sites are **prevailing wage sites**, in full compliance with the requirements outlined under the **Carbon Capture, Utilization, and Storage (CCUS) Investment Tax Credit (ITC)** regulations in Canada. This ensures that all workers receive fair, industry-standard compensation that reflects local wage benchmarks and supports workforce equity and retention.

Fair Treatment and Equal Opportunities

Deep Sky is an equal opportunity employer. We maintain robust anti-discrimination and anti-harassment policies and require the same from all contractors and vendors. Discrimination based on race, gender, ethnicity, religion, disability, age, sexual orientation, or any other protected status is not tolerated. We actively promote diversity, equity, and inclusion throughout our organization and supply chain.

Prohibition of Forced Labor, Child Labour, and Human Trafficking

We categorically prohibit the use of forced labor, child labor, and trafficked persons in any part of our operations or through our third-party relationships. All contractors and vendors

are required to uphold these standards, with mandatory contractual obligations and periodic audits or verifications as part of our oversight protocols.

Protections for Third-Party Workers

Labor standards apply equally to all third-party workers employed by our contractors and vendors. We conduct rigorous screening and due diligence during procurement to ensure our partners maintain ethical labor practices. Compliance is monitored throughout the duration of their engagement with Deep Sky.

D.3.2 Land acquisition and involuntary resettlement in the context of your deployment site selection

	Above risks are applicable to this Project
✅	Not applicable to this Project

The land at Alpha is industrially zoned and was zoned as such prior to the start of the Project. The storage facilities were operational prior to the start of the Project.

D.3.3 Environmental and social justice and gender equality (equal opportunities and pay), as it relates specifically to deployment site selection.

	Above risks are applicable to this Project
✅	Not applicable to this Project

Deep Sky is committed to promoting environmental justice, social equity, and gender equality in alignment with § 3.7 of the Isometric Standard. Our approach, specifically related to deployment site selection, included the following considerations:

Environmental and Social Justice:
The Deep Sky Alpha capture facility is located in Innisfail, Alberta, on land zoned specifically for industrial use. The site selection process prioritized minimizing impacts on local communities by ensuring the facility was established in an already industrialized area. Additionally, no disproportionately adverse environmental or social impacts have been identified, and extensive stakeholder consultations conducted throughout project planning confirmed local support and no outstanding community concerns.

Similarly, the transportation routes and schedules were carefully selected to avoid impacting residential communities.

The storage site operated by [redacted] received regulatory approval from the AER. This rigorous approval process explicitly included assessments of environmental and social impacts on surrounding communities, indigenous groups, and other stakeholders. These assessments confirmed no disproportionate environmental or social impacts to vulnerable populations or marginalized communities.

Gender Equality (Equal Opportunities and Pay):
Deep Sky adheres strictly to all applicable federal and provincial laws and regulations regarding equal employment opportunities, workplace safety, gender equality, and fair compensation practices.

The Deep Sky team maintains explicit policies on diversity, equity, and inclusion, ensuring equitable hiring, training, and compensation practices regardless of gender, race, ethnicity, or any other characteristic. These practices align with Canada's human rights legislation, the Alberta Human Rights Act, and applicable labour regulations.

D.3.4 Human rights, and in particular gender-based violence, including sexual harassment, human trafficking, slavery, imprisonment, physical and mental drudgery, and punishment or coercion.

	Above risks are applicable
✅	Not applicable to this Project

D.3.5 Confirm whether there are **indigenous land rights, ancestral or customary rights or equivalent claims** pertaining to the area in which the project intends to operate**.** Outline any measures being taken to mitigate any negative impacts on rights-holders, indigenous peoples and local communities.

	Applicable to this Project (please provide details below)
✅	Not applicable to this Project

Deep Sky acknowledges the importance of respecting Indigenous land rights and customary claims. For the Capture phase of the project, Deep Sky has been working closely with a Knowledge Keeper to establish relationships within the adjacent Indigenous communities, and held a land blessing for the Deep Sky Alpha site in April 2025. For the storage phase of the project, our third-party storage provider, [redacted], obtained the necessary approvals from the AER.

The AER's approval process includes a thorough assessment of potential impacts on Indigenous communities. Specifically, the AER collaborates with the Government of Alberta's Aboriginal Consultation Office (ACO) to ensure that any potential adverse effects on First Nations and Métis settlements are identified and addressed. This process involves determining whether consultation is required and, if so, overseeing the consultation to ensure it meets the province's standards.

By securing AER approval, our storage provider has demonstrated compliance with Alberta's rigorous consultation requirements, ensuring that Indigenous rights and interests have been considered and respected in the development of the storage sites.

D.4 Additional risks

In addition to the above areas of environmental and social impacts, I attest that further risks of potential harm arising from the Project have been assessed, and please select one option below:

✅	A) No such additional risks have been identified.
	B) For any such risks identified, appropriate risk mitigations have been put in place and are detailed below.

Please describe any such risks identified, and the corresponding risk mitigations which have been put in place.

In the event of a full containment loss due to an accident or damage during CO_2 transport, there is a risk of incurring emissions debt. This risk is mitigated by limiting the amount of CO_2 transported in a single vehicle.

D.5 Sustainable Development Impact

Please explain in the below table, where relevant, which Sustainable Development Goals (SDGs) other than SDG13 ("Climate Action") your Project has a positive impact and how this is consistent with the SDG objectives of all jurisdictions in which you operate. If applicable, please include information on any data and parameters monitored before or during the crediting period.

Please see here for a full list and details of all 17 SDGs.

#SDG with name	**Description of project impact** (*as per selected indicators corresponding to the targets (example) predefined under each SDG by the UN)*	**Description of alignment with indicators of jurisdiction(s), if relevant and applicable**	**If applicable, unit of measurement** *(e.g. removal credits, MWh)*
SDG 8 - Decent Work and Economic Growth	The construction and operation of the Alpha facility will create both direct and indirect employment opportunities for those near the site. The Project will also bring investment to local communities by increased spending.	The federal government's Carbon Capture, Utilization and Storage Investment Tax Credit (CCUS ITC) and provincial government's Alberta Carbon Capture Incentive Program (ACCIP) are both in place to encourage the development of the carbon capture industry.	The Project is projected to create 80 construction jobs and 15 ongoing operations jobs. The facility is expected to infuse more than $110 million in the local community over the next 10 years.
SDG 9 - Industry,	The Project will pilot cutting-edge DAC technologies. Successful	The CanCO2Re Initiative is focused on rapidly deploying CDR	Deep Sky is currently collaborating with

Innovation and Infrastructure	demonstrations at Alpha will be scaled up to commercial-scale plants. Analysis of the technology performance at Alpha will be accomplished through a series of industrial and academic partnerships.	technologies to meet Canada's net-zero targets. CanCO2Re involves academic collaborators from across the country including some from the University of Calgary and University of Alberta.	CanCO2Re to perform life cycle assessments of the Alpha facility.

Please explain whether you assessed the SDG impact of your project prior to this qualitative reasoning. If so, please describe if and which standardized assessment tools and methods you relied on.

No formal assessment of the SDG impact has been performed.

Section E – Stakeholder Input Process

E.1 Stakeholder Input Process Summary

Please provide a description and documentation of how comments by local stakeholders have been invited and compiled, a summary of comments received, and report on how due account was taken of comments received. Refer to Section 3.5 "Stakeholder Input Process" of the Isometric Standard for full requirements.

DAC Process

Throughout the community engagement period, Deep Sky undertook a variety of activities in Innisfail, Alberta to build relationships and gather insights from stakeholders:

- **Stakeholder Meetings:** Deep Sky conducted over 30 meetings with stakeholders, including local residents, business owners, environmental organizations, and municipal leaders. These meetings served as platforms for sharing information about our project, addressing concerns, and gathering valuable feedback.
- **Open Houses:** Two open houses were organized in September 2024, inviting the public to learn more about the DAC project and engage in direct discussions with our team. These events featured informational presentations, interactive Q&A sessions, and opportunities for community members to voice their thoughts and inquiries. Both Open Houses had more than 200 community members in attendance.
- **Communication Channels:** We established multiple communication channels to maintain ongoing dialogue with the community. This included dedicated email addresses for inquiries, newsletters providing updates on project progress, and a project website featuring detailed information about our operations and impact, including FAQ.

CO_2 Storage & Monitoring

For the storage phase of the Deep Sky Alpha project, our third-party storage provider, [redacted], obtained the necessary approvals from the AER.

The AER's approval process includes a thorough assessment of potential impacts on stakeholders. Specifically, the AER requires applicants to develop and execute a participant involvement program in advance of any energy development application. This includes defining the area per regulatory guidelines, providing sufficient advance notice to all who are within these parameters, and sharing an information package with them.

By securing AER approval, our storage provider has demonstrated compliance with Alberta's stringent stakeholder consultation requirements, ensuring that the rights and interests of stakeholders have been considered and respected in the development of the storage sites.

E.2 Grievance Mechanism

Please outline the mechanism for stakeholders to voice, process and resolve grievances.

We encourage community members to reach out with any questions or concerns to innisfail@deepskyclimate.com.

Section F – Project Changes

F.1 Summary of changes

Please provide details of the proposed or actual changes to the implementation, operation or monitoring of the project activity description submitted to Isometric.
Project Proponents must determine whether the proposed or actual changes are temporary deviations or permanent changes

If there are temporary changes or deviations which are only relevant to a specific Reporting Period, please note this instead in Section C in the corresponding GHG Statement Report.

(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

Section is intentionally left blank.

F.2 Impact of changes

Please provide details on the impact of the proposed or actual changes (temporary/permanent) on the following sections of the project:

a) *Additionality*
b) *Applicability of Protocol/ Module*
c) *Quantification of the carbon removals*
d) *Any other (stakeholder consultation, safeguard assessment etc.)*

(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

Section is intentionally left blank.

F.3 History of changes

Please provide the summary of the changes in the table
(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

Date of change	*Nature of change*	*Impact of change*	*Corresponding version of the PDD*

Document History

Version	Date	Description
v1.10	April 2025	B.15 Storage site overview for closed systems removed in favour of new Subsurface storage PDD Appendix.
v1.9	March 2025	B.8 Durability updated B.13 GHG Statement Calculations moved from GHG Statement Report
v1.8	November 2024	B.13 Use of models: Reordered so this is now B.10. Added option to streamline model descriptions if the information is provided elsewhere in PDD. Rename B.6 “Leakage” to “Market Leakage”
v1.7	August 2024	B.11 Reversals updated in line with Isometric Standard questionnaire update Inclusion of D3.4 and D3.5
v1.6	June 2024	Clarification to explanation that “B.14 Storage site overview” is only applicable to closed systems; revision to require “Regulatory Authority / Jurisdiction” to be provided for this question
v1.5	May 2024	Revision to include section on project changes, guidance to the template and other editorial changes
v1.4	November 2023	Public version (initial adoption)

Subsurface Injection PDD Appendix

Version 1.0

This appendix should be completed for projects credited using subsurface injection, which includes the following storage modules:

- CO_2 storage in Saline Aquifers
- CO_2 storage via in-situ mineralization
- Biomass storage in permeable reservoirs
- Bio-oil storage in permeable reservoirs
- Biomass and Bio-oil storage in Salt Caverns

Throughout this appendix, please include citations to any published data sources that were used or referenced.

