CARBON CAPTURE & STORAGE

Summary Report of the Regulatory Framework Assessment
# TABLE OF CONTENTS

Letter from the Chair .................................................................................................................................6  
Executive Summary ...............................................................................................................................7  
1 Introduction ................................................................................................................................... 10  
2 Purpose of This Document .......................................................................................................... 15  
3 What is Carbon Capture and Storage? .......................................................................................20  
4 The Importance of Carbon Capture and Storage to Alberta and Developments to Date ....24  
5 Public Safety ..................................................................................................................................32  
6 CO₂ Capture ..................................................................................................................................33  
7 CO₂ Transportation .........................................................................................................................37  
  7.1 Overview .....................................................................................................................................37  
  7.2 Pipeline Technical Requirements ............................................................................................38  
  7.3 Pipeline Open Access ................................................................................................................40  
8 CO₂ Sequestration Project Lifecycle ..........................................................................................45  
9 Site Selection Period .........................................................................................................................46  
  9.1 Site Selection and Characterization ...........................................................................................46  
  9.2 Sequestration Quality Pore Space Resource .............................................................................49  
10 Initial Application and Permitting Period ....................................................................................50  
  10.1 Overview ....................................................................................................................................50  
  10.2 Regulatory Roles and Responsibilities .......................................................................................52  
  10.3 Tenure and Tenure Requirements ............................................................................................54  
    10.3.1 Pore Space Tenure: Process ..............................................................................................54  
    10.3.2 Pore Space Competition and Access .................................................................................64  
  10.4 Discretionary Activity Review and Potential Environmental Impact Assessment .......................77  
  10.5 Energy Resources Conservation Board (ERCB) Approvals ........................................................79  
    10.5.1 Stakeholder Engagement ...................................................................................................79  
    10.5.2 Well Classification and CCS Schemes ..............................................................................82
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Pre-injection Period</td>
<td>85</td>
</tr>
<tr>
<td>11.1</td>
<td>Overview</td>
<td>85</td>
</tr>
<tr>
<td>11.2</td>
<td>Pre-injection Monitoring, Measurement and Verification (MMV)</td>
<td>86</td>
</tr>
<tr>
<td>11.3</td>
<td>Injection Well Drilling, Completion and Testing</td>
<td>86</td>
</tr>
<tr>
<td>12</td>
<td>Injection Period</td>
<td>90</td>
</tr>
<tr>
<td>12.1</td>
<td>Overview</td>
<td>90</td>
</tr>
<tr>
<td>12.2</td>
<td>Monitoring, Measurement and Verification</td>
<td>91</td>
</tr>
<tr>
<td>12.3</td>
<td>Reporting</td>
<td>92</td>
</tr>
<tr>
<td>12.4</td>
<td>Post-closure Stewardship Fund and Financial Security</td>
<td>94</td>
</tr>
<tr>
<td>13</td>
<td>Closure Period</td>
<td>98</td>
</tr>
<tr>
<td>13.1</td>
<td>Overview</td>
<td>98</td>
</tr>
<tr>
<td>13.2</td>
<td>Entering the Closure Period</td>
<td>99</td>
</tr>
<tr>
<td>13.3</td>
<td>Closure Period Activities</td>
<td>101</td>
</tr>
<tr>
<td>13.4</td>
<td>Requirements for a Closure Certificate</td>
<td>102</td>
</tr>
<tr>
<td>14</td>
<td>Closure Point and the Post-Closure Period</td>
<td>106</td>
</tr>
<tr>
<td>14.1</td>
<td>Overview</td>
<td>106</td>
</tr>
<tr>
<td>14.2</td>
<td>Assumption of Liability</td>
<td>108</td>
</tr>
<tr>
<td>14.3</td>
<td>Allowable Uses of the Post-closure Stewardship Fund</td>
<td>110</td>
</tr>
<tr>
<td>14.4</td>
<td>Post-closure Monitoring and Remediation</td>
<td>111</td>
</tr>
<tr>
<td>15</td>
<td>Related Activities</td>
<td>112</td>
</tr>
<tr>
<td>16</td>
<td>Progress and the Path Forward</td>
<td>116</td>
</tr>
</tbody>
</table>
November 21, 2012

Honourable Mr. Ken Hughes  
Minister of Energy  
404 Legislature Building  
Edmonton, Alberta T5K 2B7

Dear Minister Hughes:

The Steering Committee of the Carbon Capture and Storage (CCS) Regulatory Framework Assessment is pleased to present its final report to you. This report recommends regulatory changes related to the technical, environmental, safety, and monitoring requirements for the safe deployment of CCS as well as other actions to increase the body of knowledge on CCS-related topics.

The Regulatory Framework Assessment was initiated in March 2011 in response to Alberta’s $1.3 billion investment in two commercial-scale CCS projects in the province. These projects will provide a starting point for CCS in Alberta, and are a key part of the province’s efforts to reduce greenhouse gas emissions. As well, projects of this scale will reaffirm Alberta’s commitment to innovation and environmental sustainability.

This report is the result of a multi-stakeholder process, which included the steering committee, a panel of international experts and four specialized working groups. Each of these bodies had participants from around the world, including senior members of several Canadian provincial governments, the federal government, industry, academia, and non-governmental organizations. The collaborative working environment fostered by the Assessment’s process, combined with the breadth and depth of expertise of participants, has produced these comprehensive recommendations.

I would like to personally thank each contributor to the Assessment for their expertise and for their dedication to the process. I believe I can speak for all of the Assessment’s participants in expressing that it has been both a pleasure and an honour to serve Albertans with our efforts. This report continues Alberta’s success as a world leader in the development of this important technology to address climate change.

Yours truly,

Jim Ellis  
Deputy Minister  
Chair, Regulatory Framework Assessment Steering Committee
EXECUTIVE SUMMARY

Alberta is committed to addressing climate change by reducing greenhouse gas emissions such as carbon dioxide (CO$_2$). Carbon capture and storage (CCS) will be a fundamental piece of the equation. Alberta’s Climate Change Strategy (2008) identifies CCS as a key mitigation technology, which will provide 70 percent of the province’s targeted greenhouse gas emission reductions by 2050.\(^1\)

Carbon capture and storage is a process that captures CO$_2$ from large industrial CO$_2$ emitters and injects it deep underground for permanent storage. Carbon capture and storage is the internationally recognized terminology for this process. However, this report refers to CO$_2$ sequestration to differentiate this process from other temporary underground storage activities. CCS is a key technology to advance the responsible and sustainable development of Alberta’s energy resources while addressing greenhouse gas emissions from large CO$_2$ sources.

The oil and gas industry, and electricity production are important contributors to the economy and quality of life in Alberta. However, these industries emit about 60 percent of Alberta’s total CO$_2$ emissions. CCS is one of the few ways to substantially reduce CO$_2$ emissions from these industries while ensuring that the economic benefits they create for Albertans continue.

The Government of Alberta is taking action to deploy CCS and has committed over $1.3 billion to two commercial-scale CCS projects in the province. These projects will reduce Alberta’s greenhouse gas emissions by approximately 2.76 megatonnes (Mt, or million tonnes) per year by 2016. They will also provide momentum for reaching the province’s long term greenhouse gas reduction targets. To address regulatory barriers to the deployment of CCS, several legislative changes have been made, including the clarification of pore space ownership and disposition, and a procedure to enable the transfer of long term liability for CO$_2$ sequestration sites from industry to the Government of Alberta.

In order to make sure that the right regulations are in place before full-scale CCS projects start operating, the Government of Alberta initiated a process called the Regulatory Framework Assessment (RFA) in March 2011. This process looked at the regulations that currently apply to CCS in Alberta as well as regulations and best practices in other parts of the world. It examined in detail the technical, environmental, safety, monitoring and closure requirements that apply to a CCS project. To ensure that the regulatory review was complete and balanced, many Canadian and international experts from industry, universities, research organizations, environmental groups and provincial and national governments participated. This multi-stakeholder process was guided by a steering committee and included an international expert panel, and four specialized working groups that examined various CCS-related issues in detail. The RFA concluded in December 2012.

The CCS RFA process resulted in 71 individual recommendations and 9 conclusions, which can be combined into 25 actionable items for the Government of Alberta to consider. These recommendations are summarized below by theme.

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Applications, Approvals and Regulatory Framework

Issues and Gaps
- CCS, CO₂-Enhanced Oil Recovery (CO₂-EOR), and Acid Gas Disposal (AGD) projects share many similarities and may overlap, but are subject to different regulatory frameworks.
- The regulatory and approval processes for CCS need to be clearer and more efficient.
- CCS projects do not currently require an Environmental Impact Assessment (EIA).
- There are no industry-wide standards or limits on the level of impurities in CO₂ streams.
- CO₂ sequestration may impact or be impacted by the development of other resources.
- CCS expansion may result in a large number of pipelines and a shortage of sequestration sites.

Summary of Recommendations
- Clearly define how projects will be classified as CCS, CO₂-EOR or AGD, and the process for CO₂-EOR projects to become CCS projects. Evaluate if differences in the three regulatory frameworks are appropriate.
- Define the roles and responsibilities of each regulator of CCS operations and create clear industry guidance documents.
- Determine the conditions under which an EIA should be required, and make EIAs mandatory in the interim.
- Require monitoring, measurement and verification (MMV) plans and closure plans to accompany all CCS-related applications to the regulator and all tenure applications to the Department of Energy.
- Consider subsurface CO₂ injection applications on a case-by-case basis, and give the regulator flexibility to determine the activities a proponent must undertake before approval.
- Have the Crown Mineral Disposition Review Committee review all applications for CCS tenure to determine if surface restrictions are required to protect the environment.
- Evaluate all resource development applications on a case-by-case basis for their potential to impact other resources (including pore space), and inventory Alberta’s pore space.
- Promote efficient and fair development of CCS by:
  - Encouraging CCS project proponents to work together,
  - Allowing proponents to apply for access to another operator’s pipelines or sequestration site(s) if private negotiations have failed and established conditions have been met, and
  - Changing tenure agreements to enable tenure to be revoked if it remains unused.
- Require CCS projects to report any production or atmospheric release of CO₂ and reconcile earned emission credits.

Risk Assessment, Monitoring, and Technical Requirements

Issues and Gaps
- CO₂ sequestration projects are not explicitly required to submit risk assessments or monitor effects beyond the injection site.
- Alberta’s current use of amines (and resulting impacts) are unknown, but would be increased by CCS.
- Current regulations do not include technical criteria for defining the capacity of a CO₂ sequestration site.
- Existing requirements for evaluating and addressing legacy wells may not be sufficient.

Summary of Recommendations
- Require MMV and closure plans to be based on a project-specific risk assessment, and include the use of best available technologies to monitor the atmosphere, surface, ground and surface water, and subsurface.
• Determine if Alberta should adopt all or part of the new CSA standard for geological storage of CO₂.
• Conduct research on Alberta’s use of amines and their effects, and determine if further regulation of post-combustion capture technologies is needed.
• Require CO₂ sequestration sites to demonstrate sufficient capacity, injectivity, and containment parameters.
• Define the concentrations of other components at which an injection well will be classified as Class IIIa.
• Require Class IIIa well casing strings to be cemented from the well base to the surface, or equivalent.
• Evaluate if further research is needed on methods for detecting leaks from CO₂ pipelines.

Public Consultation and Notification, Surface Access, and Public Safety

Issues and Gaps
• Current public consultation and notification requirements were not designed specifically for CCS.
• It is unclear if CCS projects will require establishment of an emergency planning zone (EPZ).
• Existing legislation does not explicitly allow applications for surface access to conduct monitoring activities beyond the surface lease site or by the Government of Alberta after the transfer of liability.

Summary of Recommendations
• Review and update notification and consultation requirements to ensure that they are appropriate for CCS, including the requirement that everyone within the tenure boundary be informed about a CCS project.
• Develop requirements for EPZs around CCS project infrastructure.
• Improve public access to information on the regulatory process for CCS. Make pipeline integrity management plans available on request.
• Clarify that CCS operators (including the Government of Alberta after transfer of liability) can apply for access to conduct MMV or reclamation activities over the entire area of their carbon sequestration lease.

Site Closure and Long Term Liability

Issues and Gaps
• The Carbon Sequestration Tenure Regulation provides little detail on what a closure plan must contain.
• The Mines and Minerals Act does not specify what performance criteria must be met to receive a closure certificate.
• Assumed liabilities by the Government of Alberta do not include liability for CO₂ credits under climate change legislation.

Summary of Recommendations
• Clarify the process for closing a CO₂ sequestration site and the information that closure plans must contain.
• Establish performance criteria for closing a CO₂ sequestration site, including that the CO₂ is behaving as predicted, there are no significant risks to people or the environment, required closure activities have been carried out, and at least 10 years have passed since approval of the final closure plan.
• Transfer liability for CO₂ credits to the Crown when a closure certificate is issued.
• Set project-specific PCSF rates that cover the costs of long term monitoring and maintenance, CO₂ credits liability, and costs associated with unforeseen events. Pool PCSF payments to cover costs from any project.
• Require operators to post financial security to pay for site closure and reclamation if they become defunct.
1 INTRODUCTION

Carbon capture and storage (CCS) is a key technology to advance the responsible and sustainable development of Alberta’s energy resources while addressing greenhouse gas emissions from large CO₂ sources. Alberta’s Climate Change Strategy (2008)² identifies CCS as a key mitigation technology, which will provide 70 percent of the greenhouse gas emission reductions to meet the 2050 targets. For example, deployment of CCS will reduce emissions from oil sands development and electricity generated using the province’s vast coal reserves. World consumers of fossil fuels are demanding greener energy production and emissions management, and CCS is a technology that will enable Alberta to continue to be a responsible and competitive producer of energy in a carbon-constrained future.

The Government of Alberta is taking action to deploy CCS and has committed over $1.3 billion to two commercial-scale CCS projects in the province. These projects will reduce Alberta’s greenhouse gas emissions by approximately 2.76 megatonnes (Mt, or million tonnes) per year by 2016, and will provide momentum for reaching the province’s long term greenhouse gas reduction targets. To address regulatory barriers to the deployment of CCS, several legislative changes have been made including the clarification of pore space ownership and disposition, and a procedure to enable the transfer of long term liability for CO₂ sequestration sites from industry to the Government of Alberta.

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To be sure that the regulations for the sequestration of carbon dioxide (CO₂) are comprehensive and transparent, the Government of Alberta initiated the Regulatory Framework Assessment (RFA) in March 2011. The RFA was a multi-stakeholder process that reviewed the technical, environmental, safety and monitoring requirements for CCS, and recommended regulatory changes to enable the deployment of CCS in a safe, responsible and efficient manner. Additionally, the RFA identified a number of issues related to CCS that were beyond the original scope of the review. In response, the RFA has made several recommendations identifying areas where additional review may be warranted. The RFA concluded in December 2012.

This multi-stakeholder process was guided by a steering committee and included an international expert panel, and four specialized working groups that examined various CCS-related issues in detail. The organizational structure of the RFA is illustrated in Figure 1.
The steering committee included senior executive members from:
- Governments of Alberta, British Columbia and Saskatchewan
- Government of Canada
- industry leaders
- academic community
- non-governmental organizations.

The steering committee defined the scope of the assessment, guided and provided feedback to the working groups, consulted with the expert panel and approved working group recommendations to be provided to the Minister of Energy for consideration and decision.

The expert panel included internationally-recognized engineers and scientists in CCS and related fields from Australia, Canada, the United Kingdom and the United States. The expert panel was responsible for advising the steering committee and working groups on the scope and content of the review and the resulting recommendations.
The working groups included members from government, industry, academia, research community and non-governmental organizations. The working groups addressed issues related to the large scale deployment of CCS in Alberta. The primary role of the working groups was to review technical, environmental, safety and monitoring requirements for CCS in Alberta and to provide recommendations to address requirements for large scale CCS and opportunities for an effective regulatory framework. Working group members attempted to reach consensus; when consensus was not achieved, the non-consensus items were identified and are noted in this report.

Over the course of the RFA, guiding principles were identified for CCS to be deployed in a safe, responsible and efficient manner. These principles are:

- CCS activities must be conducted in a manner that ensures public safety.
- The regulatory framework must provide a high level of protection for the environment.
- Underground sources of potable water must be afforded a high level of protection within the regulatory framework.
- The long term liability for sequestered CO₂ must not become a financial burden to Albertans.
- Regulations must be robust, enable science-based assessment and adaptive management of CCS projects.
- The regulatory framework must be transparent and must be openly and clearly communicated to all stakeholders.
- The Government of Alberta and CCS project operators must make use of site-specific risk management for CCS activities.
- Subsurface resource development, including CO₂ sequestration, must consider potential resource interactions.
- The Government of Alberta must seek to gain and share knowledge internationally with regard to CCS.
- CCS expertise and analogous experience in the oil and gas industry must be leveraged to successfully deploy CCS.

These principles have guided the RFA recommendations for enhancing Alberta’s regulatory framework for CCS. Implementation of these recommendations will result in a regulatory framework that is consistent with the standards Albertans expect; namely, a regulatory framework that is comprehensive, transparent, ensures public safety and environmental sustainability.
This report is a summary of the analysis and the recommendations of the RFA. The recommendations roughly follow the sequential order of the regulatory process for CCS activities. The order is described in the following sections:

- CO₂ capture
- CO₂ transportation
- the lifecycle of a CO₂ sequestration project.

This report assumes familiarity with CCS and is intended for those with a specific interest in policy development and/or the regulatory framework for CCS. The Government of Alberta recognizes the important role stakeholders and the public play as CCS is deployed in the province. To increase public awareness of CCS, the Government of Alberta undertook a public education and outreach campaign in 2011. The campaign provided information about CCS to the public via newspaper inserts, a website (www.SolutionsStartHere.ca), and television commercials. This website provides information of general interest on CCS and the Government of Alberta’s CCS development program.

The recommendations and conclusions in the main body of this report have been modified to improve readability and to increase consistency in wording across recommendations and conclusions. These modifications do not change the intended meaning of the recommendations and conclusions. For this reason it is important for the reader to refer to the issue-specific recommendations located in Appendix D for the original text approved by the steering committee. Appendix D also contains important additional background on the recommendations. Table 1 provides a list of the report recommendations, the related topics and the corresponding location in the report and appendix.
Table 1. List of Recommendations and Conclusions

<table>
<thead>
<tr>
<th>Issue</th>
<th>Topic</th>
<th>Location in Report: Recommendation/[conclusion] number (page number)</th>
<th>Appendix number, Recommendation number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approvals, Permits and Regulatory Process</td>
<td>Roles and Responsibilities</td>
<td>#18 (pg. 52)</td>
<td>D1, #1</td>
</tr>
<tr>
<td></td>
<td>MMV and Closure Plan</td>
<td>#23 (pg. 57)</td>
<td>D1, #2</td>
</tr>
<tr>
<td></td>
<td>Guidance Document</td>
<td>#19 (pg. 53)</td>
<td>D1, #3</td>
</tr>
<tr>
<td></td>
<td>Scheme Approach</td>
<td>#46 (pg. 83)</td>
<td>D1, #4</td>
</tr>
<tr>
<td></td>
<td>Regulatory Alignment</td>
<td>#70 (pg. 115)</td>
<td>D1, #5</td>
</tr>
<tr>
<td></td>
<td>CCS Research Activities</td>
<td>#22 (pg. 56)</td>
<td>D1, #6</td>
</tr>
<tr>
<td></td>
<td>CO₂ Accounting</td>
<td>#52 (pg. 93)</td>
<td>D1, #7</td>
</tr>
<tr>
<td>Closure and Transfer of Liability</td>
<td>Closure Process Outline</td>
<td>#58 (pg. 99)</td>
<td>D2, #1</td>
</tr>
<tr>
<td></td>
<td>Closure Plan Requirements</td>
<td>#30 (pg. 63)</td>
<td>D2, #2</td>
</tr>
<tr>
<td></td>
<td>Closure Plan Requirements</td>
<td>#29 (pg. 62)</td>
<td>D2, #3</td>
</tr>
<tr>
<td></td>
<td>Closure Period</td>
<td>#60 (pg. 100)</td>
<td>D2, #4</td>
</tr>
<tr>
<td></td>
<td>Minimum Closure Period</td>
<td>#62 (pg. 103)</td>
<td>D2, #5</td>
</tr>
<tr>
<td></td>
<td>Final Closure/MMV Report</td>
<td>#64 (pg. 105)</td>
<td>D2, #6</td>
</tr>
<tr>
<td></td>
<td>Data Management</td>
<td>#51 (pg. 93)</td>
<td>D2, #7</td>
</tr>
<tr>
<td></td>
<td>Climate Liability</td>
<td>#65 (pg. 109)</td>
<td>D2, #8</td>
</tr>
<tr>
<td>CO₂ Classification</td>
<td>CO₂ Classification</td>
<td>[3] (pg. 38)</td>
<td>D3, #1</td>
</tr>
<tr>
<td>CO₂ Enhanced Oil Recovery and Acid Gas Disposal</td>
<td>Definition</td>
<td>#68 (pg. 114)</td>
<td>D4, #1</td>
</tr>
<tr>
<td></td>
<td>Regulatory Differences</td>
<td>#69 (pg. 114)</td>
<td>D4, #2</td>
</tr>
<tr>
<td></td>
<td>CO₂-EOR Transition to CCS</td>
<td>#71 (pg. 115)</td>
<td>D4, #3</td>
</tr>
<tr>
<td>CO₂ Transportation and Composition</td>
<td>CO₂ Pipelines Non-routine</td>
<td>[1] (pg. 38)</td>
<td>D5, #1</td>
</tr>
<tr>
<td></td>
<td>CO₂ Stream Composition</td>
<td>#6 (pg. 39)</td>
<td>D5, #3</td>
</tr>
<tr>
<td></td>
<td>CO₂ Leak Detection</td>
<td>#8 (pg. 40)</td>
<td>D5, #4</td>
</tr>
<tr>
<td></td>
<td>Pipeline Integrity Management</td>
<td>#7 (pg. 40)</td>
<td>D5, #5</td>
</tr>
<tr>
<td>Issue</td>
<td>Topic</td>
<td>Location in Report: Recommendation/ [conclusion] number (page number)</td>
<td>Appendix number, Recommendation number</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td><strong>Competition with Other Resources</strong></td>
<td>Pore Space Inventory</td>
<td>#16 (pg. 49)</td>
<td>D6, #1</td>
</tr>
<tr>
<td></td>
<td>Pore Space Inventory</td>
<td>#17 (pg. 49)</td>
<td>D6, #2</td>
</tr>
<tr>
<td></td>
<td>Subsurface Resource Interaction</td>
<td>#32 (pg. 66)</td>
<td>D6, #3</td>
</tr>
<tr>
<td></td>
<td>Stacking and Joint Utilization</td>
<td>#33 (pg. 69)</td>
<td>D6, #4</td>
</tr>
<tr>
<td><strong>Environmental Assessments</strong></td>
<td>Environmental Impact Assessments</td>
<td>#41 (pg. 78)</td>
<td>D7, #1</td>
</tr>
<tr>
<td><strong>Environmental Impacts, Mitigation and Remediation</strong></td>
<td>Shallow Groundwater Monitoring</td>
<td>#28 (pg. 61)</td>
<td>D8, #1</td>
</tr>
<tr>
<td></td>
<td>Amines</td>
<td>#5 (pg. 36)</td>
<td>D8, #2</td>
</tr>
<tr>
<td></td>
<td>Post-combustion CO₂ Capture</td>
<td>#4 (pg. 35)</td>
<td>D8, #3</td>
</tr>
<tr>
<td><strong>Monitoring, Measurement and Verification</strong></td>
<td>Performance Criteria for Closure</td>
<td>#63 (pg. 104)</td>
<td>D9, #1</td>
</tr>
<tr>
<td></td>
<td>MMV Plans</td>
<td>#26 (pg. 60)</td>
<td>D9, #2</td>
</tr>
<tr>
<td></td>
<td>MMV Plans</td>
<td>#27 (pg. 60)</td>
<td>D9, #3</td>
</tr>
<tr>
<td></td>
<td>MMV Reporting</td>
<td>#50 (pg. 92)</td>
<td>D9, #4</td>
</tr>
<tr>
<td><strong>Pipeline Open Access</strong></td>
<td>Market Considerations</td>
<td>#9 (pg. 41)</td>
<td>D10, #1</td>
</tr>
<tr>
<td></td>
<td>Common Carrier System</td>
<td>#10 (pg. 41)</td>
<td>D10, #2</td>
</tr>
<tr>
<td></td>
<td>CO₂ Capture Facility Approval</td>
<td>#2 (pg. 33)</td>
<td>D10, #3</td>
</tr>
<tr>
<td></td>
<td>Common Carrier Considerations</td>
<td>#13 (pg. 43)</td>
<td>D10, #4</td>
</tr>
<tr>
<td></td>
<td>Open Season</td>
<td>#11 (pg. 42)</td>
<td>D10, #5</td>
</tr>
<tr>
<td></td>
<td>Shared Transportation Infrastructure</td>
<td>#12 (pg. 43)</td>
<td>D10, #6</td>
</tr>
<tr>
<td></td>
<td>Regional Planning</td>
<td>#14 (pg. 44)</td>
<td>D10, #7</td>
</tr>
</tbody>
</table>
### Table 1. Continued

<table>
<thead>
<tr>
<th>Issue</th>
<th>Topic</th>
<th>Location in Report: Recommendation/ [conclusion] number (page number)</th>
<th>Appendix number, Recommendation number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pore Space Open Access</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Considerations</td>
<td>#34 (pg. 70)</td>
<td></td>
<td>D11, #1</td>
</tr>
<tr>
<td>Collaboration</td>
<td>#31 (pg. 64)</td>
<td></td>
<td>D11, #2</td>
</tr>
<tr>
<td>Tenure</td>
<td>#35 (pg. 71)</td>
<td></td>
<td>D11, #3</td>
</tr>
<tr>
<td>Third Party Access Criteria</td>
<td>#36 (pg. 73)</td>
<td></td>
<td>D11, #4</td>
</tr>
<tr>
<td>Compensation</td>
<td>#37 (pg. 74)</td>
<td></td>
<td>D11, #5</td>
</tr>
<tr>
<td>Liability</td>
<td>#38 (pg. 75)</td>
<td></td>
<td>D11, #6</td>
</tr>
<tr>
<td>Site Transfer</td>
<td>#39 (pg. 76)</td>
<td></td>
<td>D11, #7</td>
</tr>
<tr>
<td>Tenure Term</td>
<td>#40 (pg. 76)</td>
<td></td>
<td>D11, #8</td>
</tr>
<tr>
<td>Pore Space Availability</td>
<td>#3 (pg. 33)</td>
<td></td>
<td>D11, #9</td>
</tr>
<tr>
<td><strong>Post-closure Stewardship Fund and Financial Security</strong></td>
<td>Financial Security</td>
<td>#56 (pg. 96)</td>
<td>D12, #1</td>
</tr>
<tr>
<td>PCSF Rate</td>
<td>#53 (pg. 94)</td>
<td></td>
<td>D12, #2</td>
</tr>
<tr>
<td>PCSF Rate</td>
<td>#54 (pg. 95)</td>
<td></td>
<td>D12, #3</td>
</tr>
<tr>
<td>Allowable Uses</td>
<td>[9] (pg. 110)</td>
<td></td>
<td>D12, #4</td>
</tr>
<tr>
<td>Allowable Uses</td>
<td>#66 (pg. 110)</td>
<td></td>
<td>D12, #5</td>
</tr>
<tr>
<td>Pooling</td>
<td>#55 (pg. 95)</td>
<td></td>
<td>D12, #6</td>
</tr>
<tr>
<td>Future PCSF Review</td>
<td>#57 (pg. 97)</td>
<td></td>
<td>D12, #7</td>
</tr>
<tr>
<td><strong>Public Engagement and Stakeholder Consultation</strong></td>
<td>Review of Requirements</td>
<td>#42 (pg. 80)</td>
<td>D13, #1</td>
</tr>
<tr>
<td>Information Sharing</td>
<td>#43 (pg. 81)</td>
<td></td>
<td>D13, #2</td>
</tr>
<tr>
<td>Public Information Documents</td>
<td>#44 (pg. 81)</td>
<td></td>
<td>D13, #3</td>
</tr>
<tr>
<td><strong>Public Safety</strong></td>
<td>Emergency Planning Zones</td>
<td>#1 (pg. 32)</td>
<td>D14, #1</td>
</tr>
<tr>
<td><strong>Risk Assessment</strong></td>
<td>Requirement</td>
<td>#24 (pg. 58)</td>
<td>D15, #1</td>
</tr>
<tr>
<td>Guidelines</td>
<td>#25 (pg. 59)</td>
<td></td>
<td>D15, #2</td>
</tr>
<tr>
<td>CSA Standard</td>
<td>#47 (pg. 84)</td>
<td></td>
<td>D15, #3</td>
</tr>
<tr>
<td>Issue</td>
<td>Topic</td>
<td>Location in Report: Recommendation/ [conclusion] number (page number)</td>
<td>Appendix number, Recommendation number</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Site Closure</td>
<td>Well Abandonment</td>
<td>[8] (pg. 105)</td>
<td>D16, #1</td>
</tr>
<tr>
<td></td>
<td>Closure Plan Content</td>
<td>#59 (pg. 100)</td>
<td>D16, #2</td>
</tr>
<tr>
<td></td>
<td>Site Selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Access</td>
<td>Post-closure MMV Activities</td>
<td>#49 (pg. 91)</td>
<td>D18, #1</td>
</tr>
<tr>
<td></td>
<td>Pre-tenure</td>
<td>#67 (pg. 111)</td>
<td>D18, #2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[4] (pg. 47)</td>
<td>D18, #3</td>
</tr>
<tr>
<td>Surface Reclamation</td>
<td>Surface Reclamation</td>
<td>[7] (pg. 102)</td>
<td>D19, #19</td>
</tr>
<tr>
<td>Tenure Process</td>
<td>Information Sharing</td>
<td>#21 (pg. 55)</td>
<td>D20, #1</td>
</tr>
<tr>
<td></td>
<td>Tenure Review</td>
<td>#20 (pg. 54)</td>
<td>D20, #2</td>
</tr>
<tr>
<td>Well Construction</td>
<td>Well Classification</td>
<td>#45 (pg. 82)</td>
<td>D21, #1</td>
</tr>
<tr>
<td></td>
<td>Well Completion</td>
<td>#48 (pg. 88)</td>
<td>D21, #2</td>
</tr>
<tr>
<td></td>
<td>Well Completion</td>
<td>[5] (pg. 89)</td>
<td>D21, #3</td>
</tr>
<tr>
<td></td>
<td>Well Completion</td>
<td>[6] (pg. 89)</td>
<td>D21, #4</td>
</tr>
<tr>
<td></td>
<td>Well Abandonment</td>
<td>#61 (pg. 101)</td>
<td>D21, #5</td>
</tr>
</tbody>
</table>
WHAT IS CARBON CAPTURE AND STORAGE?

CCS is an integrated activity that includes the capture, compression, transportation, injection, and geological sequestration of anthropogenic carbon dioxide (CO₂) from large industrial sources (see Figure 2). The objective of CCS is to mitigate global climate change by reducing the amount of industrial CO₂ emissions entering the atmosphere. Although CCS is a relatively new activity, there are several integrated CCS projects operating globally. Furthermore, in Alberta, there exists significant expertise in all of the individual elements that constitute CCS (e.g. capture, transportation and injection). The recovery and processing of resources have provided Albertans with the experience and the technical capability to accomplish CCS in a safe and responsible manner.

Carbon capture and storage is the internationally recognized terminology for this process. However, this report refers to CO₂ sequestration to differentiate this process from other temporary underground storage activities.

Table 2 describes the different elements of a CCS project and examples of how they compare to other activities in Alberta.
What is Carbon Capture and Storage?

1. CO₂ captured from large industrial facility
2. CO₂ transported by pipeline

SEQUESTRATION OPTION:
Depleted oil and gas reservoirs

3a. CO₂ injected into a suitable rock formation for permanent sequestration

SEQUESTRATION OPTION:
Deep-saline formation

3b. CO₂ injected for enhanced oil recovery

Impermeable caprock

Non-saline groundwater

1 km minimum

Figure 2. Carbon Capture and Storage as an Integrated Activity
### Carbon Capture and Storage

CCS involves the separation of CO₂ from gas streams at large stationary anthropogenic sources of emissions. Typical sources of CO₂ for CCS include fossil-fuel power plants, ethanol plants, fertilizer plants, upgraders and refineries, and cement and steel plants.

The captured CO₂ stream is compressed to enable efficient transportation typically by pipeline. Rail or truck transportation could be used for smaller volumes.

CO₂ is injected into a deep well to the target geological formation.

CO₂ sequestration occurs in a sequestration complex containing multiple geological formations with impermeable seals (caprocks). CO₂ is held in the pore spaces present in the sequestration formation, and seals will ensure that the CO₂ stays permanently in place. Sequestration formations include saline formations, depleted oil and natural gas reservoirs, and unmineable coal seams. Alberta legislation requires that sequestration must take place at a depth of more than 1000 metres below the surface.

After CO₂ has been injected into the sequestration formation, it is monitored to ensure it is contained and is behaving as expected. All CCS projects in Alberta must develop a detailed monitoring, measurement and verification (MMV) plan to ensure that the project is meeting requirements.

### Analog to Other Activities in Alberta

CO₂ capture uses similar techniques such as separating CO₂ and hydrogen sulfide (H₂S) from sour natural gas at a gas processing plant.

Alberta has a vast network of pipelines. Similar to other commodities, CO₂ pipelines must meet design, construction and operation standards. Pipelines and gathering fields in Alberta use pump and compressor stations to move a variety of fluids.

Alberta’s oil and gas sector has extensive experience with wells for multiple applications, including injection wells. Drilling and completion of a well for CO₂ injection is similar to the well construction practices used for conventional resource developments.

Alberta’s oil and natural gas resources were formed and have been held underground by geological seals for millions of years. The same type of geology that has resulted in the province’s rich oil and gas reserves also makes the province suitable for CCS. Exploration and production of oil and natural gas has also provided industry and government with knowledge of the subsurface geology of the province. This knowledge will enable the most suitable sites to be chosen for CO₂ sequestration.

Techniques used to monitor oil and natural gas production and to explore for new reserves can also be used to monitor CO₂ sequestration sites. In addition, techniques already used to monitor water, soil and air quality can be employed to assure there are no adverse effects to the environment as a result of CCS projects.

<table>
<thead>
<tr>
<th>Table 2. Elements of CCS and Similarities to Comparable Activities in Alberta</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon Capture and Storage</strong></td>
</tr>
<tr>
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</tr>
<tr>
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<tr>
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<tr>
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<tr>
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</tr>
</tbody>
</table>
What is Carbon Capture and Storage?
THE IMPORTANCE OF CARBON CAPTURE AND STORAGE TO ALBERTA AND DEVELOPMENTS TO DATE

To prevent adverse changes to the climate, significant reductions in CO$_2$ emissions are required to stabilize greenhouse gas concentrations in the atmosphere. The International Energy Agency believes that a portfolio of mitigation technologies will be needed to achieve this stabilization, and attributes one-fifth of the total projected global greenhouse gas emissions reduction through 2050 to the large scale deployment of CCS.$^3$

In Alberta, the Alberta Sedimentary Basin$^4$ provides many suitable sites for CO$_2$ sequestration as shown in Figure 3. CO$_2$ can be sequestered in several types of geological formations including deep saline formations, depleted oil and gas reservoirs and unmineable coal seams. The North American Carbon Storage Atlas$^5$ provides a midrange estimate of CO$_2$ sequestration potential of at least 46 gigatonnes (billion tonnes) in Alberta. Within this report, sequestration quality pore space refers to subsurface pore space that meets injectivity, capacity and containment criteria for CO$_2$ sequestration activities.

The Government of Alberta’s Climate Change Strategy estimates that by 2050 the rate of CO$_2$ sequestration will have to be 139 megatonnes of CO$_2$ per year to meet the 2050 targets. At that rate, Alberta will have approximately 330 years of sequestration capacity.$^6$ These estimates demonstrate why CCS can provide such a significant contribution to Alberta’s Climate Change Strategy.

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4 What is commonly referred to as the Western Canadian Sedimentary Basin comprises the Alberta Basin (in Alberta and Northeastern British Columbia) and the Williston Basin (in Saskatchewan and Manitoba). These basins are geologically different.
6 This is based on a mid-range estimate of total sequestration capacity.
Figure 3. CO₂ Sequestration Suitability in the Western Canadian Sedimentary Basin

CCS is a key technology to advance responsible and sustainable development of Alberta’s energy resources while addressing greenhouse gas emissions. CCS is an important part of Alberta’s greenhouse gas emissions mitigation portfolio because Alberta’s emissions profile consists primarily of large point source industrial emitters, including coal-fired power plants and oil and gas facilities. As shown in Figure 4 below, approximately two-thirds of Alberta’s anthropogenic greenhouse gas emissions originate from large industrial sectors that are potential candidates for application of commercial-scale CCS.

In 2008, the ecoENERGY Carbon Capture and Storage Task Force provided a final report to the Government of Alberta and the Government of Canada and identified the need for public funding for the first CCS projects, regulatory clarity, and a collaborative advisory group.

Figure 4. Contribution of 2010 Alberta Greenhouse Gas Emissions by Sector

In 2008, the ecoENERGY Carbon Capture and Storage Task Force provided a final report to the Government of Alberta and the Government of Canada and identified the need for public funding for the first CCS projects, regulatory clarity, and a collaborative advisory group.

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To respond to the recommendations from the Task Force, the Government of Alberta formed the Alberta Carbon Capture and Storage Development Council. In 2009, the Development Council released a report, Accelerating Carbon Capture and Storage Implementation in Alberta. This report provides a blueprint for successfully achieving widespread adoption of CCS in Alberta, and includes policy, regulatory and technology recommendations. The key recommendations coming out of the report include:

- Financial investment from federal and provincial governments and the use of CO₂ for enhanced oil recovery (CO₂-EOR) are necessary to offset the financial disadvantages of CCS.
- Funding and policy mechanisms should be put in place to promote large scale deployment of CCS.
- The ownership of pore space and long term storage liability should be clarified by the Government of Alberta.

The report also notes that CCS will have a positive impact on the Alberta economy as it enables the continued development of the province’s conventional oil reserves by using captured CO₂ for CO₂-EOR. For example, the incremental oil produced from injecting CO₂ into oil reservoirs could translate to an additional $105 billion of revenue over the life of the development. This revenue, and the associated royalties and taxes would benefit all Albertans. Revenues generated from CO₂-EOR will also help offset the initially high capital costs of CCS, as well as promote the development of infrastructure necessary for large scale CCS deployment. Experience gained from CO₂-EOR activities will also enhance existing knowledge of geological sequestration of CO₂.

Developing CCS technology represents a way to extract the economic benefits of Alberta’s petroleum resources, including oil sands, while maintaining strong environmental objectives. Deployment of CCS will also enable Alberta to produce cleaner electricity from hydrocarbon resources, including continued development of the province’s coal reserves. This will ensure a diversified portfolio of power generation technologies for a reliable supply of electricity for Albertans.

In response to the Task Force and Development Council recommendations, and to enable the development of large scale CCS projects, the Government of Alberta made several key regulatory changes. The Carbon Capture and Storage Funding Act was passed in 2009 to encourage and expedite the design, construction and operation of CCS projects in Alberta. Under this Act, the Government of Alberta has committed over $1.3 billion to two CCS projects, which are expected to reduce Alberta’s greenhouse gas emissions by approximately 2.76 megatonnes per year by 2016. These projects include:

- The Alberta Carbon Trunk Line – a 240 kilometre pipeline that will transport CO₂ from an existing fertilizer plant and an oil sands refinery to CO₂-EOR projects in central Alberta.
- Quest – an integrated CCS project that will capture CO₂ from an existing oil sands upgrader, and transport it by pipeline for sequestration underground in a deep saline formation.

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The Government of Alberta also recognized the Task Force and Development Council’s recommendation regarding regulatory and policy barriers facing the deployment of commercial-scale CCS and has implemented legislation to address these issues. The *Carbon Capture and Storage Statutes Amendment Act, 2010* updated several key pieces of legislation and was essential to enable the Government of Alberta to proceed with the two funded projects. This Act:

- Clarifies that all pore space is owned by the province, except pore space under federally owned land.
- Enables the Minister of Energy to enter into agreements to grant pore space rights.
- Allows the province to accept long term liability for sequestered CO₂.
- Creates the Post-closure Stewardship Fund (PCSF) to ensure that money is available when the province assumes liability for a CCS site.

Prior to passage of the *Carbon Capture and Storage Statutes Amendment Act, 2010*, the Energy Resources Conservation Board (ERCB) was already designated as the provincial regulator for permitting CCS operations in Alberta. The ERCB is an independent quasi-judicial agency of the Government of Alberta which regulates the province’s energy resources. Section 39 of the *Oil and Gas Conservation Act* requires ERCB approval for the storage or disposal of any substances to an underground formation through a well.
The RFA made recommendations relevant to current government agencies and governance structures, including the ERCB and Alberta Environment and Sustainable Resource Development. However, in November 2012, the Alberta Legislature passed the Responsible Energy Development Act, which creates a single regulator for all oil, gas, oil sands, coal, and CCS projects in the province. The Energy Resources Conservation Board (ERCB) was the regulator when the RFA was developing this report. As this report is being released at the time when the ERCB transitions to the new Alberta Energy Regulator, references to the regulator throughout the report will refer to the Alberta Energy Regulator when the transition is finalized. References to ERCB directives have been left in this report.

To support the Carbon Capture and Storage Statutes Amendment Act, 2010 the Carbon Sequestration Tenure Regulation was passed in April 2011. The regulation addresses four main aspects of tenure for CCS, including:

- Allowing operators to acquire a permit for the evaluation of a potential storage site to investigate the geology and determine the suitability of the site for CO₂ sequestration.
- Allowing operators to obtain leases for large scale CO₂ sequestration at suitable storage sites.
- Specifying what criteria must be included in MMV and closure plans in order to gain Ministerial approval.
- Stipulating that pore space tenure can only be granted at depths greater than 1000 metres.
In addition to these legislative changes, the RFA addressed a number of remaining regulatory issues and identified opportunities for improving the regulatory framework. These recommendations and other conclusions are highlighted in the blue boxes throughout this report. The rest of the report is organized as follows:

- Section 5 outlines the review undertaken by the RFA regarding potential public safety impacts from CCS projects.
- Sections 6 through 14 describe the regulatory process for CCS activities and offer recommendations for opportunities to improve Alberta’s regulatory framework for CCS.
- Section 15 includes recommendations related to CO₂ enhanced oil recovery and acid gas disposal.
- Section 16 concludes the report.
Public safety is the primary concern in the regulation of upstream oil and gas developments, which include CCS activities. A review of the scientific literature was conducted to ensure potential impacts to public safety from a CCS project are fully addressed in Alberta’s regulatory framework. This review identified hazards and analyzed potential acute health impacts on the public from an accidental release of CO$_2$, and associated impurities, during transportation and injection. While hazards and potential impacts are project-specific, the information contained in the literature review could provide further insight into how public safety can be addressed for large scale CCS projects.

To address potential incidents that could present hazards to the public and the environment, oil and gas licensees in Alberta must ensure that they are fully prepared to respond to any level of emergency as required by ERCB Directive 071. Directive 071 outlines the requirements for a corporate-level emergency response plan (ERP) and stipulates that these plans must have preplanned procedures that will aid in effective response to an emergency. An ERP for a CCS project does not currently require approval from the regulator. However, the regulator may review the ERP upon request.

An emergency planning zone (EPZ) is a geographical area surrounding a well, pipeline or facility containing a hazardous product that requires specific emergency response planning by the licensee. The licensee is required to carry out notification and education for the public who live within the EPZ. Directive 071 requires an EPZ to be calculated if the operation contains or produces either one of the two identified hazardous substances – H$_2$S or high vapour pressure hydrocarbons. While corporate ERPs are required for CCS projects, currently EPZs may not be required if CO$_2$ streams have a H$_2$S content below the amount specified in ERCB Directive 071.

To ensure public safety and build confidence, a conservative and precautionary approach should be taken to include the development of EPZ requirements for CCS. The information, science and modelling that are used to inform emergency response and planning measures should be specific to the properties of CO$_2$ to ensure public safety. Based on the review of potential hazards of an accidental release during transportation and injection, and the requirements for emergency preparedness in Alberta, the steering committee recommends that:

**RECOMMENDATION 1**

The regulator should develop emergency planning zone requirements specific to CCS project infrastructure as part of ongoing efforts to ensure adequate emergency response and planning.\(^{12}\)
CO\(_2\) capture for CCS focuses on separation of CO\(_2\) from gas streams at large anthropogenic sources of emissions. Examples of capture sources include electricity generators, upgraders, cement plants, ethanol plants, fertilizer plants and oil refineries. In Alberta, these types of operations are primarily overseen by the Energy Resources Conservation Board (ERCB), Alberta Utilities Commission (AUC), and Alberta Environment and Sustainable Resource Development.

Alberta’s Climate Change Strategy forecasts that CCS will account for 139 megatonnes of CO\(_2\) reductions per year by 2050. Assuming that an average facility captures one to two megatonnes annually, this level of CO\(_2\) reduction could result in 80 to 100 commercial-scale capture facilities. Therefore, it is important that appropriate planning is carried out to ensure that there is adequate transportation infrastructure and opportunity for CO\(_2\) sequestration or utilization. As a result, the steering committee recommends that:

**RECOMMENDATION 2**

When applying for regulatory approval of a new CO\(_2\) capture facility, the proponent should be required to demonstrate that it has, or can reasonably obtain, access to both a CO\(_2\) sequestration site, including CO\(_2\) enhanced oil recovery fields, and pipeline capacity to transport CO\(_2\) to that site.\(^{13}\)

Presently, greenhouse gas emissions are managed in Alberta through the *Climate Change and Emissions Management Act*. If the Government of Alberta considers new policies that will significantly increase the amount of captured CO\(_2\), it is important to give adequate consideration to operators’ ability to suitably dispose of captured CO\(_2\). Therefore, the steering committee recommends that:

**RECOMMENDATION 3**

The availability and capacity of sequestration sites (or markets for captured CO\(_2\)) should be one of the factors considered if the Government of Alberta contemplates setting regulations that mandate carbon capture operations.\(^{14}\)

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\(^{13}\) Refer to Appendix D10.

\(^{14}\) Refer to Appendix D11.
The working groups also reviewed CO₂ capture technologies to determine potential environmental impacts that could result from large scale operation of CO₂ capture facilities. As Alberta moves toward large scale deployment of CCS, liquid-solvent-based CO₂ capture systems will likely be the primary technology for capture.

Post-combustion capture involves removing CO₂ from a flue gas stream after a fuel has been combusted with air. This type of process can be retrofitted onto existing facilities such as coal-fired power plants. Figure 5 shows an example of post-combustion capture applied to a power plant. Instead of flowing directly up the flue stack and into the atmosphere, a slip-stream of the flue gas is cooled and then treated to separate the CO₂ at an adjoining capture plant. Currently, the most common way to separate the CO₂ is to bring it into contact with a liquid solvent, such as an amine or ammonia. The CO₂ binds to the solvent, thereby removing it from the other gases in the flue gas stream. Other gases (mostly nitrogen (N₂) and water vapour (H₂O)) are then returned to the flue stack. The solvent is then heated to release the CO₂ in a process called regeneration, and is then reused. The CO₂ stream released from the solvent undergoes further processing and is compressed to pipeline pressure specifications and/or requirements.

Amines have been used industrially to remove CO₂ and other components such as H₂S from gas streams for more than 70 years, for example from natural gas as is shown in Figure 6. Whether the process is cleaning natural gas or capturing CO₂ in a post-combustion system, a very small percentage of amine remains in the treated gas stream leaving the absorber. In natural gas processes the cleaned gas is handled in a closed system until it is used. The difference with post-combustion capture systems is that the treated gas stream is returned to the flue stack. This presents a potential increase in the amount of amines or associated degradation products released to the environment; however the concentrations of amines in the stack exhaust would be very low.
While there are alternative technologies for separating CO$_2$ which may become widely used in the future (e.g. zeolites and membranes), liquid-based technologies that use amines or ammonia will be the dominant process used by CCS projects in Alberta in the near future. Regarding ammonia, Alberta has established an Ambient Air Quality Objective of two parts per million that is based on low odour thresholds and the Air Monitoring Directive$^{15}$ specifies the manner in which an owner/operator must monitor and report ammonia emissions. Based on these requirements, the steering committee agreed that the current legal and regulatory framework in Alberta regarding the use of ammonia for CCS projects is adequate. However, as noted earlier, the use of amines for CCS could potentially increase the quantity of amine released into the environment. Also, there may be novel amines introduced to the environment whose potential health and environmental effects are poorly understood. Research is being undertaken worldwide to better understand the potential impacts of these solvents and emerging technologies. Therefore, the steering committee recommends that:

**RECOMMENDATION 4**

The Government of Alberta should determine whether further regulation of the use of post-combustion CO$_2$ capture technologies is warranted. To achieve this, the Government of Alberta should join international efforts to fill important knowledge gaps relating to the use of post-combustion CO$_2$ capture technologies for CCS projects, such as amine usage, so that an understanding of their potential environmental impacts can be attained.$^{16}$

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$^{16}$ Refer to Appendix D8.
Amines have been used in Alberta for many years. However, there are concerns regarding the potential release of amines and their degradation products, and the potential health and environmental impact they could have. It was found that little information is available regarding the quantity of amines that are used in the province. As a result, understanding the relative proportion of amine use stemming from anticipated CO$_2$ capture operations is difficult. Therefore, the steering committee recommends that:

**RECOMMENDATION 5**

The Government of Alberta should assess the volumes of amines used for CO$_2$ capture in Alberta to provide context for the relative scope and scale of amine use for CCS projects.$^{17}$
7 \textbf{CO}_2 \textbf{TRANSPORTATION}

7.1 OVERVIEW

Alberta has excellent geology for CCS in the Alberta Basin with a significant number of suitable sequestration sites. It will be necessary to transport \text{CO}_2 to these sequestration sites from the large and numerous point sources of \text{CO}_2. Given the quantities of \text{CO}_2 needed to be sequestered to meet Alberta’s Climate Change Strategy targets, transportation will likely be by pipeline. \text{CO}_2 pipelines are not new in North America. There are about 6,500 kilometres of \text{CO}_2 pipelines in the United States, transporting \text{CO}_2 for enhanced oil recovery projects\textsuperscript{18}.

7.2 PIPELINE TECHNICAL REQUIREMENTS

In Alberta, CO₂ pipelines are regulated by the ERCB under the Pipeline Act. Pipelines that cross provincial or national borders are regulated by the National Energy Board. Regulatory requirements for CO₂ pipelines generally cover important design elements such as: size, materials selection, design pressure, resistance to degradation, protection from damage, appropriate monitoring facilities, safety systems and siting considerations.

Under ERCB Directive 056, an application for a CO₂ pipeline is considered non-routine. Such a designation triggers an in-depth review of the application. The review also considers the anticipated concentrations of impurities in the CO₂ stream, and limits may be placed on impurities based on project-specific criteria. As CO₂ pipelines for CCS become more common in Alberta, it may be possible to consider CO₂ pipeline applications routine at some point in the future. Until that time, the steering committee concludes that:

CONCLUSION 1

It is appropriate for licence applications for all CO₂ pipelines (for the purposes of CCS) to be treated as non-routine.21

The Pipeline Regulation contains the technical requirements for pipelines in Alberta, including those recommended in the latest published edition of several Canadian Standards Association (CSA) standards, particularly CSA Z662. This detailed and descriptive standard allows for engineering judgment to address site-specific issues and incorporate improvements to materials and design techniques. Even though CSA Z662 is intended to apply to CO₂ pipelines used in CO₂-EOR schemes, the existing requirements and standards adequately address CO₂ pipeline design, operation and maintenance for large scale CCS projects. To ensure that the most up-to-date standard is used to evaluate future applications for CO₂ pipelines in Alberta, the steering committee concludes that:

CONCLUSION 2

It is appropriate for the regulator to reference the most recent Canadian Standards Association Standard Z662: Oil and Gas Pipeline Systems.23

Currently there is no single, definitive classification for CO₂ in Alberta and in Canada. How CO₂ is classified depends on how it is produced, its concentration, what it is used for and what legislation it falls under. When transporting CO₂ by pipeline, the Pipeline Act would apply. Currently the Pipeline Act has no explicit classification for CO₂, although it would fall under the definition of a gas. The steering committee does not believe that the lack of a single classification will have a negative impact on CCS deployment or public safety in Alberta. As a result, the steering committee concludes that:

CONCLUSION 3

There is no need to change how CO₂ is currently classified in Alberta.24
The working groups reviewed purity requirements for CO₂ pipelines for CCS. It was found that the composition of the CO₂ stream and the associated impacts to phase behaviour, water solubility, toxicity and corrosivity must be understood in order for CCS projects to be designed to minimize the risks to public safety and the environment. The composition of the CO₂ stream is affected by many factors, including feedstock composition, capture technologies and operating conditions. However, it is difficult to set an industry-wide standard or limit for any impurity. This could be due to the lack of available data on the interactions of multiple impurities and other interrelated variables that affect stream composition.

Although there are no prescribed limits for impurities in CO₂ streams used for CCS, the existing regulatory framework considers impurities when designing and operating the different components of a CCS project. Materials and operating parameters are selected according to the anticipated stream characteristics. Currently, acid gas projects need to consider impurities in their design and are evaluated on a case-by-case basis. This includes compositions that may have impacts on public safety and confidence. However, the total percentage of impurities in a CO₂ stream would likely not exceed 10 percent.

In cases when a new stream with a different composition is introduced to an existing CO₂ pipeline, pipeline operators and CO₂ stream suppliers would monitor the stream composition in order to determine if the stream meets the pipeline specifications and approval conditions. Additionally, re-evaluation may be necessary if there are changes to the stream composition that could negatively impact infrastructure and/or public safety. Individual impurities have very different effects on the behaviour of the CO₂ stream and their concentrations are what drive design considerations, not solely the concentration of CO₂.

In Alberta, CO₂ stream composition is not specified in the current regulatory regime for CCS. It is addressed as an inherent issue during the specification and design of CO₂ pipelines and is reviewed in the approvals process. In regard to CO₂ stream composition, the steering committee recommends that:

RECOMMENDATION 6

The composition of the CO₂ stream should continue to be tracked over time and evaluated by the regulator on a case-by-case basis to ensure that the physical and chemical properties conform to the design capabilities of the infrastructure used to capture, transport and inject the CO₂ stream. Any composition standards or specifications that may arise from subsequent regulatory reviews should be based on the concentrations of impurities that might be present in the stream. The stream should be predominantly CO₂ in order to satisfy the intended purpose of using the stream for CCS.25
In addition to pipeline design and operation, pipeline integrity is addressed in Alberta’s regulatory requirements. A pipeline licensee is required to develop and implement a pipeline integrity management program, to ensure that pipelines are capable of transporting product safely. The steering committee recognized that Albertans may wish to have access to these plans; therefore, the steering committee recommends that:

**RECOMMENDATION 7**

Pipeline integrity management programs for CO₂ pipelines, as required under Energy Resources Conservation Board Directive 077: Pipelines – Requirements and Reference Tools, should be made available by CO₂ pipeline operators to the public on request.²⁶

Monitoring pipelines is an operational requirement in Alberta, regulated by the ERCB. There are methods in place to detect leaks from pipelines such as operational monitoring, site inspections, infrared cameras, flyovers, the addition of odorants, as well as leak detection and repair programs. Although Alberta has experience with CO₂ pipelines, the volume of CO₂ being transported will increase with widespread deployment of CCS. Because there may be monitoring methods specific to CO₂ pipelines that would benefit the operational, public safety and public confidence aspects of leak detection, the steering committee recommends that:

**RECOMMENDATION 8**

The Government of Alberta should investigate the possibility of conducting research and/or experiments on leak detection methods for CO₂ pipelines.²⁷

### 7.3 PIPELINE OPEN ACCESS

As the number of commercial CCS operations increases, the demand for access to CO₂ transportation will rise. As a result, the number of CO₂ pipelines in the province is expected to increase. To promote an economically-efficient pipeline system, ensuring reasonable access to sequestration opportunities, and minimizing the environmental impact of the pipeline system, the working groups considered recommending policy or regulatory drivers to incent or compel third party access to pipelines.

²⁶ Refer to Appendix D5.
²⁷ Refer to Appendix D5.
In general, upstream pipelines are not subject to any form of economic regulation other than general competition law. In this market-based system, parties construct their own facilities or obtain access to other parties’ facilities through private negotiations. The working groups found that market principles should be the primary driver for CO₂ pipeline development, as they currently are in the oil and gas industry in Alberta. As a result, the steering committee recommends that:

**RECOMMENDATION 9**

Market considerations should be the primary driver behind access to CO₂ pipelines. In this regard, pipeline operators and third parties should be expected to explore all reasonable avenues of private negotiation before applying to the regulator for access.\(^{28}\)

Alberta does not currently have any existing regulatory requirements for third party access to CO₂ pipelines. The system used for upstream oil and gas pipelines is the common carrier order. However, Sections 48, 49 and 55 of the *Oil and Gas Conservation Act* do not include CO₂ pipelines in the common carrier system.

The common carrier order is available to parties when private negotiations for pipeline access break down. When this system is employed, a party desiring access to another party’s pipeline can apply to the regulator to request a common carrier order. In general, the applicant must demonstrate:

- The need for access (i.e. producible reserves and a reasonable expectation of a market).
- That the pipeline operator is acting unreasonably in negotiations.
- That the pipeline is:
  - the only economically feasible way or the most practical way to transport the product or
  - clearly superior environmentally.

If the regulator designates a pipeline as a common carrier, then the pipeline owner must provide non-discriminatory access to the pipeline. The regulator can also direct the proportion of production to be taken by the common carrier from each producer using the pipeline to make capacity available for a new party. This concept is referred to by the working groups as prorationing. If the parties cannot agree on the tariff to be paid for use of the pipeline once a common carrier order is in place, either party can apply to the Alberta Utilities Commission to set the tariff.

In the analysis of this issue the working groups recognized that, even though pipeline operators are expected to negotiate in good faith and provide access to pipelines in a non-discriminatory manner, private negotiation will not always lead to satisfactory results. It is also important to have a method to prevent a pipeline operator from controlling access to the transportation network or imposing unreasonable conditions as a result of market position. A process is needed whereby parties can apply to the regulator for access to a CO₂ pipeline. Therefore, the steering committee recommends that:

**RECOMMENDATION 10**

The common carrier system should be expanded to apply to all CO₂ pipelines.\(^{29}\)

\(^{*}\text{Refer to Appendix D10.}\)
It is important that careful planning on pipelines takes place so that new capture operators’ access to CO₂ pipelines does not affect the transportation capacity for existing users. Recommendation 2 was provided to ensure that new capture facilities applying for approval demonstrate appropriate access to transportation. Planning can also be addressed in the development of a new pipeline. One such way to do this is to hold an open season, a process whereby a proponent planning a new pipeline provides or posts information on the project and allows potential shippers to submit capacity requests. This process can help to ensure that the pipeline is correctly sized to meet regional needs and therefore help reduce the likelihood of applications for common carrier orders. An open season will help achieve efficient development of CCS infrastructure, resulting in reduced costs, increased deployment of CCS, reduced environmental impact of CO₂ transportation, and increased safety and support to the development of CO₂-EOR markets. Furthermore, it will help protect pipeline operators against future access claims by ensuring that proponents take reasonable steps to assess demand for pipeline access. Therefore, the steering committee recommends that:

RECOMMENDATION 11

Pipeline operators should undertake some form of open season, where the operator seeks interest from other parties desiring access to the pipeline.

The open season should be evaluated by the regulator when reviewing applications for common carrier orders. This evaluation should include examining:

a) The adequacy of the open season conducted when hearing arguments why the order should not be granted.

b) Whether or not the third party engaged with the pipeline operator during the open season when hearing the third party’s reasons why the order should be granted.30

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30 Refer to Appendix D10
In order to minimize the incremental environmental footprint and reduce industry costs, CO₂ sequestration operations should be encouraged to share transportation infrastructure whenever reasonable and feasible to do so. This is particularly true for operations that are stacked (vertically overlaid). Consistent with current ERCB policies, the steering committee recommends that:

**RECOMMENDATION 12**

All CO₂ sequestration operations should be encouraged to use shared transportation infrastructure whenever feasible and reasonable.

In a review of open access requirements for CO₂ pipelines, significant attention was paid to the issue of prorationing. Prorationing impacts oil and gas producers, but to a lesser extent than it would be expected to impact a CO₂ capture facility and/or sequestration operator. If an oil or gas producer’s access to a pipeline is reduced, the product remains in the ground waiting to be produced and would still be brought to market at a later time. For CO₂ capture facilities, reduced access to a pipeline would mean that the capture facility would vent a portion of the captured CO₂, with multiple environmental and financial consequences. As a result, the operator’s emissions would likely increase, leading them to be in contravention of their emissions reduction requirements. In addition, the operator’s per tonne abatement costs would increase because capital and operating costs would not change, but the amount of CO₂ sequestered (and subsequent credits or CO₂ enhanced oil recovery sales) would decrease. Although prorationing could have significant consequences for capture facility operators, it should be an option for the common carrier system to be effective. When hearing a common carrier application for a CO₂ pipeline and considering prorationing, the regulator should carefully consider all factors to decide if it is appropriate to proration existing users of the pipeline. In most cases it would likely be appropriate to proration new users for the excess capacity before prorationing existing ones.

Recognizing the consequences that the risk of prorationing can have for capture and/or sequestration operators, the working groups developed a list of considerations to ensure that prorationing is used as an option of last resort. The considerations also suggest that the regulator gives adequate attention to the impacts of prorationing. The requirements necessary for the applicant to show that a common carrier designation is appropriate would be relatively difficult to demonstrate, particularly if the pipeline is already full. Prorationing could have significant consequences for capture facility and/or sequestration operators, but prorationing should be an option for the common carrier system to be effective. Therefore, the steering committee recommends that:

**RECOMMENDATION 13**

When hearing an application for a common carrier order, the regulator should consider the multiple impacts and implications of making a common carrier declaration on a case-by-case basis. This includes, but is not limited to, the impact on companies that would be affected by the decision, the effect on CCS/CO₂ system dynamics and the historical operating context of the pipeline. Common carrier orders, and more specifically the application of prorationing within a common carrier order, should be the option of last resort.

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31 Refer to the discussion on pore space competition and access in Section 10.3.2.
32 Refer to Appendix D10
33 Refer to Appendix D10 for further information and a non-consensus viewpoint.
The Government of Alberta has expended significant effort developing regional plans under the Land Use Framework to address the unique aspects and needs of each region in the province. These regional plans will provide context to help make decisions to better balance conservation and development of Alberta’s land and natural resources. The Government of Alberta takes a role in the planning of some types of pipelines (e.g. water) and should consider whether or not there is a need for similar involvement in CO₂ pipeline planning. The steering committee recommends that:

**RECOMMENDATION 14**

The Government of Alberta should consider taking a larger role in the regional planning of CO₂ pipeline infrastructure, particularly if there is government funding involved. This will help to ensure that infrastructure development meets the goals of the region and the needs of CCS deployment in Alberta.³⁴

³⁴ Refer to Appendix D10.
The Regulatory Framework Assessment focused on CO$_2$ sequestration activities. The lifecycle of a sequestration project includes the following periods (as shown in Figure 7):

- Site selection and characterization period
- Initial application and permitting period
- Pre-injection period
- Injection period
- Closure period
- Closure point
- Post-closure period

The following sections provide a brief overview of each period and background information on the associated regulatory process. Each period is described in more detail in Sections 9 through 14 and associated recommendations are presented.
9 SITE SELECTION PERIOD

9.1 SITE SELECTION AND CHARACTERIZATION

For CO$_2$ sequestration to contribute to mitigating climate change, long term isolation of the injected CO$_2$ from the atmosphere must be ensured. A well-chosen sequestration site safeguards against future loss of containment. Sites that will provide safe and secure long term sequestration are selected based on a number of criteria. For a CO$_2$ geological sequestration site to be technically feasible, three major parameters are considered to be essential:

- The sequestration complex must have sufficient capacity to sequester all the volume of CO$_2$ requested in any application for geological sequestration.

- Injection zones in the sequestration complex must have sufficient injectivity to sequester CO$_2$ at the required rate (i.e. at the rate supplied by the capture facility).

- The sequestration complex must have adequate seals to contain all injected and displaced fluids.
In order to choose sites that best meet the parameters above, proponents will review existing data from oil and gas exploration and production activities and may gather new data. The data compiled for site selection may form part of the baseline data set in the monitoring, measurement and verification (MMV) plan that will be developed for the project. The working groups reviewed the process for obtaining access to land in order to collect data for site selection. Prior to issuing an evaluation permit, this process requires coming to an agreement with the land owner through direct negotiation similar to oil and gas activities. The steering committee concludes that:

CONCLUSION 4

The current process for obtaining access for pre-tenure activities is adequate. Specific surface access provisions for pre-tenure activities are not required.35
Geological sequestration sites are unique and therefore the approach to proper site selection should be tailored to the characteristics of each site. Sequestration site management should be informed by a site-specific risk assessment and management plan. This will reduce uncertainties and enhance site understanding through iterative data collection and analysis throughout the entire life of the project. A risk-based approach is the most prudent for CO₂ sequestration as attention is directed towards potential adverse events specific to that site. Adopting a risk-based approach to site selection provides the proponents with more flexibility in the project design. Levels of acceptable risk should be defined by the regulator on a case-by-case basis for each project through an interactive dialogue between project proponents and the regulator.

In their application for CO₂ sequestration, proponents must demonstrate that the sequestration complex has adequate capacity, sufficient injectivity and suitable containment. This includes a review of all wells within the area of review\(^{36}\) that penetrate the sequestration complex.

Adoption of general criteria for site selection will assist proponents in demonstrating achievement of these objectives. Examples of parameters for which criteria should be developed include fracture pressure, pressure front evaluation and induced seismicity. Such criteria will help ensure public safety of CCS projects and contribute to the acceleration of CCS activities in the province. Therefore, the steering committee recommends that:

RECOMMENDATION 15

The Government of Alberta should adopt general site selection criteria and the regulator should review the requirements that apply to CO₂ sequestration to ensure that they adequately reflect the overarching objectives of adequate sequestration volume capacity, sufficient injectivity and suitable containment.\(^{37}\)
9.2 SEQUESTRATION QUALITY PORE SPACE RESOURCE

Currently, decision makers in the private or public sector do not typically consider pore space as a resource. In the near future, this could impede the ability to achieve the emissions reduction targets attributed to CCS if high quality pore space for CO₂ sequestration is not effectively managed. Thus, the steering committee recommends that:

RECOMMENDATION 16
The Government of Alberta should promote and/or facilitate the development and periodic updating of an inventory of sequestration-quality pore space in the province.\(^{38}\)

Currently, the *Oil and Gas Conservation Act* requires a project proponent to demonstrate that a CO₂ sequestration project will not interfere with the recovery, conservation, or storage of oil or gas. A number of pore space inventories have already been developed, or are currently under development, by various federal and provincial organizations and in collaboration with other jurisdictions. Although estimates have been made, more work needs to be done by the Government of Alberta to accurately inventory sequestration-quality pore space in Alberta. An increasingly detailed inventory of sequestration pore space in the province would be a useful tool for pore space management and subsurface resource decision making in the province. Therefore, the steering committee recommends that:

RECOMMENDATION 17
When developing the inventory of sequestration-quality pore space, and when practical, the Government of Alberta should identify potential areas of interaction between subsurface resources and sequestration-quality pore space, particularly those interactions with resources that have a higher development priority.\(^{39}\)

The working groups identified that a well-chosen site is a key outcome of sequestration risk management. Development of CO₂ sequestration projects requires careful site selection to ensure that CO₂ is permanently contained in the deep subsurface. Once an appropriate site is identified, proponents must acquire the legal rights and necessary regulatory approvals to proceed with the sequestration project, as outlined in the next section.

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\(^{38}\) Refer to Appendix D6.

\(^{39}\) Refer to Appendix D6.
10 INITIAL APPLICATION AND PERMITTING PERIOD

10.1 OVERVIEW

The initial application and permitting period begins when a proponent applies for a tenure agreement for the chosen site and includes granting of all initial regulatory approvals required. There are several stages to this process, which can be described as:

- initial acquisitions
- discretionary activity review and potential Environmental Impact Assessment (EIA)
- regulatory approvals.

The permitting process is outlined in Figure 8.
The initial acquisitions stage includes obtaining subsurface and surface rights. Any other requirements needed to conduct exploration activities to further characterize the chosen site must also be met. For CO₂ sequestration, subsurface rights agreements include evaluation permits and carbon sequestration leases. After subsurface rights are obtained, surface rights must be acquired because permission is required to access the land. The process differs for private versus public land. Private land requires an agreement between the lessee and the landowner. On public lands, a mineral surface lease must be obtained from Alberta Environment and Sustainable Resource Development.

Following the initial acquisitions stage, a review is completed to determine whether a project requires a provincial Environmental Impact Assessment (EIA). EIA is administered by Alberta Environment and Sustainable Resource Development. CCS projects are not specifically listed in the regulation as requiring EIAs. However, an assessment may be triggered through a review of the project as a discretionary activity. It is important to note that a completed EIA does not mean that the project is approved. The EIA provides the regulator with the data in order to make an informed decision that is in the public interest.

A well licence application can be completed while the project is in the initial acquisitions stage. Under the ERCB Directive 056, any petroleum industry development that includes wells, pipelines or other structures requires a licence from the ERCB to construct and operate. These requirements are intended to ensure environmental protection, public safety and effective resource management. It also requires applicants to consider stakeholder issues. For a CCS project, an evaluation well(s) may be drilled to acquire specific information needed for approval of an injection scheme. A CCS proponent must apply to ERCB for approval of injection and monitoring wells under ERCB Directive 051 which sets out the technical requirements of an injection well.

After drilling, completion and testing of an injection well, proponents can apply for an injection scheme approval under ERCB Directive 065. Directive 065 currently requires an applicant to have all proposed injection wells completed and test results available prior to scheme approval. Applications under this directive provide information necessary for the ERCB to determine that there will be containment of the disposal fluid. Injection wells must also meet the requirements of Directive 051.

Prior to the ERCB providing final approval for schemes for CO₂ sequestration, the application is referred to the Minister of Alberta Environment and Sustainable Resource Development for review and approval. As part of this review the Minister may impose additional conditions. Once final approval is obtained from the ERCB the project can commence subject to conditions and regulatory requirements.

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40 There are also Environmental Assessments required for certain projects under federal law. These requirements are not contemplated in the RFA recommendations.
10.2 REGULATORY ROLES AND RESPONSIBILITIES

For some aspects of the regulatory process for CCS, the division of roles and responsibilities among the ERCB and other various government departments is unclear. In order to ensure the effectiveness and efficiency of the CCS regulatory system, and to reduce uncertainty for project proponents, the Government of Alberta should clarify those roles and responsibilities, and make this information readily available.

One of the areas where roles need to be clarified and possibly changed is the role of the regulator in the issuance of closure certificates. It will be important for the regulator to have a significant role in this process either as the entity that issues the certificate or by providing advice to the Minister of Energy on closure certificate applications. The Government of Alberta will need to determine how best to involve the regulator in this role. Therefore, the steering committee recommends that:

RECOMMENDATION 18

The Government of Alberta should clarify the regulatory roles and responsibilities related to the regulatory process for CCS. Particular attention should be given to determine the regulator’s role in issuing closure certificates. This process should also aim to identify and implement efficiencies in the regulatory and approval process to promote the timely review and approval of CCS project applications.44

Presently, there is limited information available on the regulatory process for CCS, and most of it is either outdated or difficult to access. For example, the ERCB has in place Bulletin 2010-22 ERCB Processes Related to Carbon Capture and Storage Projects.45 This bulletin provides a high-level overview of ERCB processes and approvals. However, the bulletin has become outdated and does not contain sufficient detail of the entire regulatory process to represent a stand-alone guidance document useful to all stakeholders. The ERCB has another document entitled Upstream Oil and Gas Authorizations and Consultation Guide46 that is a reference document that identifies the common authorizations (approvals, licenses, dispositions, permits, and registrations) required by Alberta regulatory agencies and government departments for upstream oil and gas development activities. However, the guide does not currently offer specific information for CCS projects.

44 Refer to Appendix D1.
The regulatory process and requirements for CCS must be openly and clearly communicated to project proponents, operators, stakeholders and the public. A comprehensive document detailing the full regulatory process for CCS is important to:

- Ensure that the CCS regulatory framework is transparent.
- Provide regulatory certainty for CCS project proponents.
- Help proponents efficiently navigate the regulatory process.
- Provide assurance to stakeholders and the public that the CCS regulatory process and framework is robust, and that CCS is being managed properly.

Therefore, the steering committee recommends that:

**RECOMMENDATION 19**

The Government of Alberta and the regulator should coordinate the development of a CCS Regulatory Guidance Document, similar to the existing Upstream Oil and Gas Authorizations and Consultation Guide,\(^{47}\) that clearly:

a) Provides detailed information on all approvals and authorizations related to CCS.

b) Documents roles and responsibilities for regulators and government departments.

c) Provides detailed information on the process for acquiring pore space tenure and a permit to inject \(\text{CO}_2\).

d) Provides detailed information on the requirements for the issuance of a closure certificate.

e) Includes process maps, regulatory flow charts, web links, etc.\(^{48}\)

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\(^{47}\) Available at http://authorizationsguide.ercb.ca

\(^{48}\) Refer to Appendix D1.
10.3 TENURE AND TENURE REQUIREMENTS

10.3.1 Pore Space Tenure: Process

After identifying a site for CO₂ sequestration, project proponents must acquire pore space tenure before they can seek regulatory approvals to drill evaluation wells, injection and monitoring wells, or sequester captured CO₂. Like the Crown mineral tenure for petroleum and natural gas, pore space tenure is administered by Alberta Energy. Pore space rights are granted to project proponents on a first-come, first-served basis, and are subject to various requirements depending on the type of tenure agreement that a proponent seeks to acquire.

The Carbon Sequestration Tenure Regulation creates two separate pore space agreements which are the primary mechanisms for proponents to acquire rights to pore space for CCS purposes. The first agreement is known as an evaluation permit which has a five-year term (non-renewable) and grants proponents the right to conduct evaluations and testing of subsurface reservoirs for the purposes of determining their suitability for CO₂ sequestration. The second type of agreement is a carbon sequestration lease which has a renewable 15-year term and grants proponents the right to drill wells, conduct evaluation and testing and inject captured CO₂ into subsurface reservoirs for permanent sequestration.

For Crown mineral tenure, once an application has been received, Alberta Energy examines the requested rights to ensure that they have not been allocated, and refers the request to the multi-agency Crown Mineral Disposition Review Committee (CMDRC) for a review of any potential surface access restrictions relating to the requested lands. The CMDRC reviews, at the request of Alberta Energy, all surface restrictions affecting Crown mineral rights (e.g. petroleum and natural gas, oil sands, metallic and industrial minerals, and ammonite shell) to consider the possible effects of mineral exploration and development activities on the environment within and adjacent to the requested rights prior to leasing them. The CMDRC may recommend that lands be withdrawn from disposition, or that the proposed disposition be granted with or without special terms and conditions. To ensure the same level of rigour for reviews of applications of pore space tenure, the steering committee recommends that:

**RECOMMENDATION 20**

Sequestration tenure applications submitted to Alberta Energy’s Tenure Branch should be subject to review by the Crown Mineral Disposition Review Committee.\(^{49}\)

\(^{49}\) Refer to Appendix D20.
Alberta Energy’s website contains detailed information on the tenure process and application requirements for Crown resources. To facilitate an efficient and transparent tenure process, and to increase public knowledge about the CCS industry, it is important for clear information about pore space and the tenure process to be available to CCS project proponents, stakeholders and the public. To enhance the transparency of the tenure process for pore space, the steering committee recommends that:

**RECOMMENDATION 21**

All requirements for acquiring a sequestration tenure agreement and information on pore space should be accessible to industry and the public on Alberta Energy’s website.\(^{50}\)

In Alberta, the Crown owns the pore space found below the surface of the land, excluding the pore space found below land owned by the Government of Canada. As a pore space owner, the Crown is responsible for the disposition for CCS and other subsurface activities. Currently, the Crown grants access to pore space through the mechanisms outlined in the Carbon Sequestration Tenure Regulation as well as section 54(5) of the *Mines and Minerals Act*.

This legislation offers a mechanism for project proponents to obtain rights to pore space. Section 54(5) is used to provide tenure for undisposed Crown rights where resource tenures do not currently apply. This section is commonly used to grant access to pore space for acid gas disposal (AGD) schemes, where a proponent is proposing injection into an area with no petroleum or natural gas tenure. Applications for section 54(5) authorizations are rigorously reviewed by Alberta Energy, and the standard ERCB application and approval process applies for all facilities and wells included within a project. Depending on project characteristics, the project may also require approval from Alberta Environment and Sustainable Resource Development.
In order to support the development of CCS knowledge both within Alberta, and globally, it is important for the Government of Alberta to facilitate CCS research projects within the province. In some instances, it may be appropriate to allow small-scale CCS research projects to operate at depths shallower than 1000 metres. Section 54(5) outlines the way these projects may acquire pore space tenure in lieu of evaluation permits or a carbon sequestration lease, which are only applicable for pore space deeper than 1000 metres below the surface of the land. Therefore, the steering committee recommends that:

10.3.1.1 Measurement, Monitoring and verification (MMV) and Closure plans

Under the Carbon Sequestration Tenure Regulation, carbon sequestration lease applicants are required to submit an MMV plan and an initial closure plan. Proponents applying for an evaluation permit are required to submit an MMV plan, but not a closure plan. The MMV plan sets out the monitoring, measurement and verification activities that a project proponent will undertake for the term of the permit or carbon sequestration lease. The closure plan sets out a description of the activities that a lessee will undertake to close down sequestration operations and facilities. Both MMV and closure plans must also contain an analysis of the likelihood that a project will interfere with other mineral recovery activities in the area.

RECOMMENDATION 22

The Government of Alberta should use the Ministerial letter of consent under the authority of section 54(5) of the Mines and Minerals Act to facilitate CCS research activities in the province.

51 Refer to the Carbon Sequestration Tenure Regulation, Section 1(c), 2011.
52 Refer to Appendix D1.
Presently, the Minister of Energy is responsible for the approval of MMV and closure plans as part of the tenure application process. These plans are an important component of the application package that is submitted to Alberta Energy as they contain pertinent information to inform its decision on allocation of pore space tenure, including information related to potential impacts on other mineral resources. However, these plans will also contain specific technical performance criteria requirements and outline proposed MMV and closure activities. It is important for the regulator to undertake a detailed review and approve these plans to ensure that the reviews are transparent for the public. Therefore, the steering committee recommends that:

**RECOMMENDATION 23**

Submission of a monitoring, measurement and verification (MMV) plan and closure plan should be a requirement for all CCS related applications to the regulator, and should continue to be a requirement for tenure applications to Alberta Energy (closure plans for sequestration lease applications; monitoring, measurement and verification plans for both evaluation permit and sequestration lease applications).\(^{53}\)

The purpose of MMV is to address health, safety and environmental risks, evaluate sequestration performance and provide evidence that the site is suitable for closure. MMV is central to CO\(_2\) sequestration risk management. There are no requirements for the submission of a risk assessment of CO\(_2\) sequestration projects in Alberta legislation. However, the *Mines and Minerals Act* allows for the creation of regulations that require applicants to conduct risk assessments before being granted an agreement for CO\(_2\) sequestration.\(^{54}\)
The submission of a risk assessment will allow for more thorough risk management throughout the life of the project. MMV and closure plans are developed in response to the risks identified. Requiring a risk assessment will enable the proponent to communicate to the regulator and stakeholders what the MMV and closure plans are based on. The ongoing development of the risk assessment over the life of the project could be used as a tool to communicate sequestration performance and permanence of greenhouse gas reductions when applying for transfer of liability and transferring MMV infrastructure. As a result the steering committee recommends that:

RECOMMENDATION 24

The Government of Alberta should require risk assessment as an integral part of the MMV plan and closure plan submissions for carbon sequestration projects. A risk assessment provides the foundation for the MMV and closure plans and should be performed, reviewed and updated together as required to support the regulatory process.\textsuperscript{55}

\footnotesize{Refer to Appendix D15.}
The project proponent should determine, in consultation with the regulator, the methodology appropriate to the project to ensure that the risk assessment meets the requirements of the regulator. Although different risk assessment methods are in use, appropriate methods will contain similar analytical elements and will identify similar threats and consequences for any given project. For CO₂ sequestration risk assessments, the steering committee recommends that:

RECOMMENDATION 25

The Government of Alberta should endorse the following guidelines for risk assessments:

a) Risk assessments should be iterative, systematic, technically defensible, transparent and available to the public as integral to monitoring, measurement and verification, and closure plans.

b) Modelling and simulations should be undertaken (as applicable on a site-specific basis) to evaluate and predict the behaviour of the CO₂ sequestration complex and inform the risk assessment.

c) Records of risk assessments (including all iterative updates and comparisons of predicted behaviour of the sequestered CO₂ with measured performance) should be retained for the life of the project to support MMV plans and closure certificate applications.

d) Non-technical risks related to public acceptance of MMV should be identified and addressed by project proponents.\(^{56}\)
CO₂ sequestration projects are monitored extensively to address health, safety and environmental risks, and to collect data regarding containment, conformance and utilization of pore space. MMV plans are developed by the project operator to meet regulatory requirements and conditions specified in project approvals. Sufficient data must be collected regarding the behaviour of the sequestered CO₂ for several purposes. Measurement and monitoring of the injection facilities, geological sequestration site and surrounding environment provide assurance that CO₂ is confined to the sequestration complex (containment). Verification refers to the comparison of measured and predicted performance and is used to ensure sequestration sites are operating as predicted and permitted (conformance). MMV plans should be fit for purpose and developed to include several elements identified by the working groups. Therefore, the steering committee recommends that:

**RECOMMENDATION 26**

The Government of Alberta should require MMV plans to be risk-based and site-specific.⁵⁷

Technology selection for MMV plans must address the site-specific nature of CO₂ sequestration. A wide range of technologies are available for different monitoring tasks. In development of a MMV plan, monitoring tasks are identified and suitable technologies are selected to provide comprehensive data. The steering committee recommends that:

**RECOMMENDATION 27**

The Government of Alberta should recognize that MMV plans require a comprehensive suite of technologies to address health, safety and environmental risks, evaluate sequestration performance and provide evidence to support the issuance of a closure certificate.