Storage

As outlined in the Project Design Document (PDD), Deep Sky has selected the [redacted] as its storage provider. This choice secures long-term CO_2 sequestration, streamlines project execution, and satisfies all data and performance requirements of the **Isometric CO_2 Storage in Saline Aquifers Module v1.1.0**. [redacted] has undergone extensive review and received approval from the Alberta Energy Regulator (AER), demonstrating full compliance with provincial requirements for geological characterization, environmental impact assessment, and safe operations. Alberta's robust regulatory framework also provides exceptional transparency, with much of the subsurface data, operational information, and environmental evaluations available in the public domain.

Various public data sources facilitate independent verification and monitoring of CO_2 injection and storage performance, including:

- **Directive 065 Applications and Approvals**: Detailed application files and approvals, including geological characterization and MMV strategies, are publicly accessible via the AER's Integrated Application Registry (IAR) at https://dds.aer.ca/iar_query/FindApplications.aspx
- **Monthly Injection Volumes**: Injection data, including volumes injected at each well, is available through Petrinex's public data portal (https://www.petrinex.ca). This information allows independent verification of storage volumes reported.
- **Annual MMV Reports**: Performance monitoring and verification results, including plume migration, pressure trends, and induced seismicity, are published annually and available through the AER's Carbon Capture, Utilization & Storage resource page (Carbon Capture, Utilization, and Storage | Alberta Energy Regulator)

While Alberta requires thorough disclosure as part of its rigorous approval process, certain site-specific technical information - particularly detailed MMV strategies - may remain confidential at the operator's discretion. This confidentiality reflects significant financial and intellectual investment by storage operators in developing proprietary MMV techniques, reservoir modelling approaches, and operational strategies. Operators maintain this confidentiality to preserve competitive advantages within the evolving CCS market.

Deep Sky's agreement with [redacted] includes detailed Data & Evidence Schedules that require storage providers to supply:

- Custody-transfer meter files and monthly Petrinex reconciliation statements,
- Updated reservoir conformance data such as dynamic models, plume-migration grids, and induced-seismicity logs,
- Comprehensive MMV packages, identical to those submitted to the AER, along with underlying datasets.

Upon custody transfer at the injection points, ownership and rights to all CO_2 removal claims transfer to Deep Sky, supported by a clear contractual agreement allowing Deep Sky to share necessary datasets with Isometric, validators, and buyers. This contractual framework, along with Alberta's comprehensive open-data resources, fulfills the Isometric Standard's requirements for legal ownership and data transparency, effectively supporting regulatory compliance and market verification needs.

Storage Location - [redacted]

Section A – Storage Site Overview

Storage site overview
Please provide a description of the storage well/site:
The [redacted] CO_2 Storage Hub [redacted] is an Alberta Energy Regulator (AER)-approved CO_2 sequestration scheme situated at [redacted]. The facility comprises an AER Class III injection well and associated surface infrastructure necessary to facilitate secure and permanent geological storage of CO_2. CO_2 at [redacted] will be injected into the [redacted], specifically targeting the [redacted] formations at an approximate depth of 1,500 m. These formations have been comprehensively evaluated and are characterized by high-quality, regionally extensive porous [redacted] reservoirs with an average porosity of approximately 10.5% and permeability indications ranging from 40 millidarcy (mD) to greater than one darcy. The storage interval exhibits significant vertical and lateral continuity, ensuring ample storage capacity and injectivity.

The primary geological seal for the storage complex is the [redacted] shale, which overlies the injection interval. The [redacted] shale at the injection site has been measured at approximately 30 metres thick, providing an effective, proven regional seal. This shale formation is historically recognized for sealing extensive hydrocarbon accumulations, notably at the [redacted] fields, where it effectively traps over 1.2 billion barrels of oil. Locally, its sealing effectiveness is demonstrated in adjacent fields such as [redacted] Comprehensive core analyses and Formation MicroImager (FMI) borehole imaging confirm the integrity of the caprock, showing minimal porosity (<3%), negligible permeability (<0.01 mD), and no evidence of fracturing or structural discontinuities.

The lower boundary of the storage interval is formed by the [redacted], characterized by a basinal sequence of limestones and shales, providing additional vertical containment security. Reservoir modelling and dynamic simulations completed as part of [redacted] Directive 065 application indicate a minimal areal displacement and formation pressure increase due to the robust aquifer system's extensive size and quality. The modelled CO_2 plume radius after 15 years of continuous injection at 0.5 Mtpa is approximately 873 metres, encompassing a plume area of roughly 2.4 km².

The [redacted] D065 application explicitly confirms that the targeted [redacted] storage interval [redacted] at the [redacted] site is entirely water-wet. There is no current or historical hydrocarbon production within the injection area, ensuring no interference or interactions with hydrocarbon reservoirs.

Injection operations at the [redacted] facility will be carefully managed and monitored to maintain reservoir integrity, with bottom-hole pressures continuously measured to ensure they remain within regulatory limits. Additionally, comprehensive Measurement, Monitoring, and Verification (MMV) plans, approved by the AER, have been developed to ensure the safe, long-term containment of injected CO_2.

Storage well/site location (Address / GPS coordinates): [redacted]

Regulatory Authority / Jurisdiction: Alberta Energy Regulator (AER)

Well Class (if applicable): Class III Disposal

Permit number:
Well Licence: [redacted]
Directive 065 Disposition: [redacted]

Permitting authority: Alberta Energy Regulator (AER)

Permit validity start date: 2024-07-30

Permit validity end date: 2039-07-30

Well/site storage capacity (total): 7.5 million tonnes CO_2

Well/site storage capacity (used): 0
Well/site storage capacity (available): 7.5 million tonnes CO_2

Section B – Permitting

Permitting Information
Regulatory Authority / Jurisdiction: Alberta Energy Regulator (AER)
Well Class (if applicable): Class III Disposal
Permit number: Well Licence: [redacted] Directive 065 Disposition:[redacted]
Permitting authority: Alberta Energy Regulator (AER)
Permit validity start date: 2024-07-30
Permit validity end date: 2039-07-30

Section C – Monitoring

Monitoring overview
Please outline any deviations from the standard permitting requirements for the relevant national/international regulating body:
There are no deviations from the standard permitting requirements outlined by the Alberta Energy Regulator (AER).
Please outline and justify any deviations from the relevant injection module for example due to differing monitoring requirements within the permit:
Deep Sky Alpha and its storage provider, [redacted], have thoroughly reviewed the **Isometric CO_2 Storage in Saline Aquifers Module v1.1.0** alongside the detailed Measurement, Monitoring, and Verification (MMV) requirements established by the Alberta Energy Regulator (AER). The outcome of this review and a comprehensive comparison is captured in **Appendix G – MMV Requirements and Deviations**, clearly outlining all module requirements, their corresponding Alberta regulatory obligations, and any deviations. The primary deviation identified for [redacted]pertains specifically to the frequency of **internal mechanical integrity testing**. While the Isometric module prescribes internal integrity tests every six months, [redacted]proposes instead to follow the rigorous testing

protocols already established and mandated by the AER under Directives 051 and 087, which include annual packer isolation tests.

Justification for Deviation

- **Regulatory Context and Proven Equivalency:**
    - [redacted] storage operations fall under the stringent oversight of AER's Directive 065 for Class III CO_2 disposal schemes. This directive incorporates comprehensive technical criteria informed by decades of experience, especially involving higher-risk fluids such as acid gas and hydrogen sulphide (H_2S) disposal.
    - Specifically, Directive 051 mandates rigorous casing, cementing, logging, and mechanical integrity testing protocols, ensuring sustained well integrity from installation through long-term monitoring and closure.
    - Directive 087 requires an annual packer isolation test that effectively verifies the mechanical isolation of well components, including tubing, casing, and annulus, and is sensitive enough to promptly detect minor leaks or integrity issues.
    - Historical performance and third-party analyses (such as Bachu, 2009) have confirmed that the Alberta regulatory framework, through these directives, reliably maintains mechanical integrity standards equal to or exceeding international best practices, even in higher-risk operational contexts.
- **Real-Time Integrity Monitoring and Enhanced Operational Safeguards:**
    - In addition to mandatory AER protocols, [redacted] has implemented advanced real-time monitoring technologies surpassing the assurance provided by intermittent mechanical tests alone. Key technologies include:
        - **Permanent Downhole Gauges:** Continuously monitor bottom-hole pressures and temperatures, immediately flagging potential anomalies indicating integrity concerns.
        - **Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS):** Fibre-optic installations along the wellbore detect temperature shifts and acoustic signals continuously, enabling rapid identification of potential fluid migration or wellbore integrity breaches.
        - **Spring-loaded Check Valve:** A specifically designed valve at the tubing base maintains consistent wellhead pressure (~8,000 kPag), mitigating risks related to CO_2 phase changes, density fluctuations, or associated corrosion risks.
    - These enhanced monitoring capabilities, combined with rigorous Surface Casing Vent Flow (SCVF) and gas migration testing under Directive 087,

substantially reduce the risk of undetected mechanical integrity issues and provide a robust, continuous safeguard.

- **Alignment and Transparency via Appendix G:**
    - Beyond this primary mechanical integrity testing frequency deviation, Appendix G transparently presents a complete comparative table. It clearly identifies all Isometric module monitoring requirements, explicitly maps these to Alberta's stringent regulatory standards, and highlights any additional minor deviations or enhancements adopted by [redacted].
    - This structured mapping exercise reaffirms overall compliance and transparent alignment with both Isometric requirements and Alberta's rigorous regulatory framework, ensuring comprehensive and verifiable long-term containment of injected CO_2.

Through these detailed justifications and by clearly documenting deviations in Appendix G, [redacted] confidently demonstrates a monitoring and management approach meeting or exceeding the intent and rigour of the Isometric standard, while remaining firmly rooted within Alberta's proven regulatory regime.

Please outline the relevant regulations regarding liability after site closure:

Regulatory framework and authority

Liability and long-term stewardship of CO_2 storage in Alberta are governed by the Alberta Energy Regulator (AER) under a well-defined legal and permitting framework, including:

- **Oil and Gas Conservation Act (OGCA)**: Overarching regulatory authority for CO_2 injection and storage.
- **Directive 065 (Resources Applications for Oil and Gas Reservoirs)**: Scheme approval, operation, monitoring, closure, and long-term containment.
- **Directive 051 (Injection and Disposal Wells)**: Well integrity programs, completions, logging, and testing requirements.
- **Directive 020 (Well Abandonment)**: Detailed requirements for permanent abandonment to minimize leakage risk after closure.
- **Mines and Minerals Act, Part 9 (Sequestration of Captured CO_2)**: Pore-space tenure, liability-transfer procedures, and Closure Certificates for sequestration projects.
- **Environmental Protection and Enhancement Act (EPEA)**: Remediation and reclamation obligations associated with site closure.