Monitoring should take place in each domain of review⁵⁸ and technologies should be selected based on a site-specific evaluation of the ability of the technology to perform the identified monitoring task. As there is no single technology that can provide complete data on sequestration performance, a comprehensive suite of complementary technologies should be selected to provide the information required.⁵⁹

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⁵⁷ Refer to Appendix D9.
⁵⁸ Refer to Appendix C for a description of this term.
⁵⁹ Refer to Appendix D9.
The protection and monitoring of potable groundwater is an important consideration in the site selection and development of a CO$_2$ sequestration project and associated MMV plan. In Alberta, the Water Act provides a framework for protection of non-saline groundwater and the Environmental Protection and Enhancement Act prohibits the release of a substance in an amount that may cause a significant adverse effect. Groundwater monitoring above the base of groundwater protection (BGWP) is important to establish baseline data for freshwater aquifers. It also protects the quality of the drinking water and provides assurance to the public. The steering committee recommends that:

**RECOMMENDATION 28**

The Government of Alberta should require shallow groundwater monitoring programs as part of the MMV plan for CO$_2$ sequestration projects. Programs should be project-specific and risk-based.\(^{61}\)

Under the *Carbon Capture and Storage Statutes Amendment Act*, the Government of Alberta assumes long-term liability for a CCS storage site once a closure certificate is issued. When the Government of Alberta issues a closure certificate it will indicate that a lessee has met the regulatory requirements of Alberta Energy, Alberta Environment and Sustainable Resource Development, and the ERCB concerning closure (activities, plan and period) and the behaviour of the sequestered CO$_2$ is trending toward stability. Closure plans set out a description of the activities that a lessee will undertake to close down CO$_2$ sequestration operations, and contains specific informational requirements that a project operator is required to track and report on throughout the life of the project. The purpose of the closure plan is to minimize the risks associated with liabilities assumed by the Crown after a closure certificate is issued.

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\(^{60}\) In Alberta, the *Water Act* defines saline groundwater as water that has total dissolved solids (TDS) exceeding 4000 milligrams per litre. Aquifers with total dissolved solids less that 4000 mg/L are described as non-saline.

\(^{61}\) Refer to Appendix D8.
The Carbon Sequestration Tenure Regulation sets out the requirements for what must be included in interim closure plans that are submitted every three years for review and renewal.\footnote{Carbon Sequestration Tenure Regulation, Section 19(3), 2000.} The steering committee believes all closure plans should fulfill these requirements and recommends additional requirements for project proponents to systematically communicate sequestration performance, and project updates to the Government of Alberta and the regulator. Therefore, the steering committee recommends that:

RECOMMENDATION 29

In addition to requirements already in the Mines and Minerals Act and Carbon Sequestration Tenure Regulation, information required to be in a closure plan should include, but not be limited to, the following:

a) project overview
b) storage performance criteria for site closure
c) storage performance evidence
d) operating plan updates
e) description of current and potential surface or subsurface interactions
f) proposed closure activities
g) any other information required by the regulator, other departments or agencies of the Government of Alberta.\footnote{Refer to in Appendix D2.}
Project proponents are required to submit an initial closure plan with their tenure (carbon sequestration lease) application. In addition, lessees are required to submit a revised interim closure plan to Alberta Energy and the ERCB every three years for renewal. This three-year review offers the opportunity for the Government of Alberta and the operator to continuously assess and monitor the state of the project and identify any risks. Finally, operators should also be required to submit a final closure plan when applying for site closure. To provide clarity for project proponents, operators and the public, and to ensure consistency among a lessee’s different closure plans, all closure plans (initial, interim and final) should contain, at a minimum, all of the required information categories established by the Government of Alberta. It is important for this information to be easy to understand and access for project proponents, operators and the public. This ensures that the regulatory framework is transparent, and that the requirements for closure are clearly communicated to all stakeholders. As a result, the steering committee recommends that:

**RECOMMENDATION 30**

The Government of Alberta should develop a regulation, directive or guidance document outlining the categories of information required for all closure plans. This detailed information should allow for the closure plans to be project-specific.

At a minimum, the categories of information currently required in an interim closure plan should be present in all plans. If the Government of Alberta or a project proponent feels supplementary information is beneficial or necessary, additional categories can be included when a plan is renewed.

In cases where a category is not applicable (e.g. because the project is in early stages), the proponent should provide an explanation of its expectations for that category and/or why it is not applicable.\(^{64}\)
10.3.2 Pore Space Competition and Access

In addition to tenure process considerations, the working groups also undertook a review of high level policy objectives related to pore space to determine opportunities to improve pore space management and development in the province.

In the Climate Change Strategy, Alberta predicted that CCS will account for 139 megatonnes of CO₂ emissions reductions per year by 2050. Assuming average capture rates of one to two megatonnes annually, this level of CO₂ reduction would result in 80 to 100 commercial scale facilities. If each facility were to have its own sequestration site, this could result in a similar number of sequestration sites across the province. This potential proliferation of sequestration sites introduces policy challenges related to resource competition and pore space management and development. As the CCS regulatory process progresses, there are important policy issues that Alberta Energy needs to consider during the tenure process.

Based on the rate of CO₂ that needs to be sequestered to meet the 2050 goals, it is important that industry make reasonable attempts to collaborate on CO₂ sequestration projects. This will allow industry to capture economies of scale, share knowledge and experience, maximize pore space utilization, and reduce the incremental environmental impact (e.g. surface infrastructure) of CCS. The steering committee does not believe that such collaboration should be required. However, it would be prudent to encourage industry to adopt these practices. This collaboration would ideally be achieved prior to the tenure application, during the site selection phase. Any additions to a project after tenure is issued would likely require additional tenure to be allocated. As a result, the steering committee recommends that:

**RECOMMENDATION 31**

Proponents of CO₂ sequestration projects should be encouraged to solicit indications of interest from other large CO₂-emitting facilities to attempt to identify opportunities for collaboration on CO₂ sequestration and receive additional sources of CO₂ for injection where appropriate and feasible.65

As with all subsurface resource development projects, CO₂ sequestration projects can interact with and impact other subsurface resources and developments. Sedimentary basins that have high CO₂ storage potential also host fossil fuel, groundwater, minerals and geothermal energy resources. They also provide options for gas storage and the permanent disposal of waste materials. These subsurface interactions can have negative impacts, leading to competition for pore space. The interactions can also be positive and provide the opportunity for development synergies. During the pore space tenure review process, the proponent must identify and assess any potential interactions that a proposed CCS project may have with other subsurface resources. The Government of Alberta will then make decisions on subsurface resource development priorities.
Presently, the Government of Alberta manages potential interactions between CO₂ sequestration and hydrocarbon resources. Prior to the RFA, the Government of Alberta took steps to manage the interaction between CCS and hydrocarbon resources by amending a number of pieces of legislation explicitly mandating that CCS projects will not interfere with or negatively impact hydrocarbon projects in the province. Within the MMV plan submitted for evaluation permits and carbon sequestration leases, project proponents must analyze the likelihood that their project will interfere with other mineral recovery operations. If there is potential for a CCS project to interact with hydrocarbon resources, then Alberta Energy must decide whether to deny pore space tenure, or grant tenure and leave it to the regulator to evaluate if the potential resource interactions can be effectively managed to prevent negative impacts on mineral recovery. The current ERCB process is guided by Government of Alberta resource development policies, and is well-suited for evaluating and managing mineral resource interactions with CCS development.

Conservation of hydrocarbon resources is currently the prime resource development priority for the Government of Alberta, and the pore space tenure process is the primary process to ensure that CCS development will not negatively impact the hydrocarbon development industry in the province. As illustrated by the recent surge in development of coalbed methane and shale oil and gas, it is important to recognize that the definition of ‘resource’ and ‘resource development priorities’ are constantly changing.

In the future other resources such as geothermal and dissolved minerals in saline brine may increase in value and importance. Therefore, it is important that the Government of Alberta and the regulator identify the full suite of potential subsurface resource interactions related to CCS development, and evaluate them based on realistic expectations for future resource development opportunities and priorities.
When considering subsurface resource applications, it will be important for the Government of Alberta and the regulator to evaluate the impact that other resource developments may have on high-quality pore space resources and seals (e.g. caprock). Currently, most decision makers in the private or public sector do not consider pore space a resource because it is viewed as having no value and does not need to be considered when making trade-off decisions relating to resource development and planning. This could impede the Government of Alberta’s ability to achieve the emissions reduction targets from CCS outlined in the Climate Change Strategy. Therefore, the steering committee recommends that:

RECOMMENDATION 32

When reviewing subsurface resource development applications, the Government of Alberta and the regulator should continue to evaluate potential resource and development interactions on a case-by-case basis based on resource development policies of the day and realistic future resource development opportunities and priorities. Moreover, the Government of Alberta should:

a) Explicitly consider the impact on sequestration-quality pore space, seals (e.g. caprock) and existing stored CO\textsubscript{2} when making decisions relating to subsurface resource development and planning in the province.

b) Identify potential subsurface resource interactions when reviewing CCS applications.\textsuperscript{66}

In addition to the need to manage potential interactions between pore space tenure and other resources and resource developments through the tenure process, it will also be important for the Government of Alberta to manage the development of the province’s pore space resources to ensure they are used to their full potential.

Presently, CCS project proponents submit an application for carbon sequestration tenure for a tract of pore space that is available and meets their project specifications, including: depth, porosity, permeability and location. As CCS becomes a prominent activity in the province, demand for pore space, especially in those regions with high numbers of large industrial facilities, may compel project proponents to acquire pore space tenure in geological zones with close proximity to other pore space tenure areas. For example, project proponents could apply for pore space tenure in zones that are stacked or vertically overlaid (see Figure 9). Moreover, project proponents may apply for tenure adjacent to other tenure zones in order to operate as close as technically feasible in order to maximize pore space utilization in a particular area – referred to as jointly utilized (see Figure 10).
Figure 9. Illustration of Stacked or Vertically Overlaid Sequestration Zones
Both of these development scenarios present potential opportunities for Alberta Energy to maximize pore space utilization in a particular zone through tenure allocation, which could become increasingly important if CCS becomes a significant activity in the province. However, both scenarios also present a number of potential technical and regulatory challenges that suggest that there are reasons to be cautious about granting overlapping or adjacent leases to different parties. Competing CO$_2$ sequestration operations have the potential to affect one another in terms of injectivity, monitoring, liability and through overlapping pressure fronts. Therefore, when reviewing pore space tenure applications, and when reviewing project approvals, the steering committee recommends that:

Situations may arise where there is a high demand for pore space tenure agreements in regions that already contain existing agreements. In these situations where demand for pore space tenure outweighs the supply, it will be important for the Government of Alberta to introduce policy or regulations to incent or compel third party access to pore space for CO$_2$ sequestration to facilitate the development of CCS in Alberta.

There is currently no regulation in Alberta directly dealing with third party access or open access to pore space or CO$_2$ sequestration. There are, however, some portions of the Mines and Minerals Act and Carbon Sequestration Tenure Regulation that allow for the transfer of tenure between parties, and that give the Minister of Energy the authority to reduce the area of a permit or lease upon application of the permittee or lessee.

**RECOMMENDATION 33**
Applications for ‘stacked’ or ‘jointly utilized’ CCS projects should be considered on a case-by-case basis.\(^{67}\)
When confronted with unbalanced supply and demand for pore space tenure in an area, market principles and private negotiation should in most cases lead to appropriate agreements between parties, and there is no compelling reason to regulate third party access to tenured pore space without first exhausting reasonable avenues of private negotiation. It is important that regulations, legislation and directives do not pose unreasonable barriers to voluntary negotiations. Therefore, the steering committee recommends that:

In situations where private voluntary negotiations for third party pore space access have failed, the Government of Alberta should introduce policy or regulations to compel third party access to pore space for CO₂ sequestration. There are two primary policy drivers behind pore space open access regulations. First, the policy could be used to mitigate market power to prevent a few operators from controlling access to sequestration sites or imposing unreasonable conditions as a result of a favourable market position. Second, the policy could be used to ensure that the public-good aspects of CCS are fully realized, including reduced environmental footprint of CCS operations in Alberta and lower costs for industry and government.

The process for compelling third party access to another party’s pore space tenure refers to a situation where the regulator grants a CCS operator access to another party’s pore space tenure. Compelling third party access to pore space in this way is not a preferable course of action for CCS development in the province. A key concern with the policy is the potential negative impact that it could have on the original tenure holder and on the management of the sequestration complex. CCS projects are complex undertakings and require large financial investments by project proponents.

RECOMMENDATION 34
Market considerations should be the primary driver behind third party access to sequestration tenure and CO₂ injection. In this regard, sequestration site operators and other parties are expected to explore all reasonable avenues of private negotiation before applying to the regulator for access. Therefore, voluntary third party access to CO₂ disposal should be encouraged and should not be prohibited by regulations or legislation.⁶⁸

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⁶⁸ Refer to Appendix D11.
When developing regulations for pore space open access, it will be important for the Government of Alberta to balance the need for investment certainty for CCS tenure holders, and the need to promote the fair and efficient development of the province’s pore space for the public good. The Government of Alberta should not have the authority to allow other operators onto a tenure-holder’s site or to unilaterally transfer a portion of an operator’s tenure to another party. Only the site operator will have the most complete knowledge of the site’s geology and other characteristics necessary to ensure proper site operation. Therefore, the steering committee recommends that:

**RECOMMENDATION 35**

The Government of Alberta should not impose orders that give other parties the right to conduct their own injection operations on an operator’s sequestration site (i.e. within the operator’s tenure). Similarly the Government of Alberta should not have the authority to remove an operator’s sequestration tenure for the sole purpose of allocating it to another party.

There are certain situations where it may be necessary for the Government of Alberta to order a sequestration site operator to inject another party’s CO₂ when adequate sequestration sites are scarce (see Figure 11). When sites are scarce, this may lead to projects being sited close to each other, increasing the risk of pressure front and/or plume interactions. Additionally, pore space open access may also be justified if high quality sequestration sites which have been allocated through leases are not being used to their full potential (e.g. captured CO₂ is being sold to CO₂-EOR operators instead of being injected into the sequestration site).
Figure 11. CO2 Sequestration Project Open Access
In the event that there are compelling reasons to require an operator to inject another party’s CO$_2$, a mechanism should be in place to enable mandated access. However, it is critical that the burden of proof be on the party requesting access to demonstrate that there is sufficient justification for an access order. The conditions that a requesting party must satisfy should be relatively difficult to demonstrate, especially in the early days of the CCS industry, because mandated access is not a desirable outcome unless absolutely necessary. Therefore, the steering committee recommends that:

**RECOMMENDATION 36**

The Government of Alberta should create a mechanism whereby other parties can apply to the regulator to have their CO$_2$ injected by an existing CCS operator. Such an application should only be considered if the applicant can demonstrate all of the following:

a) There is sufficient capacity (over the life of the project, but taking into consideration pressure effects and the integrity of the sequestration complex) within the sequestration site to accommodate the applicant’s CO$_2$
   
   or
   
   The sequestration site’s capacity can reasonably be increased (including acceptable cost sharing provisions) to accommodate the applicant’s CO$_2$.

b) Injection of the applicant’s CO$_2$ will not restrict the ability of the site operator to inject its own CO$_2$ and/or other CO$_2$ the operator is contractually obligated to inject.

c) The sequestration site operator is not negotiating reasonably with the applicant and the applicant has exhausted all reasonable avenues of private negotiation.

d) The sequestration site is the only economically feasible way, or the most practical way for the third party to inject the CO$_2$, or is clearly superior environmentally to other options.

e) The sequestration site operator’s pore space tenure would not be affected and no additional tenure would be required.

f) The applicant’s CO$_2$ meets the technical requirements, including CO$_2$ composition, of the sequestration project.

g) Injection of the applicant’s CO$_2$ will not compromise the integrity of the sequestration complex.\textsuperscript{70}

\textsuperscript{70} Refer to Appendix D11.
If a party requesting pore space access is able to demonstrate all of the conditions outlined above, then any orders for access should include a determination of compensation to be paid to the sequestration site operator by the other party (the applicant) to ensure that the operator does not suffer economic harm, unless terms of settlement are agreed by the parties. Therefore, the steering committee recommends that:

**RECOMMENDATION 37**

The mechanism for other parties to apply to the regulator to have their CO$_2$ injected by an existing CCS operator should include provisions for the setting of reasonable rates of compensation to be paid to the sequestration site operator by the applicant. Determination of this compensation should take into account, but not be limited to, the following:

a) Any necessary increases in MMV activities.

b) Increases in operational and capital costs.

c) A reasonable share of upfront costs and financial risks for the project.

d) Liability for injected CO$_2$, including greenhouse gas liability (e.g. CO$_2$ credits).

e) Additional payments into the Post-closure Stewardship Fund (PCSF).\(^{71}\)

Refer to Appendix D11.
When mandating third party access to a sequestration site, the Government of Alberta will also need to consider issues related to liability for CO₂. Under normal operating conditions, a CCS tenure holder is fully liable for all of the CO₂ injected into the subsurface (and related PCSF payments). Because potential orders for third party access would require an operator to inject another party’s CO₂, and not allow other operators into the storage site, liability (including PCSF payments) for the CO₂ should continue to rest with the tenure holder. Any costs associated with this liability and PCSF payments can be recovered through compensation paid by the third party for injecting its CO₂. Companies should be permitted to enter into private agreements to share liability burdens; however, it is important that the Government of Alberta and landowners have complete certainty that they only need to deal with a single legal entity regarding liability for an operation, and that entity is the tenure holder. Therefore, the steering committee recommends that:

**RECOMMENDATION 38**

When a pore space tenure holder injects another party’s CO₂, whether via voluntary private negotiation or by order of the regulator, liability for that CO₂ should remain with the holder of pore space tenure until the transfer of liability to the Government of Alberta. Furthermore, the tenure holder should be responsible for paying into the Post-closure Stewardship Fund for that additional injected CO₂.\(^\text{72}\)
The fact a sequestration site operator has been ordered by the regulator to inject a third party’s CO₂ should not affect the operator’s ability to cease operations when it so desires. As long as satisfactory terms of transfer can be agreed upon and the Government of Alberta is satisfied that the third party is capable of effectively operating the sequestration operation, there should be no prohibition against transferring the operation to that third party. Encouraging such a transfer when a sequestration operator wishes to cease operations would allow the third party’s CO₂ to continue to be injected without the investment required to develop a new project. This can help to reduce costs for CCS and reduce the overall environmental impact (e.g. surface infrastructure). Therefore, the steering committee recommends that:

**RECOMMENDATION 39**

If a sequestration site operator that is injecting a third party’s CO₂ wishes to cease operation of the site, then, if both parties and the Government of Alberta agree and satisfactory terms can be arranged, a transfer of the site to the third party should be allowed and encouraged.73

The mechanisms for third party access outlined above are relevant in situations where a tenure holder has injection infrastructure already developed on site. However, there may be situations where tenure is completely unused at a site and where no injection infrastructure has been constructed. In these situations it would be unreasonable for the Government of Alberta to require a tenure holder to construct injection infrastructure in order to accommodate and inject a third party’s CO₂. In this case, it may be necessary for the Government of Alberta to have the ability to rescind or revoke tenure that is wholly unused.

Under the Mines and Minerals Act and the Carbon Sequestration Tenure Regulation, the Government of Alberta does not currently have the ability to revoke unused tenure, except to elect not to approve renewal of the tenure (a carbon sequestration lease) at the end of the 15-year term. Therefore, a mechanism should be created to allow the Minister of Energy to make changes to tenure after a defined period of time, if it is not being used. It is important that the Government of Alberta have the flexibility to decide what period of time is appropriate for each application for pore space tenure. To ensure that investors have a reasonable level of certainty in their tenure, it is important that the lessee know, when the tenure is issued, under what conditions and after what period of time the tenure could be revoked. The conditions and time period should be discussed with the lessee during review of the tenure application. This is similar to provisions in mineral tenure. Therefore, the steering committee recommends that:

**RECOMMENDATION 40**

The Government of Alberta should consider restructuring carbon sequestration leases so that the Minister of Energy has the authority to revoke or rescind tenure that has not been used after a defined period of time.74
10.4 **DISCRETIONARY ACTIVITY REVIEW AND POTENTIAL ENVIRONMENTAL IMPACT ASSESSMENT**

An Environmental Impact Assessment (EIA) is an assessment of the potential positive or negative impacts that a proposed project may have on the environment. Project proponents are responsible for evaluating the project-specific and cumulative impacts that a project may have on the environment and reporting that information to the regulatory decision makers. The purpose of an EIA is to ensure that decision makers consider all of the potential impacts of a proposed project before making a decision to allow it to proceed.

In Alberta the governing legislation for environmental assessment is the *Environmental Protection and Enhancement Act*, and is administered by Alberta Environment and Sustainable Resource Development. Alberta’s environmental assessment process has three basic goals:

- gather information
- provide a forum for public involvement
- support sustainable development in the province.

In Alberta, EIAs are a useful tool to gather information about a proposed activity, but they are not the mechanism by which a proponent is given approval to construct and operate a facility. This is accomplished via approvals granted under the *Environmental Protection and Enhancement Act*, *Water Act*, *Public Lands Act*, *Oil and Gas Conservation Act*, *Pipeline Act*, ERCB directives, and other legislation and regulations. These approval processes are the mechanisms by which the province can set conditions and requirements for the operation of the various components of a CCS project.

The Environmental Assessment (Mandatory and Exempted Activities) Regulation determines whether an environmental assessment is required for a particular project. This regulation defines the type of projects requiring an EIA and what projects specifically do not require an EIA. If a proposed activity is not on either the mandatory or exempt list, the Director (as designated by the Minister of Alberta Environment and Sustainable Resource Development) has the discretion to determine if the proposed activity warrants further environmental assessment.

Presently, the capture component of a CCS project is not on the mandatory or exempt list within the Environmental Assessment (Mandatory and Exempted Activities) Regulation. It also does not need an approval under the *Environmental Protection and Enhancement Act* unless it is part of a larger facility that is required to undergo that level of scrutiny. Similarly, the transportation and subsurface CO₂ sequestration components of a project are not on the mandatory or exempt list within the regulation, and do not require an *Environmental Protection and Enhancement Act* approval. Therefore, CO₂ capture and sequestration projects are only required to undertake an EIA if directed to do so by the Director of Alberta Environment and Sustainable Resource Development.

Alternatively, as with Quest, project proponents may elect to undertake a provincial EIA voluntarily. To date, no CCS projects have been required to undergo an EIA by the Government of Alberta. Due to funding from the Government of Canada, federal environmental assessments were required by the federal government for the Alberta Carbon Trunk Line and Quest.

To ensure a robust and efficient regulatory framework, it will be important for the Government of Alberta to determine the specific conditions under which an EIA would provide greater understanding of the project than the current regulatory process provides. While there is local and worldwide experience with various components of CCS technology, large scale integrated CCS is a relatively new development. For this reason, it will be important for the Government of Alberta to build public confidence in the regulatory framework. EIAs are one regulatory tool to collect information on the potential environmental and social impacts of a CCS project.
In the meantime, it will be important for the Government of Alberta to demonstrate to the public that CCS is subject to a high level of scrutiny. Requiring EIAs to be mandatory for CCS projects over the next three years, while a government review of EIA requirements for CCS is underway, will demonstrate the Government of Alberta’s commitment to public safety and the protection of the environment. Therefore, the steering committee recommends that:

**RECOMMENDATION 41**

By the end of 2015, the Government of Alberta should determine the specific conditions under which an Environmental Impact Assessment (EIA) provides significantly greater understanding of potential impacts stemming from CCS projects or components than the understanding that can be achieved through other regulatory requirements. From that, the government should evaluate:

a) If EIAs should be mandatory for CCS projects (or project components).

b) Whether threshold criteria should be established that would call for mandatory EIAs for CCS projects.

c) Whether a comprehensive assessment process specific to CCS should be developed that is appropriate for the unique aspects of CCS projects and builds upon current regulatory processes.

Until the above evaluation is complete, EIAs should be mandatory for CCS projects.\(^75\)

Refer to Appendix D7.
10.5 ENERGY RESOURCES CONSERVATION BOARD (ERCB) APPROVALS

After a project proponent acquires pore space tenure for CO₂ sequestration, they must acquire approvals from the ERCB to drill wells and to operate a CO₂ injection scheme. Approval for the operation of a CCS scheme in Alberta is the responsibility of the ERCB under the *Oil and Gas Conservation Act*. Currently, applicants for a CO₂ sequestration project use the acid gas disposal scheme requirements, which require approval for both surface and subsurface development, including ERCB’s Directive 056, Directive 051 and Directive 065 approvals.

10.5.1 Stakeholder Engagement

One of the first steps an applicant must complete before submitting an application to the regulator is to develop and implement a participant involvement program. Alberta has a comprehensive regulatory framework in place for oil and gas developments which emphasizes the importance of effective, early and ongoing public engagement. Broadly, public engagement serves to inform local stakeholders and address concerns.

Participant involvement requirements and expectations exist within ERCB Directive 056, Directive 065, and Directive 071 that must be considered both in advance of submitting an application for energy development and throughout the life of that development. Prior to filing an application, the applicant must address all questions, objections and concerns regarding the proposed development and attempt to resolve them. This includes concerns and objections raised by members of the public, industry, government representatives, First Nations, Métis and other interested parties.

ERCB requirements and expectations for stakeholder engagement apply to First Nations and Métis stakeholders. The Government of Alberta also has policy and guidelines related to First Nations Consultation on land management and resource development. Consultation will be required if it is deemed that a project may adversely impact the Rights and Traditional Uses (e.g. by affecting animal populations on nearby lands on which a First Nation exercises a treaty right to hunt those animals for food). Proponents are strongly encouraged to begin notifying First Nations early on when planning their projects and, where possible, consult First Nations before applying for government approvals. The steering committee did not identify any need to make CCS-specific recommendations regarding First Nations and Métis engagement requirements.

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76 In November 2012, the Alberta Legislature passed the *Responsible Energy Development Act*, which creates a single regulator for all oil, gas, oil sands, coal, and CCS projects in the province. This means that the ERCB is transitioning into the Alberta Energy Regulator at the time of writing of this report. Any reference to the ERCB in this report is also intended to refer to the Alberta Energy Regulator.


Effective public engagement and participant involvement programs are critical to promote long term relationships that will foster a collective and amenable approach to CCS in Alberta. A sound process for participant involvement exists in Alberta. However, the challenges associated with analogous approaches and uncertainties around public acceptance of CCS underline the need for CCS-specific requirements. These requirements will provide clear and transparent direction to industry, provide opportunity for communication and feedback, and continue to make public safety and confidence paramount. Therefore, the steering committee recommends that:

**RECOMMENDATION 42**

The regulator should review consultation and notification requirements for CO$_2$ sequestration projects and implement industry-wide minimum requirements specific to CCS and the inherent challenges and risks. The review should achieve, but not be limited to, the following outcomes:

a) Parties that may be affected through activities that require surface access must be identified and included in a participant involvement program. Consultation with these parties should include discussion of a MMV plan.

b) Notification of land owners, occupants and residents, including First Nations and Métis, should occur over a wider range than is currently required. This will increase transparency, public assurance and acceptance, and decrease the chance of misinformation. Identification of the range of formal notification activities should occur on a case-by-case basis considering elements relevant to the project application. This could include the extent of MMV activities, inherent risks of the project, subsurface CO$_2$ dispersion and precedents set.

c) Due to the extent and nature of large scale CO$_2$ sequestration operations, requirements to notify subsurface resources stakeholders, as defined in ERCB Directive 065, should extend beyond the 1.6 kilometres minimum currently required, but not further than the boundary of the sequestration lease.

d) Establishment of the required consultation and notification distances for the purposes of emergency response planning with reference to the properties of CO$_2$ (e.g. heavier than air, odourless, potential risks to human health, public safety) and expected air dispersion.

Refer to Appendix D13.
Formal notification and consultation requirements would likely apply to a smaller area than that of the sequestration lease area. However, to promote public awareness and enhance public acceptance of CCS, it is important that all landowners, occupants and residents within the lease boundary have an opportunity to learn about the project outside of formal notification and consultation activities. Therefore, the steering committee recommends that:

**RECOMMENDATION 43**

Land owners, occupants and residents (including First Nations and Métis) within the sequestration lease boundary should be informed about the project by the operator of the project through activities that may include, but not be limited to:

a) an expansion of consultation and notification requirements
b) open houses
c) information packages
d) advertising in local media
e) public outreach and education initiatives.

The scope of these activities should be developed in consultation with the regulator.\(^{80}\)

For many energy development projects, the regulator often requires operators to distribute standardized fact sheets as part of their project-specific information package that answer frequently asked questions on energy development topics (i.e. ERCB EnerFAQs). These documents are useful tools for increasing energy literacy in the province. Currently, the regulator does not have public information documents on CCS available for distribution. Because CCS is a relatively new process in Alberta, public acceptance and knowledge about it will be key to ensuring successful implementation. Therefore, the steering committee recommends that:

**RECOMMENDATION 44**

The Government of Alberta should develop public information documents on CCS.\(^{81}\)
10.5.2 Well Classification and CCS Schemes

Upon development and implementation of a stakeholder engagement program, project proponents can submit applications to drill wells and develop a CO₂ injection scheme. There are several techniques to determine if a reservoir is suitable for CO₂ sequestration, among them drilling wells to confirm the characteristics of the subsurface geology. There are two main ERCB Directives that outline the requirements for acid gas/CO₂ injection wells. The requirements and procedures for filing energy development applications are set out in Directive 056. Directive 056 authorizations also include approvals to construct and operate any petroleum energy development, including surface facilities, pipelines and wells.

Once a well licence has been granted, proponents are then permitted to drill, log and complete a well. Several existing ERCB directives regulate well completion, including:

- Directive 008, which regulates the minimum requirements for the depth of surface casing.
- Directive 009 and Directive 010, which regulate the minimum requirements for cementing and design.
- Directive 036, which regulates the requirements for drilling blowout prevention.

The ERCB requirements for intial drilling, completing, and open hole logging for acid gas well contructions are appropriate to meet the needs of CO₂ sequestration for large scale CCS injection wells.

Once a well has been drilled, logged and completed, an applicant must confirm the wellbore is suitable for acid gas injection. Directive 051 requirements are used to determine whether a well is both suitable and properly completed to handle the type of fluid proposed for injection or disposal. Directive 051 also clarifies completion, logging, testing, monitoring, and application requirements for injection and disposal wells, and specifies procedures designed to protect the subsurface environment, including potable groundwater and hydrocarbon-bearing zones.

Currently, CO₂ injection wells are classified as Class III wells under Directive 051. The Class III well classification covers a wide range of fluids and project activities. The ERCB is currently reviewing Directive 051 well classifications, and has proposed a new Class IIIa classification for injection wells for acid gas and impurities. The proposed new classification was reviewed by the working groups during the RFA, and it has been suggested that the proposed revisions and Class IIIa classification should consider all the various components and concentrations of fluids within the acid gas stream. This is important because there may be a continuum of gases in an acid gas stream, including CO₂ and H₂S, among others. Therefore, the steering committee recommends that:

RECOMMENDATION 45
Classification of CO₂ injection wells needs to be more specific and indicate the concentrations of other components at which a well will be classified as Class IIIa. All Class IIIa wells should be evaluated against the same criteria regardless of the purpose for which they are to be used.86

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86 Refer to Appendix D21.
Once the applicant determines that the well and reservoir are suitable for an acid gas disposal scheme, the applicant can file a disposal scheme application with regulator. Presently, CO₂ injection for CCS is regulated under the acid gas disposal section of ERCB Directive 065. Directive 065 requires an applicant to provide the regulator with information regarding reservoir characteristics and details of the proposed scheme.

Directive 065 requires applicants to provide significant details to demonstrate a full understanding of the geology for a CO₂ injection scheme. These requirements have been designed to ensure containment of the disposal fluid within a defined area, and the protection of offset hydrocarbon-bearing zones and groundwater. Therefore, the standard Directive 065 approval process requires proponents to drill and complete all wells (each requiring an ERCB Directive 056 approval) prior to receiving approval for a sequestration scheme.

This standard Directive 065 approval process may not always be appropriate for some large scale CCS projects containing multiple potential wells. Multiple-well CCS projects will typically develop in phases over a number of years. During initial operation, only a select number of the potential wells are required. As a project matures, and the CO₂ plume migrates away from the initial injection wells, it may become necessary to drill additional injection wells to maintain or increase injection rates. Because some of the anticipated wells may not be needed initially, requiring all wells to be drilled at the outset of a project could increase the project risk by introducing unnecessary potential leakage pathways.

To address some of these challenges, the regulator should adopt a scheme approach for approval of long term, multiple-well CCS projects. An example of a scheme approach would be where a project proponent acquires Directive 065 scheme approval after drilling some, but not all, of the proposed wells for a project. This is similar to the modified application process that is used for in-situ oil sands projects, and was followed for a CCS project already under development. The scheme approach allows the project proponent, in consultation with the regulator, to define a range of project descriptions that can be refined over time. The scheme approach will allow the regulator to approve a reasonable number of initial wells to be drilled that will still ensure a sufficient understanding of the geology and other aspects of a CCS scheme. It may also provide an opportunity to enhance public engagement throughout the entire development of a CCS scheme. Therefore, the steering recommends that:

**RECOMMENDATION 46**

The regulator should adopt a scheme approach for approval of CCS projects involving multiple wells. These applications should continue to be considered by the regulator on a site-specific, case-by-case basis, based on risk analysis.  

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88 Refer to Appendix D1.
After the ERCB has reviewed both Directive 065 and Directive 051 applications, and has a sufficient understanding of the project and all the potential impacts, a disposal scheme approval document is created. The approval document contains specific operating conditions, monitoring requirements, and reporting requirements for the specific disposal scheme. Transparency of information is important; as such, the regulator and industry should ensure easy public access to this information.

Current acid gas disposal scheme approvals require reporting to the ERCB on an annual basis to verify that the licensee is complying with the conditions stated in the approval. All standard monitoring and reporting is required for acid gas disposal schemes and wells, in addition to the monitoring and reporting requirements specified in the approval document.

To ensure that Alberta’s regulatory framework for CCS is robust and adaptive in how it regulates projects, it will be important for the Government of Alberta to continue to leverage local and global CCS expertise and knowledge. One important piece is the Canadian Standards Association (CSA) document Z741-12: Geological Storage of Carbon Dioxide. The standard is the first of its kind in the world and proposes guidelines for regulatory agencies, industry and others involved with CCS projects. A review of this standard would identify similarities and differences between the standard and the principles, guidelines and requirements already in place in Alberta legislation (regulations, standards and directives).

Therefore, the steering committee recommends that:

**RECOMMENDATION 47**

The Government of Alberta should undertake a review of the Canadian Standards Association Z741: Geological Storage of Carbon Dioxide following its final publication. The review would inform the decision as to whether the standard, or parts thereof, should be adopted by the province.\(^\text{89}\)
11 PRE-INJECTION PERIOD

11.1 OVERVIEW

The pre-injection period refers to the time from when the required initial regulatory approvals are received to the start of sustained injection. Several permits are required at this point in the development of a CO₂ sequestration project from different Government of Alberta departments and agencies. Certain activities can begin upon receipt of the initial permits and prior to final approval being granted to the project. As a result, some overlap will occur between the pre-injection period and the initial application and permitting period. Activities in the pre-injection period can include gathering additional information such as baseline monitoring data, drilling and completion of evaluation wells and an injection well, well integrity testing, and sequestration complex testing. Following final approval, construction of additional infrastructure can begin.
11.2 PRE-INJECTION MONITORING, MEASUREMENT AND VERIFICATION (MMV)

Following the selection of a sequestration site, several pre-injection tasks should take place with regard to monitoring. An initial monitoring, measurement and verification (MMV) plan is submitted with the application for an evaluation permit or a carbon sequestration lease. Once tenure is granted, the MMV plan will be refined during the pre-injection period. In the MMV plan, monitoring tasks are identified based on a site-specific risk assessment. The specific technologies to monitor areas of potential leakage are screened, evaluated and selected. The frequency of monitoring is determined and a schedule is proposed. Appropriate baseline data are acquired for monitoring targets using technologies selected. Some data used to characterize and select the site (e.g. seismic data) may form part of the baseline data set. Approvals for CO₂ sequestration projects may contain conditions from the ERCB or Alberta Environment and Sustainable Resource Development. Any additional monitoring and/or baseline data requirements identified by the regulator are incorporated into the MMV plan during the pre-operational period.

11.3 INJECTION WELL DRILLING, COMPLETION AND TESTING

As noted previously, an applicant must determine that the well and reservoir are suitable for a CO₂ sequestration scheme as per ERCB Directive 065. Once a well license is received, an operator can drill, complete and test an injection well. The particular requirements for this fall under ERCB Directive 051. This directive clarifies completion, logging, testing, monitoring, and application requirements for injection and disposal wells. Procedures and practices to protect the subsurface environment, including all potable groundwater, formation waters of potential economic value and hydrocarbon-bearing zones are specified. Within Directive 051, CO₂ injection wells are classified as Class III wells. It is of note that Directive 051 is one of a series of directives currently being reviewed by the ERCB. Figure 12 represents the construction of an injection well.

Other ERCB directives applicable to CO₂ well design and integrity that were also investigated include:

- Directive 008: Surface Casing Depth Requirements
- Directive 020: Well Abandonment
- Directive 009: Casing Cementing Minimum Requirements
Figure 12. Schematic Representation of an Injection Well.
A study that reviewed CO₂ and acid gas injection well failures in Alberta concluded that cementing to the surface is a key element for reducing the incidence of well failures. This includes surface casing vent flow and gas migration. The ERCB draft revision of Directive 051 proposes that CO₂ injection wells (proposed Class IIIa) require cementing to surface for both the surface and the next casing string run (see Figure 12). It was determined that, if implemented, the proposed requirements in conjunction with other casing and cementing measures may be adequate for the purposes of CO₂ sequestration.

Cementing to surface from both the surface and next casing string is the norm for new acid gas injection wells in Alberta. However, there may be reasons for a proponent to propose a modified well completion to the regulator including the need to implement specialized MMV technologies, or to obtain reservoir fluid samples that have not been contaminated by cement. A proponent may also wish to propose a modified well completion if they intend to convert existing wells, which currently do not meet the new Class IIIa cementing requirement, into injection wells. Based on the review of the current and proposed well construction requirements, the steering committee recommends that:

**RECOMMENDATION 48**

The regulator’s proposed requirements for surface casing, cementing the surface casing, and the next external casing string from the base of well (casing shoe) to the surface will generally be adequate for the purposes of CCS. However, if additional casing strings are used, the combined casing strings must isolate all formations from the base of the well to the surface. These requirements should be applicable to all Class IIIa wells (new wells and conversions). However, the proponent may propose a modified well completion which will be reviewed by the regulator using a performance-based approach as is the current practice. The reasons for a modified well completion may include:

a) Differences in the age, construction and prior use of converted wells (i.e. existing wells may be suitable for conversion to injection in an enhanced oil recovery scheme using the current risk-based assessment practice).

b) The implementation of special MMV technology (such as a downhole fluid sampling apparatus).

c) The need to obtain fluid samples that have not been contaminated by cementing.