[redacted] Class III sequestration scheme operates under [redacted] with AER-approved MMV and Closure Plans that are maintained and updated on a multi-year cycle.

Decommissioning & abandonment

Isometric's CO_2 Storage in Saline Aquifers Module (§3.7) requires, at decommissioning: (a) flushing with a buffer fluid; (b) determining bottom-hole reservoir pressure; and (c) a final external mechanical-integrity confirmation to ensure correct plugging materials and procedures. Under Alberta's Directive-based regime and [redacted], these steps are embedded in the closure pathway:

- **Buffer-fluid flush (well conditioning).** Directive 020 **Level A abandonment** requires circulating a clean, non-damaging fluid before placing permanent plugs/cement, conditioning the wellbore for abandonment.
- **Reservoir-pressure determination.** Stabilized bottom-hole reservoir pressure is established and used to inform plug selection/placement and to demonstrate no adverse pressure conditions at closure (consistent with ongoing surveillance under the approved MMV plan).
- **Final integrity confirmation.** Alberta's program combines required **packer-isolation testing** during operations (annual under AER oversight) with AER's authority to require **additional hydraulic-isolation logs**. At abandonment, Directive 020 prescribes verification of the final barrier configuration to AER standards.

[redacted] Closure Plan further commits to proposing post-closure steps once modelled plume distribution and monitoring confirm no loss of containment, providing the technical basis to select materials and procedures for permanent abandonment in line with §3.7.

Post-injection monitoring and Closure Certificate

The AER will issue a **Closure Certificate**, transferring regulatory responsibility and long-term liability from the operator[redacted] to the Government of Alberta, only after the operator demonstrates:

- **Plume stabilization:** the injected CO_2 plume is stable with no significant further migration.
- **Integrity verification:** continuous monitoring confirms no leakage/out-of-zone migration and pressures remain within approved thresholds.
- **Compliance with MMV obligations:** all monitoring and verification criteria under Directive 065 and the approved MMV plan have been met.
- **Monitoring duration:** a **site-specific, multi-year** post-injection monitoring period set by the AER based on risk and conclusive technical evidence.

Only once these criteria are satisfied will the AER grant a Closure Certificate; at that point, all further regulatory and environmental responsibilities, including liability for durable storage and any ongoing monitoring, transfer to the Government of Alberta.

Financial assurance and stewardship after closure

In addition, the Alberta Environment and Protected Areas (AEPA) administers a dedicated Post-Closure Stewardship Fund as outlined in the **Quantification Protocol for Carbon Dioxide Capture and Permanent Geologic Sequestration**. This fund ensures sufficient financial resources are available for ongoing stewardship, monitoring, and management of CO_2 storage sites after the closure certificate is issued and liability has transferred to the Government of Alberta. Contributions to the fund are collected from operators during the operational phase, ensuring robust financial security and sustained environmental protection beyond site closure.

This well-defined regulatory approach ensures maximum environmental protection, public safety, and confidence in the long-term security of CO_2 storage operations, aligning fully with the rigorous requirements outlined in the Isometric storage module.

Document History

Version	Date	Description
v1.0	April 2025	Initial version

RESERVOIR MODELLING

Reservoir Modelling

A reservoir modelling study was conducted to investigate storage capacity, the CO2 plume size and the pressure effects as a result of injection in the [redacted]. This is described in two sections below. First the building of the static reservoir model is described, followed by the dynamic simulations and the results.

The Static Model

The following geological information and maps were used for building of the static model.

- A 2D E-W cross-section of porosity shown in Figure R-1, which honors the main features of the stratigraphic understanding including the difference in reservoir quality between the [redacted] margins and the [redacted] interior. Furthermore, the three main units of the [redacted] are represented with their internal features. Each of the units in Figure R-1 represent 20 m in height and 1 km in length, consistent with the size of the grid blocks used in the simulation study[1].



[1] As discussed in under Dynamic Modelling, fine-gridding is used in the vicinity of the injector.

- A 2D map showing the two outlines, [redacted] and one for the [redacted] as shown in Figure R-2 (left). On the east, north and south of the [redacted] the continuation of [redacted] formation beyond the mapped interval (shown by the dashed brown line) is accommodated by connecting the grids to an analytical aquifer. This is further discussed under Dynamic Modelling.
- The structure map of top of [redacted], exhibiting the regional dip to the north and east, as well as internal features including a structural roll on the west side of the [redacted], as shown in Figure R-2 (right).

Further information about the above is given under Geology.

[redacted]

To build the geological model, the E-W cross-section of porosity (Figure R-1) was used to build a slice of the [redacted] where its width is approximately 15 km. Other slices were created by replicating the same slice, with the following modifications. (i) cells that represent the reef interior were either removed or added to accommodate the change in the E-W width of the reef. (ii) the porosity of an interior cell was randomly chosen from among the porosity values of all interior cells within that layer. This was done to introduce additional heterogeneity.

Next, between the two outlines (320 and 60 m contour lines) a number of the grids were removed from the top. This was done to build the [redacted] front. And finally, the structure map at top of [redacted] was assigned to the top of the upper most grids. Figure R-3. Shows the 3D structure of the [redacted] where the colour scheme represents the subsea elevation of the grid top. Location of the [redacted] injector is also shown.

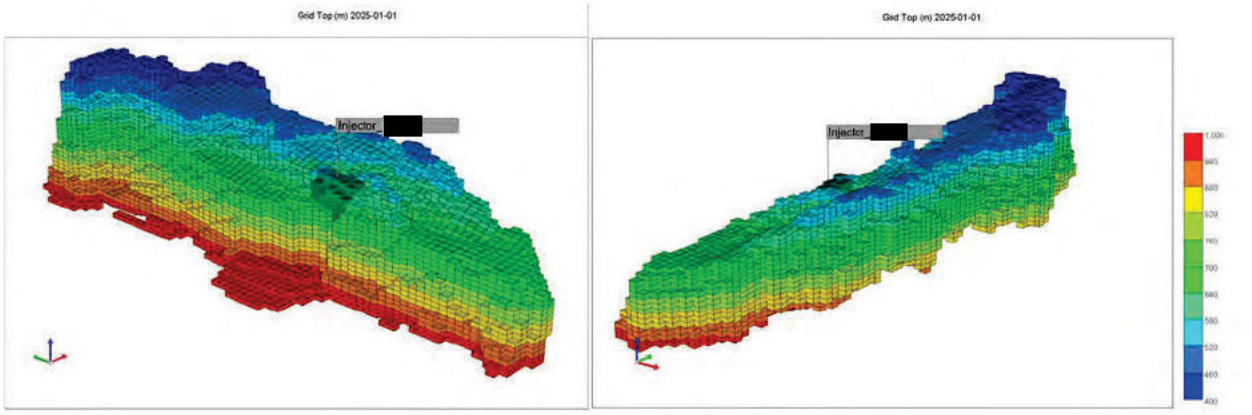


Figure R-3: Two views of the 3D structure of the [redacted] showing the sub-sea elevation of the grids. Grid blocks are 1000 m x 1000 m x 20 m.

The total pore-volume of the [redacted] was calculated, and this was found to be approximately 25% more than the corresponding pore volume of the model used for the evaluation permit. Without any independent way to calibrate the pore volume, and just for consistency, all porosity values were reduced by two porosity-units resulting in a total pore-volume of 17.2×10^9 m^3 (closer to 18.7×10^9 m^3 in the model used for evaluation permit) which we feel is a conservative estimate.

Figure R-4 shows three E-W cross-sections where the colour scheme demonstrates the final grid porosity. The cross-sections from left to right are 10 km north of the [redacted] well, at the [redacted] well, and 10 km south of the well. Figure R-5 shows the 3D arrangement of the porosity in the model.

The sequestration permit being applied for here, is for injecting CO2 into the [redacted] well for a period of 15 years at a rate of 0.5 Mtpa. As we shall see in the next section, this CO2 will occupy significantly less than 1% of the pore volume of the [redacted] suggesting sufficient static capacity. The injection scenarios are studied in the next section.

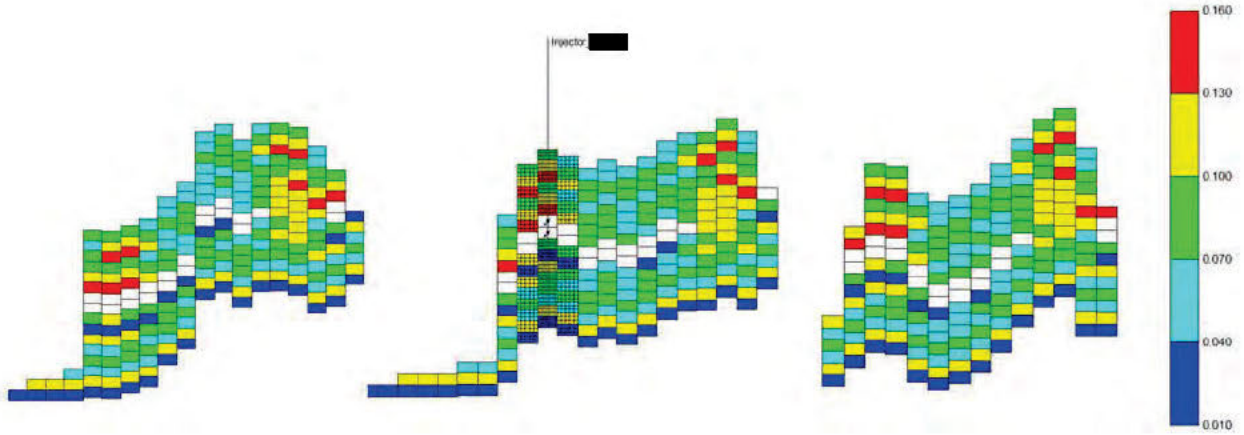


Figure R-4. three E-W cross-sections where the colour scheme demonstrates the grid porosity as follows: Dark blue: 1%, Light blue: 4%, Green: 7%, Yellow: 10%, Red: 13%, white cells have a porosity of zero and represent non-reservoir rock e.g. [redacted] The cross-sections from left to right are 10 km north of the [redacted] well, at the [redacted] well, and 10 km south of the well. The bottom three grids are connected to the "regional" [redacted] aquifer from the East as well as North and South, not shown here.