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91 Refer to Appendix D21.
ERCB Directive 010 details minimum casing design requirements and includes information and requirements on various design criteria, including burst and yield strengths, alternative design methods and casing wear considerations. Licensees must also follow Directive 010 appendices to select the proper material specifications for all wells, taking into account composition and design factors, to determine the appropriate material specifications. When selecting materials, the licensee must consider current and anticipated future reservoir environments. Based on the review of the current requirement, the steering committee concludes that:

**CONCLUSION 5**

ERCB directives adequately cover material selection, casing and well head pressure requirements.\(^{92}\)

The proposed Directive 051 update will prescribe many of the requirements, including the frequency for hydraulic isolation and casing inspection logging. To address ongoing integrity and hydraulic isolation, Directive 065 also has minimum measurement and reporting requirements for well operation, corrosion protection and hydraulic isolation logs. The working groups found that current requirements for CO\(_2\) injection wells are appropriate for large scale CO\(_2\) sequestration projects and adequately protect underground sources of potable water. Therefore, the steering committee concludes that:

**CONCLUSION 6**

Current and proposed regulations adequately address the integrity and hydraulic isolation of well construction and testing requirements for new CO\(_2\) repository wells.\(^{93}\)

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92 Refer to Appendix D21.
93 Refer to Appendix D21.
12 INJECTION PERIOD

12.1 OVERVIEW

Once all project regulatory approvals are granted and construction is complete, a CO₂ sequestration project can begin operation and enter the injection period. The injection period is from the start of sustained injection (consistent with project applications) to permanent cessation of injection (with no further intent to resume operations). During this time, the project operator is responsible for operating the project as required by the regulations and within the parameters of the approval. Ongoing compliance is ensured by the ERCB and Alberta Environment and Sustainable Resource Development. The operator conducts monitoring as outlined in the project monitoring, measurement and verification plan and as required in the project approval. Reporting and updates to approvals and plans are submitted to the regulator as required throughout the injection period. Operators also have an obligation in this period to pay a fee-per-tonne rate into the Post-closure Stewardship Fund.
12.2 MONITORING, MEASUREMENT AND VERIFICATION (MMV)

During the injection period, monitoring is undertaken to demonstrate compliance with legislation, applications and approvals. At this point, data are gathered to demonstrate containment, conformance and use of the pore space. Monitoring results are used to inform and optimize project operations as well as trigger the investigation of non-conformance and mitigation and/or remediation activities as required. Monitoring data are used to ensure public safety and to confirm that the environment and availability of underground sources of drinking water are not adversely affected.

Updated MMV plans are submitted every three years along with an updated closure plan. Risk assessment is an iterative activity, and monitoring results are used to inform and update the project risk assessment. Monitoring technologies are evaluated during the injection period to ensure effectiveness. Results will also be incorporated into simulations and models so that actual and predicted behaviour can be compared and the MMV plan can be updated as necessary. This process will enable a systematic improvement of model predictive capability throughout the injection period. Ongoing dialogue with the regulator ensures that time-sensitive data are collected when available and to the extent required.

Conducting MMV activities are imperative in order to demonstrate conformance and containment of sequestered CO₂. The majority of MMV activities will occur in the areas overlying and surrounding the CO₂ plume, however there may be some activities required beyond them. Certain MMV techniques cannot provide complete data if access cannot be gained to key monitoring areas.

If access to land is required for MMV activities, an operator would typically negotiate with the private land owner (or Alberta Environment and Sustainable Resource Development for public land) to reach an agreement around land access. These agreements would also include compensation measures and address land owner concerns. If negotiations are unsuccessful, the Surface Rights Act enables the Surface Rights Board to issue a Right of Entry Order to an operator in order to conduct MMV activities. However, there is currently uncertainty as to whether the Surface Rights Act allows an operator access to land beyond the surface lease site (i.e. lands associated with wells, installations, pipelines or other lands required to give the operator access to the drilling operations). As a result, the steering committee recommends that:

RECOMMENDATION 49

The Surface Rights Act should be amended to enable the Surface Rights Board to grant an operator a Right of Entry Order for any land within the carbon sequestration lease or evaluation permit boundary in order to conduct required MMV activities as outlined in an approved MMV plan pursuant to Part 9 of the Mines and Minerals Act.\(^\text{94}\)
It is crucial that the process to review applications for Right of Entry Orders is rigorous and transparent to ensure that the process is fair to landowners and that their rights are adequately taken into account. The Government of Alberta’s recent Property Rights Task Force recognized this point, which led the government to commit to a review of the Surface Rights Act and Expropriation Act, and create a Property Rights Advocate. Recommendation 49 should be considered by the Government of Alberta in light of this need for a rigorous and transparent process and should take into consideration the results of reviewing those two acts.

12.3 REPORTING

The Carbon Sequestration Tenure Regulation presently requires an annual report to the Minister of Energy containing the findings and observations from MMV activities conducted for carbon sequestration lease holders. Reporting requirements have been reviewed and it was found that there are well established regulatory processes in place for reporting of volumetric data and monthly operations (e.g. injected volume and well status). These same requirements for measurement and production reporting would be applicable to carbon sequestration projects. The regulator acts as a data repository and manager, and handles public requests for information for upstream petroleum operations. The steering committee considers that this existing reporting system should be extended to include MMV data for carbon sequestration projects, and therefore the steering committee recommends that:

RECOMMENDATION 50

Reporting of MMV results by the project operator should fall under the jurisdiction of the regulator, following similar processes for approval of specific reporting requirements for upstream petroleum operations.

For the Government of Alberta to act as the operator after transfer of liability, it will need sufficient information about the project. To ensure that the Government of Alberta will receive all the necessary data, and that the lessee will know well in advance what data it will need to transfer, these data requirements should be discussed early in the project life and reviewed regularly. Designation of an authority with the sufficient experience to deal with this information will help to ensure the appropriate management of submitted data. As a result, the steering committee recommends that:

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95 Carbon Sequestration Tenure Regulation, Section 17(2), 2011.
96 Refer to Appendix D9.
Under Alberta’s Specified Gas Emitters Regulation, the use of offset credits is one of three compliance options available to regulated facilities (industrial facilities in Alberta emitting over 100,000 tonnes of CO₂ equivalent per year) to reduce emissions intensity. The Quantification Protocol for Capture of CO₂ and Permanent Storage in Deep Saline Aquifers is being finalized and will apply to CO₂ sequestration projects in deep saline formations. With respect to the offset protocol, the MMV plan will provide evidence of permanent containment of CO₂ in the sequestration complex, and that there is no release of CO₂ to the atmosphere. To ensure that offset credits for CO₂ sequestration are real and permanent reductions are achieved, the steering committee recommends that:

**RECOMMENDATION 51**

The Government of Alberta should designate an agency (either existing or a new one) to be responsible for the management of data submitted by operators of CCS projects.

This agency should develop and implement standards for the transfer and management of project data to the Government of Alberta. These standards will ensure that data are in a consistent, accessible, readable and interpretable format, and will prevent the loss of data.97

If any CO₂ is produced and/or released that was injected under a carbon sequestration lease, it must be accounted for and reported, and previously earned emissions reduction credits must be reconciled and/or properly accounted for under any other potential future provincial climate change policies.98

The Government of Alberta should determine the appropriate threshold of CO₂ volume produced or released that would trigger this requirement.

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97 Refer to Appendix D2.
98 Refer to Appendix D1.
12.4 POST-CLOSURE STEWARDSHIP FUND AND FINANCIAL SECURITY

The Government of Alberta passed legislation to assume regulatory and civil liabilities and obligations of the lessee upon the issuance of a closure certificate. To ensure that costs associated with those liabilities and obligations will not become a burden to Albertans, the Post-closure Stewardship Fund (PCSF) was created in 2010 with passing of the Carbon Capture and Storage Statutes Amendment Act, 2010. The PCSF was established to cover the costs associated with some of those liabilities and obligations in the post-closure period, and to protect the Alberta public from bearing those costs. Holders of carbon sequestration leases must pay into the PCSF at a yet to be specified rate per tonne of CO$_2$ injected. Section 122 of the Mines and Minerals Act establishes the PCSF and sets out the allowable uses. Currently, the PCSF can be used for monitoring injected CO$_2$, paying for expenses related to orphan facilities and fulfilling the other obligations assumed by the Government of Alberta upon issuance of a closure certificate.

The rates that commercial operators will pay into the PCSF should be determined based on the allowable uses of the fund. Therefore, the steering committee recommends that:

RECOMMENDATION 53

The Post-closure Stewardship Fund (PCSF) rate should include three components:

a) monitoring and maintenance,

b) unforeseen events and,

c) administrative costs associated with management of the PCSF and management of the data submitted by the lessee.

These components should be used only for calculating the PCSF rate. Money collected into the PCSF should not be segregated into these components.  

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99 A discussion of the liabilities and obligations assumed by the Government of Alberta upon the closure of a sequestration site is found in Section 14.  
100 Refer to Appendix D12.
The Government of Alberta should set a PCSF rate (fee per tonne of injected CO₂) for each project individually. This means the rate would be calculated based only on the risks and cost obligations of each respective project. The rate for a project would not be changed directly as a result of withdrawals from the fund to cover costs associated with other projects. Because CCS as an integrated activity is relatively new, there is still uncertainty about the potential costs the Government of Alberta will be required to bear after a closure certificate is issued. As a result, the rate and financial security requirements (see recommendation 56 below) should be periodically reviewed. These reviews will allow the rate to incorporate knowledge and operating history of the project. To ensure that the rate paid by lessees is appropriate and reasonable, the steering committee recommends that:

**RECOMMENDATION 54**

The Post-closure Stewardship Fund rate that lessees pay should:

a) Be set on a risk-based and probability-weighted basis.
b) Be based only on the specifics of the lessee’s project.
c) Not increase due to withdrawals from the PCSF, or risks associated with other projects.
d) Be reviewed, along with the security posted by the lessee, every three years in accordance with the above requirements. Any adjustments to the PCSF rate during these reviews should be on a go-forward basis only and not be retroactive.101

The funds paid into the PCSF by lessees should be pooled into a common fund. Pooling of PCSF funds will help ensure that sufficient money is available in the unlikely event of an incident. Therefore the steering committee recommends that:

**RECOMMENDATION 55**

Funds paid into the PCSF should be pooled amongst all PCSF payees.102

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101 Refer to Appendix D12.
102 Refer to Appendix D12 for further information and a non-consensus viewpoint.
In Alberta, the Orphan Well Fund is used to cover the costs incurred by the ERCB for the abandonment and reclamation of orphaned upstream oil and gas wells, facilities and pipelines. Contributions to the Orphan Well Fund are collected from industry participants on an annual basis, and some operators must post financial security as outlined by the regulator in Directive 006. The existing provisions for financial security do not currently extend to CCS projects. Therefore, to reduce the rate paid by lessees to cover the costs associated with orphaned facilities as stipulated by the *Mines and Minerals Act*, and to avoid operators paying for orphaned facilities from other companies, the steering committee recommends that:

**RECOMMENDATION 56**

The Government of Alberta should require lessees to post financial security sufficient to cover the full anticipated cost of suspension, abandonment, remediation and reclamation, including surface and subsurface costs, in case a CO$_2$ sequestration operation becomes orphaned before the issuance of a closure certificate. The acceptable forms of security instruments and the calculation of the amount of security required should be determined by the regulator. This security would be returned to the lessee when a closure certificate is issued.

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104 Refer to Appendix D12.
The requirement to post this security would only be applied to CO₂ sequestration projects, and not to capture or transport facilities and infrastructure. The regulator already has experience, expertise and established processes for financial security. Therefore it is appropriate for the regulator to make these determinations for CCS operations.

As three-year rate reviews are completed and more projects enter the industry, the rate setting process and other PCSF policies should be reviewed to determine whether or not they are still appropriate. For example, if it becomes apparent rates are generally similar or within the same range, there may be justification for switching to a uniform rate or a set of rate classes. Thus the steering committee recommends that:

**RECOMMENDATION 57**

As the number of CCS projects increases, and the Government of Alberta and lessees gain experience with CCS and the rate setting process, the recommendations related to the PCSF, and the associated policies, should be reviewed.\(^{105}\)
13 CLOSURE PERIOD

13.1 OVERVIEW

The closure period is the time between permanent cessation of injection and the closure point, when the closure certificate is issued. During this period, monitoring continues to ensure conformance of the sequestered CO₂, while abandonment and reclamation occur to the extent required by the regulator.
13.2 ENTERING THE CLOSURE PERIOD

The closure process is new in Alberta and needs to be detailed to provide transparency to project proponents, operators and the public. As a result the steering committee recommends that:

RECOMMENDATION 58

The Government of Alberta and the regulator should develop an outline of the closure process. This outline should detail the criteria and order of events necessary for closure from submission of the initial closure plan to issuance of a closure certificate.106

A suggested outline would include an initial closure plan, interim closure plans, a final closure plan, and a final closure and MMV report. Project operators and regulatory agencies should communicate throughout the injection period to ensure that MMV and closure plans evolve as required. As a project progresses, a staged approach to reporting and the review of closure criteria will help ensure that time-sensitive data are collected when available and to the extent required by the regulator. This process is depicted in Table 3.

Table 3. Timeline of the Closure Process

<table>
<thead>
<tr>
<th>Tenure Application</th>
<th>Injection Period</th>
<th>Closure Period</th>
<th>Closure Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial closure plan (submitted with tenure application)</td>
<td>Interim closure plans (submitted every three years)</td>
<td>Final closure plan (submitted to enter the closure period)</td>
<td>Final closure and MMV report (submitted as part of closure certificate application)</td>
</tr>
</tbody>
</table>

106 Refer to Appendix D2.
In the development of MMV and closure plans, a site-specific risk assessment is used to identify adverse events, assess the likelihood of their occurrence and to inform project risk management activities. One area of concern for CO₂ sequestration is the wells that penetrate the sequestration complex within the area of review as some of these wells could provide potential pathways for loss of containment. During the injection period, the movement of the CO₂ plume within the area of review may be different than that initially predicted (i.e. due to subsurface conditions, modelling techniques and/or changes in operation). The actual movement of the plume and pressure front could impact wells penetrating the sequestration complex that were not initially anticipated to be affected. Both existing and new wells need to be addressed in the closure plans, and as a result the steering committee recommends that:

**RECOMMENDATION 59**

The Government of Alberta should require that interim and final closure plans include assessment of all the wells that have penetrated the sequestration complex within the area of review to ensure that the evolution of the CO₂ plume or pressure front over the life of the project has not introduced potential leakage pathways that were not anticipated.

To enter the closure period it is recommended that a final closure plan be submitted outlining:

- Intentions to stop injecting CO₂ and enter the closure period.
- How compliance with closure requirements will be achieved.

The closure period begins at a time authorized by the regulator. This is when the final closure plan is approved, and not before the permanent cessation of injection has occurred. Appropriate advance notice is necessary so that the regulator and the lessee can discuss the lessee’s intent to enter the closure period. Therefore, the steering committee recommends that:

**RECOMMENDATION 60**

Notwithstanding other obligations for suspension and abandonment of facilities, the closure period should be considered to begin on a date authorized by the regulator when it is reviewing and approving the final closure plan. This date should be no earlier than the time at which the lessee permanently ceases CO₂ injection (planned or unplanned), or if the Government of Alberta withdraws approval, or the lease expires. The lessee should be required to provide the regulator with appropriate advance notice of intent to enter the closure period and submit the final closure plan for approval at that time. The lessee should be required to continue normal operational monitoring until initiation of a formal closure plan.

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107 Licensees of third-party petroleum and natural gas wells penetrating the sequestration complex retain perpetual liability for well abandonment and site reclamation.
108 See Appendix C for a description.
109 Refer to Appendix D16.
110 Refer to Appendix D2.
13.3 CLOSURE PERIOD ACTIVITIES

During the closure period, CO₂ sequestration project operators must continue certain monitoring activities to demonstrate containment and conformance of the sequestered CO₂. Well abandonment and surface reclamation activities are completed to the extent possible as agreed upon with the regulator. When requested, the project operator will also provide information to the regulator regarding appropriate MMV techniques that could be used in the post-closure period.

To help ensure that the sequestered CO₂ is permanently isolated, abandonment of the injection wells is required unless they are converted into monitoring wells. ERCB directives address timeframes and technical requirements for well abandonment. The objective of a well abandonment as described in Directive 020 is to protect all non-saline groundwater and to isolate all porous zones with cement. Acid resistant cement is not a prescribed requirement. However, CO₂ sequestration wells undergo a detailed review and have more stringent abandonment requirements than conventional oil and gas wells. As a result, the steering committee recommends that:

RECOMMENDATION 61

ERCB directives provide adequate guidance for the abandonment of CO₂ injection wells. A best practices review should be undertaken to determine whether acid-resistant cement should be required.¹¹¹

Proposed abandonment plans for CO₂ sequestration wells are reviewed and approved as part of the closure plan. With current technology, abandonment of down-hole monitoring equipment will also occur as wells are abandoned. The timing of well abandonment activities must take into consideration the requirements and availability of data.

¹¹¹ Refer to Appendix D21.
Reclamation activities will also occur during the closure period. Complete site reclamation in the closure period may not be desired for CO₂ sequestration projects as MMV equipment and access to the site may be required by the regulator for monitoring in the post-closure period. Arrangements are made between the regulator and the operator for the transfer of any MMV equipment that the regulator requires to be left in place at the point of closure. It must be assured that any down-hole MMV equipment left in place will not compromise the long term integrity of the abandoned wells. Proposed reclamation activities will be included in the final closure plan and will be approved by the regulator. The Government of Alberta’s existing surface reclamation requirements under the Conservation and Reclamation Regulation for both injection well sites and pipelines are scientifically and technically sound. There is no evidence that CO₂ injection wells and pipelines will cause surface disturbances that differ from those currently created by well sites or pipelines. As a result, the steering committee concludes that:

CONCLUSION 7

It is appropriate for the Government of Alberta to continue requiring the following for surface reclamation for CCS:

a) CO₂ injection site reclamation follows the current physical and technical requirements for upstream oil and gas projects.

b) CO₂ pipeline site reclamation follows the current physical and technical reclamation requirements for pipelines.

c) Operators remain accountable for site reclamation, while allowing for required infrastructure to remain in place where necessary for long term monitoring activities.¹¹²

13.4 REQUIREMENTS FOR A CLOSURE CERTIFICATE

The steering committee recommends that an operator receive a closure certificate once they can demonstrate that the site is in compliance with performance criteria for closure, and not before a minimum period has passed. While the sustained compliance with performance criteria is the primary requirement, a minimum closure period is necessary to allow the Government of Alberta to be confident the site is in compliance before accepting future liability for the site. This will also enhance public confidence in the process.

¹¹² Refer to Appendix D19.
Because CCS is new as an integrated activity, and minimum closure periods vary widely among other jurisdictions, it is difficult to determine what the minimum time period should be. After analysis, the steering committee decided it was most appropriate to accept the recommendation of the Alberta CCS Development Council and recommend a 10-year minimum period. This is shorter than in most other jurisdictions, but it is proposed as a non-discretionary minimum and is backed by the sustained performance criteria. This approach means that if there are any issues with performance, a longer period of time may be necessary to demonstrate sustained compliance. The regulator must determine how sustained compliance should be interpreted and implemented based on risk analysis on a case-by-case basis. In regard to the closure period, the steering committee recommends that:

**RECOMMENDATION 62**

The Government of Alberta should only grant a closure certificate after a period no shorter than 10 years after commencement of the closure period and when the lessee has demonstrated sustained compliance with required performance criteria for closure.

As more experience is gained in CCS, the Government of Alberta should re-evaluate the appropriateness of the performance criteria for closure and the minimum closure period.

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114 Refer to Appendix D2.
Demonstration of compliance with closure requirements for a site should include interpretation of MMV data, simulations and modelling, and completion of all surface reclamation and well abandonments. The regulator and the project operator should agree on how the project will demonstrate that CO₂ behavior is predictable and trending towards stability for the site and how the evidence being collected supports these criteria. The steering committee recommends that:

**RECOMMENDATION 63**

The Government of Alberta should require the following performance criteria for closure of a project:

a) Sequestered CO₂ and affected fluids are conforming to the objectives and regulatory requirements as described in the project application and approvals.

b) There is no significant adverse effect of sequestered CO₂ or affected fluids to health, the environment and other resources (including but not limited to hydrocarbons, non-saline groundwater and pore space outside of the operator’s sequestration lease).

c) Sequestered CO₂ and affected fluids are contained in the sequestration complex.

d) Sequestered CO₂ is behaving in a predictable manner.

e) Sequestered CO₂ is expected to continue to behave in a predictable manner and is trending towards stability.

f) The project-specific risk profile is decreasing and the risk of future leakage or adverse effects on health, the environment or other resources is acceptable.

g) Decommissioning and abandonment is complete as required by the regulator.

h) Surface reclamation is complete to the extent agreed upon with the regulator for the post-closure period.\(^\text{115}\)

\(^{115}\) Refer to Appendix D9.
Current regulatory requirements for well abandonment were reviewed and it was found that testing, subsurface isolation and subsurface abandonment practices are adequate to ensure conformance and containment of wells used for the purpose of CO$_2$ sequestration. Any applicable advances in abandonment techniques and practices should be incorporated into abandonment requirements for wells in the future. The steering committee concludes that:

**CONCLUSION 8**

The current ERCB Directive 020 adequately addresses the conformance and containment requirements for abandonment of wells used for CO$_2$ sequestration.$^\text{116}$

To apply for a closure certificate, the lessee must demonstrate how it has complied with the closure requirements and fulfilled the terms of its closure plan. The lessee should also be expected to provide evidence that other requirements have been met such as well abandonment, satisfaction of financial obligations and reconciliation of CO$_2$ credits. As a result, the steering committee recommends that:

**RECOMMENDATION 64**

Lessees should be required to submit a final closure and MMV report as part of the application for a closure certificate. This report should detail how the lessee addressed items within the closure plan and achieved the requirements for closure, including compliance with performance criteria.$^\text{117}$

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$^{116}$ Refer to Appendix D16.

$^{117}$ Refer to Appendix D2.
14 Closure Point and the Post-Closure Period

14.1 Overview

Following the recommended minimum 10-year closure period, and upon meeting performance criteria, an operator can apply for a closure certificate. Upon receipt of a closure certificate application, the Government of Alberta will undertake a detailed review to determine if all the requirements for closure have been met. The issuance of a closure certificate to a project operator signifies that a project has successfully reached the closure point. At this point responsibility and long term liability for the sequestered CO₂ are transferred from the project operator to the Government of Alberta. The post-closure period starts with the closure point and continues in perpetuity.
Under the Carbon Capture and Storage Statutes Amendment Act, 2010 the Government of Alberta assumes long term liability for a CCS storage site once a closure certificate is issued. CCS projects are long term, and the CO₂ sequestered during a project remains trapped underground for hundreds, and potentially, thousands of years. Due to these long timeframes, it is conceivable that the sequestered CO₂ will remain in place much longer than any corporation or company operating a project would be expected to exist. Therefore, the Government of Alberta made a policy decision to assume long term responsibility for the sequestered CO₂ to ensure that it will be monitored and, if necessary, managed in the future. This assumption of liability for the sequestered CO₂ differs from the perpetual liability that operators hold for other upstream petroleum operations. The Government of Alberta’s policy decision to assume long term liability for CCS was also designed to incent CCS development, and to ensure long term stewardship of the sequestered CO₂. The requirements for closure, outlined in both closure and MMV plans, have been designed to minimize the risks to the province in accepting long term liability for the sequestered CO₂.

The Mines and Minerals Act¹¹８ sets out the liabilities and obligations that the Government of Alberta will assume when it issues a closure certificate. When issuing a closure certificate, the Government of Alberta becomes the owner of all injected CO₂, and assumes all obligations of the lessee, including responsibilities related to wells and facilities, the environment and land.
In addition to the obligations already included in the *Mines and Minerals Act*, the working groups identified liability for CO\(_2\) credits as another liability that should be assumed by the Government of Alberta following the issuance of a closure certificate. Alberta has a regulated carbon offset market where offset credits can be purchased by large industrial emitters or other interested parties. CCS offers an opportunity for large industrial emitters to generate offset credits by sequestering their CO\(_2\) emissions deep underground. These industrial facilities can then use the credits to meet their own compliance obligations with the province’s greenhouse gas emissions reduction program, or sell the credits that they generate to other industrial emitters who need to comply with the reduction program.\(^{119}\) Offset credits would be generated for every tonne of sequestered CO\(_2\) from eligible and participating projects.\(^{120}\)

If there is loss of CO\(_2\) containment from a sequestration site in the post-closure period, it will be necessary to account for the quantities of CO\(_2\) released in order to ensure accurate greenhouse gas accounting and reporting in the province. As owner of the CO\(_2\) in the post-closure period, the Government of Alberta should accept liability for reconciling CO\(_2\) credits or other climate change obligations that may be required. Assumption of these liabilities will be important for building confidence in Alberta’s climate change accounting and reduction program. The closure requirements outlined in the MMV and closure plans are important tools that the Government of Alberta will be able to use to ensure that these liabilities will not become a burden for Albertans. By issuing a closure certificate, the Government of Alberta will signal that it is confident that the CO\(_2\) has been permanently and safely sequestered at the site. Therefore, to be consistent with the treatment of other CCS liabilities, and to support Alberta’s greenhouse gas emission reduction goals, the steering committee recommends that:

**RECOMMENDATION 65**

> Section 121(1)(b) of the *Mines and Minerals Act* should be amended to include responsibilities under the *Climate Change and Emissions Management Act* and other provincial climate change legislation in the list of liabilities that transfer to the Crown when a closure certificate is issued.\(^{121}\)

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119 See the Alberta Climate Change and Emissions Management Act and related regulations for more information.

120 A draft Quantification Protocol for the Capture of CO\(_2\) and Storage in Deep Saline Aquifers is currently being reviewed by Alberta Environment and Sustainable Resource Development.

121 Refer to Appendix D2.
14.3 ALLOWABLE USES OF THE POST-CLOSURE STEWARDSHIP FUND

The Post-closure Stewardship Fund (PCSF) was established in order to ensure that liabilities for the sequestered CO₂ assumed by the Government of Alberta will not become a burden to Albertans by protecting the public from bearing the costs of post-closure liabilities. Funds are collected from the CCS operator during the injection period of a project to cover potential costs for liabilities arising during the post-closure period.

The Mines and Minerals Act also outlines the allowable uses of the PCSF. Currently, the PCSF can be used for monitoring the sequestered CO₂, paying for expenses related to orphan facilities and fulfilling the other obligations assumed by the Government of Alberta upon issuance of a closure certificate. Given that the steering committee is recommending that climate change liabilities under the Climate Change and Emissions Management Act be added to the list of assumed liabilities transferred to the Government of Alberta upon closure, those future costs should be included in the rate calculation and be allowable uses of the PCSF. Therefore, the steering committee recommends that:

RECOMMENDATION 66

The allowable uses of the PSCF should be expanded to include covering costs associated with the assumption of liabilities under the Climate Change and Emissions Management Act and other provincial climate change legislation.¹²²

When amending the Mines and Minerals Act, the Government of Alberta made a policy decision to indemnify lessees against liability for tort damages that may arise in the post-closure period.¹²³ Costs associated with any actions in tort brought against a closed sequestration site by another party will be the responsibility of the Government of Alberta. The costs associated with indemnifying the operator against tort damages, however, are not currently covered by the PCSF, despite being included as a transferred liability upon closure. The policy decision to exclude post-closure tort indemnification from the PCSF was intended to provide an incentive to encourage CCS development, by decreasing the amount of money that operators will have to pay into the PCSF.

Recognizing that deployment of CCS is vital for reducing greenhouse gas emissions, the Government of Alberta’s decision to exclude tort indemnification as an allowable use of the PCSF is appropriate and necessary at this time. Rather than paying into the PCSF to cover the long term costs associated with tort indemnification, the Government of Alberta can use the stringency of site selection, MMV, and closure requirements to minimize the public’s exposure to potential risks in the post-closure period. Therefore, the steering committee concludes that:

CONCLUSION 9

The Government of Alberta’s previous decision to exclude costs associated with indemnification against tort damages (Section 121(2) of the Mines and Minerals Act), as an allowable use of the PCSF is appropriate.¹²⁴

¹²² Refer to Appendix D12.
¹²⁴ Refer to in Appendix D12 for further information and a non-consensus viewpoint.
14.4 POST-CLOSURE MONITORING AND REMEDIATION

Post-closure monitoring and remediation (in the case of unforeseen CO₂ release from the sequestration complex) is important for developing and maintaining public support for CCS development. Once a CO₂ sequestration project is closed, and ownership and liability for the CO₂ has been transferred to the Government of Alberta, the province will be responsible for conducting post-closure monitoring and any potential remediation. The degree and type of post-closure monitoring will be determined on a site-specific and risk-based basis.

CO₂ sequestration projects can occupy vast geographic areas, requiring multi-technology monitoring programs. It will be important for the Government of Alberta to be able to gain surface access to lands above the sequestration complex in order to monitor the sequestered CO₂. The Carbon Capture and Storage Statutes Amendment Act, 2010 made changes to surface access, enabling the Surface Rights Board to issue a Right of Entry Order to an operator to allow them to conduct the required monitoring, measurement and verification specified in an approved MMV plan. A Right of Entry Order can only be granted once all avenues of private negotiation have been exhausted. Currently, no provisions exist to enable the Government of Alberta to gain surface access to conduct MMV activities following the transfer of liability. Therefore, the steering committee recommends that:

RECOMMENDATION 67

All necessary legislation should be amended to enable the Government of Alberta to gain surface access in order to conduct MMV and reclamation activities after transfer of liability.¹²⁵

¹²⁵ Refer to Appendix D18.
In Alberta, and around the world, CO₂ is injected underground in order to achieve a number of different objectives. Within the oil and gas industry, CO₂ is injected into depleted petroleum reservoirs as a means of improving oil recovery, a process called CO₂ enhanced oil recovery (CO₂-EOR). CO₂-EOR provides the opportunity to increase knowledge about CO₂ sequestration and continue development of conventional hydrocarbon reserves, benefiting all Albertans.

In other oil and gas operations, CO₂ and H₂S are injected as waste products into the subsurface for permanent disposal, a process called acid gas disposal. Finally, as detailed in the preceding sections, CO₂ will also be injected into the subsurface to mitigate climate change, a process called CO₂ sequestration. Although these three activities differ in objective, they are fundamentally similar in that they all involve injecting CO₂ into the subsurface.
Before submitting an application to the ERCB to inject CO₂ under the ground, a project proponent must determine which type of subsurface rights it desires, and obtain these rights under the *Mines and Minerals Act*. The type of subsurface lease or authorization obtained will determine the regulatory requirements for the project. CO₂-EOR proponents must obtain petroleum and natural gas tenure. CO₂-EOR applications are reviewed to ensure that hydrocarbon recovery is optimized and that the enhanced recovery scheme requirements are being met.

Subsurface injection of CO₂ is regulated under a number of different frameworks, with differing regulatory requirements, depending on the type of subsurface lease or authorization obtained by a project proponent. Proponents looking to inject CO₂ into the subsurface for permanent disposal can acquire one of three different subsurface leases or authorizations. Proponents can acquire either a section 54(5) authorization or a petroleum and natural gas tenure agreement to dispose of CO₂ and/or H₂S into the subsurface, depending on the tenure available for their target disposal zone. Proponents with these authorizations are regulated under the existing ERCB regulatory requirements for acid gas disposal schemes including those detailed in Directive 065 and Directive 051. However, proponents could also acquire a carbon sequestration lease for permanent sequestration of CO₂ into the deep subsurface. Proponents with a carbon sequestration lease will be subject to additional regulatory requirements as recommended by the Regulatory Framework Assessment for CO₂ sequestration.
The Government of Alberta and project proponents need clarity on where projects fit under Alberta’s various regulations for subsurface injection of CO₂. The Government of Alberta should clearly indicate the criteria and parameters for which projects can qualify as CO₂ sequestration, CO₂-EOR, and acid gas disposal. Therefore, the steering committee recommends that:

**RECOMMENDATION 68**

The Government of Alberta should define what qualifies as CO₂ sequestration, CO₂-EOR and acid gas disposal, with particular attention to the distinction between CO₂ sequestration and acid gas disposal.\(^\text{126}\)

In addition, the Government of Alberta needs to carefully examine how CO₂ injection is regulated under each of the CO₂-EOR, acid gas disposal and CO₂ sequestration regulatory frameworks. The public may question why there are different regulatory requirements for CO₂-EOR, acid gas disposal and CO₂ sequestration projects, and this could impact the deployment of CCS in the province. In light of the recommendations from the RFA, it may be appropriate for the Government of Alberta to conduct a review of CO₂-EOR and acid gas disposal policies and regulations to identify, address and/or justify any regulatory differences in how CO₂ subsurface injection is regulated. Therefore, the steering committee recommends that:

**RECOMMENDATION 69**

The Government of Alberta should identify differences in how CO₂ injection and storage activities are regulated as CO₂ sequestration, CO₂ enhanced oil recovery and acid gas disposal, and address them appropriately to ensure regulatory consistency and/or that regulatory differences can be justified.\(^\text{127}\)

\(^{126}\) Refer to Appendix D4.

\(^{127}\) Refer to Appendix D4.
There are a number of significant differences between CO₂ sequestration and CO₂-EOR in terms of their regulatory frameworks and physical operations. However, a CO₂-EOR project operator may want to transition to a CO₂ sequestration project in the future. Although this transition is not explicitly contemplated or prohibited by current legislation, the regulatory process to do so is not presently defined. The steering committee recognizes that a clear regulatory process to transition a CO₂-EOR project to a CO₂ sequestration site is necessary. Therefore, the steering committee recommends that:

RECOMMENDATION 70
The regulator should align and/or amend its regulations and requirements to explicitly cover CO₂ sequestration, as deemed appropriate (e.g. Directive 065).

RECOMMENDATION 71
The Government of Alberta should review the requirements for CO₂-EOR projects requesting to transition to CO₂ sequestration to ensure that they meet the same objectives as the requirements for CO₂ sequestration projects.

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128 Refer to Appendix D1.
129 Refer to Appendix D4.
In conclusion, CCS is a key technology to advance responsible and sustainable development of Alberta’s energy resources while addressing greenhouse gas emissions. Alberta’s Climate Change Strategy identifies CCS as a key mitigation technology, which will provide 70 percent of the greenhouse gas emissions reductions to meet the 2050 targets. World consumers of fossil fuels are demanding greener energy production and emissions management, and CCS is a technology that will enable Alberta to be a responsible and competitive supplier of energy in a carbon-constrained future.
The recommendations from the steering committee in this report identify specific opportunities to improve the Alberta regulatory framework for large scale CCS activities. Implementation of these recommendations will result in a regulatory framework that is consistent with the guiding principles identified throughout the assessment, namely that CCS activities provide for increased public safety, improved environmental sustainability and are comprehensively and transparently addressed in Alberta’s regulatory framework.
The work of the RFA would not have been possible without the significant contributions of knowledge and time made by the many members of the steering committee, expert panel and working groups. The RFA began with an opening workshop in March 2011, and the efforts made by all the contributors are summarized in this final report. The recommendations from the RFA will guide the development of legislation, regulations and the regulatory processes for CCS in Alberta.

The following individuals participated on the steering committee. The steering committee members provided guidance throughout the process and approved final content of recommendations for delivery to the Government of Alberta.

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The following individuals participated on the expert panel. The expert panel members advised the steering committee and working groups by providing subject matter expertise and identified gaps and potential solutions.

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The following individuals participated on at least one of the four working groups (Environmental, Geology/Technical, Regulatory, and Monitoring, Measurement & Verification). The working groups analyzed technical, environmental, safety and monitoring issues related to CCS in Alberta, and drafted recommendations to address requirements for large scale CCS and opportunities for an effective regulatory framework.

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# APPENDIX B. RFA ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AUC</td>
<td>Alberta Utilities Commission</td>
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<tr>
<td>BGWP</td>
<td>Base of Groundwater Protection</td>
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<tr>
<td>CCS</td>
<td>Carbon Capture and Storage</td>
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<tr>
<td>CMDRC</td>
<td>Crown Mineral Disposition Review Committee</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
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<tr>
<td>CO₂-EOR</td>
<td>Carbon Dioxide Enhanced Oil Recovery</td>
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<tr>
<td>CSA</td>
<td>Canadian Standards Association</td>
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<td>CSA Z662</td>
<td>Canadian Standards Association, Z662: Oil and Gas Pipeline Systems</td>
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<tr>
<td>Development Council</td>
<td>Alberta Carbon Capture and Storage Development Council</td>
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<td>Directive 065</td>
<td>ERCB Directive 065: Resources Applications for Oil and Gas Reservoirs</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>EOR</td>
<td>Enhanced Oil Recovery</td>
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<td>EPZ</td>
<td>Emergency Planning Zone</td>
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<td>ERCB</td>
<td>Energy Resources Conservation Board</td>
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<td>ERP</td>
<td>Emergency Response Plan</td>
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<td>ESRD</td>
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<tr>
<td>H₂S</td>
<td>Hydrogen Sulphide</td>
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<tr>
<td>MMV</td>
<td>Monitoring, Measurement and Verification</td>
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<td>Mt</td>
<td>Megatonne</td>
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<td>PCSF</td>
<td>Post-closure Stewardship Fund</td>
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<tr>
<td>ppm</td>
<td>Parts Per Million</td>
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<tr>
<td>RFA</td>
<td>Regulatory Framework Assessment</td>
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<tr>
<td>Task Force</td>
<td>ecoEnergy Carbon Capture and Storage Task Force</td>
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APPENDIX C.
RFA GLOSSARY OF WORKING TERMS

The Regulatory Framework Assessment identified common working terms that are compiled in this appendix. These terms are not intended to be formal definitions for implementation, but rather to describe the context of the terms as used in the RFA final report and appendices.

**Adverse effect:** defined by the Environmental Protection and Enhancement Act (EPEA) to mean ‘impairment of or damage to the environment, human health or safety or property.’

**Affected fluid:** the reservoir fluid that has been impacted due to the injection of CO₂; either as a result of mixing with CO₂ or as a result of displacement caused by CO₂ and/or pressure increase.

**Amine:** the class of nitrogen-containing organic compounds that are being proposed for large scale capture of CO₂.

**Area of Influence:** the spatial footprint of the maximum connected pore volume in the sequestration complex affected by an increase in pore pressure. The area of influence is a useful concept for the regulator to provide assurance for the allocation of pore space within a sequestration complex and on how close other injection activities could be placed.

Notes:

a) The area of influence will be proposed by the operator and agreed by the regulator.
b) The operator can apply to the regulator to modify (expand or limit) the area of influence based on agreement between monitoring data and long term predictions of pressure elevation.
c) Additional projects which increase subsurface fluid pressure in the area of influence should be restricted until the impact on the project is understood and the operator agrees that it will not compromise the project’s injection objectives.
d) The area of influence should be a subset of the assessment area.
e) The area of influence should be based both on the physical (pressure) boundaries of the sequestration complex determined through site characterization, and the limits of the dynamic pressure anomaly through modeling/simulations of the pressure elevation.
f) For a non-closed system where the pressure anomaly may be decreasing asymptotically towards the background pressure level, a reasonable judgment needs to be made on the pressure contour which defines the boundary of the dynamic effect.
g) The area of influence should account for geological uncertainties that impact the pressure increase.

**Area of Review:** is the surface area within which potential adverse effects may occur due to CO₂ plume migration and pressure elevation. The purpose of the area of review is to assist the regulator and all stakeholders in assuring that that sequestration risks are being appropriately managed.

Notes:

a) The area of review will be a subset of the area of influence.
b) The area of review should be proposed by the proponent/operator and must be agreed with the regulator.
c) Within the area of review the proponent/operator is obliged to show that the risk associated with any event has been reduced to an acceptable level for the proposed injection plan.
d) The area of review should be defined prior to commencement of baseline monitoring.
e) After commencement of injection the operator has the option of updating the area of review with each submission of the interim closure plan as uncertainty on plume expansion and/or pressure elevation is reduced by ongoing conformance monitoring.
f) Specific monitoring methodologies will be chosen to address specific risks in the area of review, and may only address a subset of the total area of review.
g) The risks addressed in the area of review will include:
   – The potential for loss of containment of the sequestration complex either through geological seals or along wellbores and the impact on groundwater and oil and gas operations.
   – The potential for induced seismicity and its impact.
   – Any risks related to surface heave.
h) The area of review should account for geological uncertainties that impact the CO₂ plume expansion or pressure elevation.
Assessment area: refers to the surface geographic footprint of a volume (from the sequestration complex to the surface) which has undergone assessment for CO₂ sequestration suitability. The purpose of the assessment area is to provide assurance of the site selection and suitability of the area of influence.

Notes:

a) While applying for an evaluation permit the operator should indicate an initial assessment area along with the existing basic geological, geophysical, geochemical and hydrological data within that area which provides the regional geological context for the selection of the sequestration site.

b) Within the initial assessment area the operator should identify:
   - Any potential conflicts with any other known resources (including oil and gas, potable groundwater, water used for industrial purposes, mineral and/or geothermal resources, and disposal and/or storage operations and other carbon storage complexes).
   - Any potential conflicts with any subsurface rights.

c) While applying for a carbon sequestration lease the operator should indicate an assessment area along with the existing and additional data gathered under the evaluation permit which provides the input to the site characterization/modeling and simulation to support the area of influence/area of review definitions.

d) There may be different scales for each investigation in an assessment area. This may be due to data that are restricted to a specific area or to specific requirements for a particular numerical simulation.