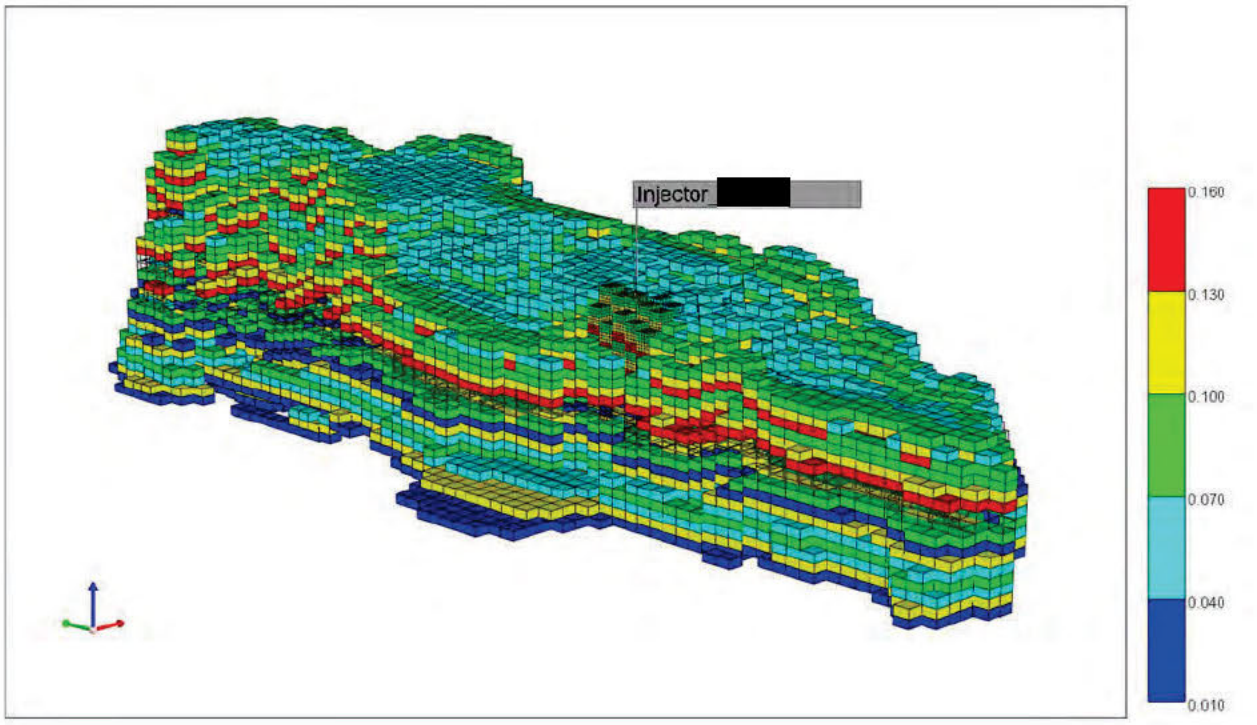


Figure R-5: 3D arrangement of porosity. The colour scheme is the same as Figure R-4, except that the cells with porosity of zero [redacted] appear transparent.

The Dynamic Model

The 3D static model built above was incorporated into GEM; the compositional simulator of the CMG and a dynamic model was built to study the evolution of the CO2 and pressure plumes. For this purpose, the pressure and temperature conditions were set according to that described previously, and the fluid model was defined for the in-situ brine and the CO2 that will be injected. Additional important parameters include the relative permeability curves, the reservoir compressibility, the connections to the regional [redacted] and quite importantly the permeability. Each of these is described below, followed by the results.

Pressure and Temperature: As described previously, formation pressure was measured throughout the [redacted] using the MDT tool. Correspondingly, the dynamic model was initialized with a pressure of 9.7 MPa at top of [redacted] at a depth of 1320 m TVD. Correspondingly, this pressure was set at the top of the uppermost grid block at the location of the [redacted] well in the model (- 586 mSS). The initial pressure gradient in the formation is determined using the brine density of 1060 kg/m^3. Simulation studies were conducted under isothermal conditions using a temperature of 52 °C.

Fluid Properties: To model fluid properties of the CO2 under reservoir conditions including density, viscosity, and compressibility, the Peng-Robinson EOS was chosen with the default parameters of GEM. Solubility was modelled using the Henry's law, with parameters found from the experimental work reported in Pooladi-Darvish et al. (2009), after adjusting them to reservoir temperature and salinity. Table R-1 gives some of the important fluid properties at the initial reservoir conditions.

Table R-1. Fluid Properties in the Dynamic Model at the reference conditions of 9700 kPa and 52 C.

CO_2 Density, kg/m^3	CO_2 Viscosity, cp	Brine density, kg/m^3	Brine Viscosity, cp	CO_2 solubility in Brine, m^3/m^3
328	0.027	1060	0.66	17

Relative Permeability Curves: To model two-phase flow properties, Corey-type relative permeability functions with the relative permeability parameters measured by Bennion and Bachu (2010) were considered. These authors and others find that the resistance associated with two-phase flow could be significant, represented by a wide range of end-point relative permeability curves and exponents. Through a series of modelling studies, using the range of relative permeability curves found by Bennion and Bachu (2010), Burton et al. (2009) found that the uncertainty in the relative permeability could have a significant effect (up to a factor of four) in estimation of injectivity. This wide range of uncertainty might have been a reason for the original application of Quest have concluded that the

project might require between 3 and 11 wells for injection of 1 Mtpa. One of the objectives of this project with the lower rate of 0.5 Mtpa is to determine CO2 injectivity and to use it for determining the relative-permeability parameters in the [redacted] reservoir before applying for the Phase II project at 3 Mtpa.

The base values of relative permeability parameters are end-point relative permeability to CO2, krg0=0.17, CO2 exponent, ng=4, and residual brine saturation, Swr=0.5. Hysteresis in relative permeability, which is responsible for residual trapping was not included.

The effect of the uncertainty in the relative permeability function on the results is investigated using a sensitivity study.

Formation Compressibility: Much has been made of the issue of low compressibility of water and formation and its potential effect on storage capacity (Ehlig-Economides and Economides, 2010). The concern is that because of the low compressibility of the water and rock, CO2 injection could lead to significant increase in formation pressure, at least in closed systems. There is previous experience with an acid gas injection project in one of the oil pools of the [redacted], where the injection permit rescinded by the regulator because of over-pressurization [redacted] While in that case, the cause of over-pressurization was determined to be water injection in an adjacent pool that was connected through a permeable carbonate platform beneath the [redacted], that and similar studies have highlighted the effect of low compressibility and importance of large-scale connectivity.

Overpressurization is not expected to be an issue for the [redacted] complex. Experience with other [redacted] of the [redacted] trend indicate an open system, where effective communication with the [redacted] aquifer is expected to allow for pressure dissipation. Nevertheless, compressibility can play a large role on how much does the pressure rise. To assign formation compressibility, we used data and correlations gathered in the literature for [redacted]. These provided a range. Considering the range of porosity in the [redacted], a base value of $1x10^{-6}$ 1/kPa was chosen. The effect of the uncertainty in this parameter is investigated using a sensitivity study, where the formation compressibility is lowered to $0.4x10^{-6}$ 1/kPa.

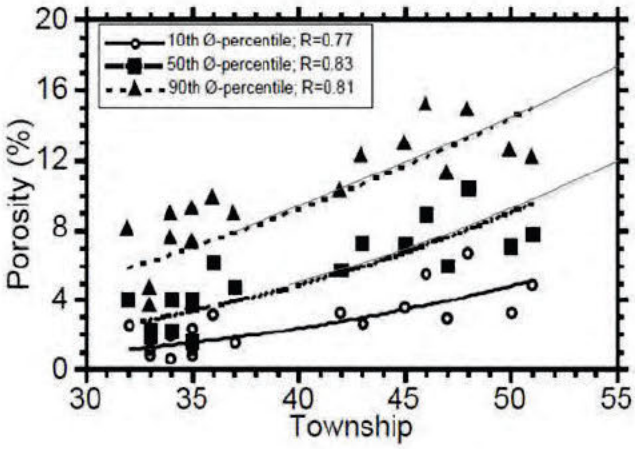
Connection to the [redacted]: As mentioned above the [redacted] is expected to allow for dissipation of formation pressure associated with CO2 injection. In reservoir simulation studies, this is modelled by characterizing the aquifer through parameters including porosity, permeability, thickness, and size. The most important parameters among these are probably permeability and size. To determine these

parameters, we consulted two studies which characterized the regional [redacted] aquifer [redacted]. The study by [redacted] assessed the impact of the [redacted] gas cap blowdown on the other [redacted] pools. For this purpose, the authors modeled the 10 dolomitized pools [redacted], between [redacted] in the south and [redacted] in the north (See Figure R-6 for pools studied. [redacted]) The authors found that in order to match the effects of production and injection on pressure of the neighbouring pools, an important parameter is permeability within the [redacted]. The initial permeability trend that was used in the simulation study is shown (Figure R-6, right). Also shown is the final fit where the authors needed to increase the permeability to better model inter-pool communication and thereby match the pool pressures. As shown in Figure R-6 (right) the values of permeability used are between 100 and 1000 md. Furthermore, they found a positive correlation between the permeability and the thickness. To be conservative, the Base value of permeability that we chose for the [redacted] permeability is 100 md.



Figure R-6. [redacted]
permeability used to obtain the history match (right)

The other important study is that of [redacted], where the authors used core data from approximately 30 wells to study regional-scale porosity and permeability [redacted] within the trend. The location of the approximately 20 pools that was studied is shown in Figure R-7, along with the map of the dolomitized portion of the [redacted]. The location of the [redacted] is identified. One of the strongest factors that the authors find is an improvement of reservoir quality with lower depth, with the quality improving from the south to the north. Extrapolation of the trend lines to township [redacted], suggest p50 porosity of ~11-12% and permeability of 100's of md.



[redacted]

Figure R-7. The study area (right) and the correlation found between porosity and location (left). [redacted]

The third study that we considered is that conducted by [redacted], where the [redacted] was considered for large scale CO2 storage, [redacted]. This multi-disciplinary study included detailed core work, where the extent of the dolomitized portion of the [redacted] was mapped to be with the Western portion of the [redacted] consistent with that shown in the work [redacted] in Figure R-7. [redacted] is among the [redacted], and the volumes of fluid injected and produced from the field are significantly larger than what is being considered in this project. Field experience and the pressure history of the reservoir indicates that there has been significant pressure support from the [redacted]. Another part of the project included a stochastic material balance study to characterize the permeability of the [redacted] The results of this study suggested that the strong aquifer communication between the [redacted] and the underlying [redacted], is most likely through the western high permeability [redacted] portion of the reef with permeability of 100's of md.

All of these studies suggest that the permeability of the [redacted] in the [redacted] and its vicinity is in the 100's of md. To be conservative, the base value of permeability that we chose for the [redacted] permeability is 100 md, and for the sensitivity study we removed the connections to the aquifer. As will be shown, the pressure increase in the [redacted]

was not significantly affected by the presence (or properties) of the [redacted]. This is because of the relatively small size of the project being considered in this phase. It is expected that connectivity to the [redacted] aquifer will play a significant role, for the larger scale project (of 25 years of injection of up to 3 Mtpa).

Permeability

One of the important attributes of a good storage site is good injectivity requiring a smaller number of injection wells. Field experience in [redacted] indicate very high injectivity. For example, injection history of the [redacted] well [redacted] demonstrates injection capability of many thousands of m3/day over many decades (see Figure R-8). An injection rate of 0.5 Mtpa of CO2 is equivalent to just a fraction on injection rates in this well in volumetric terms. Cumulative water injected over a 30-year period was close to 30 Mt (30 e6m3).