Base of groundwater protection: is the assigned elevation above which groundwater is deemed non-saline or useable without treatment. Alberta Environment and Sustainable Resource Development defines an aquifer containing non-saline groundwater as any strata capable of producing water with a total dissolved solid content less than 4000 mg/L.\textsuperscript{131}

Carbon capture and storage (CCS): means the capture and transport of carbon dioxide from large stationary anthropogenic sources of emissions, and the injection of the captured carbon dioxide into an underground complex of geologic formations for long term isolation from the atmosphere.

Carbon sequestration lease: Alberta's Carbon Sequestration Tenure Regulation has defined a carbon sequestration lease as an agreement under section 116 of the Mines and Minerals Act issued in the form of a lease under section 9.

CO₂ plume: is the free-phase injected CO₂ in the sequestration complex.

CO₂ sequestration project: the activity of injection and geologic sequestration of CO₂ under a carbon sequestration lease.

Closure period: the period of time extending from the permanent cessation of injection to the closure point.

Closure point: the point in time when responsibility and long term liability are transferred to the Government of Alberta and a closure certificate is issued to the project operator.

Conformance: the degree to which the sequestered CO₂ behaves as predicted, as informed by monitoring. For example, demonstration of conformance could include:
   - Output from models match monitored data within acceptable limits, and the need to modify static and dynamic model parameters has been systematically reduced over a certain time period.
   - Final models are within acceptable confidence limits of the history match.

Where the time period and acceptable limits are developed based on a technical assessment of comprehensive site and project data.

Consultation: involves direct communication with nearby stakeholders including land owners, residents, occupants, and municipalities. ERCB Directive 056 may require project operators to confirm that stakeholders do not have objections to the project (i.e. confirmation of non-objection). In this context, if confirmation of non-objection is not obtained, the project may proceed to a hearing. Note: This use of the term consultation is not intended to account for the Crown's duty to consult First Nations under section 35 of the Constitution Act.

Containment: retention of injected CO₂ and affected fluids within the sequestration complex.

Domains of review: Within the area of review several domains have been identified as listed below and as represented in Figure 13.

Appendix C: RFA Glossary of Working Terms

Complementary monitoring techniques should be employed to provide areal and depth coverage.

- **Atmosphere**: the layer of air above the Earth’s surface.
- **Near-surface zone**: the zone that comprises the soil and its biological processes, including ecosystems and surface water.
- **Protected groundwater zone**: the zone where water salinity measured as a concentration of total dissolved solids is less than 4000 milligrams per liter.132
- **Sedimentary succession and overburden**: the sedimentary succession and overburden that overlies the sequestration complex.
- **Sequestration complex**: refers to the succession of geological formations that contribute to providing secure long term sequestration of CO₂. It may include one or more seals and one or more zones that have the potential to sequester CO₂.

**Emission**: a substance that is emitted or released into the air.

**Environmental impact assessment**: a process that allows companies and government decision makers to examine the effects that a proposed project may have on the environment. The information gathered during the environmental assessment process helps the appropriate regulator determine if the project should be approved. In Alberta, Alberta Environment and Sustainable Resource Development administers the laws governing environmental assessment under the *Environmental Protection and Enhancement Act* and *Water Act*.

**Evaluation permit**: a form of tenure granted by Alberta Energy that grants the right to conduct evaluations and testing into deep subsurface reservoirs to evaluate their suitability for CO₂ sequestration.133

**Initial application and permitting period**: the period from when a proponent applies for lease of the chosen site to the granting of all initial regulatory approvals (e.g. agreements, licences and permits) as required.

**Injection period**: the period from the start of sustained injection to permanent cessation of injection with no further intent to resume operations.

**Life of a project**: the time extending from the project tenure submission to the closure point.

**Monitoring, measurement and verification (MMV)**: monitoring and measurement are surveillance activities necessary for ensuring the safe and reliable operation of a CO₂ sequestration project. Verification refers to the comparison of measured and predicted performance, which is also known as conformance.

**Mitigation**: an action or planned action to reduce the likelihood and/or severity of an unwanted event to an acceptable level.

**Notification**: differs from personal consultation in that communication can take place through written correspondence rather than face-to-face or telephone conversations. Notification is less onerous and can involve the mailing of information packages to assist in understanding the project and typically occurs in a geographical area larger than that of consultation.

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132 Alberta Environment and Sustainable Resource Development has defined saline groundwater as water that has total dissolved solids exceeding 4000 milligrams per litre in the *Water (Ministerial) Regulation*, Section 1(1), 1998.
133 Carbon Sequestration Tenure Regulation, 2011.
Orphan: a project that does not have any legally responsible or financially able party to deal with its abandonment and reclamation.

Pore Space: defined by the Carbon Sequestration Tenure Regulation as the pores contained in, occupied by or formerly occupied by minerals or water below the surface of land. In the context of RFA documents, pore space refers to subsurface pore space that meets injectivity, capacity and confinement criteria for CO₂ sequestration activities.

Post-closure period: the period following the closure point and transfer of liability to the Government of Alberta.

Potable water: water that is suitable for human consumption.¹³⁴

Predictable: behaving in a manner that can be forecast by analytical modelling and verified by monitoring. The regulator and the project operator should agree on the specific criteria and data by which the project will demonstrate that behavior is predictable for the site.

Pre-injection period: the period from when required initial regulatory approvals are received to the start of sustained injection. Commonly includes the gathering of baseline data, site preparation and construction of field facilities. There may be some overlap between the pre-injection period and the initial application permitting period for some activities.

Prorationing: if the regulator has already designated a pipeline as a common carrier, prorationing refers to the proportion of production to be taken by the common carrier from each producer or owner offering production to be gathered, transported, handled, or delivered by means of a pipeline.

Remediation: defined by the Remediation Certificate Regulation under EPEA to mean reducing, removing or destroying substances in soil, water or groundwater through the application of physical, chemical or biological processes. Within the CCS RFA, remediation takes into account measures that reduce significant adverse effects in all domains of review including the subsurface.

Risk: the product of the probability or likelihood of an unwanted event and the potential impact of the event. In regards to the acceptability of risk, the United Kingdom Health and Safety Executive have developed a framework for the risk tolerance, and have classified risks as:¹³⁵

- Unacceptable risk: risks that are regarded as unacceptable whatever the level of benefits associated with the activity. Any activity or practice giving rise to risks falling in this category, would, as a matter of principle, be ruled out unless the activity or practice can be modified to reduce the degree of risk so that it falls in one of the regions below, or there are exceptional reasons for the activity or practice to be retained.
- Tolerable risk: a tolerable risk falls between the unacceptable and broadly acceptable risk categories.
- Acceptable risk: risks falling into this region are generally regarded as insignificant and adequately controlled. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.

The factors that determine the tolerability of a risk are dynamic in nature, governed by the particular circumstances, time and environment in which the activity giving rise to the risk takes place.

Risk assessment: the process of risk identification, risk analysis and risk evaluation.

Saline groundwater: water with total dissolved solids exceeding 4000 milligrams per litre.¹³⁶

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¹³⁶ Water (Ministerial) Regulation, Section 1(1), 1998.
**Seals:** one or more geological formations above and/or below the injection formation that restrict fluid migration. Seals have very low permeability, are continuous over the area of influence, and may be regionally consistent. Seals act as capillary barriers to the escape of CO$_2$ from the sequestration complex.

**Sequestration:** defined by the Mines and Minerals Act to mean permanent disposal.

**Sequestration complex:** the succession of geological formations that contribute to provide secure long term sequestration of CO$_2$. It may include one or more seals and one or more zones that have the potential to sequester CO$_2$.

**Sequestration performance:** measure of containment, conformance and utilization of pore space.

**Site characterization:** part of the site selection process and consists of a detailed evaluation of at least the area of review of one or more candidate sites for CO$_2$ sequestration to confirm and refine containment integrity, sequestration capacity, and injectivity estimates. Site characterization provides basic data for initial predictive modelling of fluid flow, geochemical reactions, geomechanical effects, risk assessment, and monitoring measurement and verification program design.

**Site selection and characterization period:** the period in which screening and characterization are carried out to identify a suitable site for a CO$_2$ sequestration project.

**Stable:** since many trapping methods continue to operate over a significant time-scale (hundreds to thousands of years), complete cessation of movement of the CO$_2$ plume is unlikely to occur in many storage formations during the closure period. A state of stability is considered to be attained when key parameters and acceptable limits have been reached. These parameters and limits are developed based on a technical assessment of comprehensive site and project data. For example, such an assessment could show that:

- The calibrated models predict eventual stability of the CO$_2$ plume within the sequestration complex.
- Key monitored parameters are within an acceptable range and the rate of change is small and declining.

**Surface reclamation:** the process of returning disturbed areas of land to an equivalent capability as the pre-disturbed state through replacement and preparation of soil materials and establishment of a protective vegetative cover.
APPENDIX D. 
RFA ISSUE RECOMMENDATION DOCUMENTS

This appendix contains the issue-specific recommendations as they were provided by the steering committee and working groups. The versions included in the main body of this report have been modified to improve readability and to increase consistency in wording across recommendations and conclusions.

Contents

D1. Approvals, Permits and Regulatory Process ........................................................................................................................................................................ D2
D2. Closure and Transfer of Liability .................................................................................................................................................................................. D8
D3. CO₂ Classification ............................................................................................................................................................................................... D15
D4. CO₂ Enhanced Oil Recovery and Acid Gas Disposal ......................................................................................................................... D20
D5. CO₂ Transportation and Composition ..................................................................................................................................................... D25
D6. Competition with Other Resources ......................................................................................................................................................... D29
D7. Environmental Assessments ....................................................................................................................................................................... D33
D8. Environmental Impacts, Mitigation and Remediation ......................................................................................................................... D37
D9. Monitoring, Measurement and Verification ............................................................................................................................................... D43
D10. Pipeline Open Access ................................................................................................................................................................................... D49
D11. Pore Space Open Access ............................................................................................................................................................................. D55
D12. Post-closure Stewardship Fund and Financial Security .................................................................................................................. D60
D13. Public Engagement and Stakeholder Consultation .......................................................................................................................... D68
D14. Public Safety ........................................................................................................................................................................................................... D73
D15. Risk Assessment ........................................................................................................................................................................................................... D76
D16. Site Closure ........................................................................................................................................................................................................... D79
D17. Site Selection ........................................................................................................................................................................................................... D82
D18. Surface Access ........................................................................................................................................................................................................... D85
D19. Surface Reclamation ........................................................................................................................................................................................................... D87
D20. Tenure Process ........................................................................................................................................................................................................... D89
D21. Well Construction ........................................................................................................................................................................................................... D91
D1. APPROVALS, PERMITS AND REGULATORY PROCESS

Author

Regulatory Working Group

Issue

Determine if the approval processes, and the information requirements necessary to assess applications, are in place to provide Government and stakeholders with confidence that Alberta’s regulatory system will ensure the safe and effective operation of CCS while providing for the conservation of other resources.

Scope and Key Questions

Review the overall flow of the current regulatory process to ensure that the process is sufficient for the full spectrum of CCS activities and is open and transparent for both industry, which may want to conduct CCS projects, and the public. The goal of the review is to make certain that stakeholders have a common and consistent understanding of Alberta’s regulatory expectations around CCS.

Background

The current regulatory regime for CCS projects in Alberta is governed by several pieces of provincial legislation (federal legislation primarily applies to CCS if there are interprovincial or international components of a project). Alberta has established legal authorizations (approvals, permits, etc.) and a regulatory process for the capture and transportation phases of CCS activities and has recently passed the Carbon Capture and Storage Statutes Amendment Act, 2010 and Carbon Sequestration Tenure Regulation to address carbon dioxide (CO₂) sequestration and other issues, including liability.

In general, approval for the operation of a CCS scheme in Alberta is the responsibility of the Energy Resources Conservation Board (ERCB) under the Oil and Gas Conservation Act. Currently, applicants for a CO₂ sequestration project use the current ERCB acid gas disposal scheme requirements, which require approval for both surface and subsurface development, including Directive 056, 065 and 051 approvals, among others.

Prior to ERCB approval, a tenure agreement is required with the Government of Alberta under the Mines and Minerals Act in order to inject CO₂ into Crown-owned pore space. CCS project proponents are required to obtain an evaluation permit to evaluate a storage site and a carbon sequestration lease to secure pore space tenure for long term sequestration from the Department of Energy. At the end of a project, a closure certificate is required to close a site and transfer long-term liability to the Government of Alberta.

Proponents may also require various authorizations from other government departments, including Alberta Environment and Sustainable Resource Development (AESRD), depending on the scope, location and scale of the CO₂ storage project.

The working group has reviewed existing authorizations for CCS activities (authorizations required, the information needed to obtain them and the overall regulatory process) and has not identified the need for any additional authorizations at this time, aside from the potential for environmental impact assessments (EIA) and Environmental Protection and Enhancement Act (EPEA) approvals being examined by the Environmental working group. The working group found that, although the appropriate agreements, approvals, and permits appear to be in place, there is a need for clarity around the regulatory process and the regulatory roles and responsibilities for CCS. The working group also identified the need for efficiency improvements in the regulatory and approval process for CCS projects.
Analysis Principles

Review of existing authorizations for CCS activities (authorizations required, the information needed to obtain them and the overall regulatory process). Gathered input from Government of Alberta agencies involved in the regulation of CCS activities, including the Energy Resources Conservation Board (ERCB) and Alberta Environment and Sustainable Resource Development (AESRD). The working group also gathered input from Natural Resources Canada (NRCan) on federal government regulatory approvals and processes relevant to CCS.

Areas of Non-Consensus

None.

Recommendations and Conclusions

1. The Government of Alberta and its agencies should clarify the regulatory roles and responsibilities related to the regulatory process for CCS. Particular attention should be given to determining the ERCB’s role in issuing closure certificates. This process should also aim to identify and implement efficiencies in the regulatory and approval process to promote the timely review and approval of CCS project applications.

For some aspects of the regulatory process for CCS, the division of roles and responsibilities among the ERCB and various government departments is unclear. In order to ensure the effectiveness and efficiency of the CCS regulatory system, and to reduce uncertainty for project proponents, the Government of Alberta should clarify those roles and responsibilities, and make this information readily available.

One of the areas identified where roles need to be clarified and possibly changed is the role of the ERCB in the issuance of closure certificates. The working group believes that the ERCB should have a significant role in this process either as the entity that issues the certificate or providing advice to the Minister of Energy on closure certificate applications. The Government of Alberta will need to determine how best to involve the ERCB in this role.

2. Submission of an MMV and closure plan should be a requirement for all CCS related applications to the ERCB, and should continue to be a requirement for tenure applications to the Department of Energy (closure plans for sequestration lease applications; MMV plans for evaluation permit and sequestration lease applications).
Under the current regulatory process, the Department of Energy is tasked with approval of MMV and closure plans as part of the tenure application process. In order to allow for the review and approval of these plans to be transparent for the general public, and as rigorous and technically informed as possible, the working group recommends that these plans also be reviewed and approved by the ERCB as part of its current regulatory approval process for CCS (e.g. under Directive 065 and 051).

The working group agreed that there are different purposes for the reviews of these plans undertaken by the Department of Energy and the ERCB. Therefore, the working group agreed that the information and level of detail included in the plans for the Department of Energy and the ERCB could be different, and fit for purpose; plans submitted to the Department of Energy for tenure approval could describe the approach and rationale of the plans, whereas plans submitted to the ERCB for approvals should be more detailed and technically focused. The working group encourages the Government of Alberta and the ERCB to work together to clarify these requirements, and include them in a CCS Regulatory Guidance Document.

3. The Government of Alberta, through its appropriate agencies, should coordinate the development of a CCS Regulatory Guidance Document similar to the Government of Alberta’s existing Upstream Oil and Gas Authorizations and Consultation Guide that clearly:
   - Provides detailed information on all approvals and authorizations related to CCS.
   - Documents roles and responsibilities for regulators and government departments.
   - Provides detailed information on the process for acquiring pore space tenure and a permit to inject CO₂.
   - Provides detailed information on the requirements for the issuance of a closure certificate.
   - Includes process maps, regulatory flow charts, web links, etc.

The working group identified the need for clear information for stakeholders about the regulatory process for CCS schemes. The working group found that although there is currently material available on the regulatory process for CCS, this information is either outdated or convoluted.

The ERCB has a document entitled The Upstream Oil and Gas Authorizations and Consultation Guide that is a reference document that identifies the common authorizations (approvals, licenses, dispositions, permits, and registrations) required by Alberta regulators and government departments for the development of upstream oil and gas development activities. The guide, however, does not make specific reference to CCS.
In support of the guide, the ERCB has in place Bulletin 2010-22 ERCB Processes Related to Carbon Capture and Storage Projects. This bulletin provides a high-level overview of ERCB processes and approvals. However, the bulletin has become outdated since the release of the Carbon Capture and Storage Statutes Amendment Act, 2010 and the Carbon Sequestration Tenure Regulations and does not contain sufficient detail of the entire regulatory process to represent a standalone guidance document useful to all stakeholders. Moreover, there is currently no document from the Department of Energy that thoroughly explains the CCS process from acquiring pore space tenure to the transfer of liability.

The working group determined that there is no document that clearly provides information on the full CCS regulatory process and is therefore recommending the creation of a comprehensive regulatory guidance document for CCS projects.

The working group encourages the regulator to adopt a scheme approach for approval of long-term, multiple-well CCS projects. The scheme approach allows the project proponent, in consultation with the regulator, to define a range of project descriptions that can be refined over time as a project develops and more data becomes available.

An example of a scheme approach would be where a project proponent acquires Directive 065 scheme approval after drilling some, but not all, of the proposed wells for a project. This is similar to the modified application process that was followed for a current CCS project and that is used for in-situ oil sands projects.

The standard Directive 065 approval process requires proponents to drill and complete all wells (requiring an ERCB Directive 056 approval) prior to receiving a scheme approval for CO₂ sequestration under ERCB Directive 065. The working group believes that the standard Directive 065 approval process is not always appropriate for CCS projects, as requirements to drill all wells prior to a Directive 065 scheme application and approval:

• May increase project risks by introducing unnecessary leakage pathway if some of the anticipated wells are not needed.
• May be inconsistent with ERCB planning and facility proliferation guidelines.

The working group agreed that a scheme approach resolves many of these potential issues with the standard Directive 065 approach as it would be applied to long-term, multiple-well CCS projects. The scheme approach allows the regulator to approve a reasonable number of initial wells to be drilled that will still ensure a full understanding of the geology and other aspects of a scheme. It may also provide an opportunity to enhance public engagement throughout the entire development of a CCS scheme.

The working group determined that there is no document that clearly provides information on the full CCS regulatory process and is therefore recommending the creation of a comprehensive regulatory guidance document for CCS projects.

### 4. The regulator should adopt a scheme approach for approval of CCS projects containing multiple wells. These applications should continue to be considered by the regulator on a site-specific, case-by-case basis, based on risk analysis.

- May increase project risks by introducing unnecessary leakage pathway if some of the anticipated wells are not needed.
- May be inconsistent with ERCB planning and facility proliferation guidelines.

The working group agreed that a scheme approach resolves many of these potential issues with the standard Directive 065 approach as it would be applied to long-term, multiple-well CCS projects. The scheme approach allows the regulator to approve a reasonable number of initial wells to be drilled that will still ensure a full understanding of the geology and other aspects of a scheme. It may also provide an opportunity to enhance public engagement throughout the entire development of a CCS scheme.

### 5. The ERCB should align and/or amend its regulations and requirements to explicitly cover CO₂ sequestration, as deemed appropriate (e.g. ERCB Directive 065).
In the CO₂ Enhanced Oil Recovery and Acid Gas Disposal issue, the Regulatory and MMV Working Groups identified the need for the Government of Alberta to clearly define what activities qualify as CO₂ sequestration, acid gas disposal (AGD) and carbon dioxide enhanced oil recovery (CO₂-EOR), and to provide clarity on where projects undertaking these activities fit under Alberta’s various regulations for subsurface injection of CO₂.¹

In support of these recommendations, this working group recommends that the ERCB consider how it could best align and/or amend its current regulations and directives related to the injection of CO₂ to achieve this clarity. Presently, CO₂ sequestration does not have its own chapter in Directive 065, and is regulated under the AGD section of that directive. The ERCB should consider amending Directive 065 to clearly define CO₂ sequestration versus AGD activities. This work will add transparency to the regulatory framework for CO₂ sequestration, AGD and CO₂-EOR by providing stakeholders and the public with clear information about the requirements and regulatory processes for each activity.

6. The Government of Alberta should use the Ministerial letter of consent under the authority of section 54(5) of the Mines and Minerals Act to facilitate CCS research activities in the province.

The working group discussed whether a new form of tenure was required to facilitate CCS research activities at depths shallower than 1000 meters. After reviewing current legislation, the working group agreed that a letter of consent under the authority of section 54(5) of the Mines and Minerals Act represents a pathway that a research organization may take to acquire tenure in lieu of a CCS evaluation permit or a carbon sequestration lease.

A section 54(5) letter of consent is used to provide tenure for undisposed Crown rights. Applications for a letter of consent are rigorously reviewed by the Department of Energy and are only ever approved with several conditions. The standard ERCB application and approval process still applies.

7. If any CO₂ is produced and/or released that was injected under a carbon sequestration lease, it must be accounted for and reported, and previously earned emission reduction credits must be trued-up and/or properly accounted for under current and any potential future provincial climate change policies.

The Government of Alberta should determine the appropriate threshold of CO₂ volume produced or released that would trigger this requirement.

¹ Please refer to the Carbon Dioxide Enhanced Oil Recovery and Acid Gas Disposal Recommendations.
The working group believes that there is a need to ensure proper accounting of CO₂ sequestered under a carbon sequestration lease. Ensuring accurate accounting of all CO₂ injected, released or removed under a carbon sequestration lease is necessary to support the Government of Alberta's climate change regulations, policies and emission reduction targets. Therefore, the Government of Alberta should require accurate monitoring, accounting, reporting and true-up for all CO₂ sequestered under a carbon sequestration lease that is produced or released throughout the entire lifecycle of a project. Responsibility for these actions should fall with the party liable for the sequestered CO₂ at the time.

This recommendation is not intended to put an undue burden on operators by requiring them to undertake complex accounting and reporting activities for very small volumes of CO₂ produced or released. Therefore it is important for the Government of Alberta to determine the appropriate threshold of CO₂ volume produced or released that would trigger this requirement. This threshold could take into account required MMV detection thresholds and the negligible emissions threshold defined by Alberta Environment and Sustainable Resource Development under the Specified Gas Emitters Regulation.²

Appendix D: RFA Issue Recommendation Documents

D2. CLOSURE AND TRANSFER OF LIABILITY

Author
Regulatory Working Group

Issue
The working group will propose the regulatory process that lessees must follow to obtain a closure certificate.

Scope and Key Questions
The regulatory process that lessees must follow to obtain a closure certificate and the criteria and the process for transfer of responsibility have yet to be established. The working group started discussion of this issue at the end of September, 2011.

Background
Under the Carbon Capture and Storage Statutes Amendment Act, 2010, the Government of Alberta assumes long-term liability for a CCS storage site once a closure certificate is issued. When the Government of Alberta issues a closure certificate it will indicate that a lessee has met the regulatory requirements of Alberta Energy, Alberta Environment and Sustainable Resource Development, and the ERCB in regard to closure (activities, plan and period) and the behaviour of the sequestered carbon dioxide. Specific technical performance criteria requirements are to be identified by the Monitoring, Measurement and Verification Working Group. The purpose of these requirements is to minimize risk to Alberta in accepting the long-term liability for sequestered CO2.

Section 120 of the Mines and Minerals Act (MMA) provides the Minister the ability to issue a closure certificate. Subsection 3 describes the criteria that must be met before a closure certificate can be issued:

- Monitor all wells and facilities, and perform all closure activities in accordance with the regulations.
- Abandon all wells and facilities.
- Comply with reclamation requirements.
- The closure period, as specified in regulations, has passed.
- Other conditions specified in regulations are met.
- The captured CO2 is behaving in a stable and predictable manner with no significant risk of future leakage.

Section 121 sets out the liabilities and obligations the Crown will assume when it issues a closure certificate. When issuing a closure certificate, the Crown:

- Becomes owner of all injected CO2
- Assumes all obligations of the lessee (Section.121(1)(b))
  - as owner and licensee of wells and facilities under the Oil and Gas Conservation Act
  - as person responsible for the injected CO2 and as the operator under the Environmental Protection and Enhancement Act
  - under the Surface Rights Act
- Indemnifies the lessee against liability for tort damages.
The Carbon Sequestration Tenure Regulation requires submission of an initial closure plan as part of the application for a sequestration lease and re-submission of the plan every three years for re-approval (interim plans). Section 19(3) of the Carbon Sequestration Tenure Regulation sets out what must be included in a closure plan when submitted for three year renewals:

- Summary of activities conducted in the lease area.
- Quantity of CO₂ injected.
- Evaluation of behavior of the CO₂ compared to initial geological interpretations and calculations.
- Most recent geological interpretations and calculations for the CO₂ and associated pressure front.
- Location, condition, plugging procedures and integrity testing results for all injection wells.
- Description of any decommissioning, abandonment or reclamation activities.
- Inventory of reports and documents submitted to the ERCB, Government of Alberta or Government of Canada for the project.
- Advice and recommendations about MMV activities the Government of Alberta should conduct post-closure.

When applying for closure, the lessee should submit a final closure plan to be agreed on with the regulatory agency.

**Analysis Principles**

The working group examined existing regulatory requirements for closure as well as the closure plan submitted as part of the sequestration lease application for a current CCS project. Those existing requirements and the example from a current project were compared to what the working group believes will be necessary to demonstrate that a closure certificate should be issued.

The minimum closure periods in other jurisdictions (US, EU) were examined in analysis of what minimum closure period is appropriate for Alberta.

**Areas of Non-Consensus**

None.

**Recommendations and Conclusions**

1. The Government of Alberta and regulator should develop an outline of the closure process. This outline should detail the criteria and order of events necessary for closure from submission of the initial closure plan to issuance of a closure certificate.
This outline will help to provide clarity to both project proponents and to the public about what the process is. It should provide detail on the following steps of the process:

1. Submission of initial closure plan, MMV plan and risk assessment for review and approval as part of the sequestration lease application.
2. Submission of interim closure plans for review and approval every three years and when the sequestration lease is renewed.
3. Submission of final closure plan, outlining how compliance with closure requirements will be achieved, along with notification of intent to enter the closure.
4. The lessee and regulator meet to review and discuss the final closure plan and agree on final site closure performance targets. The closure period begins at a time authorized by the regulator when it approves the final closure plan, but no earlier than the time of permanent cessation of injection.
5. Through the closure period, the lessee and regulator frequently meet to discuss state of conformance, staged abandonment, and reclamation activities.
6. Submission of final Closure/MMV report as part of the closure certificate application.

The Carbon Sequestration Tenure Regulation provides some information about the information required to be in an interim closure plan submitted for renewal, but no detail about what categories of information are required in an initial closure plan. The regulation also does not contain any reference to a final closure plan.
To provide clarity for project proponents, operators and the public, and to ensure consistency between the different closure plans, the working group believes that:

- Project proponents need additional detail beyond what is in the regulation specifying what should be included in all closure plans.
- All closure plans (initial, interim and final) should contain all of the required information categories established by the government, at a minimum.

3. In addition to requirements already in the Mines and Minerals Act and Carbon Sequestration Tenure Regulation, information required to be in a closure plan should include, but not be limited to, the following:
   - Project overview
   - Storage performance criteria for site closure (as per MMV submission)
   - Storage performance evidence
   - Operating plan updates
   - Description of current and potential surface or subsurface interactions including developments that may impact or be impacted by the project
   - Proposed closure activities
   - Any other information required by the regulator or Government of Alberta

The project overview will provide general information about the project as a whole.

Storage performance criteria will indicate what criteria will be used to demonstrate performance of the storage complex. These criteria could include CO₂ inventory accuracy criteria and criteria for performance of containment and conformance.

Storage performance evidence would provide an inventory of wells, for injection and observation as well as other wells in the project area; the inventory of CO₂ injected and released; and predictions, results and comparisons of the two for containment and conformance performance.

Operating plan updates should provide a summary of all activities conducted as part of the project.

Proposed closure activities should include a timeline of proposed activities, as well as a description of facility decommissioning and surface reclamation activities, and an assessment of the surface access needs, including identification of properties on which access will be needed.

4. Notwithstanding other obligations for suspension and abandonment of facilities, the closure period should be considered to begin on a date authorized by the regulator when it is reviewing and approving the final closure plan. This date should be no earlier than the time at which the lessee permanently ceases injection (planned or unplanned), or if the Government of Alberta withdraws approval or the lease expires.

The lessee should be required to provide the proper authority with appropriate advance notice of intent to enter the closure period and submit the final closure plan for approval at that time. The lessee should be required to continue normal operational monitoring until initiation of a formal closure plan.
The closure period should begin at a time when no more CO$_2$ injection will occur. This time should be authorized or approved by the regulator to ensure it is appropriate for the lessee to enter the closure period. The regulator and the lessee should discuss the lessee’s intent to enter the closure period, therefore appropriate advance notice of that intent is necessary.

5. The minimum closure period should be the following:

The Government of Alberta may grant a closure certificate after a period no shorter than 10 years after commencement of the closure period and when the lessee has demonstrated sustained compliance with required performance criteria for closure.

As more experience is gained in CCS, the Government of Alberta should re-evaluate the appropriateness of the performance criteria for closure and the minimum closure period.

The working group believes that an operator should only be able to receive a closure certificate after a minimum period has passed and that the decision on whether or not to issue the closure certificate should be performance based. Most jurisdictions (e.g. European Union and individual EU states, US EPA, Australia, UNFCCC) have considered a purely performance based regulation for closure before deciding to include some form of minimum closure period. Most jurisdictions that allow for a transfer of liability require a minimum time period to pass.

A minimum closure period is important for the following reasons:

1. To allow time for Government to be confident about the sustained nature of compliance with the performance criteria when making the decision to issue a closure certificate
   a. Conformity of the actual behaviour of the sequestered CO$_2$ to the modelled behaviour, with minimal need for re-calibrations and adjustments to the models, needs to be demonstrated over a prolonged period after cessation of injection.
   b. This is a relatively new field of analysis, where standards are likely still to be developing when the initial sites enter the closure period.
   c. Absence of CO$_2$ leakage or other significant irregularity will have to be shown over a sustained period after the cessation of injection, abandonment of wells and removal of surface facilities, in order to demonstrate continuing site integrity and provide a sound basis for judgments about permanent containment (with some jurisdictions requiring the clock to be re-set if any leakage or irregularity occurs in this period).
   d. In the same vein, multiple simulations over an extended period will be required to show that continuing migration of the CO$_2$ plume, and other changes within the storage complex, are trending towards long-term stability.

2. To enhance public confidence in the closure and transfer process. This is necessary for four key reasons:
   a. CCS is a new industry where no projects have yet gone through the closure process.
   b. Transfer of responsibility and liability protection is a very unusual step, offered to very few industrial activities, requiring the public to take on long-term risk exposures about which it knows little.
   c. Any significant post-transfer incidents that arise could seriously damage public confidence in CCS activities.
   d. With almost all other jurisdictions that allow for transfer of liability opting for some default closure period, not having a minimum period may be problematic from the standpoint of public perception.
The Alberta public is being asked to accept all future liability in perpetuity, at a time when there is little accumulated data on the long-term performance of carbon sequestration sites. In this case, a minimum closure period has been seen elsewhere as simply a prudent strategy for securing public acceptance. The reasons listed above combined with precedents set in other jurisdictions lead the working group to the conclusion that Alberta should also require a minimum closure period.

Because CCS is a new industry in which no projects have gone through the closure process and because minimum periods vary widely among other jurisdictions, it is difficult to determine what that minimum time period should be. After discussions with the other three working groups, the Regulatory Working Group decided it was most appropriate to accept the recommendation of the Alberta CCS Development Council and recommend a 10 year minimum period. This is shorter than in most other jurisdictions, but is proposed as a non-discretionary minimum and is backed by the sustained performance criteria. This approach means that if there are any issues with performance, a longer period of time may be necessary to demonstrate sustained compliance.

Performance criteria for closure are being recommended by the MMV Working Group. The Regulatory Working Group intentionally leaves it for the regulator to determine how ‘sustained compliance’ should be interpreted and implemented based on risk analysis on a case-by-case basis.

6. **Lessees should be required to submit a final closure and MMV report as part of the application for a closure certificate. This report should detail how the lessee addressed items within the closure plan and demonstrate achievement of requirements for closure, including compliance with performance criteria.**

Demonstration of how the lessee complied with closure requirements and fulfilled the closure plan, would be expected to include information on any issues of non-compliance or circumstances requiring remediation; and updates to forecast models including descriptions of how those forecasts changed over the life of the project and deviations from expected plume/pressure behavior.

The lessee would also be expected to provide evidence that other requirements have been met such as well abandonment, satisfaction of financial obligations, and true-up of CO₂ credits.

Lastly, the final closure report should be accompanied by all data required for the Government of Alberta to act as a licensee, and any other information requested by the Government or regulator.

7. **The Government of Alberta should designate an agency (either existing or a new one) to be responsible for the management of data submitted by operators of CCS projects.**

   This agency should develop and implement standards for the transfer and management of project data to the Government. These standards will ensure that data are in a consistent, accessible, readable and interpretable format, and will prevent the loss of data.
For the Government to act as operator after the transfer of liability, it will need sufficient data about the project. To ensure the Government will receive all the necessary data and the lessee will know well in advance what data it will need to transfer, these data requirements should be discussed early in the project life and reviewed regularly. Designation of an authority with the sufficient experience and capability to deal with this data, will help to ensure the adequate and appropriate management of submitted data.

Section 121(1)(b) lists a number of acts for which the Government of Alberta will assume liability when a closure certificate is issued. This list does not currently include liability for CO\textsubscript{2} credits under the Climate Change and Emissions Management Act.

The working group believes this liability should be assumed by the Government of Alberta for the following reasons:

1. It is consistent with the treatment of other CCS liabilities.
2. After closure, the project proponent will lose the ability to take action in the case of a CO\textsubscript{2} leak.
3. Failure to accept this liability may signal a lack of confidence on the part of Government in the permanence and safety of CCS.
4. In absence of government assumption of this liability, Alberta Environment and Sustainable Resource Development will need another measure to ensure permanence, such as an upfront hold-back of credits.

This recommendation is limited to provincial climate change legislation. It does not pertain to any assumptions around liabilities under federal climate change legislation. However, the reasons that liability under provincial legislation should transfer to the Government of Alberta may also be relevant for federal climate legislation. Therefore, the Governments of Alberta and Canada may need to re-examine this issue.
D3. **CO₂ CLASSIFICATION**

**Author**
Regulatory Working Group

**Issue**
The Regulatory Working Group has reviewed the current regulatory regime for CO₂ classification to determine how CO₂ in CCS should be or should not be classified under various regulations.

**Scope and Key Questions**
The need for the CO₂ stream for CCS to be explicitly defined and classified was considered. This was done to understand if doing so would resolve any regulatory or legal uncertainties and to determine the overall adequacy of the CCS regulatory framework.

In conducting this analysis, the working group considered the following: potential scenarios of conflict (cross border movement/transport, etc.), gaps in Alberta’s regulatory regime with respect to CO₂ Classification, the need to recommend any changes to current legislation, and any processes/policy changes that could enhance Alberta’s current regulatory regime.

Issues related to trans-boundary transport of CO₂ and transport of CO₂ using vehicles (e.g. trucks or trains) was considered out of scope, since there are no plans for these activities to occur in Alberta for at least the next ten years.

**Background**

**Alberta**
Currently there is no single, definitive classification for CO₂ in Alberta and Canada. How CO₂ is classified depends on how it is produced, its concentration, what it is used for and what legislation it falls under. The suite of Alberta legislation and regulations addressing CO₂ may be classified under the following statutory objectives:

- environmental protection and climate change
- natural resource extraction
- health and safety
- transportation.

CO₂ classification in Alberta generally occurs within the context of each of these areas and is based on the treatment of, and definition for, “gas”.

Under various statutes of current provincial legislation, the ways CO₂ may be classified include, but are not limited to:

- an industrial product or commodity
- a waste
- a controlled product, hazardous substance or hazardous waste
- a specified gas.
These classifications are described below.

**Industrial Product**

Under the existing legislation and regulations in Alberta, CO₂ may be classified, on an activity-driven basis, as a product of industrial activities or as a commodity. Examples of this categorization include the following:

- Under the *Mines and Minerals Act* ("MMA") “fluid mineral substance” is defined as a fluid substance consisting of a mineral or of a product obtained from a mineral by processing or otherwise.³

- The *Pipeline Act* and its regulation⁵ govern pipes used to convey a substance or combination of substances.⁶ While neither the *Pipeline Act* nor its regulation specifically mentions CO₂, the *Pipeline Act* defines gas to include any substance recovered from natural gas, crude oil, oil sands or coal for transmission in a gaseous state, and any gaseous substance for injection to an underground formation through a well.⁷

**Waste**

Captured carbon dioxide for the purposes of sequestration under Part 9 of the MMA is defined as a fluid substance consisting mainly of carbon dioxide captured from an emissions source.

Sequestration is defined as permanent disposal in the MMA.⁹

Captured CO₂ obtained from emission sources for permanent disposal in accordance with Part 9 of the MMA can therefore reasonably be characterized as waste.

The characterization of CO₂ as a waste, if it is in a liquid or solid form, is founded under regulations made pursuant to the *Environmental Protection and Enhancement Act*¹⁰(EPEA). Both the *Activities Designation Regulation*¹¹ (ADR) and the *Waste Control Regulation*,¹² (WCR) define waste as any solid or liquid material or product or combination of them that is intended to be treated or disposed of or stored, but does not include recyclables.¹³ Therefore both the MMA and regulations under EPEA appear to establish that CO₂ may be categorized as waste.

**Controlled product,**¹⁴ *harmful substance*¹⁵ or *hazardous waste*¹⁶

Health and safety legislation and regulation is also informative with respect to CO₂ classification, examples of which are set out below:

- Under the *Occupational Health and Safety Regulation*¹⁷ (OHSR) harmful substance is defined as a substance that, because of its properties, application or presence, creates or could create a danger, including a chemical or biological hazard, to the health and safety of a worker exposed to it.¹⁸ CO₂ could be captured under the legislation of harmful substance.

- A product material or substance specified by the *Controlled Product Regulations* to be included in any of the classes listed in Schedule II to the *Hazardous Product Act* (Canada) is designated as a “controlled product.”¹⁹ This includes Class A – Compressed Gas, defined as any product, material or substance contained under pressure, including compressed gas, dissolved gas or gas liquefied by compression or refrigeration, and therefore likely encompasses CO₂.
Regulatory Framework Assessment

• Under the Occupational Health and Safety Code 2009\(^{20}\) ("OHSC"), “controlled product” and "harmful substance" have the same meaning as in the OHSR. “Hazard” means a situation, condition or thing that may be dangerous to the safety or health of workers. “Hazardous waste” means a controlled product that is intended for disposal, or is sold for pressure that is intended for disposal would qualify as hazardous waste for the purposes of Occupational Health and Safety. \(\text{CO}_2\) would likely qualify as hazardous waste for this purpose.

**Specified Gas\(^{21}\)**

Under the Climate Change and Emissions Management Act ("CCEMA"), “specified gas” means any gas that traps heat near the earth’s surface, which includes carbon dioxide.\(^{22}\) This definition does not distinguish the source of the \(\text{CO}_2\). In the preamble to the CCEMA, it is stated that “atmospheric carbon dioxide” and methane are “not toxic” and are inextricably linked with the management of renewable and non-renewable natural resources. The source of the atmospheric \(\text{CO}_2\) referred to is not stated under CCEMA.

**Canada (Federal)**

As with Alberta legislation and regulations, how \(\text{CO}_2\) is classified depends on how it is produced, what it is used for and what legislation it falls under. Also similar to Alberta, Canadian federal legislation pertaining to \(\text{CO}_2\) may be broadly classified based on various statutory objectives:

- environmental protection and climate change
- natural resource extraction
- health and safety
- transportation.

The National Energy Board (NEB), which regulates international and interprovincial aspects of the oil, gas and electric utility industries, has jurisdiction over interprovincial and international commodity pipelines and classes \(\text{CO}_2\) pipelines as a type of commodity pipeline,\(^{23}\) implying that \(\text{CO}_2\) is a commodity. Yet, as with Alberta, there are potentially several other ways whereby \(\text{CO}_2\) could be classified; some other examples include: industrial product,\(^{24}\) a hazardous waste,\(^{25}\) a deleterious substance,\(^{26}\) or a toxic substance.\(^{27}\)

**Analysis Principles**

Scoping of this issue resulted in the decision to outsource the examination of the current \(\text{CO}_2\) classifications and the identification of implications of such classifications on CCS projects. The contractor also examined federal classification of \(\text{CO}_2\), including identification of implications. This work was performed by Borden Ladner Gervais (BLG), a national law firm.