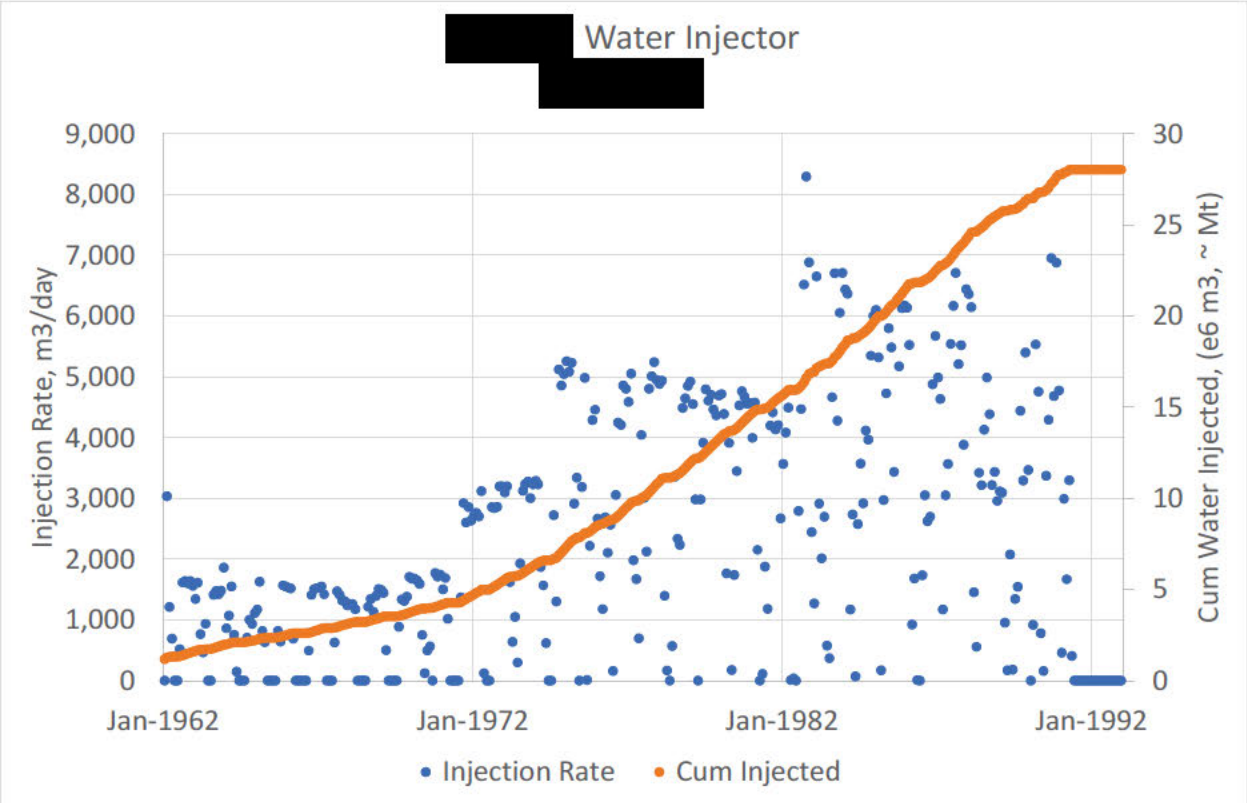


Figure R-8. Water injection history of the [redacted] well in the [redacted]

To determine the injectivity of the [redacted] well, a step-rate test was conducted where injection rate was increased from 0.5 m3/min to more than 3.5 m3/min (equivalent to 720 to more than 5000 m3/day). The bottomhole pressures shown in Figure R-9 indicate that bottomhole pressure increased by less than 3 MPa (and remained sub-hydrostatic) hence confirming excellent injectivity.

Unfortunately, the interpretation of the fall-off test after the step-rate test was complicated by first the well going on vacuum that had significant effect on the interpretability of the results, and second the use of friction reducer for the final rates that not only reduced the wellhead injection pressure as intended, but also led to a reduction in bottomhole pressure as seen in Figure R-9. Because of these, it was decided to also analyze two shorter periods of injection one approximately a day before the step-rate test and the other one a day after.

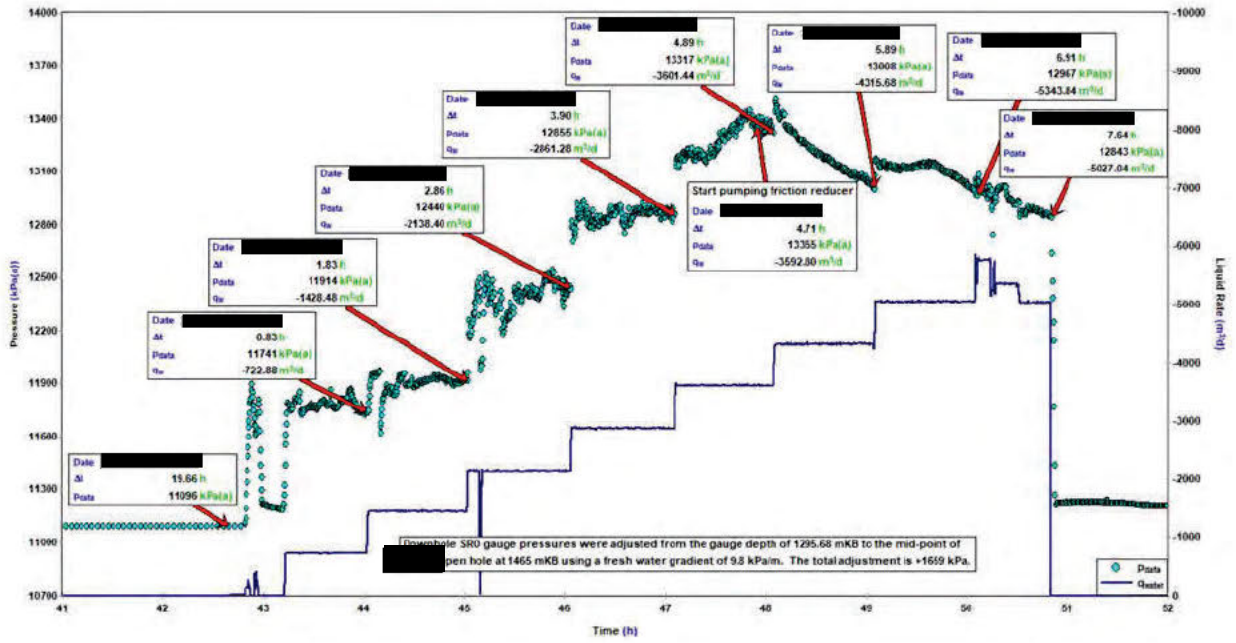


Figure R-9: Injection rate and bottomhole pressure during the step-rate test. The start of pumping friction reducer at 4.7 hrs after start of the test is marked on the graph. (Note that the bottomhole pressures shown here are corrected to the mid-point of the open interval at 1465 mKB, by adding 1660 kPa to the measured pressures).

Figure 10 shows the derivative plots of the three fall-offs. Significant scatter is present during the first few hours, as a result of the well going on vacuum. Because the quality of all tests is significantly affected by this wellbore effect, by the debris in the wellbore during the first injection (requiring a clean-out before the step-rate test), and the short period of injection and the low rate of injection in injection periods 1 and 3 it was decided that the results obtained from interpretation of the fall-off tests are used in a semi-quantitative way i.e. only for developing a range of models (i.e. low- and high-k.h. cases).

The interpretation of these fall-offs leads to a range of permeability-thickness product (k.h.) of between ~7100 and 25,000 md.m, corresponding to kh/μ of between 11,000 and 39,400 md.m/cp seen in Figure R-10. The radius of investigation associated with this interpretation is between 0.5 and 2 km, which corresponds reasonably well with the size of grid blocks used in the model (of 1 km).

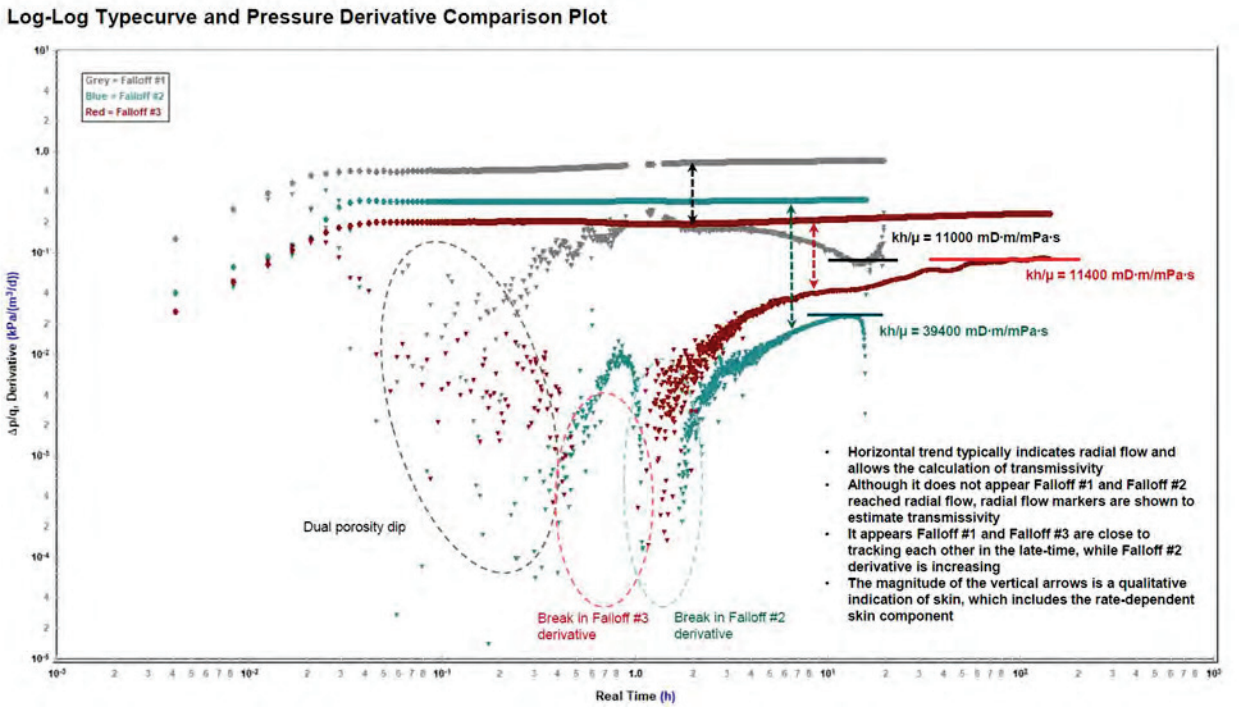


Figure R-10 Log-Log type curve and derivative plots for the fall-off after the step-rate test (Fall-off #2) and the fall-offs before and after.

Because of the early-time data were not interpretable, and the wide range of k.h., four different models were developed each consistent with some of the data. Since these were to be used to calibrate the numerical reservoir simulation model for large-scale CO2 injection, they were used to model water injection at a rate up to 5000 m3/day. After a period of injection of one month, three of them exhibited a pressure increase of ~ 3 MPa and one model exhibited a pressure increase of ~7 MPa. These will be used as additional consistency check as explained below.