Aided by the BLG report, the working group reviewed the potential classifications of \(\text{CO}_2\) under current Alberta and federal legislation and regulations. The working group also reviewed other Canadian and international jurisdictions’ classification of \(\text{CO}_2\).

**Areas of Non-Consensus**

None.

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21 Climate Change and Emissions Management Act, SA 2003, c. C-16.7.
22 In 1998, the NEB approved the construction and operation of Canada’s first international \(\text{CO}_2\) pipeline, the Souris Valley pipeline, which transports \(\text{CO}_2\) from North Dakota to the Weyburn and Midale oil fields in Saskatchewan. See International Energy Agency, Carbon Capture and Storage Legal and Regulatory Review Edition 1, October 2010.
25 Fisheries Act, R.S.C 1985, c. H-3, section 2; Controlled Products Regulations SOR/88-66, sections 21(1) and 34. SOR/88-66, sections 2(1) and 34.
Recommendations

1. There is no need to change how CO$_2$ is currently classified in Alberta.

Legal basis

Current classifications of CO$_2$ are not likely to affect the legal basis for CCS projects at any stage of development and operation in Alberta. Capture and transportation of CO$_2$ for EOR purpose have been in existence in Alberta and have a well-defined legal and regulatory framework. Injection of CO$_2$ and other substances (acid gas and natural gas) into underground formations has also been in existence with recognized legal and regulatory regimes. Storage of natural gas and permanent disposal of acid gas have defined legal and regulatory regimes as well. These frameworks are currently being applied ad hoc to CCS projects in Alberta, and it does not appear that changing the classification of CO$_2$ would increase the efficacy of existing regulations being applied.

The Borden Ladner Gervais report helped clarify how CO$_2$ is classified in the three main phases of a CCS project, which is outlined below.

Capture

The chief risks and regulatory concerns at the capture stage of CCS include health, safety and environmental control. These risks and concerns include worker protection in potentially high CO$_2$ concentration environments, as well as accidental release during the capture process. For worker safety, Alberta has classified CO$_2$ as a “harmful substance,” “controlled product,” and “hazardous waste.” The result of these classifications is that at the capture stage, CCS could be regulated through the mechanisms put in place by OHSA, its regulations and code.

Routine engineering design, commissioning and start-up activities associated with new petrochemical facilities would likely be applicable to the capture and compression of CO$_2$. Accidental release would likely be governed by Part 5 of EPEA relating to release of substances, and its regulations. These classifications appear adequate for the capture stage of a CCS project since capture for various industrial uses, including EOR, has been in existence before CCS.

Transport

The transport stage of CCS would generally be similar to the regulatory framework concerned with public safety and environmental control that governs pipelines and shipping. The Pipeline Act has no express classification for CO$_2$ although it is likely to come under the definition of “gas”. While this is a potential gap,
it does not appear that a regulatory amendment would strengthen the regulations. CO₂ for transportation purposes via pipeline would also benefit from an express classification, potentially including a quality specification akin to that applicable to enhanced recovery operations. If the CO₂ stream being transported is for CCS and contains a significant amount of other substances such as H₂S, ERCB Directives that manage the production, transport and storage of gas containing H₂S would be utilized.

Storage

Concerns at the storage stage include leakage from storage sites. The existing classifications of CO₂ in Alberta which fit this stage would be “specified gas.” This is because any leakage would likely amount to emission of CO₂ into the atmosphere. If the stored CO₂ contained other impurities, it may also be classified as “toxic.”

Because of the absence of specified legislative classification, the ERCB currently regulates CCS under Acid Gas Disposal (AGD) Regulation. Acid gas is classified as a waste stream and regulated as such in Alberta. In the absence of express legislative classification of sequestered CO₂, the existing framework applicable to public safety and industrial accidents may cover the storage aspects of CCS operations. Examples of a potentially applicable framework include EPEA and the ERCB’s acid gas disposal regime. It is doubtful that an express classification would strengthen these regulations.

Inter-jurisdictional conflicts

Several differences exist between the Alberta and federal classifications. Despite these inter-jurisdictional differences in the treatment of CO₂, at present there is no need to address this concern. Specifically, the federal government includes CO₂ as a toxic substance, with respect to air emissions, under Schedule 1 of the Canadian Environmental Protection Act (“CEPA”), whereas this is not the case in Alberta under the Climate Change and Emissions Management Act. Legal scholars have suggested it is unlikely that the federal government’s recognized authority to regulate CO₂ emissions by having CO₂ classified as a toxic substance in CEPA, could extend into frameworks that prescribe the manner in which CCS are projects implemented.28

Supporting documents provided to working group

- Final Report on Assessment of existing classification of CO₂ Alberta and Canadian federal legislation and regulations (Agreement #002140), November 4, 2011.

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28 Bankes (2008) suggests that in order to achieve regulatory oversight over CCS through the CEPA, the fundamental nature of CEPA would change. Instead of being federal legislation “in relation to criminal law,” it would become regulatory legislation “in relation to property and civil rights,” which are enumerated Provincial heads of power. It would therefore be difficult to justify the use of federal powers under the CEPA to support such sweeping regulatory control. (Bankes, N.D., “Legal Issues Associated with the Adoption of Commercial Scale CCS Projects”, Pembina Institute – ISEE Thought Leader Forum, November 10, 2008.)
D4. CO₂ ENHANCED OIL RECOVERY AND ACID GAS DISPOSAL

Authors
Monitoring, Measurement & Verification Working Group
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Issue
The Regulatory Framework Assessment (RFA) Working Groups have identified that there are many technical similarities between CO₂ sequestration, CO₂ enhanced oil recovery (CO₂-EOR) and acid gas disposal (AGD) activities.

The expert panel and steering committee provided direction to the working groups that requirements for the transition of a CO₂-EOR operation to a CO₂ sequestration project should be considered within the scope of the RFA. When considering this issue, discussion within the working groups raised additional issues beyond transitioning, and identified that there are broader considerations to be made regarding the relationship between CCS and CO₂-EOR activities in the province.

The expert panel and steering committee also provided direction to the working groups that regulatory requirements and standards for AGD be considered as they relate to CCS. Throughout the RFA, there have been proposals for a more rigorous regulatory process for CO₂ sequestration under a carbon sequestration lease than for CO₂ (or hydrogen sulphide (H₂S)) acid gas disposal under a section 54(5) authorization under the Mines and Minerals Act. Therefore, working groups have identified the need for clarity around project classification as well as the need to address differing regulatory requirements for similar activities.

Background: CO₂-EOR
CO₂-EOR is a well-established oil recovery technique and widely applied in many regions, mainly in the Permian basin in the United States but also in Canada. Historically, CO₂ EOR has been valued principally as a means of improving recovery of oil from mature oil reservoirs. Given the value associated with CO₂ used for EOR, it is seen as a means of driving deployment of CO₂ capture and development of transportation infrastructure, and will offer opportunities to learn about CO₂ geological sequestration.

The RFA working groups have recognized that it is likely that initial projects will use CO₂-EOR to improve the economics of deploying CCS.

In general, approval for the operation of a CO₂-EOR scheme in Alberta is the responsibility of the Energy Resources Conservation Board (ERCB) under the Oil and Gas Conservation Act. For example, applicants for a CO₂-EOR project require approval for both surface and subsurface development, including Directive 056, Directive 065 and Directive 051 approvals, among others. Directive 065 applications are reviewed to ensure hydrocarbon recovery is optimized and enhanced recovery scheme requirements are met, including Directive 051 wellbore integrity and completions requirements. In addition to the requirements specified in ERCB Directives, site-specific operational parameters, monitoring requirements, and annual reporting requirements may be identified and specified in approvals. Proponents may also require various authorizations from other government departments, including Alberta Environment and Sustainable Resource Development, depending on the scope, location and scale of the project.

In regard to other jurisdictions, in the United States, enhanced hydrocarbon recovery (EHR) wells are classified separately from CO₂ geologic storage wells. The European Union Directive 2009/31/EC defines requirements for geologic storage of CO₂. The directive does not include EHR; however it states, “where EHR is combined with geological storage of CO₂, the provisions of this directive for the environmentally safe storage of CO₂ should apply”.

29 The working group has used the term CO₂ enhanced oil recovery (CO₂-EOR) throughout this document, but does not intend to limit the issue to only oil production. The working group has recognized that it may be appropriate to include other types of CO₂ enhanced recovery techniques (for example enhanced coal-bed methane recovery) when implementing the recommendations.
The working groups have recognized that there is significant work and many ongoing efforts in the CO₂-EOR field that should be considered or reviewed in future assessments. Several such projects and studies have been identified and include:

- The Regulatory Enhancement Project.
- Alberta Innovates Technology Futures (AITF) and International Performance Assessment Center for Geologic Storage of CO₂ (IPAC-CO₂) study of technical issues affecting transition of a CO₂-EOR site to a CCS project.
- The upcoming review being led by Alberta Environment and Sustainable Resource Development of the Quantification Protocol for Enhanced Oil Recovery.
- The Carbon Sequestration Leadership Forum (CSLF) Technical Committee has set up a Task Force to review transitioning of a CO₂-EOR site to a CCS project and anticipates that a final report will be published in 2013.
- Future development of quantification protocols as a result of CCS in geological formations being recognized by the United Nations as a Clean Development Mechanism.

The issue of public perception has also been raised by the RFA working groups as CO₂-EOR and CCS are viewed as similar activities by the public. This perception may be reinforced by the Government of Alberta’s selection of projects under the CCS Fund, one of which is related to providing CO₂ for EOR (the Alberta Carbon Trunk Line). Working group members have also raised concerns that negative perception of differing regulatory requirements for CO₂ sequestration and CO₂-EOR activities could adversely impact the deployment of CCS in the province.

**Background: Acid Gas Disposal**

Approval for AGD in Alberta is the responsibility of the ERCB under the Oil and Gas Conservation Act. Applicants require approval for both surface and subsurface development, including Directive 056, Directive 065 and Directive 051 approvals, among others. Proponents may also require various authorizations from other government departments, including Alberta Environment and Sustainable Resource Development, depending on the scope, location and scale of the AGD project.

Within the current regulatory framework, any subsurface disposal of CO₂ is regulated by the ERCB as AGD under Unit 4 of Directive 065: Resource Applications for Oil and Gas Reservoirs. Before an application is made to the ERCB, the project proponent must determine which type of subsurface rights agreement is desired, and obtain these rights as per the Mines and Minerals Act. The type of subsurface lease or authorization obtained will determine which regulatory requirements the application for subsurface disposal will be evaluated against. In the case of a section 54(5) authorization or a petroleum and natural gas tenure agreement, the project will follow the existing regulatory requirements for an AGD scheme. In the case of a carbon sequestration lease, the project will follow the regulatory framework being designed for CO₂ sequestration. It is evident that clear guidelines are required as to which type of subsurface rights should be required. For example, project proponents wishing to dispose of CO₂ into the subsurface could apply for an AGD scheme approval (based on the subsurface rights agreement obtained) and face fewer regulatory requirements than for a CO₂ sequestration scheme. In this case, they would also forego the opportunity to transfer liability as without a carbon sequestration lease agreement well licensees maintain perpetual liability.

30 The definition of CCS does not preclude EOR activities.
Analysis Principles

Although monitoring, measurement and verification (MMV) for CO\textsubscript{2}-EOR was originally included as an issue assigned to the MMV working group, subsequently it has been identified that CO\textsubscript{2}-EOR is a subject applicable to all issues being assessed in the RFA. As a result, the working groups are providing joint recommendations.

This assessment has focused on the general activities of CO\textsubscript{2} sequestration, AGD and CO\textsubscript{2}-EOR. Injection well construction and conversion requirements are reviewed as part of the Geology/Technical working group recommendations on Well Construction.\textsuperscript{31}

Areas of Non-Consensus

None.

Recommendations and Conclusions

1. The Government of Alberta should define what qualifies as CO\textsubscript{2} sequestration, CO\textsubscript{2} enhanced oil recovery (CO\textsubscript{2}-EOR) and acid gas disposal (AGD), with particular attention to the distinction between CO\textsubscript{2} sequestration and AGD.

The Government of Alberta and project proponents need clarity on where projects fit under Alberta’s various regulations for subsurface injection of CO\textsubscript{2}. The Government of Alberta should clearly indicate criteria and parameters of what projects can qualify as CO\textsubscript{2} sequestration, CO\textsubscript{2}-EOR, and AGD. Potential contributing factors for determining what defines CO\textsubscript{2} sequestration, CO\textsubscript{2}-EOR and AGD could include, but not be limited to:

- Scale: the volume of CO\textsubscript{2} being injected.
- Whether or not emissions reductions requirements are being met and/or offset credits are earned through injection of CO\textsubscript{2}.
- Composition of the injected stream.
- Monitoring and reporting required.
- Reservoir pressure as compared to original reservoir pressure.
- Hydrocarbon production rate.

2. Implementation of RFA recommendations will give rise to differences in how CO\textsubscript{2} injection and storage activities are regulated as CO\textsubscript{2} sequestration, CO\textsubscript{2} enhanced oil recovery (CO\textsubscript{2}-EOR) and acid gas disposal (AGD). The Government of Alberta should identify these differences and address them appropriately to ensure regulatory consistency and/or that regulatory differences can be justified.

\textsuperscript{31} The Geology/Technical Working Group reviewed proposed changes to Directive 051: Injection and Disposal Wells – Well Classification, Completions, Logging, and Testing Requirements, and recommended that the proposed requirements for surface casing and cementing may be adequate for CCS. It was also recommended that these requirements should be applicable to all class IIIa wells (new wells and conversions); however, that the proponent may propose a modified well completion which would be reviewed by the ERCB using a performance-based approach as is the current practice. Refer to the Well Construction recommendation document (Appendix 021), recommendation 2, for further information.
In addressing CO$_2$-EOR and AGD, the RFA working groups were advised to focus on the requirements for CO$_2$-EOR projects to transition to CO$_2$ sequestration projects and on the requirements for AGD as they relate to CCS. However, during the course of the review a number of other potential concerns and significant issues were raised:

- The public may not understand why or may question why there are different regulatory requirements for CO$_2$-EOR, AGD and CO$_2$ sequestration projects.
- It may be appropriate to conduct a review of CO$_2$-EOR and AGD policies and/or regulations to:
  - ensure containment and address permanence of greenhouse gas reductions for CO$_2$ injected in CO$_2$-EOR and AGD.
  - assess the need for collection of baseline data and provide recommendations on the appropriate types and amounts of data to be collected.
  - review the extent to which CO$_2$-EOR and AGD can play a role in meeting Alberta’s greenhouse gas reduction targets.
  - assess the need for changes in regulatory requirements and approval with regard to impact assessment, risk assessment, tenure, MMV and public notification for CO$_2$-EOR and AGD.
- The applicability of risk based regulations for CO$_2$-EOR activities to enable project specific conditions (e.g. injection volume, composition, etc.) to be considered in determining fit for purpose monitoring and operational requirements.

3. The Government of Alberta should review the requirements for CO$_2$ enhanced oil recovery (CO$_2$-EOR) projects wishing to transition to CO$_2$ sequestration to ensure that they meet the same objectives as the requirements for CO$_2$ sequestration projects.
Although it is not explicitly prohibited by current legislation, the regulatory process to transition a CO₂-EOR scheme to a CO₂ sequestration project is not presently defined. A review of this process may lead to differences in specific requirements for CO₂-EOR projects that transition to CO₂ sequestration sites (to enable potential transfer of long-term liability) compared to requirements for projects that start out as CO₂ sequestration projects. However, the same objectives should be met to ensure equivalent protection of the public and environment.

There are a number of significant differences between CO₂ sequestration and CO₂-EOR in terms of their regulatory frameworks and the physical operations. The working groups identified some specific considerations for this review arising from those differences:

- The definition of a sequestration complex for CO₂ sequestration versus a hydrocarbon reservoir used for CO₂-EOR, including the number and quality of caprock seals and pressurization effects.
- The treatment of liability and the closure process, including payments into the PCSF and Orphan Well Fund.
- Pore space ownership and tenure issues, including depth of operations (CO₂-EOR may be shallower than the 1000 metre minimum depth for sequestration tenure), multiple tenure holders in an oil field and the definition of area of influence.
- Similar MMV activities and associated risk assessment approaches are used in CO₂-EOR projects, but may be more limited in scope compared to CO₂ sequestration projects. MMV activities are required in CO₂-EOR projects to understand the location of CO₂; if the project chooses to access emissions offsets and/or transfer of liability as would occur for a CO₂ sequestration project then equivalent MMV activities should be required.
- The MMV working group feels that a possible lack of baseline data from the start of injection operations should not preclude an existing CO₂-EOR scheme from transitioning to a CO₂ sequestration project; however, MMV plans would need to reflect these conditions and provide the same assurance of containment via alternative means.
- Depleted hydrocarbon reservoirs and former CO₂-EOR sites would likely have more legacy wells than other geologic sequestration sites as the primary purpose for selection of a CO₂-EOR site is for hydrocarbon recovery rather than for CO₂ sequestration. The MMV working group feels that undertaking a site-specific risk assessment to inform MMV and closure plans would enable an operator to identify potential adverse events associated with legacy wells and put appropriate safeguards in place which would account for differences in site selection between former CO₂-EOR sites and CO₂ sequestration sites.
D5. CO₂ TRANSPORTATION AND COMPOSITION

Author
Environmental Working Group

Issue
The Environmental Working Group has reviewed the technical considerations and regulatory requirements for carbon dioxide (CO₂) pipelines used for the purpose of Carbon Capture and Storage (CCS) in Alberta to determine if existing design standards for CO₂ pipelines are adequate. Further, the composition of CO₂ streams were assessed to understand whether existing CO₂ composition requirements are adequate for capture, transport and injection, with considerations for wise use of storage capacity.

Scope and Key Questions
Cross-border transportation of CO₂ was out of scope for this review because the RFA is focussed on the development of CCS within Alberta, and cross-border regulatory requirements generally fall under federal authorities. Transportation via methods other than pipeline (e.g., train, truck, boat) were out of scope because there are no current or near-future economically viable options other than pipelines for large-scale CO₂ transport. Impurities and stream compositions that are unlikely to be encountered for CCS projects were not included in the review.

The working group focused on technical considerations and regulatory requirements pertaining to:

- Standards for CO₂ pipelines that are to be used for commercial-scale CCS.
- The composition of the CO₂ streams that are to be used for CCS.

Background
Regulatory requirements for CO₂ pipelines generally cover important design elements such as: size, materials selection, design pressure (e.g., wall thickness, over-pressure protection systems), resistance to degradation (e.g., internal degradation due to corrosion and external degradation due to environmental conditions), protection from damage (e.g. varying depth of burying the line), appropriate monitoring facilities and safety systems and siting considerations.

CO₂ pipelines are regulated by Energy Resources Conservation Board (ERCB) under the Pipeline Act and Canadian Standards Association (CSA) standards. The CSA Standard Z662: Oil and Gas Pipeline Systems is a detailed yet descriptive standard that allows for engineering judgment to address site-specific issues and incorporate improvements to materials and design techniques. In terms of pipeline access, each pipeline has specifications that must be met. For example, each pipeline has pressure requirements to ensure the CO₂ stream remains in the dense phase, and there are corrosion abatement requirements such as specifying maximum water content in the stream. The suppliers and pipeline operators ensure that the physical properties of the CO₂ stream and any additional streams conform to the pipeline design capability. Even though the CSA Z662 standard applies to CO₂ used in oilfield enhanced recovery schemes, and the existing requirements and standards adequately address CO₂ pipeline design, operation and maintenance for large-scale CCS projects, the Environmental Working Group is recommending some improvements to the current regulatory regime.

The composition of the CO₂ stream and the associated impacts to phase behaviour, water solubility, toxicity and corrosivity must be understood in order for CCS projects to be designed and operated such that risks to the environment are minimized. In general, the impurities of greatest concern for
Appendix D: RFA Issue Recommendation Documents

A CCS project are water (H$_2$O), hydrogen sulphide (H$_2$S), sulphur dioxide (SO$_2$), carbon monoxide (CO) and non-condensables such as hydrogen (H$_2$) and nitrogen (N$_2$). However other impurities in the CO$_2$ stream can affect the phase behaviour and solubility of other components in the stream. There is limited information on the chemical and physical interactions of multiple impurities within a CO$_2$ stream, especially near its critical point. As well, the composition of the CO$_2$ stream is affected by many factors including feedstock composition, capture technologies and operating conditions. Due to the lack of available data and multitude of interrelated variables that affect stream composition, it is difficult if not prohibitive to set an industry-wide standard or limit of any given impurity at this time. In Alberta, CO$_2$ stream composition is not specified in the current regulatory regime for CCS; however it is still addressed as an inherent issue that is reviewed in the approvals process. As well, new technologies are being investigated that could reduce potential safety concerns of the CO$_2$ stream in the future.

As part of an ERCB Directive 056: Energy Development Applications and Schedule application, CO$_2$ pipelines are considered ‘non-routine’, which triggers an in-depth review of the application. The review also considers the anticipated concentrations of impurities in the CO$_2$ stream, and limits may be placed on impurities based on the project-specific criteria.

**Analysis Principles**

The working group reviewed the current design standards for CO$_2$ pipelines, which are specified and required according to standards such as the CSA Z662: Oil and Gas Pipeline Systems. The current scientific information on the potential effects and limitations of stream impurities on different components of CCS operations (i.e. capture, transport, storage) were reviewed. The requirements in the United States and other jurisdictions were assessed in comparison to the requirements in Alberta for both CO$_2$ transportation and composition.

**Areas of Non-Consensus**

None.

**Recommendations and Conclusions**

1. ERCB license applications for all CO$_2$ pipelines for the purposes of CCS should continue to be considered non-routine.

This will ensure that a comprehensive technical review of the application will be undertaken. As CO$_2$ pipelines for CCS become more common in Alberta, it may be possible to consider CO$_2$ pipeline applications routine at some point in the future.

2. Regulatory agencies should continue to reference the most recent CSA Standard Z662: Oil and Gas Pipeline Systems.
This will ensure that the most up-to-date standard will be used for future CO₂ pipeline systems in Alberta. Project proponents need to be aware of when such updates become available. The ERCB released Information Bulletin 2011-26 on September 9, 2011 notifying all oil and gas license holders and operators that the CSA issued CSA Z662-11 and that it supersedes all previous editions.

3. **The composition of the CO₂ stream should continue to be tracked over time and evaluated by the regulator on a case-by-case basis to ensure that the physical and chemical properties conform to the design capabilities of the infrastructure used to capture, transport and inject the CO₂ stream. Any composition standards or specifications that may arise from subsequent regulatory reviews should be based on the concentrations of impurities that might be present in the stream. The stream should be predominantly CO₂ in order to satisfy the intended purpose of using the stream for CCS.**

Although there are no prescribed limits for impurities in CO₂ streams used for CCS, the existing regulatory framework considers impurities when designing and operating the different components of a CCS project. This is to allow for the application of engineering judgement for selection of materials and operating parameters according to the anticipated stream characteristics. Currently, projects need to consider impurities in their design and are evaluated on a case-by-case basis. This should include any compositions that may have impacts on public safety and confidence. However, the total percentage of impurities in a CO₂ stream would likely not exceed 10 percent.

In cases when a new stream with a different composition is introduced to an existing CO₂ pipeline, pipeline operators and CO₂ stream suppliers monitor the stream composition in order to determine if the stream meets the pipeline specifications. Additionally, re-evaluation may be necessary at any time if changes to the stream composition could potentially negatively impact infrastructure or public safety. Individual impurities have very different effects on the behaviour of the CO₂ stream and their concentrations are what drive design considerations, not solely the concentration of CO₂. The Alberta CO₂ Purity Project is working towards developing guidelines for composition that could be useful to the regulator once the work is complete.

The MMV Working Group is recommending that risk assessments be required for the subsurface component of CCS projects. This would include an assessment of the potential risks associated with impurities in the CO₂ stream.

4. **The Government of Alberta should investigate the possibility of conducting research and/or experiments on leak detection methods for CO₂ pipelines.**
There are methods in place to detect leaks from pipelines such as flyovers, infrared cameras, site inspections, the addition of odorants and leak detection and repair programs. There may be more suitable methods specifically for CO₂ pipelines that would benefit the operational, public safety and public confidence aspects of leak detection.

5. Pipeline Integrity Management Programs (IMPs) for CO₂ pipelines, as required under ERCB Directive 077, should be made available by CO₂ pipeline operators to the public on request.

If any member of the public wishes to view a CO₂ pipeline operator’s Pipeline Integrity Management Program, the operator should provide the IMP on request. However, proponents or operators should not be required to distribute IMPs to all affected stakeholders.
D6. COMPETITION WITH OTHER RESOURCES

Author
Regulatory Working Group

Issue
Determine the provisions required to manage the interaction of CCS development with other resource development (and conservation) interests.

Scope and Key Questions
- Consider the potential impacts of CCS implementation on the conservation, production and protection of other resources, and the potential impacts of other resource developments and conservation on CCS development.
- Review the current regulatory process for managing subsurface resource interactions to ensure that the process is sufficient for CCS development.
- Review potential CCS development scenarios, including stacking and joint pore space utilization, to identify potential issues and management options.
- Identify a number of tools and practices to facilitate the management of sequestration quality pore space in the province of Alberta.

Background
Sedimentary basins that have high CO₂ storage potential also host fossil fuel, groundwater, mineral and geothermal energy resources, as well as providing options for gas storage and permanent disposal of waste materials (e.g., acid gas disposal). Regulatory bodies have established processes and mechanisms for preventing adverse impacts from one form of resource production or utilization on others (e.g., gas over bitumen policy in Alberta). It is important that Alberta’s RFA considers the impact of CCS implementation on the conservation, production and protection of other resources. It must also recognize the impact of other resource developments and conservation on CCS development, given that subsurface interactions and impacts can be negative, leading to competition scenarios, or positive, providing the opportunity for development synergies.

To this end, the Government of Alberta has already taken steps to manage the interaction between CCS and hydrocarbon resources. The Carbon Capture and Storage Statutes Amendment Act, 2010 amended a number of pieces of legislation explicitly mandating that CCS projects will not interfere with or negatively impact hydrocarbon projects in the province.

The working group has considered a number of potential subsurface resource and development interaction scenarios related to CCS implementation and has made a recommendation related to the evaluation and management of these interactions.

Stacking and Joint Pore Space Utilization
The working group considered two potential CCS development scenarios: stacking and joint pore space utilization. Stacking refers to the vertical overlaying of CCS operations within different strata of a single tract of land. Joint pore space utilization refers to potential CCS development scenarios where CCS injection operations operate as close as technically feasible to each other to maximize pore space utilization (related to “unitization” in petroleum and natural gas operations). Both development scenarios present potential opportunities to maximize pore space utilization in a particular zone, which could become increasingly important if CCS becomes a prominent activity in the province. However, both scenarios also present a number of potential technical and regulatory challenges. The working group inventoried a number of potential challenges related to these development scenarios for the regulator to consider when reviewing applications for stacked and jointly operated CCS operations.
**Management of Sequestration Quality Pore Space**

Currently, most decision-makers in the private or public sector do not consider pore space a resource because, in most minds, it has no value and is not worthy of consideration when it comes to making trade-off decisions relating to resource development and planning in the province. Looking into the near future, the working group believes that this lack of consideration could impede Alberta’s ability to achieve the emission reduction targets from CCS outlined in the 2008 Climate Change Strategy if high quality pore space for CO₂ sequestration is not effectively managed. Therefore, the working group has made recommendations related to the management of pore space in Alberta.

**Analysis Principles**

- Review of existing regulatory framework for managing subsurface resource interactions and development scenarios, including stacking and joint utilization. Gathered input from the Energy Resources Conservation Board (ERCB) on current framework for managing subsurface resource interactions.
- The Regulatory and Geology/Technical working groups held a joint meeting to discuss the regulatory and technical considerations related to the potential CCS development scenarios of stacking and joint utilization.

**Areas of Non-Consensus**

None.

**Recommendations**

1. **The Government of Alberta should promote and/or facilitate the development and periodic updating of an inventory of sequestration quality pore space in the province.**

A number of pore space inventories have been developed, or are currently under development, by various federal and provincial organizations, including the Geological Survey of Canada and the Alberta Geological Survey (AGS), which is part of ERCB. Recognizing this work, the working group agreed that more work needs to be done by the Government of Alberta to accurately inventory sequestration-quality pore space in Alberta.

The working group believes that an increasingly detailed inventory of sequestration pore space in the province would be a useful tool for pore space management and subsurface resource decision making in the province, and encourages the Government of Alberta to assess potential options to achieve this outcome.

2. **When developing this inventory, and when practical, the Government of Alberta should identify potential areas of interaction between subsurface resources and sequestration quality pore space, particularly those interactions with resources that have a higher development priority.**
The working group identified a number of subsurface resources and development schemes, both current and potential, that could interact with CCS development. These resources include, but are not limited to:

- pore space (future potential for CCS or other subsurface storage/disposal schemes)
- groundwater (saline and non-saline)
- existing storage/disposal schemes
- hydrocarbon development (including hydraulic fracturing techniques used for shale gas and oil production)
- hydrocarbon storage
- coal
- geothermal
- dissolved minerals/materials
- solid minerals.

The ERCB has a well-developed process for evaluating and managing subsurface resource interactions that is guided by Government of Alberta resource development policies. The working group determined that the current ERCB process is sufficient for evaluating and managing resource interactions with CCS development.
However, recognizing that the definition of resource and resource development priorities are constantly changing, the working group encourages the Government of Alberta and the ERCB to evaluate potential subsurface resource interactions on a case-by-case basis based on resource development policies of the time and realistic expectations for future resource development opportunities and priorities. Notably, the working group encourages the Government of Alberta to explicitly consider impacts on pore space, seals (e.g. caprock) and existing stored CO$_2$ when making decisions relating to subsurface resource development across the province. The working group believes that effective pore space management will be necessary in order for Alberta to achieve the sequestration targets set for CCS, as outlined in the 2008 Climate Change Strategy.

4. Applications for ‘stacked’ or ‘jointly utilized’ CCS projects should be considered on a case-by-case basis.

The working group considered two potential CCS development scenarios: stacking and joint pore space utilization. A principal opportunity presented by these development scenarios is the potential to maximize pore space utilization in the province, which could become increasingly important if CCS becomes a prominent activity in the province. Conversely, these scenarios also present a number of regulatory and technical challenges.

The working group agreed that there is reason to be cautious about stacking CCS operations at this time. Regarding joint pore space utilization, the working group agreed that while these scenarios are likely technically feasible, there are a number of hurdles in the current regulatory process that would complicate these development scenarios, including tenure and ERCB scheme approvals.

Therefore, when considering applications for these development scenarios, the working group encourages the regulator to consider the unique challenges that CCS operations present. The working group has inventoried the following challenges for the regulator to consider when reviewing applications for either of these CCS development scenarios:

- access for monitoring, measuring and verification
- pressure effects and changes to stress fields
- CO$_2$ source identification
- well design requirements for drilling through pressurized zones
- public acceptance/perception
- potential for long-term resource sterilization.
D7. ENVIRONMENTAL ASSESSMENTS

Author
Environmental Working Group

Issue
The objective of this assessment is to understand the current regulatory regime for similar environmental assessment activities, identify best-in-class processes that could enhance Alberta’s current regulatory regime, recommend necessary changes to Alberta’s existing regulatory regime, and confirm the processes and resources necessary to implement a CCS regulatory framework that will be a cornerstone of a robust, efficient and effective risk management system for large scale capture, transport and geologic storage in CO₂ in Alberta.

Scope and Key Questions
The analysis entailed a comprehensive review of the current Alberta environmental assessment requirements that would apply to CCS projects. It was also necessary to thoroughly review the environmental approvals process as that is the mechanism that allows the regulator to impose requirements for mitigation of identified environmental effects. A review of the technical/science requirements of environmental assessments in other jurisdictions was necessary to ensure that Alberta’s technical requirements are consistent with the best in the world.

The key questions for this issue are:

- Should environmental impact assessments (EIAs) and/or approvals under the Environmental Protection and Enhancement Act (EPEA) be mandatory for CCS projects?
- Are the current technical and scientific information requirements adequate for EIAs or approvals for CCS projects?

Background
In Alberta the governing legislation for environmental assessment is EPEA. Alberta’s environmental assessment process has three basic goals:

- to gather information
- to provide a forum for public involvement
- to support sustainable development in the province.

The project proponent is responsible for evaluating the project-specific and cumulative impacts that a project may have on the environment and reporting that information to the regulatory decision-makers. Alberta Environment and Sustainable Resource Development (ESRD) is the government department responsible for the administration of EPEA but other provincial agencies may have a regulatory interest in a particular project and may actively participate in reviewing the proponent’s EIA report. The proposed terms of reference for each EIA are developed by the proponent. ESRD issues the final terms of reference with consideration given to input provided by various provincial or federal departments, as well as input received by the public. This often means that Alberta Health and Wellness and other agencies and private entities fully participate during EIA terms of reference development and review. This process of developing a unique terms of reference for each project provides the regulator with a method of ensuring that the information requirements are project specific and based on the most current science at the time.
In Alberta, EIAs are a useful tool to gather a great deal of information about a proposed activity, but they are not the mechanism by which a proponent is given approval to construct and operate a facility. This is accomplished via approvals granted under EPEA, Water Act, Public Lands Act, Oil and Gas Conservation Act, Pipeline Act, ERCB Directives, and other legislation where authorization is needed. The current regulatory regime for approving components of CCS operations is fairly robust; however the subsurface component of CCS does not currently require an EPEA approval, nor does the capture and processing of CO₂ for storage as a stand-alone facility. The CO₂ capture component of CCS would be considered in an EPEA approval and/or EIA if it was part of a larger facility that was required to undergo that level of scrutiny. The subsurface component of CCS is subject to any relevant ERCB requirements for subsurface disposal. The approval process is the mechanism by which the province can set conditions and requirements for the operation of the various components of a CCS project.

The regulation that determines whether an environmental assessment is required is the Environmental Assessment (Mandatory and Exempted Activities) Regulation. This regulation defines what types of projects require an EIA and what projects specifically do not require an EIA. Some examples of projects on the mandatory list include:

- An oil sands mine.
- A surface coal mine producing more than 45,000 tonnes per year.
- A thermal electrical power generating plant that uses non-gaseous fuel and has a capacity of 100 megawatts or greater.
- A chemical fertilizer manufacturing plant.
- A commercial oil sands, heavy oil extraction, upgrading or processing plant producing more than 2,000 cubic metres of crude bitumen or its derivatives per day.
- A sour gas processing plant that emits more than 2.8 tonnes of sulphur per day.
- An oil refinery.

Some examples of projects on the exempted activities list include:

- A sweet gas processing plant that emits less than 384 kilograms of oxides of nitrogen per day.
- A pipeline with a length in kilometres times diameter in millimetres resulting in an index number of less than 2690.
- The drilling, construction, operation or reclamation of an oil or gas well.

If a proposed activity is not on either the mandatory or exempt list, the director (as designated by the Minister) has discretion to determine if the proposed activity warrants further environmental assessment due to the potential environmental impacts by considering the following criteria:32

- The location, size and nature of the proposed activity.
- The complexity of the proposed activity and the technology to be employed in it.
- Any concerns in respect of the proposed activity that have been expressed by the public of which the director is aware.
- The presence of other similar activities in the same general area.
- Any other criteria established in the regulations.
- Any other factors the director considers to be relevant.

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32 Province of Alberta, Environmental Protection and Enhancement Act, Revised Statutes of Alberta 2000: Chapter E-12, Section 44(3), Alberta Queen’s Printer.
With respect to the size of the proposed activity, CCS projects are by nature very large compared to other injection or disposal facilities. For example, a project that would sequester one million tonnes of CO₂ per year would inject CO₂ volumes that are much greater (at least an order of magnitude) than the majority of current acid gas disposal schemes. In terms of the nature of the activity, permanent underground disposal of CO₂ for the purposes of climate change mitigation is a novel concept to the general public. As well, after the operator has received a closure certificate, the Government of Alberta will assume liability of these projects in perpetuity which is in contrast to current oil and gas projects where the operator remains liable in perpetuity for certain parts of their operation. In addition, the presence of public funding may increase public scrutiny. Together, these factors contribute to public concerns regarding CCS.

To date, no CCS projects have been required to undergo an EIA by the Government of Alberta. Due to funding from the Government of Canada, federal environmental assessments were required by the federal government for the 3 recent CCS project proposals in Alberta: Project Pioneer, Alberta Carbon Trunk Line, and Shell Quest. Shell voluntarily submitted an EIA to the Province of Alberta for its Quest project.

Analysis Principles

A review of technical and scientific information requirements for environmental assessments that would apply to CCS projects in other jurisdictions including Australia, Germany, the United Kingdom, the United States, and Norway was conducted and the working group determined that the technical and scientific information requirements for EIAs in Alberta are adequate for CCS projects. Although there are widely differing requirements in other jurisdictions, Alberta’s requirements and flexible process allow for a very comprehensive EIA to be developed.

Recommendations and Conclusions

1. By the end of 2015, the Government of Alberta should determine the specific conditions under which an environmental impact assessment (EIA) provides significantly greater understanding of potential impacts stemming from CCS projects or components than the understanding that can be achieved through other regulatory requirements, and from that, the government should evaluate:

   • If EIAs should be mandatory for CCS projects (or project components) and whether threshold criteria should be established that would call for mandatory EIAs for CCS projects
   • Whether a comprehensive assessment process specific to CCS should be developed that is appropriate for the unique aspects of CCS projects and builds upon current regulatory processes.

Until the above evaluation is complete, EIAs should be mandatory for CCS projects.
Through work on other Regulatory Framework Assessment recommendations, the Environmental Working Group has identified possible regulatory gaps related to amine usage, shallow groundwater monitoring, and the potential impacts of CO₂ plume migration and pressure build-up. While many of these gaps are being addressed through other RFA recommendations, assurance is needed that these gaps will be identified and potential impacts will be mitigated through an appropriate, effective and comprehensive process.

Although there is currently local and worldwide experience with various components of CCS, CCS projects as a whole are a relatively recent development. In particular the notion of permanent underground sequestration of CO₂ for the purposes of climate change mitigation is a relatively recent idea. As well, CO₂ sequestration can differ from other activities such as enhanced oil recovery (EOR) in that sequestration involves pressurizing storage reservoirs whereas EOR can maintain a relatively constant reservoir pressure. Any environmental assessment of CCS projects should ensure that subsurface components and potential cumulative impacts are considered. Also, requiring EIAs to be mandatory for CCS projects over the next three years will ensure every effort is made to identify potential impacts until such time as the appropriate process can be confidently implemented for CCS projects in Alberta.

Public confidence in the regulatory process that ensures potential environmental and social impacts are identified and mitigated is key to the success of large scale CCS deployment in Alberta, including considerations such as the Government of Alberta assuming liability of CCS projects. A period requiring mandatory EIAs will demonstrate to the public that CCS is subject to a high level of scrutiny. Precedents have been set internationally where environmental and social impact assessments are required for CCS; within Alberta, Shell completed a provincial EIA for its Quest project on a voluntary basis.

It may be possible that a novel comprehensive assessment process, specific to the unique challenges of CCS, could be developed that will a ensure timely, integrated, and holistic approach and better facilitate the successful deployment of CCS in Alberta over the current EIA process.

**Areas of Non-Consensus**

None.

**Supporting documents provided to working group**

D8. ENVIRONMENTAL IMPACTS, MITIGATION AND REMEDIATION

Author
Environmental Working Group

Issue
The objective of this assessment is to understand the potential environmental impacts to air, land, and water from all phases of a carbon capture and storage (CCS) project. An assessment of the regulatory regime will determine if appropriate mitigation and remediation requirements are in place to address these potential impacts. From this, recommendations can be made to ensure best-in-class processes that would enhance Alberta’s current regulatory regime, and confirm the processes and resources necessary to implement a CCS regulatory framework that will be a cornerstone of a robust, efficient and effective risk management system for large scale capture, transport and geologic sequestration of CO₂ in Alberta.

Scope and Key Questions
The Environmental Working Group will determine the potential environmental impacts during all phases of a CCS project, identify regulations that are in place to mitigate/remediate these potential impacts and identify potential gaps, and determine if the roles and responsibilities for the emitter and the regulator are clear.

Background
The process of capturing, transporting, and sequestering CO₂ for the purposes of climate change mitigation in Alberta is a new undertaking and may present potential environmental impacts to air, land and water resources. These impacts must be understood to ensure that an effective regulatory regime is in place to address them.

Potential environmental impacts from CCS operations can be identified through monitoring, measurement, and verification activities (MMV) and addressed through mitigation measures and remediation activities. In Alberta, CCS operations are primarily overseen by the Energy Resources Conservation Board (ERCB), Alberta Energy and Alberta Environment and Sustainable Resource Development. A gap analysis with respect to CCS mitigation and remediation requirements illustrated that Alberta’s long history of industrial activities with associated approvals, processes, requirements, and regulations serve to address many potential environmental impacts. Some potential impacts on the environment related to CCS may present new challenges to Alberta and must be examined.

To assist in this, a consultant was retained to perform a literature review that assessed the potential environmental impacts on air, land, and water resources during all phases of a CCS project. The review included impacts to the following components: atmospheric environment; protected groundwater and surface water; fish and fish habitat; soil quality and land use; vegetation; and terrestrial wildlife. It was determined that many of the potential environmental impacts from a CCS project are well understood and given Alberta’s long history of industrial activities a robust regulatory regime is in place to address those impacts through proper mitigation measures and remediation requirements. For example, with respect to CCS related infrastructure, pipeline operations and well sites, potential environmental impacts are well understood and requirements to minimize impacts, perform any necessary remediation, and reclaim land are well established in Alberta.

From the review, it is apparent that the majority of potential impacts that are less well understood are those that related to air emissions from CO₂ capture processes (i.e., ammonia/amine-based systems) and potential impacts to groundwater from CO₂ sequestration operations.
**CO₂ Sequestration and Impacts to Groundwater**

Potential impacts related to CO₂ sequestration include but are not limited to:

- Unintended leakage of CO₂ from the sequestration complex.
- The migration of highly saline water into adjacent aquifers, posing a potential hazard, particularly to freshwater aquifers.
- Changes in groundwater flow caused by the pressurization of adjacent aquifers, both near the CO₂ injection site, and beyond the extent of the CO₂ plume.

Further impacts to groundwater may include: mixing of groundwater between aquifers; a reduction in pH; leaching of metals and trace elements into groundwater; and changes to groundwater flow and levels. Wells are considered the main potential leakage pathway for CO₂, particularly where the designated sequestration area is a depleted oil and gas reservoir.

Many of the potential risks to groundwater would be addressed through a number of regulatory processes and approvals that ensure proper site selection occurs and effective MMV plans are established and updated. For example, Alberta’s *Water Act* ensures non-saline groundwater is protected. With this, the base of groundwater protection is the best estimate of the depth at which saline groundwater (water with a total dissolved solid concentration exceeding 4000mg/l) is likely to occur in the province and is documented and searchable through an online database. Also, the *Environmental Protection and Enhancement Act* (EPEA) prohibits the release of a substance in an amount that may cause a significant adverse effect. Should such a release occur, it must be reported and remedial measures implemented to return the area to initial quality levels or comparable functions. Guidelines establish limits at which contaminants are considered deleterious. Also, extensive rules, regulations and requirements are laid out in ERCB directives that address items such as wellbore integrity, formation suitability, and hydraulic isolation within a limited range and the focus is primarily around the injection scheme.

**Potential Regulatory Gap**

It is uncertain to what extent shallow groundwater monitoring will occur. Monitoring of this type is important for the protection of drinking water sources, for establishing baseline data, and from a public assurance perspective. Currently there is no mechanism that ensures shallow groundwater monitoring occurs for CCS.

**CO₂ Capture and Impacts to Air**

In consideration of different CO₂ capture technologies (e.g., pre-combustion, post-combustion, and oxy-fuel combustion) the Environmental Working Group recognized possible regulatory challenges with respect to post-combustion capture technologies and air emissions. Post-combustion CO₂ capture systems, such as ammonia and amine-based systems, are currently the dominant technologies as Alberta moves toward large-scale deployment of CCS. Industrially, amines have been used for recovering CO₂ from gas streams for over 70 years and, presently in Alberta, amines are used commercially for the removal of H₂S and CO₂ from sour gas.
Amines refer to the class of nitrogen-containing organic compounds that are being proposed for large-scale capture of CO$_2$, especially from streams with relatively low CO$_2$ concentrations. Some of the products formed when amines degrade are known and/or are strongly suspected to have adverse effects on human health and the environment. The formation of by-products of concern can happen both within the process and following the release of the amines into the environment. For example:

- In-process degradation of amines creates ammonia whose release to the environment, due to its increased volatility, is more difficult to manage than the undegraded amine.
- In the atmosphere, amines react photochemically to produce nitrosamines and nitramines both of which are strongly suspected to be mutagenic and/or carcinogenic.

There are three main pathways through which amines are released to the environment. First, fugitive emissions to air, land, or water could occur through small leaks in the system, not atypical in an aging plant. These emissions can likely be controlled with regular maintenance and monitoring. Second, there is the potential for accidental releases to air, land, or water during upset conditions. Finally, as treated gas is released to the air, any gaseous or entrained amine or associated degradation products will concomitantly be released. This release is specific to a post-combustion CO$_2$ capture process used for CCS and not is synonymous with conventional operations for removal of H$_2$S and CO$_2$ from sour gas.

While there are alternative technologies for separating CO$_2$ which may become widely used in the future (e.g., zeolites and membranes), amine and ammonia-based technologies will be used by CCS projects in Alberta in the near term and large-scale CCS deployment creates two challenges for the Alberta regulatory framework with respect to amine usage. First, the use of amines could potentially increase with a corresponding increase in the quantity of amine released to the environment. Next, there may be novel amines introduced to the environment whose potential human health and environmental effects are poorly understood.

Alberta has established an Ambient Air Quality Objective of 2 ppm for ammonia and the Air Monitoring Directive specifies the manner in which a required owner/operator must monitor and report ammonia emissions. The Environmental Working Group believes that current legal and regulatory framework in Alberta regarding the use of ammonia for CCS projects is adequate.

**Potential Regulatory Gap**

There are no Ambient Air Quality Objectives for amines or their degradation products and no requirements exist for the monitoring or reporting of these amine emissions from CCS projects. As well, other post-combustion CO$_2$ capture technologies might produce emissions with potential environmental impacts.
Analysis Principles

Alberta Energy retained a consultant to perform a literature review to assess the potential environmental impacts from CCS projects, a CCS leakage scenario assessment and gap analysis of mitigation and remediation requirements in Alberta.

The working group reviewed the existing LRF for amine usage within the province of Alberta. The working group reviewed publicly available information from an Electric Power Research Institute (EPRI) workshop held on amines in fall 2011 and recent work done by the Norwegian Institute of Public Health investigating the safety of amines. All research and analysis was conducted by the working group with respect to amines and no consultants were contracted for work on this issue.

Areas of Non-Consensus

None.

Recommendations

1. The Government of Alberta should require shallow groundwater monitoring programs as part of the MMV plan for CO₂ sequestration projects. Programs should be project-specific and risk-based.

Groundwater monitoring above the Base of Groundwater Protection (BGWP) will establish baseline data for freshwater aquifers, ensure quality drinking water, reduce the risk to the Government of Alberta upon transfer of liability, and serve to boost public confidence in CCS.

Traditionally under the ERCB, Class III deep disposal wells do not require shallow groundwater monitoring. Alberta Environment and Sustainable Resource Development relies on ERCB containment monitoring. While the ERCB has the legal authority to impose shallow groundwater monitoring conditions, there is no explicit mechanism to compel this.

A shallow groundwater monitoring program should be developed to best meet the specific needs of a project and should be developed on a case-by-case basis through the collaboration of the regulator and the proponent. The plan could comprise, but not be limited to, industry monitoring wells and domestic freshwater wells monitoring where appropriate.

The MMV working group within the RFA is proposing a recommendation that would require a CO₂ sequestration project to monitor within ‘all domains of review’ (i.e., geosphere, hydrosphere, biosphere, and atmosphere), and the Environmental working group agrees that developing a shallow groundwater monitoring program from a public assurance perspective should be considered as part of the MMV plan.

Effective shallow groundwater monitoring programs can serve to build public confidence and assurance that the project is being managed appropriately.
2. The Government of Alberta should assess the volumes of amines used for CO$_2$ capture in Alberta to provide context for the relative scope and scale of amine use for CCS projects.

In spite of the fact that amines have been in use in Alberta for many years, it was revealed during the assessment that little or no information is available regarding the quantity of amines that are consumed in the province, the fate of amines that are released into the environment, and the potential human health and environmental impacts of amines and their degradation products. Further, a calculation of the relative proportion of amine use stemming from anticipated CCS operations is difficult.

The majority of current processes that use amines (e.g. gas processing) are closed-loop systems in that the gases that have been treated can be contained in subsequent processes (e.g. in a gas pipeline). Post-combustion capture of CO$_2$ using amines are open systems because the treated inert gases are released to the atmosphere, which generally causes greater releases of amines and associated degradation products to the environment because of amine carryover in the inert gases. If CCS projects adopt post-combustion capture of CO$_2$ using amines, this may significantly increase the use of amines within the province and some of this increased usage will likely include novel amines whose potential for adverse human health and environmental effects is not fully understood. Given concern that certain amine degradation products may be toxic, the assessment should increase the body of knowledge regarding the potential adverse effects resulting from the use of amines for CO$_2$ capture and include, but not be limited to:

- Assess the potential for significant adverse effects resulting from the actual use of amines. Identify opportunities for these effects to be mitigated.

Consideration should be given to potential intellectual property issues that may hinder the creation of a comprehensive assessment of amine quantities being used in Alberta.

3. The Government of Alberta should determine whether further regulation of the use of post-combustion CO$_2$ capture technologies is warranted. To achieve this, the Government of Alberta should join international efforts to fill important knowledge gaps relating to the use of post-combustion CO$_2$ capture technologies for CCS projects, such as amine usage, so that an understanding of their potential environmental impacts can be attained.
Current and emerging post-combustion CO₂ capture technologies may present regulatory challenges with respect to environmental emissions. The Environmental Working Group recommends further analysis to ensure appropriate regulations are in place based on scientific research.

Currently, the uses of liquid solvents such as ammonia and amines are the most prevalent techniques for capturing CO₂ for CCS. Much research is being undertaken worldwide to better understand the potential environmental and health impacts of these solvents as well as emerging technologies. Knowledge gaps to address include:

- emission rates of amines and their degradation products
- rates/methods of environmental degradation of amines
- environmental persistence of amine and its degradation products

The Government of Alberta has an opportunity to leverage existing activities being undertaken especially in Norway and the United States (e.g. the Electricity Power Research Institute) that will better inform the development of policies (e.g. air quality standards) and regulatory requirements (e.g. air emissions limits) pertaining to post-combustion CO₂ capture.

**Supporting documents provided to working group**

Reports prepared by a consultant:

- “Literature Review and Assessment of Potential Impacts of Emissions from Carbon Capture and Storage Projects”, November 25, 2011
- “Carbon Capture and Storage Leakage Scenario Assessment and Gap Analysis of Alberta Mitigation and Remediation Plan Requirements”, November 28, 2011
D9. MONITORING, MEASUREMENT AND VERIFICATION

Author
Monitoring, Measurement & Verification Working Group

Issue
The working group has addressed the following items in the analysis of the Monitoring, Measurement and Verification (MMV) issue:

• Determine the performance criteria that need to be addressed in a closure report.
• Define the monitoring objectives for each phase of a project.
• Determine monitoring, inspection, and reporting requirements for all phases of a carbon sequestration project.

Scope and Key Questions
The MMV Working Group recognized that the risk assessment issue and the closure issue were closely linked with the MMV issue. The recommendations prepared for the risk assessment issue were drafted to identify that risk assessment is an integral part of MMV and closure plans. Collaborative work was undertaken to ensure that there was alignment between the four working groups in addressing the closure issue.

The working group addressed the risk assessment issue for injection and sequestration as this informs the development of the MMV and closure plans. Accordingly, the working group is focusing on MMV for injection and sequestration activities and has determined that monitoring aspects involving pipelines and capture facilities are out of scope.

The MMV Working Group is addressing the aspects of the pre-injection period that involve risk assessment, selection of monitoring technologies and establishing baseline data as appropriate for the selected site. Other aspects such as site characterization and selection and regulatory approvals and permits are being addressed by other working groups.
Background

The purpose of MMV is to address health, safety and environmental risks, evaluate sequestration performance and provide evidence for closure. MMV is central to sequestration risk management. Measurement and monitoring of the injection facilities, geologic sequestration site and surrounding environment provide assurance that CO₂ is confined to the sequestration complex (containment). Verification refers to the comparison of measured and predicted performance and is used to ensure sites are operating as predicted and permitted (conformance).

Monitoring, measurement and reporting requirements in Alberta for oil and gas operations are defined by the Energy Resources Conservation Board (ERCB) and Alberta Environment and Sustainable Resource Development (AESRD). Development of an MMV plan is required when applying for an evaluation permit or a carbon sequestration lease under the Carbon Sequestration Tenure Regulation. Existing ERCB requirements in Alberta are applicable to carbon sequestration activities for monitoring and reporting of produced and injected fluids, wellhead injection pressure, maximum bottomhole injection pressure (BHIP) and well integrity. ERCB Directive 017: Measurement Requirements for Oil and Gas Operations and Directive 007: Volumetric and Infrastructure Requirements set out requirements for measurement, accounting and reporting plans (MARP) for reporting of monthly activities and volumetric data for all wells, facilities, and pipelines in Alberta. The application requirements for an acid gas disposal scheme are set out in Section 4.2 of Directive 065: Resources Applications for Oil and Gas Reservoirs and injection well requirements are described in Directive 051: Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements. To ensure containment and hydraulic isolation, the directive 065 application requires information on the geology and reservoir fluids in the disposal formation, surrounding wellbores, acid gas properties and how the requirements of Directive 051 have been met for the injection well. In addition to the requirements specified in directives, site-specific operational parameters, monitoring requirements, and annual reporting requirements may be identified and specified in approvals. Presently there are no specific requirements to monitor subsurface plumes or pressure increase for carbon sequestration projects, neither for monitoring in other horizons and the shallow subsurface.

Under Alberta’s Specified Gas Emitters Regulation (SGER), the use of offsets credits is one of three compliance options available to regulated facilities (industrial facilities in Alberta emitting over 100,000 tonnes of carbon dioxide equivalent per year) to reduce emissions intensity. The Quantification Protocol for Capture of CO₂ and Permanent Storage in Deep Saline Aquifers is in development. With respect to the offset protocol, the MMV plan will provide evidence of permanent containment of the CO₂ in the sequestration complex, and that there is no release of CO₂ to the atmosphere.

The United States and European Union require development of monitoring plans for CCS activities and have specific requirements which include: monitoring of the injection facilities, sequestration complex and surrounding environment to meet stated monitoring objectives.

Analysis Principles

The working group recognized that identifying performance criteria for closure was important as a first step so that the MMV issue could be addressed with the end goal in mind. The closure issue was addressed through collaborative work with the other RFA Working Groups. Once performance criteria were established, the MMV Working Group was able to provide recommendations as to how objectives could be achieved. Through the course of the analysis, publications and best practices were reviewed as well as monitoring programs at operating sites.

Areas of Non-Consensus

None.
Recommendations

1. The Government of Alberta should require the following performance criteria for closure of a carbon sequestration project including, as appropriate:
   - Sequestered CO₂ and affected fluids are conforming with project objectives and regulatory requirements as described in the project applications and approvals and any applicable amendments to those approvals.
   - There is no significant adverse effect\(^{34}\) of sequestered CO₂ or affected fluids to health, the environment, other resources (including but not limited to hydrocarbons, non-saline groundwater and pore space outside of the operator’s sequestration lease).
   - Sequestered CO₂ and affected fluids are adequately contained in the sequestration complex.
   - Sequestered CO₂ has behaved in a predictable\(^{35}\) manner in conformance with subsurface modelling.
   - Sequestered CO₂ is expected to continue to behave in a predictable manner and is trending towards stability.
   - The project specific risk profile is decreasing and the risk of future leakage or adverse effects on health, the environment or other resources is acceptable.
   - Decommissioning and abandonment have been completed as required by the regulator.\(^{36}\)
   - Surface reclamation has been completed to the extent possible, as agreed with the regulator for the post-closure period.

Evidence for closure should be demonstrated on a site-specific basis and should be provided by:
   - Compliance with legislation (regulations, standards, directives), applications and approvals.
   - Results and interpretation of data collected by activities under the MMV plan (a component of which is the evolution of the site-specific risk assessment).
   - Simulations and modeling to support containment and predictability of the sequestered CO₂.
   - Results and practices followed for surface reclamation.
   - Results and practices followed for decommissioning and abandonment of wells not needed for future monitoring to support long-term isolation of the sequestered CO₂.

Project operators and regulators should communicate throughout the injection period to ensure that MMV and closure plans evolve as required. As a project progresses, a staged approach to reporting and the review of closure criteria will help ensure time-sensitive data are collected when available and to the extent required by the regulator. The regulator and the project operator should agree how the project will demonstrate that behavior is predictable and trending towards stability for the site and how evidence being collected supports these criteria.

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\(^{34}\) Where adverse effect is defined by the Environmental Protection and Enhancement Act to mean “impairment of or damage to the environment, human health or safety or property.”

\(^{35}\) Refer to the RFA Glossary of Working Terms (Appendix C) for a discussion of the term predictable.

\(^{36}\) The term regulator has been used throughout this document as a general term to describe Government of Alberta regulatory agencies and departments. A general term has been used when it is yet to be defined which agency or department will be responsible for unique aspects of CCS. In addition, implementation of the Regulatory Enhancement Project (REP) recommendations will result in a single regulatory body for upstream oil, gas and coal development in Alberta. The RFA has identified that further work is required to clarify regulatory roles and responsibilities for CCS.
MMV plans should be fit for purpose and developed to include the following elements:

- Meet regulatory requirements set out in legislation (regulations, standards, directives) and as defined in project approvals.
- Collect sufficient data to enable transfer of long-term liability:
  - provide evidence of conformance of sequestered CO₂ and affected fluids within the sequestration complex.
  - provide evidence of containment of sequestered CO₂ and affected fluids within the sequestration complex.
  - provide evidence that no significant adverse effect of sequestered CO₂ or affected fluids on health, the environment or other resources has been identified including the presence of concentrations of CO₂ and/or pressure increases that are not acceptable.
- Identify and have provision for response methodologies and/or technologies that can provide evidence that anomalous concentrations of CO₂ sampled above the base of groundwater protection (BGWP) level do or do not arise from the sequestration complex.
- Provide the rationale for selection of monitoring technologies.
- Monitor threats to containment identified in the project risk assessment and where loss of containment is confirmed, trigger appropriate mitigation and/or remediation activities.
- Collect data needed to verify and update models and simulations.
- Collect data to provide evidence of sequestration inventory and to support permanent reduction of greenhouse gases as described in the Quantification Protocol for the Capture of CO₂ and Storage in Deep Saline Aquifers.37

The operational phases of a carbon sequestration project that apply to the MMV plan are the pre-injection period, the injection period, the closure period and the post-closure period. The working group has identified tasks and activities undertaken for each period below.

The pre-injection period should ensure that:

- Monitoring tasks are identified.
- Monitoring technologies are screened, evaluated and selected.
- A monitoring schedule is proposed.
- Appropriate baseline data are established for the technologies selected.
- Additional monitoring and baseline data requirements identified by the regulator during permitting and approval are incorporated into the MMV plan.

2. The Government of Alberta should require MMV plans to be risk based and site-specific.

The protocol under development includes that a MMV plan shall be used to identify emissions from the subsurface to the atmosphere so in the event of loss of containment, the mass of CO₂ released to the atmosphere can be estimated and included in project emission totals (to those claiming the sequestration offset reduction).
The injection period should include the following:

- Monitoring to:
  - demonstrate compliance with legislation (regulations, standards, directives), applications and approvals.
  - demonstrate sequestration performance.
- Monitoring results to:
  - inform and update the project risk assessment.
  - inform and optimize project operations.
  - trigger investigation of non-conformance and mitigation and/or remediation activities as required.
  - support the receipt of offset credits.
  - update simulations and models so actual and predicted behavior can be compared and the MMV plan can be updated as necessary.
  - enable a systematic improvement of model predictive capability throughout the injection period.
- Monitoring technologies are evaluated on a regular basis to:
  - ensure effectiveness of each technology for the designated task as compared to expectations in the MMV plan.
  - ensure overlapping technologies are complementary and providing the spectrum of results needed to evaluate sequestration performance.
  - evaluate technologies in use against advancements so new monitoring techniques are deployed when warranted.
- The MMV plan is periodically renewed and ongoing dialogue is held with the regulator to ensure:
  - time-sensitive data are collected when available and to the extent required.
  - expectations for modelling and simulation output are agreed upon so models evolve as required to illustrate sequestration performance at closure.

The closure period should include the following criteria:

- Selected monitoring activities continue to demonstrate sequestration performance and compliance with legislation (regulations, standards, directives), applications and approvals.
- Abandonment of monitoring equipment occurs with the timing of abandonment activities taking into consideration data requirements and availability.
- Information is provided from the operator to the regulator when requested regarding appropriate MMV techniques that could be used in the post-closure period.
- Arrangements are made between the regulator and project operator for the transfer of any MMV equipment that the regulator desires to be left in place at the point of closure that will not compromise long-term integrity of well abandonments.
During the post-closure period:

- Monitoring is conducted by the responsible authority as deemed necessary.

3. The Government of Alberta should recognize that MMV plans require a comprehensive suite of technologies to address health, safety and environmental risks, evaluate sequestration performance and provide evidence to support the issuance of a closure certificate. Monitoring should take place in each domain of review and technologies should be selected based on a site-specific evaluation of the ability of the technology to perform the identified monitoring task. As there is no one technology that can provide complete data on sequestration performance, a comprehensive suite of complementary technologies should be selected to provide the information required.

The working group has identified several contextual documents that provide information and background on MMV technologies that could potentially be used to monitor a carbon sequestration project in each respective domain of review. It is important to note that these technologies are illustrative of potential monitoring techniques only and the working group is not recommending mandating any specific technique identified. The documents should be available on a dynamic list provided to a general audience. Documents the working group identified include:


4. The Carbon Sequestration Tenure Regulation requires an annual report to the Minister of Energy containing the findings and observations from MMV activities conducted for carbon sequestration lease holders. It is recommended that reporting of MMV results by the project operator to the regulator should fall under the jurisdiction of the Energy Resources Conservation Board, following similar processes to those in place for approval specific reporting requirements for upstream petroleum operations.

The working group has reviewed reporting requirements and found that there are well established ERCB processes in place for reporting of volumetric data and monthly operations (e.g. injected volume and well status), and that these same requirements for measurement and production reporting would be applicable to carbon sequestration projects.

The Carbon Sequestration Tenure Regulation requires an annual report to the Minister of Energy containing the findings and observations from MMV activities conducted for carbon sequestration lease holders. It is recommended by the working group that MMV results be reported to the ERCB rather than to the Minister of Energy in a similar manner to approval specific reporting for upstream petroleum operations. The ERCB acts as a data deposit, data manager as well as handles public requests for information for upstream petroleum operations. It is felt that this existing reporting system should be extended to include MMV data for carbon sequestration projects.
D10. PIPELINE OPEN ACCESS

Author
Regulatory Working Group

Issue
Determine when and under what conditions third party access should be granted.

Scope and Key Questions
- Examine potential forms and operational structures of open access to determine which options best fit the needs for CCS in Alberta.
- Develop principles to guide regulation of third party access to pipelines in Alberta, excluding those not under Alberta’s jurisdiction. These principles should: lead to acceptable timing of any potential orders that mandate third party access as well as outlining considerations that will clarify the conditions and obligations for third party access.
- Determine how third party access to CCS facilities differs from third party access to pipelines.
- Examine barriers to voluntary third party access via private negotiations.

Background
As the number of commercial CCS operations increases, the demand for access to CO₂ transportation and in turn the number of pipelines in the province will also increase. In order to promote an economically efficient pipeline system, ensure capture operators have reasonable access to storage opportunities and minimize the environmental impact of the pipeline system, consideration should be given to whether or not it is in the interest of Government and stakeholders for Alberta to introduce policy or regulatory drivers to incent or compel third party access to pipelines.

Alberta does not currently have any existing regulatory requirements for third party access to CO₂ pipelines. The system used for upstream oil and gas pipelines is the Common Order System (for pipelines the Order is the Common Carrier Order). However, Sections 48, 49 and 55 of the Oil and Gas Conservation Act only include oil, gas and synthetic crude oil pipelines in the Common Carrier system. The definition does not presently include CO₂.

In general, upstream pipelines are not subject to any form of economic regulation other than general competition law. In this market-based system, parties construct their own facilities or obtain access to other parties’ facilities through private negotiations.

The Common Order (e.g. common carrier order) system is available to parties when those private negotiations break down. The following is a high-level description of the common carrier system:

- A party desiring access to another party’s pipeline can apply to the ERCB requesting a common carrier order. In general, the applicant must show:
  1. need for access — producible reserves and reasonable expectation of a market.
  2. the pipeline operator is acting unreasonably in negotiations.
  3. the pipeline is the only economically feasible way, or the most practical way to transport the product, or clearly superior environmentally.
- If the ERCB designates a pipeline as a common carrier, then the pipeline owner must provide non-discriminatory access to the pipeline.
• The ERCB can also direct the proportion of production to be taken by the common carrier from each producer using the pipeline (this concept is referred to in this paper as prorationing):
  - Once a common carrier order is in place, if the parties cannot agree on the tariff to be paid for use of the pipeline, either party can apply to the Alberta Utilities Commission to set the tariff.
  - Including CO₂ pipelines in this system would require amendment of the *Oil and Gas Conservation Act* to include CO₂ in sections 48, 49 and 55. Some amendment of ERCB Directive 065 would also be required.

• An extensive review of other jurisdictions was not conducted for this issue because Alberta already has significant experience in regulating pipelines. The considerations for third party access were influenced by European Union Directive 51.

• Scenarios of access requests:
  - A pipeline is in the planning phase and one or more parties attempt to negotiate access.
  - A pipeline is operating below capacity and one or more parties attempt to negotiate access.
  - A pipeline is operating at capacity and one or more parties attempt to negotiate access.

• The working group discussed the policy drivers or objectives for open access regulation. Those policy drivers are:
  - Mitigating market power – Preventing a pipeline operator from controlling access to the transportation network or exerting unreasonable conditions as a result of market position.
  - Public good – achieving efficient development of CCS infrastructure to reduce costs, support CCS development, reduce the environmental impact of the pipeline system, minimize safety risks and support development of EOR markets.

**Analysis Principles**

Nigel Bankes presented the findings of his draft paper on economic regulation and design of carbon infrastructure. The working group also briefly reviewed the regulatory system for CO₂ pipelines in the United Kingdom. Given Alberta’s experience with regulating pipelines, the working group decided that, apart from prorationing, there is no compelling reason to use a system different from that used to regulate upstream oil and gas pipelines.

No consultants were contracted to do work on this issue.

**Recommendations**

1. Market considerations should be the primary driver behind access to CO₂ pipelines. In this regard, pipeline operators and third parties are expected to explore all reasonable avenues of private negotiation before applying to the regulator for access.
The working group believes that market principles should be the primary driver for pipeline development as they are in the oil and gas industry in Alberta. The working group sees no compelling reason to regulate third party access without first exhausting reasonable avenues of private negotiation.

2. The common carrier system should be expanded to apply to all CO₂ pipelines. This can be done by amending section 48 (1, 2 and 3) and section 49 of the *Oil and Gas Conservation Act* to include captured carbon dioxide; and adding a new clause 55(4) mirroring clause 3 but for captured carbon dioxide. Section 1.3 of the ERCB’s Directive 065 may also need to be amended to include CO₂ pipelines.

The working group recognizes that, even though pipeline operators are expected to negotiate in good faith and provide access to pipelines in a non-discriminatory manner, private negotiation will not always lead to satisfactory results. Therefore a process is needed whereby parties can apply to the regulator for access to a CO₂ pipeline. This will help to achieve the first policy driver – mitigating market power.

3. When applying for regulatory approval of a new CO₂ capture facility, the proponent should be required to demonstrate that it has, or can reasonably obtain access to both a sequestration site, including CO₂ EOR fields and pipeline capacity to transport CO₂ to that site.

Requiring proponents to demonstrate they have a destination for their CO₂ and a way to transport their CO₂ to that destination, will help to reduce the likelihood of common carrier applications and subsequent prorationing. Recognizing the significant investments needed to develop capture operations, pipelines and sequestration projects, it is important that appropriate forward planning is carried out to minimize the risk that a new operator’s access will inhibit existing users’ access.

4. When hearing an application for a common carrier order the regulator should consider, on a case-by-case basis, the multiple impacts and implications of making a common carrier declaration. This includes, but is not limited to, the impact on companies that would be affected by the decision, the effect on CCS/CO₂ system dynamics and the historical operating context of the pipeline. Common carrier orders, and more specifically the application of prorationing within a common carrier order, should be the option of last resort.

The working group agrees that prorationing could have significant consequences for capture facility operators, but recognizes that prorationing should be an option for the common carrier system to be effective. Recognizing the consequences that the risk of prorationing can have for capture operators, the working group believes that the considerations in Recommendation #3 are necessary to ensure that prorationing is only used as an option of last resort and that the regulator will give adequate consideration to the impacts of prorationing.

When hearing a common carrier application for a CO₂ pipeline and considering prorationing, the regulator should carefully consider all factors to decide if it is appropriate to prorate existing users of the pipeline. The working group believes that in most cases it would likely be appropriate to prorate new users for the excess capacity before prorationing existing ones.

The requirements necessary for the applicant to show common carrier is appropriate would be relatively difficult to demonstrate, particularly if the pipeline is already full.
The working group believes the regulator should take into account the following considerations on a case-by-case basis when hearing applications for a common carrier order:

a. The regulator, operators and third parties should be encouraged to make use of existing dispute resolution mechanisms prior to resorting to common carrier provisions. Common carrier orders, and more specifically the application of prorationing within a common carrier order, should be the option of last resort for resolving concerns over pipeline access.

b. Regulation of CO₂ pipelines should aim to provide certainty for investors by balancing the following considerations:
   i. Providing a degree of certainty for pipeline owners and incumbent users of the pipeline, including those relying on capture to meet their compliance obligations under the Specified Gas Emitters Regulation, that their rights and needs will be respected and will not be unreasonably constrained by third party access.
   ii. Providing a degree of certainty for third parties such as capture facility operators, including those relying on capture to meet their compliance obligations under the Specified Gas Emitters Regulation, that there is a process in place to enable reasonable access to transportation networks to facilitate access to markets and/or storage sites.

c. The regulatory process to determine access should include an opportunity for all those who are potentially impacted by a decision to be heard. Upon hearing from all relevant parties the regulator should carefully weigh all the implications prior to making a common carrier declaration. Particular attention should be given to the implication of any prorationing declarations.

d. Whether sufficient capacity was available in the pipeline when the third party attempted to negotiate access (scenarios 1 and 2 above).

e. If sufficient capacity was not available, can the pipeline’s capacity be reasonably expanded with acceptable cost sharing provisions?

f. If sufficient capacity was not available, was the pipeline physically full or only contractually full? I.e. was contracted capacity actually being utilized?

g. Whether their CO₂ meets the CO₂ composition and other technical requirements of the pipeline, and whether the pipeline operator behaved unreasonably in negotiations.

h. Whether incumbent users of the pipeline have access on a committed or non-committed (nominated monthly) basis.

i. Whether a fair rate (toll) and conditions for access can be agreed upon by the owner and shippers or determined by the appropriate regulator if they cannot be negotiated.

j. The regulatory system should apply the objective of fair access that takes into account the technical requirements of the pipeline, as well as the rights and obligations of the operator and incumbent users of the pipeline.

k. This regulatory process should be conducted in a transparent manner, while respecting confidentiality of existing commercial terms, to ensure that all parties can be confident these considerations are being taken into account.

l. Whether the third party has a destination for the CO₂ that it wants to transport using the pipeline.

m. Whether it is reasonable and appropriate to proration users of the pipeline who had capacity when the third party attempted to negotiate access.

n. The net impact on provincial greenhouse gas emissions arising from a common carrier designation and/or prorationing.
5. Pipeline operators should undertake some form of open season where the operator seeks interest from other parties desiring access to the pipeline. The industry consultation should be evaluated by the regulator when deciding on requests for common carrier orders. This evaluation should include examining:

- The adequacy of the open season conducted when hearing arguments why the order should not be granted.
- Whether or not the third party engaged with the pipeline operator during the open season when hearing the third party’s reasons why the order should be granted.

This recommendation will contribute to capturing the public good aspects of CCS. It will do this by ensuring the efficient and adequate development of CCS infrastructure (the second policy driver). Furthermore, it will help protect pipeline operators against future access claims by ensuring that proponents take reasonable steps to assess near-future demand pipeline access.

The two projects funded under the Alberta CCS Fund should be exempted from this because planning for these projects occurred at a time when an open season was not required, unless dictated in the terms of their respective contribution agreements.

An open season is a process whereby a proponent planning a new pipeline provides or posts information on the project and allows potential shippers to submit capacity requests. This process can help to ensure the pipeline is correctly sized to meet regional needs and therefore help reduce the likelihood of applications for a common carrier orders.

6. All CO₂ sequestration operations should be encouraged to use shared transportation infrastructure whenever feasible and reasonable.

In order to minimize the incremental environmental footprint and reduce industry costs, sequestration operations should be encouraged to share transportation infrastructure whenever reasonable and feasible to do so. This is particularly true for operations that are stacked (vertically overlain). This recommendation is consistent with current ERCB policies.

7. The Government of Alberta should consider taking a larger role in the regional planning of CO₂ pipeline infrastructure, particularly if there is government funding involved, to ensure that development of such infrastructure meets the development goals of the region while also meeting the needs of CCS development in Alberta.
Areas of Non-Consensus

- The Regulatory Working Group does not have consensus on whether prorationing should remain part of the common carrier regulation for CO$_2$ pipelines or be removed (it is part of the common carrier system for oil and gas pipelines).
  - For the purposes of this paper, prorationing refers to the process whereby the ERCB may direct the proportion of production (in this case captured carbon dioxide) to be taken by the common carrier from each producer or owner offering captured carbon dioxide to be shipped in the pipeline (see Oil and Gas Conservation Act s.48(4)(b)).
  - The working group is in agreement that prorationing poses a significant risk and decreases certainty for investors. However, the majority of the working group believes that prorationing should be included in the common carrier system but with direction for how it should be applied by the regulator (recommendation 3).
  - Some members believe that if prorationing does remain it should only apply to situations where a pipeline has excess capacity available.
  - In the oil and gas industry, prorationing impacts producers, but to a lesser extent than it would impact a CO$_2$ capture facility operator. If an oil or gas producer’s access to a pipeline is reduced, the product remains in the ground longer and would still be brought to market at a later time.
  - For CCS, reduced access to the pipeline would mean that the capture facility will vent a portion of its CO$_2$, with multiple consequences:
    - The operator’s emissions increase, likely leading them to be in contravention of their emissions reduction requirements.
    - The operator’s per tonne abatement costs increase because capital and operating costs do not change but the amount of CO$_2$ sequestered (and subsequent credits or EOR sales) is decreased.
  - In contrast, the possibility of prorationing is an important tool for the regulator to have at its disposal when making decisions in the public interest. This tool can help ensure the system is effective and may incent pipeline owner/operators to negotiate in good faith.
- An industry member and a member from an institution/academia/non-governmental organization believe that prorationing will impact investment decisions on many levels and introduces significant risk to financing, construction and contracts/markets. They therefore believe that existing users should never be prorationed.
D11. PORE SPACE OPEN ACCESS

Author
Regulatory Working Group

Issue
Determine if and under what conditions access to pore space or CO₂ sequestration, not including enhanced oil recovery (EOR), should be granted to other parties.

Scope and Key Questions
Develop principles to guide regulation of access to pore space and CO₂ sequestration. These principles should:

• Provide certainty to operators that access will not be imposed on their operations unless a certain set of pre-conditions occur.
• Give operators certainty as to what that access would entail if it is imposed on their operations, including details regarding the obligations of both the operator and the other party, and the process for setting rates.

The subgroup will also examine barriers to voluntary access via private negotiations.

Background
In the 2008 Climate Change Strategy, Alberta predicted that CCS will account for 139 megatonnes (Mt) of CO₂ per year by 2050. Assuming average capture rates of 1-2 Mt annually, this level of CO₂ reduction could result in 80-100 commercial scale facilities. If each facility were to have its own sequestration site, this could result in a similar number of sequestration sites across the province. Consideration may need to be given to whether or not it is in the interest of Government and stakeholders for Alberta to introduce policy or regulatory drivers to incent or compel access to areas selected for use as a sequestration site.

There is currently no regulation in Alberta directly dealing with third party access or open access to pore space or CO₂ sequestration. There are some portions of the Mines and Minerals Act and Carbon Sequestration Tenure Regulation that are somewhat related to this issue. Section 118 of the Act allows for the transfer of tenure with the written consent of the Minister of Energy. Sections 5 and 12 of the Regulation give the Minister the authority to reduce the area of a permit or lease upon application of the permittee/lessee.

The working group discussed the policy drivers or objectives for open access regulation. Those policy drivers are:

• Mitigating market power – Preventing a few operators from controlling access to sequestration sites or exerting unreasonable conditions as a result of market position.
• Public good – achieving efficient development of CCS to capture efficiencies, reduce costs for industry and government, and support CCS development.
For the purposes of this document, third party access is defined as an entity seeking to gain access to another party’s (the ‘first party’) tenure or CO₂ disposal scheme.

**Analysis Principles**

The working group reviewed Nigel Bankes’ draft paper on economic regulation and design of carbon infrastructure and Dr. Bankes presented the findings that paper to the group. Open Access provisions in the European Union’s Directive 2009/31 and existing principles in Alberta’s petroleum and natural gas tenure system were also considered.

All research and analysis was conducted by the working group. No consultants were contracted for work on this issue.

**Areas of Non-Consensus**

None.

**Recommendations**

1. **Market considerations should be the primary driver behind third party access to sequestration tenure and CO₂ injection.** In this regard, sequestration site operators and other parties are expected to explore all reasonable avenues of private negotiation before applying to the regulator for access. Therefore, voluntary third party access to CO₂ disposal should be encouraged and should not be prohibited by regulations or legislation.

The working group believes that market principles and private negotiation should in most cases lead to appropriate agreements between parties. The working group sees no compelling reason to regulate access without first exhausting reasonable avenues of private negotiation.

To enable this recommendation, it is important that the regulations, legislation and directives do not pose unreasonable barriers to voluntary negotiations.

2. **Proponents of CO₂ sequestration projects should be encouraged to solicit indications of interest from other facilities to attempt to identify opportunities for collaboration on CO₂ sequestration and receive additional sources of CO₂ for injection where appropriate and feasible.**

It is important that industry make reasonable attempts to collaborate on sequestration projects to capture economies of scale, share knowledge and experience, maximize pore space utilization, and reduce the incremental environmental impact (e.g. surface infrastructure) of CCS. While the working group does not believe such collaboration should be required, they do believe that it would be prudent to encourage industry to adopt these practices.

This collaboration would ideally be done prior to the tenure application. Any additions to a project after tenure is issued would likely require additional tenure to be allocated.

3. **The Government of Alberta should not impose orders that give other parties the right to conduct their own injection operations on an operator’s sequestration site (i.e. within the operator’s tenure).** Similarly the Government should not have the authority to remove an operator’s sequestration tenure for the sole purpose of allocating it to another party.
The working group sees no compelling reason for the Government of Alberta to have the authority to allow other operators onto the site or to unilaterally transfer a portion of the operator's tenure to another party. Only the site operator will have the most complete knowledge of the site’s geology and other characteristics necessary to ensure proper site operation. In the event there are compelling reasons for another party’s CO₂ to be injected into an existing sequestration site, the mechanism in recommendation #4 should be used.

While it is recognized that the Government can take away a portion of an operator's tenure at the time of tenure renewal, and may then wish to reallocate it, the working group does not believe this should be done for the sole purpose of allocating that tenure to another party.

4. The Government of Alberta should create a mechanism whereby other parties can apply to the regulator for access to CO₂ disposal (i.e. the operator injects the other party's CO₂ for them). Such an application should only be considered if the applicant can demonstrate all of the following:

   a) There is sufficient capacity (over the life of the project, but taking into consideration pressure effects and the integrity of the storage complex) within the sequestration site to accommodate the applicant's CO₂ (e.g. it is clear the site is underutilized, the operator is known to be selling its CO₂ in other markets instead of injecting into the site)

   or

   The sequestration site’s capacity can reasonably be increased (including acceptable cost sharing provisions) to accommodate the applicant's CO₂.

   b) Injection of the applicant’s CO₂ will not restrict the ability of the site operator to inject its own CO₂ and/or other CO₂ the operator is contractually obligated to inject.

   c) The sequestration site operator is not behaving reasonably in negotiations with the applicant and the applicant has exhausted all reasonable avenues of private negotiation.

   d) The sequestration site is the only economically feasible way, or the most practical way to inject the CO₂, or is clearly superior environmentally to other options.

   e) The sequestration site operator's pore space tenure would not be affected and no additional tenure would be required.

   f) The applicant’s CO₂ meets the technical requirements, including CO₂ composition, of the sequestration project.

   g) Injection of the applicant's CO₂ will not compromise the integrity of the storage complex.