To develop a permeability-porosity relation for the reservoir simulation model the following steps are taken:

- Core data of an analogue well [redacted] from the [redacted] field was used (see Figure R-11).
- A straight-line correlation was drawn through the data that as compared with the original correlation shown on the data (shown in blue) exhibited a lower permeability at low porosity values (see the back-solid line, which I call “Core”)
- This correlation when applied to the porosity in the model exhibits too high of a k.h. The poro-perm correlation was lowered uniformly (by a factor of 5) until the total k.h. of the injector in the model corresponded to the higher k.h. identified from the fall-off analysis. The total k.h. at the [redacted] location in this k.h. model is 24,300 md.m.

- This correlation is shown as a dashed-black line in the figure (Core/5). Using this correlation, the range of permeability is between 0.1 and 450 md, for porosity between 1 and 13%.
- This correlation (Core/5) was applied to the reservoir model, and a water injection test was simulated. The bottomhole pressure response is shown in Figure R-11 (Top-Right). This exhibits a pressure rise of approximately 3 MPa, consistent with three of the four welltest models. In the simulation studies that are reported next, this correlation is used for the Base Case.
- To model the case with the lower k.h., the pore-perm correlation was further lowered by a factor of three, shown with dotted line in Figure R-11, called Core/15.
- When this correlation (Core/15) was applied to the numerical simulation model, and water was injected for a period of one month, the bottomhole pressure exhibited a pressure increase of approximately 8 MPa (see Figure R-11, Bottom-Right). This was consistent with one of the four welltest models. In the simulation studies that are reported next, this correlation is used for the k_Low Case.

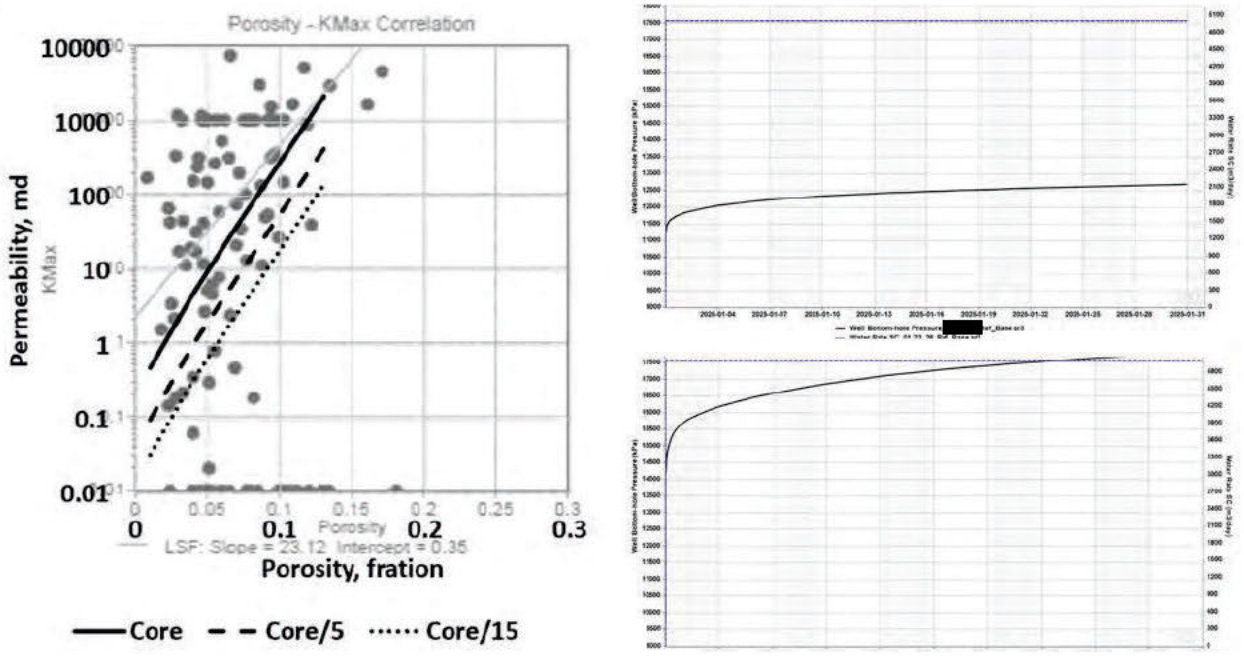


Figure R-11 Pore-Perm data from the [redacted] well, with three pore-perm correlations named Core, Core/5 and Core/15 (left). Simulation results of water injection in the Dynamic Model when Core/5 is used (Top-Right) and Core/15 is used (Top-Left). The pressure increases after a month of injection are consistent with three and one of the well-test models, respectively.

Results

Once the above input data were incorporated into the simulation model, a number of simulation cases were run to study the evolution of the CO2 and pressure plumes and the effect of uncertainty in parameters was studied. The results of the base case are presented in detail below, followed by a summary of the sensitivity studies.

Base Case

All simulation results are presented using a coarse grid (1 km x 1 km x 20 m) away from the injector. Fine-grid simulations were conducted to determine the area that requires fine-gridding and how fine they need to be. These studies suggested that two forms of fine-gridding are needed; one for the column of the grids that contains the wellbore and another one for the area beyond. In the horizontal plane, the fine-gridding in grids that contain the wellbore consisted of 10 grids in the radial direction and four grids in the angular direction. For grids beyond, each larger grid was divided into 25 smaller grids. It was found that for accurate results, the fine-gridded area should be large enough to contain the CO2 plume. Therefore, an area of 5 by 3 km around the wellbore was finely gridded. In the vertical direction, each 20 m grid in this area is divided into 3 finer grids.

The Base Case represents injection at a constant rate of 0.5 Mtpa (730,000 m3/day) for 15 years, where the wellbore is fully open from the base [redacted] to TD. This is followed by 15 years of shut-in. All simulations have a start date of first of January 2025.

This and all sensitivity cases are constrained against the maximum injection pressure of 18.2 MPa. Other properties are given in Table R-2.

The simulation results shown in Figure R-12 indicate that the well can maintain the injection rate of 0.5 Mt/a for the duration of the project, equivalent to approximately 730×10^3 m^3/day at surface conditions of 15 °C and 1 atm (see the solid black line). The cumulative mass of the CO_2 injected in 15 years is 7.5 Mt, shown by the dotted grey line.

Also shown in Figure R-12 are the bottomhole pressure at the injection well, shown by the dashed blue line. The pressure is reported at the top of [redacted], i.e. ~ 1320 m TVD. The results show that the injection pressure rises to approximately 13.2 MPa by the end of injection, and then it dissipates during the shut-in time, first sharply because of near-wellbore drop in pressure at the time of shut-in and then more slowly as the elevated pressures dissipate through the formation and because of the connectivity to the [redacted]

Table R-2. Base Case Properties

Parameter	Value
Porosity	Cross-section shown in Figure R-1, minus two units (1, 4, 7, 10, 13%) *
Pore-Perm cross-plot	Core/5** (see Figure R-11)
Kv/kh	0.1
Skin	0
NTG	1
Rock Compressibility, 1/kPa	1 e-6
Regional [redacted]	H=60 m, phi=0.08, k=100 md, Carter Tracy-infinite
Relative Permeability to CO2	Krg0=0.17, ng=4
Injection Interval	[redacted]
Maximum BH Injection Pressure Constraint	18.2 MPa
Injection Rate, Mtpa	0.5
Duration of Injection, years	15
Duration of shut, years	15
Grid refinement	The wellbore grid is divided into 10 radial grids and 4 in the angular direction. The grids around the wellbore grid are divided into 25 grid blocks (5 by 5) within an area of approximately 4 km by 5 km. In the vertical direction, all these grids are divided into 3 grids.

* Total PV=17.3 x 10^9 m^3

** Total permeability-thickness product=24,300 md.m

As the results in Figure R-12 shows injection pressure barely reach the hydrostatic pressure by the end of injection period.

Also shown in Figure R-12 is the average pressure. This is volumetric average of pressure in the reservoir and its datum depth is the average reservoir depth. Results in Figure R-12 show that starting at an average pressure of 11,180 kPa, average reservoir pressure rises by less than 400 kPa to 11,575 kPa at the end of injection, before it declines slightly as formation brine efluxes into the regional [redacted]

The relatively small increase in bottomhole injection pressure of 3.5 MPa and in average reservoir pressure of 0.4 MPa are indicative of high injectivity and dynamic capacity of the [redacted], respectively, and are consistent with experience in other large, [redacted] on the trend.

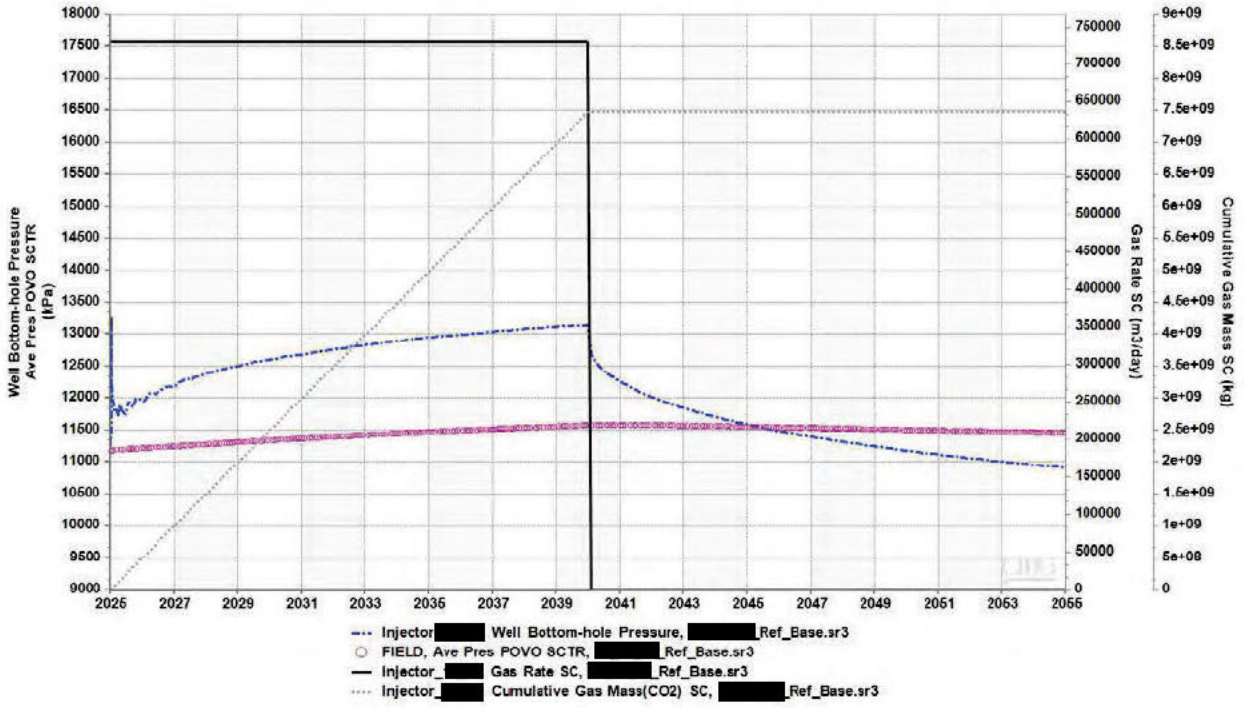


Figure R-12: Injection rate and cumulative stored mass, with bottomhole injection and average reservoir pressure for 15 years of injection @ 0.5 Mtpa followed by 15 years of shut-in. Base Case

Another view of the pressure plume is depicted in Figure R-13, where the change in reservoir pressure from its initial value is shown. The results are for the top of [redacted] (upper most layer in the simulation model) where the increase in pressure is the greatest. Here, and in subsequent figures the results are shown at the end of 15 years of injection, i.e. Year 2040, and also after the well has been such-in for an additional 15 years, i.e. year 2055.

Using the results depicted in Figure R-13, the following observations could be made. At the end of injection, the maximum increase in pore pressure is approximately 3.5 MPa. At this time, approximately half of the reservoir area is experiencing a pressure increase of less than 0.5 MPa. The area associate with a pressure-increase of more than 1 MPa ($\Delta p > 1$ MPa), is approximately two townships.

After 15 years of shut-in most of this pressure increase dissipates, such that the area with pressure increase of $\Delta p > 1$ MPa is limited to a few square-kilometres around the injector.

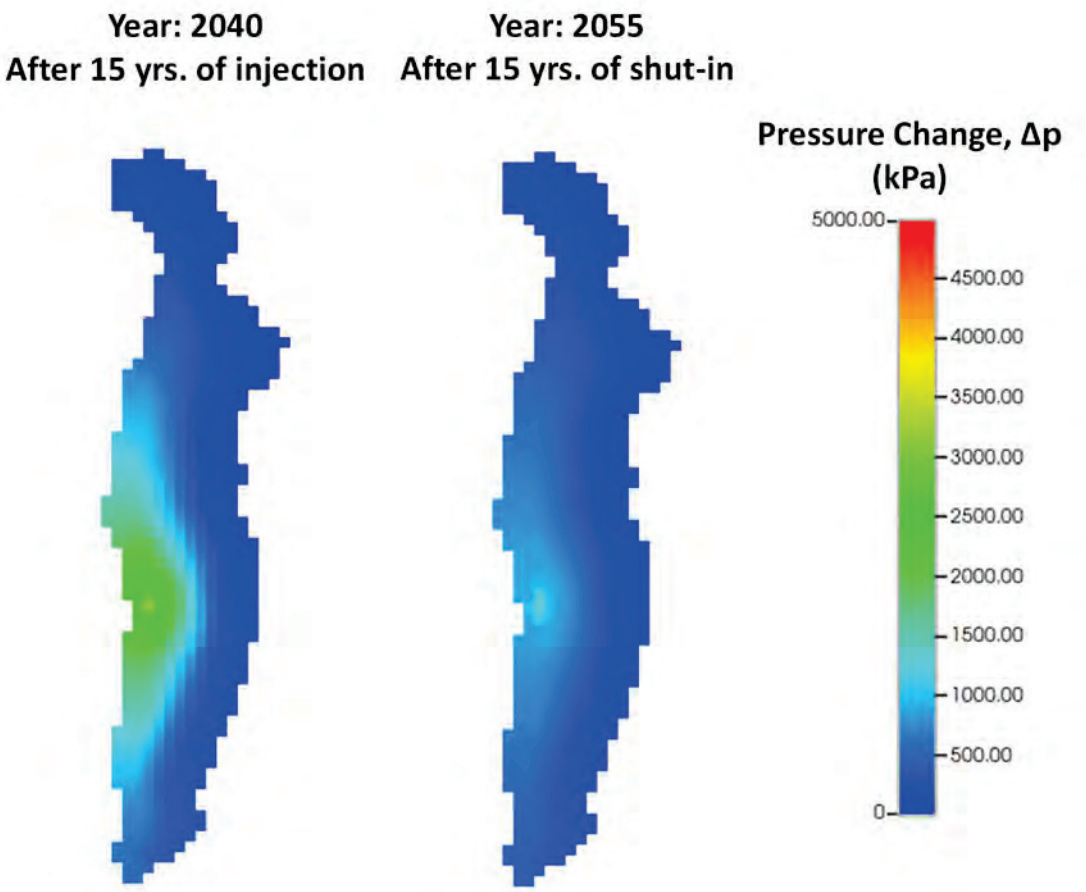


Figure R-13. Map of increase in reservoir pressure (Δp) after 15 years of injection (left), and after 15 years of shut-in (right)

In addition to pressure, the areal and vertical distribution of the CO2 plume was investigated. This is particularly important for designing monitoring activities.

Figure R-14 shows the shape and size of the CO2 plume at the end of 15 years of injection (left) and after 15 years of shut-in (right). The CO2 plume is preferentially elongated in the North-South direction affected by the [redacted] edge on the west and lower structure to the east of the injector as seen in EW cross-section in Figure R-4. The flow is mostly towards to the north following the dip of the structure. The effect of this is more apparent after the injection has stopped and viscous forces have dissipated.

As the results show, the size of the CO2 plume after 15 years of injection is approximately 2.5 square-kilometers, growing to approximately 5 square-kilometers after 15 years of shut-in. The larger area of the CO2 plume in year 2055 is result of combination of factors including pressure decline and continued vertical segregation. It is expected that with more time, the CO2 would continue to move northwards along the structure dip driven by

buoyancy. With continued flow of the plume more of the CO2 would dissolve into the formation brine, and some would get trapped by the mechanism of residual trapping[2].

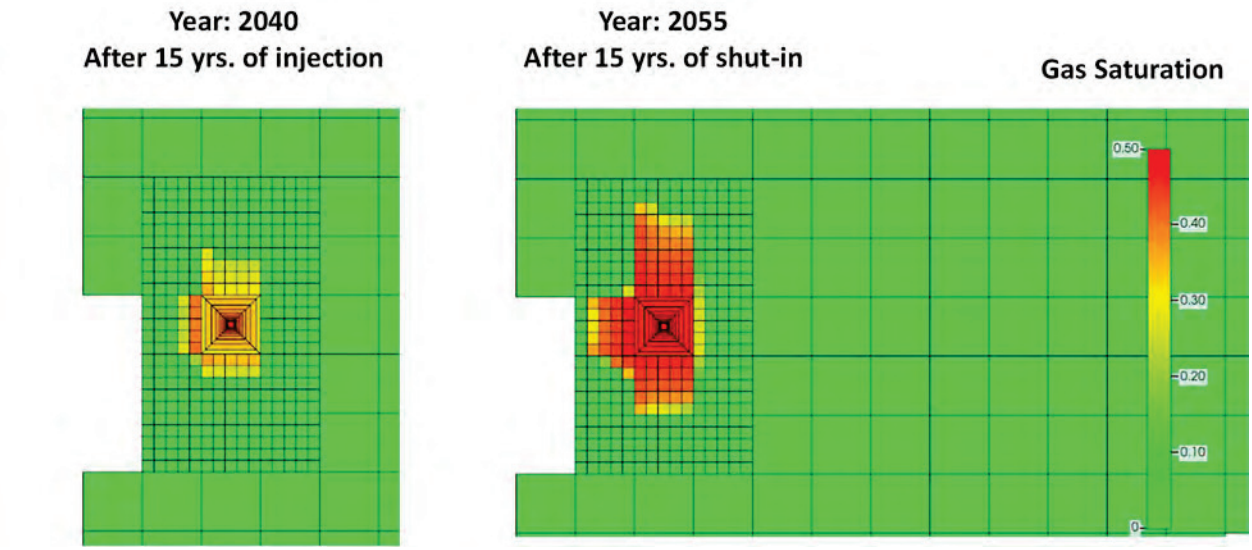


Figure R-14. Map of CO2 plume after 15 years of injection (left), and after 15 years of shut-in (right)

Figure R-15 presents a cross-sectional view of the plume shape. The following observations can be made: CO2 enters both the [redacted], with the [redacted] exhibiting a larger plume size dues to its higher permeability. Furthermore, CO2 moves upwards, where this upward rise is affected by layering and vertical permeability. Also shown in Figure R-15 is the influence of the structure roll on the plume. The results suggests that the CO2 has been mostly contained by the high-structural feature on the western rim of the [redacted]

[2] As mentioned under Fluid Properties and Relative Permeability Curves, solubility is included in the model, but residual trapping is not.



Figure R-15. E-W cross-sectional view of CO2 plume after 15 years of injection (left), and after 15 years of shut-in (right)

In a high injectivity reservoir such as the [redacted], it is expected that viscous forces be small, and the distribution of the CO2 would be affected by the forces of gravity and capillary. These in turn are affected by heterogeneities in permeability and capillary pressure. High permeability streaks and thin layers are expected to affect horizontal and vertical flow of the CO2 plume. Furthermore, the local structure at top of the formation over the CO2 plume area is expected to affect buoyancy-driven flow of the CO2. We do not expect to have a precise knowledge of the small-scale heterogeneities. Previous experience such as that in Sleipner (Chadwick et al. 2010) suggests that only after injection and with use of various monitoring programs, the factors that control the distribution of the CO2 are characterized. [redacted] operations envision starting at volumes significantly less than 0.5 Mtpa. This could provide the opportunity for calibrating the reservoir model and its input parameters.

As the colour scale shown to the right of Figures R-14 and R-15 shows the maximum gas saturation in the CO2 plume is 50%. The remaining fluid in the pores is the formation brine that is now saturated with CO2 according to its solubility parameters. For the residual water saturation considered here (50% for the base case) and solubility parameters considered here, by the end of the injection period (year 2040) approximately 13% of the injected CO2 is dissolved in the formation brine within the CO2 plume volume. This is

shown in Figure R-16 below, where the mass of the CO2 in the reservoir is depicted. The results in Figure R-16 show that after the well is shut-in more of the CO2 dissolves as the CO2 plume moves through the reservoir and comes across unsaturated brine. By the year 2055, approximately 17% of the total CO2 is dissolved.

Also shown in Figure R-16 is the fraction of CO2 that is trapped by residual trapping, which remains at zero. If residual trapping were included the size of the CO2 plume would have been smaller (everything else being the same).

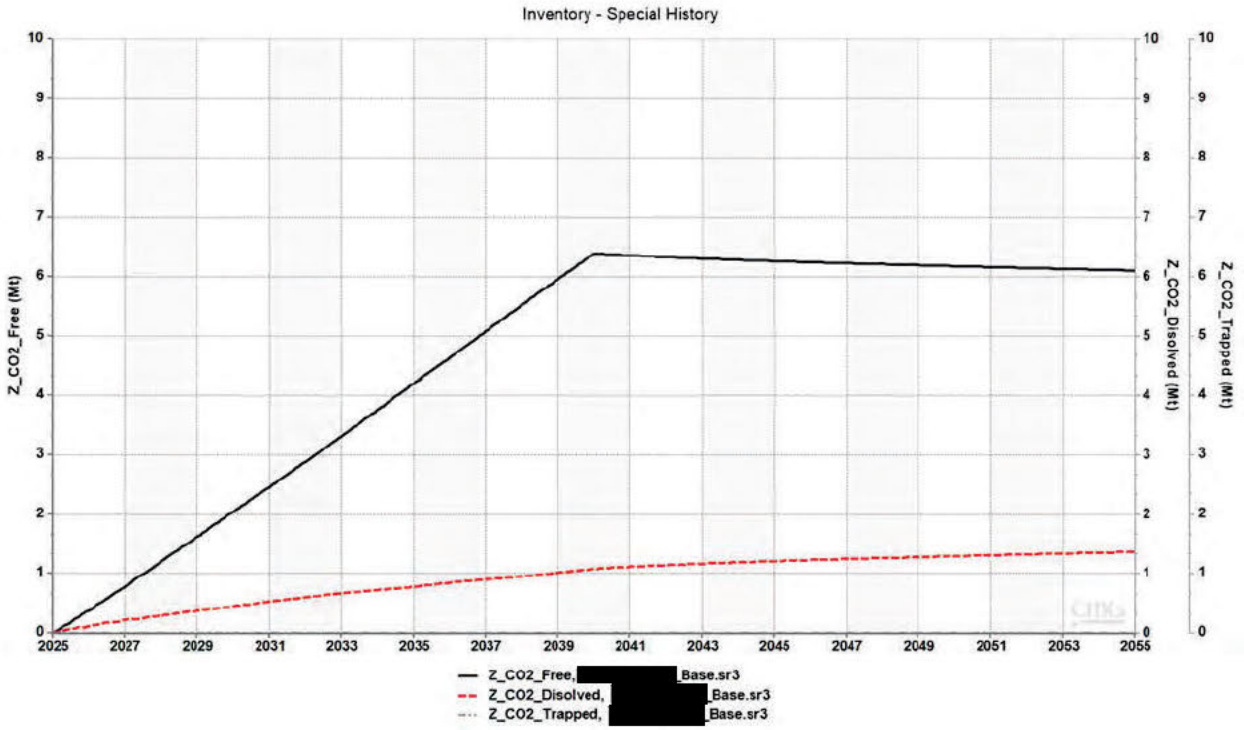


Figure R-16: Total mass of the CO2 in the reservoir in three states of "free", "dissolved" and "trapped" by the mechanism of residual trapping. Base Case.

Sensitivity Studies

The results of the sensitivity cases are reported in this section. Two groups of sensitivity studies are conducted. In the first group, one of the reservoir parameters such as permeability is varied, while in the second group, the operational conditions such as injection rate is varied.

Table R-3 lists the cases and provides a brief description of the parameter that is changed. Table R-4 gives a summary of the results, where the following four parameters are listed:

Injection pressure at the end of injection, total mass of CO2 injected, increase in average aquifer pressure, and the approximate size of the CO2 plume at the end of injection.

These sensitivity cases and their results are briefly discussed below.

Table R-3. Sensitivity Cases

Case Name	Description	Value
Ref_Base	As described in Table 1	
Sensitivity to Reservoir Parameters		
Ref_Base_Comp	Reduce rock compressibility, 1/kPa	0.4 e-6
Ref_Base_RP	Increase relative permeability to CO2	Krg0=0.3, ng=2
Ref_Base_NoAquif	Remove the connections to the regional aquifer	0
Ref_Base_Skin_Low	Stimulate (Reduce skin)	-3
Ref_ase_Skin_High	Damage (Increase skin)	2
Ref_Base_NTG	Reduce NTG to 0.85 (resulting in reduction in PV and k.h.)	0.85
Ref_Base_kv_High	Increase kv/kh to 0.3	0.3
Ref_Base_k_Low	Reduce permeability by a factor of 3 (see Core/15 in Figure 1)	Core/15
Sensitivity to Operational Parameters		
Ref_Base_Rate_High	Increase injection rate and duration to 1 Mtpa and 25 years, followed by 25 years of shut-in	1 Mtpa

Table R-4. Summary of results

Name	Injection Pressure @ end of inj., MPa	Total CO2 stored, Mt	Plume area @ end of inj., km²	Change in average pressure @ end of inj., MPa
Ref_Base	13.1	7.5	2.5	0.4
Sensitivity to Reservoir Parameters				
Ref_Base_Comp	13.4	7.5	2.5	0.5
Ref_Base_RP	12.9	7.5	3.5	0.4
Ref_Base_NoAquif	13.2	7.5	2.5	0.5
Ref_Base_Skin_Low	13.0	7.5	2.5	0.4
Ref_ase_Skin_High	13.4	7.5	2.5	0.4
Ref_Base_NTG	13.6	7.5	3	0.4
Ref_Base_kv_High	13.1	7.5	3	0.4
Ref_Base_k_Low	16.5	7.5	1.5	0.4
Sensitivity to Operational Parameters				
Ref_Base_Rate_High	16.0	25	6	1.0

In the first group of sensitivity studies, the sensitivity of the results to the following reservoir parameters is investigated: reservoir compressibility, relative permeability, connection to the regional [redacted] wellbore skin, net-to-gross ratio, vertical permeability, and reservoir permeability. As the summary of results in Table R-4 indicates, with the exception of reservoir permeability, the effect of all other parameters is small. In all cases, the bottomhole injection pressure remained below 18.2 MPa. Therefore, the well was not constrained, and injection rate was maintained at 0.5 Mt throughout the 15 years. In all cases the increase in the average reservoir pressure remained small (in the range of 0.4 to 0.5 MPa).

The case of no connection to aquifer is of particular interest. While for the case studied here (0.5 Mtpa for 15 years), presence of the aquifer makes little difference, it is expected that the situation be different for the larger case of 3 Mtpa and injection period of 25 years. This is because, for this larger case, the total CO2 injected is 10 times more than what is simulated here. Should there be no connection to the aquifer, this will result in an increase in reservoir pressure that is roughly one order of magnitude more (i.e. of the order of 4 to 5 MPa). Under these conditions, there will be a significant driving force between the reservoir and the [redacted], with the resulting outflow of formation fluid into the regional [redacted] This suggest that the results of the sensitivity cases are only valid with the range of parameters considered and should not be extrapolated o other scenarios. One more observation about this case is worth mentioning: Because the presence or absence of the connection to the regional aquifer made little difference in the results, it is unclear if field experience at these lower rates (0.5 Mtpa) could help in characterizing the regional [redacted] and its connectivity to the [redacted].

As mentioned, the reservoir parameter that had the largest impact on the results was reservoir permeability. When the reservoir permeability was reduced by a factor of three (i.e. total kh=8,100 md.m), wellbore pressure increased to 16.5 MPa. The results of this case are shown in Figure R-17 and can be compared with those in Figure R-12. Still at this level of permeability, injection was not constrained by the maximum injection pressure of 18.2 MPa, and the total stored mass of CO2 at the end of 15 years remained at 7.5. Should the wellbore exhibit a lower injectivity than what is modelled here and the bottomhole injection pressure reaches 18.2 MPa, the injection rate will have to be reduced accordingly. The size of the CO2 at the end of injection is also smaller than the base case, reflecting the higher pressures close to the wellbore.

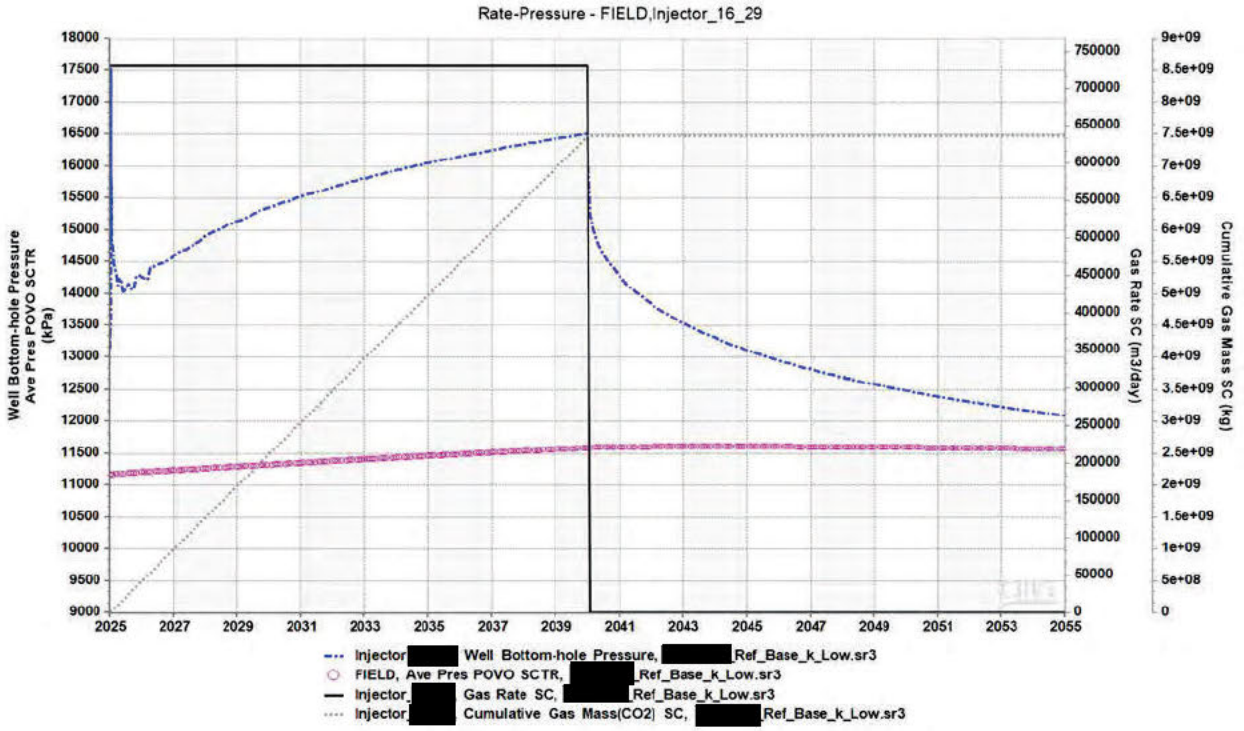


Figure R-17: Injection rate and cumulative stored mass, with bottomhole injection and average reservoir pressure for 15 years of injection @ 0.5 Mtpa followed by 15 years of shut-in. Case of low permeability (Ref_Base_k_Low)

In addition to the above, the effect of increasing injection rate and duration to 1 Mtpa and 25 years is studied. The injection pressure increases to 16 MPa, and the average reservoir pressure increase by 1 MPa. Once again, the maximum injection pressure remains below the maximum limit of 18.2 MPa and the injection rate (of 1 Mtpa) is maintained. The increase in average reservoir pressure was 2.5 times of the base case; it did not increase proportional to the total injection amount (25:7.5), suggesting an increased contribution of the aquifer.

Discussion

Simulation studies presented here were conducted at isothermal conditions. It is expected that in practice, CO2 would arrive at the sandface at temperatures lower than the reservoir pressure. Because the density of the CO2 is higher at colder temperatures, it is expected that the volumetric rate of the CO2 injection into the reservoir would be less than those modelled here, suggesting that if injection of cold CO2 were modelled, the injection pressure and potentially plumes size would tend to be lower.

The effect of (low) temperature of CO2 on stresses are accounted for in the geomechanical part of this application.

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