Although the working group recognizes that ordering a sequestration site operator to inject another party's CO₂ is not a preferable course of action, there are certain situations where it may be necessary. For example:

- Proliferation of CCS has led to a situation where operations must be sited increasingly close to each other (increasing the risk of pressure front and plume interactions) or where adequate sequestration sites are scarce either locally or throughout the province as a whole.

- High quality sequestration sites are allocated through leases but not being utilized (e.g. the CO₂ is being sold to EOR operators instead of injected into the sequestration site).
In situations like those listed above, the working group believes a mechanism should be in place to enable mandated access, as long as the burden of proof is on the party requesting access to demonstrate there is sufficient justification for an access order. The working group believes that requiring proof of all of a) through e) will satisfy that condition.

The working group also recognizes that it will likely be difficult for an applicant to demonstrate those conditions, particularly in the early days of the CCS industry. This is intentional as mandated access is not a desirable outcome unless absolutely necessary.

5. The mechanism in recommendation #4 should include provisions for the setting of reasonable rates of compensation to be paid to the sequestration site operator by the applicant. Determination of this compensation should take into account, but not be limited to, the following:

- any necessary increases to MMV activities
- increases in operational and capital costs
- a reasonable share of upfront costs and financial risks for the project
- liability for injected CO\(_2\), including greenhouse gas liability (e.g. CO\(_2\) credits)
- additional payments into the Post-closure Stewardship Fund.

Any orders for access should include a determination of compensation to be paid to the sequestration site operator by the other party (the applicant) to ensure the operator does not suffer economic harm, unless terms of settlement are agreed by the parties.

6. From the Government of Alberta’s perspective, when a pore space tenure holder injects another party’s CO\(_2\), whether via voluntary private negotiation or via regulator order, liability for that CO\(_2\) should remain with the holder of pore space tenure until the transfer of liability to the Government. Furthermore, the tenure holder should be responsible for paying into the Post-closure Stewardship Fund (PCSF) for that additional injected CO\(_2\).

Because the recommendations are only for potential orders requiring the operator to inject another party’s CO\(_2\) and not to allow other operators into the storage site, it makes sense that liability (including PCSF payments) for the CO\(_2\) should rest with the tenure holder. Any costs associated with this liability and PCSF payments can be recovered through compensation for injecting the CO\(_2\).

Even though companies may enter into private agreements to share liability burdens, it is important that the Government should have complete certainty that it only needs to deal with a single entity regarding liability for an operation, and that entity is the tenure holder.

7. If a sequestration site operator that is injecting a third party’s CO\(_2\) wishes to cease operation of the site then, if both parties and the Government of Alberta agree and satisfactory terms can be arranged, a transfer of the site to the third party should be allowed and encouraged.
The fact a sequestration site operator has been ordered by the regulator to inject a third party’s CO₂, should not affect the operator’s ability to cease operations when it so desires. As long as satisfactory terms of transfer can be agreed upon and the Government of Alberta is satisfied the third party is capable of effectively operating the sequestration operation, there should be no prohibition against transferring the operation.

Encouraging such a transfer when a sequestration operator wishes to cease operations would allow the third party’s CO₂ to continue to be injected without the investment required to develop a new project. This can help to reduce costs for CCS and reduce its overall environmental impact (e.g. surface infrastructure).

In general, such a transfer is not prohibited by current legislation.

8. The Government of Alberta should considering restructuring Carbon Sequestration Leases so that the Minister has the authority to revoke or rescind tenure that has not been used after a defined period of time.

The mechanism in Recommendation #4 would likely not be usable in a case where the tenure is completely un-used and has no injection infrastructure constructed. In a situation like this, and when sequestration sites are scarce and in high demand, it may be desirable for the Government to have the ability to rescind or revoke that unused tenure. The working group recognizes that, under the Carbon Sequestration Tenure Regulation, the Minister currently has the option not to renew tenure after 15 years, however a mechanism may be needed to allow changes after the tenure has been renewed. Such authority does currently exist for petroleum and natural gas tenure.

There are important factors that should be taken into account associated with this recommendation:

- It is important that Government have the flexibility to decide what period of time is appropriate for each application for pore space tenure, and

- To ensure that investors have a reasonable level of certainty in their tenure, it is important that the lessee know, when the tenure is issued, under what conditions and after what period of time the tenure could be revoked. The conditions and time period should be discussed with the lessee during review of the tenure application.

9. If the Government of Alberta contemplates setting regulations that mandate carbon capture operations, the availability and capacity of sequestration sites (or other markets for captured CO₂) should be one of the factors considered by the Government.

If the Government of Alberta considers new regulation that will significantly increase the amount of carbon capture operations, it is important that the ability for operators to find a suitable disposal opportunity be given adequate consideration. While not the only factor in consideration, it may not be desirable for operators to be required to capture CO₂ when there are limited reasonable opportunities to either sequester or sell that CO₂.
D12. POST-CLOSURE STEWARDSHIP FUND AND FINANCIAL SECURITY

Author
Regulatory Working Group

Issue
Establish the methodology for determining the rates (fee per tonne) that commercial operators will pay into the PCSF. Determine the financial security requirements and mechanisms that CCS project operators need to demonstrate to ensure that they will be able to uphold their financial obligations over the course of the project.

Scope and Key Questions
The working group identified several tasks to advance the PCSF and financial security issue:

- Gap analysis to determine if there are aspects of a CCS operation that are not covered by either existing financial security mechanisms or by the PCSF.
- Evaluate existing financial security mechanisms to determine if they adequately cover the risks of projects becoming orphaned during the operational phase.
- Examine uniform and project-specific PCSF rates, and pooling of PCSF funds.
- Consider recommendations concerning the operational structure of the PCSF, such as maximum and minimum balances, consideration of the governance structure to manage the PCSF, and mechanisms for adjusting the rate.

Background
With passage of the Carbon Capture and Storage Statutes Amendment Act, 2010, the Government of Alberta legislated that it will assume certain liabilities and obligations of the lessee upon the issuance of a closure certificate. To ensure that sequestered CO$_2$ and some related liabilities and obligations will not become a burden to Albertans, the Post-closure Stewardship Fund (PCSF) was created at the same time. The PCSF was established to cover the costs associated with some of the assumed liabilities and obligations in the post-closure period, and to protect the Alberta public from bearing those costs. Holders of carbon sequestration leases must pay into the PCSF at a yet to be determined rate per tonne of CO$_2$ injected. The PCSF rate will be set before a project begins operations, and payments commence once injection begins. While there are some financial security requirements in place for upstream oil and gas operators, there are currently none for CCS operations other than the PCSF.

Section 121 of the Mines and Minerals Act (MMA) sets out the liabilities and obligations the Government of Alberta will assume when it issues a closure certificate. When issuing a closure certificate, the Government of Alberta:

- becomes owner of all injected CO$_2$
- assumes all obligations of the lessee (section 121(1)(b))
  - as owner and licensee of wells and facilities under the Oil and Gas Conservation Act
  - as person responsible for the injected CO$_2$ and as the operator under the Environmental Protection and Enhancement Act
  - under the Surface Rights Act
- indemnifies the lessee against liability for tort damages
The PCSF is intended to cover the Government of Alberta’s costs associated with some of those liabilities and obligations, and to protect the Alberta public from bearing those costs. Section 122 of the MMA establishes the PCSF and sets out its allowable uses. Those uses are:

- monitoring injected CO₂
- fulfilling obligations assumed in 121(1)(b)
- paying for suspension, abandonment, reclamation and remediation of orphaned facilities
- other purposes prescribed in the regulations.

Costs associated with indemnifying the operator against tort damages are not currently covered by the PCSF.

**Orphaned Facilities**

If a CCS site is orphaned, the Government of Alberta may carry out activities related to that site (e.g. suspension, abandonment, remediation and reclamation). This does not mean that the government assumes liability for that site or the injected CO₂. Liability only transfers with the issuance of a closure certificate.

In the upstream oil and gas sector, the ERCB has a well-defined orphaning process. The ERCB determines if a licensee is defaulting in accordance to section 70 of the *Oil and Gas Conservation Act*. If so, the ERCB issues abandonment orders to all working interest participants (WIPs) to conduct the necessary work. WIPs conduct all the work but are only responsible to pay costs based upon their percentage ownership in the well; the Orphan Well Association (OWA) reimburses the defaulting WIPs orphan share. If the licensee and all WIPs are deemed defaulting, their wells, facilities and pipelines are deemed orphan and the OWA conducts the necessary abandonment and reclamation work.

The ERCB may hold financial security for the defaulting licensee as required by Directive 006. If so, the financial security is used to reimburse the OWA for expenses incurred to abandon and reclaim their wells, facilities and pipelines. The annual Orphan Well Fund levy, collected by the ERCB and transferred to the OWA, pays for the abandonment and reclamation of orphaned sites. Orphan Well Fund coverage does not include CCS projects.

**Analysis Principles**

Alberta Innovates – Technology Futures was contracted to estimate the future costs of a range of potential future MMV and remediation activities. These costs can contribute to estimation of required amounts in the PCSF.

Similar programs for CCS in the EU and US, and for other industries in Canada (Orphan Well Association, ERCB security requirements, Mine Financial Security Program, Saskatchewan Institutional Control Program, and Nuclear Waste Management Organization) were examined. Because of the early stages of CCS in other jurisdictions and differences between the PCSF’s design and purpose compared to programs in other industries, there was limited ability for learnings from those programs to contribute to the RFA’s process.
Responsibility for Paying Costs Related to CO₂ Sequestration Projects during Various Project Phases

<table>
<thead>
<tr>
<th>PROJECT PHASE</th>
<th>Operational</th>
<th>Closure</th>
<th>Post-closure</th>
<th>Orphaned Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension, Abandonment, Remediation and Reclamation of facilities</td>
<td>Operator</td>
<td>Operator</td>
<td>PCSF</td>
<td>1. Financial Security (as per Recommendation 1)</td>
</tr>
<tr>
<td>MMV</td>
<td>Operator</td>
<td>Operator</td>
<td>PCSF</td>
<td>2. Working Interest Participants</td>
</tr>
<tr>
<td>Compensation to affected third parties (if necessary)</td>
<td>Operator</td>
<td>Operator</td>
<td>Government of Alberta (not PCSF)</td>
<td>3. PCSF</td>
</tr>
</tbody>
</table>

Recommendations & Conclusions

Operational Period Financial Security

1. The Government of Alberta should require lessees to post financial security sufficient to cover the full expected cost of suspension, abandonment, remediation and reclamation, including surface and sub-surface costs, in case a CO₂ sequestration operation becomes orphaned before the issuance of a closure certificate. The acceptable forms of security instruments and the calculation of the amount of security required should be determined by the regulator. This security would be returned to the lessee when a closure certificate is issued.

There are two primary drivers for requiring these costs to be covered by upfront security instead of payments into the PCSF:

1. The expected costs are primarily dependent on the amount of infrastructure in place rather than the amount of CO₂ injected.

2. This security is necessary until the time a closure certificate is issued at which point funds (security) should return to the lessee.

The requirement to post this security would only be applied to the CO₂ sequestration component of CCS projects, and not to capture or transport facilities and infrastructure.

The ERCB already has experience, expertise and established orphaning processes, including collecting financial security and determining whether a facility is orphaned. Therefore it is appropriate for the ERCB to make these determinations for CCS operations.

This recommendation is not intended to suggest that covering costs associated with orphaned projects be removed from the list of allowable uses for the PCSF.
Post-closure Stewardship Fund – Rate components and calculation

2. The PCSF rate should be comprised of three components:
   1. monitoring and maintenance
   2. unforeseen events
   3. administrative costs associated with management of the PCSF and management of the data submitted by the lessee.

   These components should be used only for calculating the PCSF rate. Money collected into the PCSF should not be segregated into these components.

Monitoring and maintenance component

The monitoring and maintenance component will collect money to pay for MMV activities for which the Government of Alberta will be responsible after a closure certificate has been issued. This component would also include any residual reclamation that is passed to the Government for any infrastructure that has been requested to be left in place.

Post-closure MMV – This portion of the funds paid by operators into the PCSF should be on a site-specific basis, and based on the operator’s MMV and closure plans. Each project operator will have a unique closure plan that requires pre- and post-closure MMV specific for its project. Therefore, the rate levied to cover the cost of post-closure MMV for a particular project should reflect that project’s site-specific nature.

Because of uncertainty over what MMV will be performed after closure for early projects, the rate paid into the PCSF to cover post-closure MMV should initially be a relatively low amount. This component of the PCSF rate should be adjusted as MMV and closure plans are reviewed, and a better understanding is gained of what MMV will be conducted in the post-closure period. The final amount to be paid for MMV should be determined when the lessee submits its final closure plan.

Residual reclamation – If the Government requests any infrastructure be left in place that would otherwise normally be abandoned, reclaimed and remediated by the operator, responsibility for this residual reclamation is passed to the Government of Alberta at closure. Payment should be made into the PCSF to cover the associated costs for any residual reclamation. These costs should be decided by the Government, following discussion with the lessee, when the decision is made for reclamation to pass to the Government. This payment should have no impact on the return of financial security posted under recommendation 1.

Unforeseen Events component

The unforeseen events component will collect money to pay for reabandonment, reclamation and remediation costs that the government incurs because of unforeseen events (e.g. release of injected CO₂).

Long-term liabilities and risks – The rate for the portion of the PCSF to cover long-term liabilities and risks should be calculated and set by the Government of Alberta, in consultation with the lessee, on a site-specific, risk-based basis. If necessary, the Government of Alberta should obtain input from an independent third party to aid in setting this rate.
Factors considered in the rate calculation could include, but not be limited to:

- Any risk assessments and environmental impact assessments conducted for the project.
- Potential magnitudes and probabilities of release events (which are expected to be very low, otherwise a closure certificate should not be issued).
- Estimated costs of dealing with unforeseen release events, including true-up of carbon credits.
- Project characteristics such as injection rate, and composition and toxicity of the CO₂ stream.
- Number and condition of other wells (active and legacy) within the project boundary, particularly wells penetrating into or near to the storage complex.
- Location of the operation relative to potential damage (environmental, human) receptors (e.g., population centres, actively used groundwater sources, nearby surface land uses).
- Estimated cost to stop a release.
- Operational history of the lessee.

Cost models prepared for the working group by Alberta Innovates – Technology Futures can be a useful input and/or comparison point for some aspects of the rate calculations.

**Orphaned facilities** – To mitigate the risk that the security collected pursuant to recommendation 1 may be insufficient to cover the costs of suspension, abandonment, remediation and reclamation, including surface and subsurface costs, in the event a project is orphaned, a levy should be collected into the PCSF. The intention is that this levy would be relatively small compared to other PCSF components and would gradually accumulate funds over time and across many projects to cover potential Government costs associated with orphaned projects.

This portion of the PCSF could be calculated as a fraction of other rates paid into the PCSF. Other alternative ways to calculate this could be a uniform per-tonne rate paid by all projects, a levy per project or per well, or a percentage of the security posted under recommendation 1 that is added to the PCSF instead of returned to the lessee when a closure certificate is issued.

**Administrative Costs**

Some funds will need to be collected to manage the PCSF and to fund other administrative tasks the Government of Alberta must undertake for CCS projects, such as management of data transferred to the Crown throughout the life of a project.

3. The PCSF rate that lessees pay should:
   
   a) be set on a risk-based and probability-weighted basis
   b) be based only on the specifics of the lessee’s project
   c) not increase due to withdrawals from the PCSF, or risks associated with other projects
   d) be reviewed, along with the security posted by the lessee, every three years in accordance with a), b) and c). Any adjustments (positive or negative) to the PCSF rate during these reviews should be on a go-forward basis only and not be retroactive.
The rate paid by an operator should only be calculated based on the inherent risks and costs of their project. Operators should be assured that the rate that they pay into the PCSF will not be changed based on any withdrawals from the fund because of projects other than their own. However, it should be noted that an incident with one project could lead to a change in the understanding of the risks and event probabilities for other projects. This could result in increased PCSF rates unless the operator can demonstrate that the newly understood risks do not apply to their project or that they can be effectively mitigated through operator actions.

The rate should be periodically reviewed to ensure that the amounts paid into the PCSF are appropriate and reasonable. Since the CCS industry is new, there is still uncertainty about the potential costs the Government of Alberta will be required to bear after the closure certificate is issued. A periodic review of the rate is necessary because it is unlikely that the rate set at the beginning of long-term CCS projects to cover the potential future costs will be accurate, given a project's evolving risk profile over its life, technology improvements and the cost of inflation. This will help avoid the need for a lump-sum true-up prior to the issuance of a closure certificate.

At the three-year MMV and closure plan reviews, the Government of Alberta will already be examining data from the project. This time is therefore the most appropriate time for review of the PCSF rate. This review is not necessarily expected to be a full review and recalculation of the rate, but rather an opportunity to make adjustments to the rate based on new data and increased knowledge of the project, including any changes to the MMV and closure plans submitted during the time of review.

The financial security posted for the project should also be reviewed in conjunction with the rate review to ensure that the amount is appropriate for the project, its progress, and operations. Adjustment of the financial security could help minimize the risk of costs related to orphan facilities coming out of the PCSF.

Post-closure Stewardship Fund – Allowable uses

4. The working group reviewed section 121 and 122 of the Mines and Minerals Act, which excludes costs associated with indemnification against tort damages as an allowable use of the PCSF, and determined that this is appropriate.

Since CCS is a developing industry in Alberta, the Government of Alberta made a decision to exclude post-closure tort indemnification from the PCSF to provide an incentive to encourage CCS development. Recognizing that deployment of CCS is in the public interest, most working group members felt that the Government of Alberta’s decision to exclude tort indemnification as an allowable use of the PCSF is appropriate and necessary at this time.

Rather than paying into the PCSF to cover the long-term costs associated with tort indemnification, the Government of Alberta can use the stringency of site selection, MMV, and closure requirements to minimize the public’s exposure to potential risks in the post-closure period. Compensation awarded as a result of a tort claim would likely be paid from general revenue.

5. The allowable uses of the PCSF should be expanded to include covering costs associated with the assumption of liabilities under the Climate Change and Emissions Management Act and other provincial climate change legislation.
The Regulatory Working Group recommended that responsibilities under the Climate Change and Emissions Management Act and other provincial climate change legislation be included in the list of liabilities that transfer to the Crown when a closure certificate is issued (Appendix D2).

Like all other long-term liabilities or obligations assumed by the Government of Alberta after closure, the liabilities associated with carbon credits may lead to future costs. In order to fulfill the purpose of the PCSF (protecting the Alberta public from bearing those costs), those future costs should be included in the rate calculation and be allowable uses of the PCSF.

**Post-closure Stewardship Fund – Administration**

6. Funds paid into the PCSF should be pooled amongst all PCSF payees.

Pooling of PCSF funds will help ensure that money is available in the unlikely event of a low probability but high impact incident. Without pooling, some projects may need to pay significantly higher rates to achieve the same level of protection.

7. As the number of CCS projects increases, and the Government of Alberta and lessees gain experience with CCS and the rate setting process, these recommendations and related PCSF policies should be reviewed.

As three-year rate reviews are completed and as more projects enter the industry, this rate setting process and other PCSF policies should be reviewed to determine whether or not they are still appropriate. For example, if it becomes apparent rates are generally similar or within the same range, there may be justification for switching to a uniform rate or a set of rate classes.
Areas of Non-Consensus

**Indemnification against tort damages**

An industry member believes that the Government of Alberta should not indemnify lessees against damages in an action in tort (section 122(2) of the *Mines and Minerals Act*); that liability should reside with the lessee of a CCS project throughout the closure and post-closure periods.

This industry member believes that if the Government of Alberta assumes this liability, the potential costs associated with tort liability should be included in the PCSF to protect the public from bearing these costs. However, the challenge with this approach is to predict a reasonable estimate of the potential costs given the uncertainties, risks, and time scale involved with CCS projects. To avoid overcharging the lessee, or underestimating the costs associated with tort liability, this member feels it would be more appropriate to exclude tort indemnification from the transfer of liabilities. This member believes that this approach would minimize the cost of the PCSF for the lessee, eliminate the risk of tort damages being brought against the Government of Alberta, and not burden the lessee of a CCS project with costs associated with an event that may never occur.

**Indemnification against tort damages as allowable uses of the PCSF**

A member from an institution believes that the costs associated with tort liability should be an allowable use of the PCSF. The Government of Alberta has assumed this liability in Section 122(2) of the *Carbon Capture and Storage Amendment Act, 2010*. The Alberta public should be protected from bearing costs arising from CCS projects. By excluding the tort liability as an allowable use of the PCSF, the public is exposed to those potential costs. Moreover, any tort liability would most likely arise from an unforeseen event; reclamation and remediation for unforeseen events are allowable uses of the fund, so the addition of tort liability is only logical. This does not imply that there should be a fee built into the rate paid into the PCSF by a lessee to cover potential tort liability costs.

**Pooling PCSF funds**

Two industry members offer a non-consensus view on Recommendation #6. These companies disagree with pooling funds paid into the PCSF. They offer that, through pooling of rate contributions, responsible companies would become the de facto insurers for less responsible operators injecting CO₂. Further, these companies also offer that through the pooling of funds, there is increased potential for the Government of Alberta to impose a rate addition in the future if funds from the PCSF are withdrawn to address liabilities assumed by the government.

**Supporting documents provided to working group**

Final reports and cost model spreadsheet from MMV and remediation cost estimation contracts.
D13. PUBLIC ENGAGEMENT AND STAKEHOLDER CONSULTATION

Author
Regulatory Working Group

Issue
The purpose of the review is to identify any engagement and consultation gaps and barriers in the current regulatory framework for CCS projects.

Scope and Key Questions
Determine appropriate triggers for engagement and consultation associated with regulatory processes for CCS.

Background
Alberta has a strong process for public engagement and various public engagement and stakeholder notification requirements are outlined in Alberta Environment and Sustainable Resource Development approvals and Energy Resources Conservation Board (ERCB) directives and processes. With regard to oil and gas activity, Alberta has a comprehensive regulatory framework in place that emphasizes the importance of effective, early, and long term public engagement. Broadly, public engagement serves to inform local stakeholders and address concerns. The ERCB’s public engagement, or participant involvement programs, must be developed and implemented before an application for oil and gas project approval. Currently, there are no CCS specific regulations. However participant involvement requirements and expectations exist within ERCB Directives 056, 065, and 071 that must be considered both in advance of submitting an application for energy development and throughout the life of that development. Prior to filing an application, the applicant must address all questions, objections, and concerns regarding the proposed development and attempt to resolve them. This includes concerns and objections raised by members of the public, industry, government representatives, First Nations, Métis, and other interested parties.

Consultation involves direct personal communication with nearby stakeholders that includes land owners, residents, occupants, and municipalities. Confirmation of non-objection may be a requirement, as in Directive 056. In this context, if confirmation of non-objection is not obtained, the project may proceed to a hearing.

Notification differs from personal consultation in that communication can take place through written correspondence rather than face-to-face or telephone conversations. It can be less onerous and can involve the mailing of information packages to assist in understanding the project, and typically occurs in a geographical area larger than that of consultation.

Intervener Status
The ERCB has well established dispute mechanisms in place. Should concerns with an application be brought forward, and the appropriate dispute resolution process fails to resolve them, the matter may then go to an ERCB hearing for a decision as outlined in ERCB Directive 029, Energy and Utility Development Application and the Hearing Process.

Here, Section 6 states, “If you are a person, organization, or company who shows through a written submission that your rights may be directly and adversely affected if the Board approves a proposed energy or utility development and you have been unable to resolve outstanding concerns with the company through sincere negotiations or ADR, you may trigger a public hearing. The party seeking to trigger a hearing must provide information to the Board to show that it has rights that may be directly
and adversely affected by the Board’s decision on the application. The Board does not deal with disputes related to surface rights agreements.” Potential interveners may request that the Board make an advance determination of local intervener status if they are unsure whether they qualify.

Submissions for intervention can come from parties who are outside the range of notification or consultation. The ERCB examines all submissions on a case-by-case basis to determine the potential impacts on the person(s) in question and takes into account the following factors:

- Does the proposed project have the potential to affect safety or economic or property rights? Examples of such impacts include negative effects from contaminants in water, air, or soil or from noise; negative interference with livelihood or commercial activity on the land; damage to property; and concerns for the safety of persons or animals.
- Is the party affected in a different way or to a greater degree than members of the general public?
- Is the party able to show a reasonable and direct connection between the activity complained of and the rights or interests you believe to be affected?

ERCB requirements and expectations for personal consultation and notification with all potentially directly and adversely affected persons also apply to First Nations and Métis stakeholders. In addition, the Alberta Government has developed policy and guidelines related to First Nations Consultation on land management and resource development. Consultation will be required if it is deemed that a project may adversely impact Rights and Traditional Uses (e.g. by affecting animal populations on nearby lands on which a First Nation exercises a treaty right to hunt those animals for food). Proponents are strongly encouraged to begin notifying First Nations early on when planning their projects and, where possible, consulting with First Nations before applying for government approvals. The working group did not identify any need to make CCS-specific recommendations regarding First Nations and Métis engagement requirements.

Effective public engagement and participant involvement programs are critical to promote long-term relationships that will foster a collective and amenable approach to CCS in Alberta. While public engagement requirements are addressed in ERCB Directive 056, 065, and 071, the analogies do not easily lend themselves to a CCS context. The Regulatory Working Group has identified challenges specific to CCS projects including challenges related to surface access requirements, public acceptance, and emergency response planning:

CCS projects may require access to land beyond what similar activities (e.g., acid gas disposal) have called for to deploy monitoring, measurement, and verification (MMV) programs to ensure containment. Applicants should anticipate surface access needs and ensure those parties are included in participant involvement programs early in the project application and throughout the project.

Whereas acid gas disposal and the use of CO₂ for enhanced oil recovery are well established in Alberta, large scale CCS for the purpose of mitigating climate change is a new undertaking the province. There are currently no directives that require notification of surface landowners or occupants in relation to the proposed subsurface activity. There should thus be an opportunity for those who are not in close proximity to the injection or monitoring wells to learn about the project, to ensure transparency and reduce the opportunity for misinformation.

Notification of potentially affected subsurface mineral rights holders is required through Directive 065 Resource Applications for Oil and Gas Reservoirs (i.e., CO₂ storage scheme application). While the ERCB may expand the minimum requirements, notification here could occur within a minimum required radius of 1.6 km from the well. Given the scope of CO₂ sequestration operations, there may be potentially affected resources that lie beyond 1.6 km.
ERCB Directive 056, Energy Development Applications and Schedules, specifies minimum consultation and notification distances for projects based on H₂S and sulphur content. H₂S and sulphur content will likely have no relation to the CO₂ that is to be sequestered; given the fact that CO₂ has properties that distinguish it from sweet oil or natural gas, the minimum sweet oil and natural gas requirements for public engagement may not be appropriate for CO₂.

Directive 071, Emergency Preparedness and Response Requirements for the Petroleum Industry- CO₂ classification as being an acid gas, and not a sour gas, requires only a corporate level emergency response plan. While currently CCS is considered on a case-by-case basis with regard to emergency response plans and potential emergency planning zones (EPZ), the current system is not transparent and the potential for enhancement to the directive exists. (Note: Work is being done within the Environmental Working Group specific to the potential public safety risks related to CCS. This work could be used to inform regulatory enhancements with regard to emergency response planning.)

Analysis Principles
The working group retained a consultant to conduct a literature and jurisdictional review and assessment that summarizes the regulatory triggers and requirements for public engagement and stakeholder consultation for CCS projects. The consultant undertook an extensive literature review of over 80 jurisdictions which include the United States of America, Australia, the European Union and the United Kingdom. The consultant also compared Alberta’s current engagement and consultation requirements to best practices and conducted a gap analysis.

Areas of Non-Consensus
None.

Recommendations and Conclusions

1. The regulator should review consultation and notification requirements for carbon sequestration projects to implement industry-wide minimum requirements specific to CCS and its inherent challenges and risks. The review should achieve, but not be limited to, the following outcomes:
   - Parties that may be affected through activities that require surface access must be identified and included in a participant involvement program. Consultation with these parties should include discussion of a Monitoring, Measurement, and Verification (MMV) plan.
   - Notification of land owners, occupants and residents (including First Nations and Métis) should occur over a broader range than is currently required. This will increase transparency, public assurance and acceptance, and decrease the chance of misinformation. The identification of the range of formal notification activities should occur on a case-by-case basis considering elements relevant to the project application including, but not limited to: the extent of MMV activities; inherent risks of the project; subsurface CO₂ dispersion; and precedents set.
   - Due to the extent and nature of large scale CO₂ sequestration operations, requirements to notify subsurface resources stakeholders, as defined in ERCB Directive 065,[^41] should extend beyond the 1.6 km minimum currently required, but not further than the boundary of the sequestration lease.
   - Establish the required consultation and notification distances for the purposes of emergency response planning with reference to the properties of CO₂ (e.g. heavier than air, odourless, potential risks to human health, public safety) and expected air dispersion.

[^41]: The Acid Gas Disposal section of Table 1 in Directive 065 lists the subsurface stakeholders that a CCS project applicant would need to notify. The working group is not recommending any changes to that list.
• A sound process for participant involvement exists in Alberta, however, the challenges associated with analogous approaches and uncertainties around public acceptance of CCS underline the need for CCS specific requirements that provide clear and transparent direction to industry, provide opportunity for communication and feedback, and continue to make public safety and confidence paramount.

• Consultation and notification processes could be similar to those required in existing ERCB directives if the range of consultation and notification is extended, as recommended above. Alternately, new processes could be implemented to meet the unique challenges posed by large scale CO₂ sequestration.

• The working group believes that the range for notification should be based on a number of considerations specific to each project. The area of review (as defined by the Geology/Technical Working Group) could assist in identifying further considerations in determining this range.

• The draft consultation and notification revisions should be subject to public review, as is the normal process for amendments to ERCB directives.

2. Land owners, occupants and residents (including First Nations and Métis) within the sequestration lease boundary should be informed about the project by the operator of the project through activities that may include, but not be limited to:

   • an expansion of consultation and notification requirements
   • open houses
   • information packages
   • advertising in local media
   • public outreach and education initiatives.

   • The scope of these activities should be developed in consultation with the regulator.

CCS, as a proposed means of climate change mitigation in Alberta, is a relatively new process and public acceptance is key to ensuring successful implementation. Addressing /anticipating public questions and concerns are paramount.

Activities that inform occupants within the sequestration lease boundary would not necessarily need to be part of the formal notification or consultation process.

These activities would also provide opportunities for those residents who may reside in an area overlying potential subsurface pressure effects from CO₂ injection to learn about the project and the mitigative measures being taken.

3. The Government of Alberta should develop public information documents, such as an ERCB EnerFAQs, on CCS.

In Alberta, the participant involvement program requires in some cases a project proponent to include the distribution of a project-specific information package and the ERCB public information documents, at least to those within the minimum consultation and notification distances.

EnerFAQs, (i.e., frequently asked questions on energy development topics) are public information documents which, in some cases, a project proponent is required to distribute as part of its project-specific information package. Currently the ERCB does not have public information documents on CCS available for distribution.
Supporting documents provided to working group

- Final Report - Public Engagement and Stakeholder Consultation Assessment - October 31, 2011

The working group has also identified documents that emphasize the importance of broad public engagement or set a precedent for wider consultation or notification. They include:

- World Resources Institute, Guidelines for Community Engagement in Carbon Dioxide Capture, Transport and Storage Projects, which shows the importance of community engagement in general, http://pdf.wri.org/ccs_and_community_engagement.pdf
- B.C. Oil and Gas Activities Act, Consultation and Notification Regulation, especially Sections 6, 7 and 8 which, for example, may require consultation of 1.0 km and notification of 1.5 km or more for wells, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/1976694347
**D14. PUBLIC SAFETY**

**Author**
Environmental Working Group

**Issue**
The objective of this assessment is to understand the hazards and potential impacts to public safety of a carbon capture and storage (CCS) project. An assessment of the current science and literature will help to inform the requirements necessary to address these potential impacts and hazards. These requirements will ensure best-in-class processes are in place that will enhance Alberta’s current regulatory regime, and confirm the processes and resources necessary to implement a CCS regulatory framework that will be a cornerstone of a robust, efficient and effective risk management system for large scale capture, transport and geologic storage in CO₂ in Alberta.

**Scope and Key Questions**
- Within the RFA Public Safety recommendations (Appendix D14), priority was given to the transportation and injection of CO₂ as these stages of a CCS project have the highest risk on public safety due to potential releases of large volumes and high concentrations of CO₂. The CO₂ capture and sequestration stages were considered to be of lower probability for releases of high concentrations of CO₂ and therefore considered as low risk on public safety and out of scope for the public safety issue within the RFA. Work is being done in other RFA working groups that will consider the risks associated with CO₂ sequestration (e.g., Risk Assessment within the MMV Working Group).
- There exists a knowledge gap regarding the current body of literature on the topic, which can be addressed in the RFA and used to inform any necessary regulatory enhancements.
- Conducting extensive modelling and epidemiological studies that may be required are beyond the scope of the RFA.
- Impurities in the CO₂ stream need to be considered as well. Though the amounts may be only a fraction of the total emission, the importance of the effects of exposure to impurities could take precedence over exposure to CO₂. The types of impurities and their potential effects are being addressed in the CO₂ Transportation and Composition recommendations (Appendix D5) by the Environmental Working Group.

**Background**
The potential impacts of CO₂ releases from CCS operations is project-specific as there are many variables that need to be accounted for such as volumes, duration, flow rates, topography, design standards, ambient conditions (e.g., wind), modelling parameters, etc. Short-term, high concentration exposure to CO₂ is generally the result of an accidental release event, for example through a rupture or a leak, and is considered a public safety issue.

Chronic exposure to CO₂ (long-term, low concentration) is considered a human health issue. Regulatory requirements addressing chronic exposure would fall under other jurisdictions including Alberta Health and Wellness, Health Canada and others. For example, limits for CO₂ exposure currently exist within occupational health and safety requirements.
Similarly to acid gas disposal (AGD), public safety relating to oil and gas development, including CCS, primarily falls under the jurisdiction of the Energy Resources Conservation Board (ERCB) to review, approve, and enforce requirements for CCS projects. Specific to CCS, ERCB Directive 071 Emergency Preparedness and Response Requirements for the Petroleum Industry currently outlines requirements for a corporate level emergency response plan (ERP). Corporate-level ERPs must have pre-planned procedures that will aid in effective response to an emergency. The licensee is expected to determine the level of detail required in its corporate-level ERP to address the hazards and potential consequences of an emergency resulting from its operations. In addition, the corporate-level ERP is expected to be kept current. Corporate level ERPs must include key licensee contacts, 24-hour licensee emergency contact telephone number, a communication plan that addresses communication with response team, support service, government and public media, and activation of a reception centre. An emergency response plan for a CCS project does not currently require ERCB approval however the Board may review the ERP upon request.

An emergency planning zone (EPZ) is a geographical area surrounding a well, pipeline or facility containing hazardous product that requires specific emergency response planning by the licensee. EPZs are required to be calculated if the operation contains or produces either one of the two hazardous substances, i.e., H\textsubscript{2}S or High Vapour Pressure (HVP) hydrocarbons. It may not be required for CCS projects should the CO\textsubscript{2} be comprised of H\textsubscript{2}S below specified amounts in the directive.

The ERCB does assess the adequacy of a proponent’s ‘tools’ for establishing appropriate emergency response and planning requirements and modifications of existing requirements may be made if deemed warranted by the Board. With this, as of May 2012, Directive 071 is currently undergoing a review which may see changes with respect to how hazards are addressed within an EPZ and ERP. It is uncertain if this review will result in criteria that require an EPZ that are based beyond the current two hazardous substances (i.e., H\textsubscript{2}S and HVP hydrocarbons) and consider CO\textsubscript{2} as well.

It was determined by the Environmental Working Group that to best manage the risks associated with an acute exposure from a CCS project, a review of the current related literature and science was needed. A consultant performed a review of the scientific literature on behalf of the working group with the objective to identify the hazards and analyze potential acute health impacts on the public from the accidental release of carbon dioxide and associated impurities during transportation and injection. Risk management, CO\textsubscript{2} dispersion modelling, incidents involving CO\textsubscript{2}, CO\textsubscript{2} properties and behaviour and impurities in the CO\textsubscript{2} stream are among some of the elements related to public safety discussed within the review.

The information from the literature review and future research will be used by the RFA and regulatory agencies to understand the hazards associated with CO\textsubscript{2} streams and uncertainties in analyzing/ determining the potential impacts on public safety. From this, an evaluation of the existing regulatory framework can occur.
Analysis Principles
Alberta Energy commissioned a consultant to review the existing scientific literature that identifies the hazards and analyze potential acute health impacts on the public from an accidental release of carbon dioxide and associated impurities during transportation and injection. This purpose of this report is to summarize the findings from this literature study and provide a description of the hazards and potential impacts on public safety.

Areas of Non-Consensus
None.

Recommendations
1. The ERCB should develop emergency planning zone (EPZ) requirements specific to CCS project infrastructure as part of ongoing efforts to ensure adequate emergency response and planning.

While corporate emergency response plans are required for CCS projects, currently EPZs may not be required should the CO₂ be comprised of H₂S below specified amounts in ERCB Directive 071. Developing EPZ requirements for CCS projects is a conservative and precautionary approach with regards to public safety that would build confidence with the general public. The specific information, science, and modelling that are used to inform emergency response and planning measures should ensure public safety.

Consistent with Directive 071, site-specific EPZs for pipelines, wells, and facilities would identify the area that requires specific emergency response planning. The licensees are required to carry out notification and education for the public who live within the EPZ.

The success of future large scale deployment of CCS in Alberta will rely on a regulatory regime that is based on vast experience as well as current and accurate scientific information. This regulatory regime will build confidence in stakeholders that CCS regulations are of the most robust in the world. The public is a key stakeholder to the success of CCS.

The RFA-commissioned literature review provides a description of the hazards and potential impacts on public safety from an accidental release of CO₂ during a CCS project. While hazards and potential impacts are project specific, the report could be a tool to provide further insight into in determining how public safety aspects are to be addressed for large scale CCS projects.

Supporting documents provided to working group
D15. RISK ASSESSMENT

Author
Monitoring, Measurement & Verification Working Group

Issue
The Monitoring, Measurement and Verification (MMV) Working Group has reviewed requirements regarding suitable risk assessment methodologies and the establishment of guidelines for the appropriate application and comprehensiveness of risk assessments.

Scope and Key Questions
The working group has addressed risk assessment for injection and sequestration as this informs the development of the MMV and closure plans. As a result, the working group has determined that aspects involving pipelines and capture facilities are out of scope for this review. Although the working group has focused on risk assessment as it informs MMV and closure plans, risk management is being addressed broadly by the Regulatory Framework Assessment (RFA) as the scope of the RFA covers the entire carbon capture and storage (CCS) project chain.

The working group is focusing on technical risks relevant to carbon sequestration projects that may impact:

- Health, safety, the environment and other subsurface resources related to the injection and sequestration of CO₂.
- The closure and transfer of liability of a CO₂ sequestration site.

The working group has not addressed commercial aspects of risk assessment (for example: project economics, company reputation, etc.) as these are project or operator specific.

Background
There are presently no explicit requirements for submission of a risk assessment in Alberta legislation for carbon sequestration or other projects. However, the Mines and Minerals Act enables regulations to be made to require applicants to conduct risk assessments before being granted an agreement for the sequestration of carbon dioxide.42

In Alberta, the entire risk management process, including informal assessment, is incorporated into the regulatory framework. Risk assessment, therefore, is contained within the activities that contribute to the development of the application processes, monitoring requirements, and site-specific operational parameters that may be identified and specified in approvals.

A jurisdictional review found that risk assessments are not a standard submission within the regulatory process; however, several examples of jurisdictions that have requirements for risk assessments were found. For example, in the United Kingdom the Health and Safety Executive requires workplace health and safety risk assessments, and offshore installations must prepare a safety case. Specific to CCS activities, the European Union Directive 2009/31/EC requires risk assessments and has an accompanying guidance document.

Analysis Principles
The working group reviewed risk assessment approaches taken for existing projects and projects under development. Common risk assessment elements and principles were reviewed and discussed. The working group reviewed the proposed Canadian Standards Association Z741: Geological Storage of Carbon Dioxide.43

Areas of Non-Consensus
None.

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42 Part 9, Section 124 (a).
43 As released for public review on October 27, 2011.
Recommendations

1. The Government of Alberta should require risk assessment as an integral part of the MMV plan and closure plan submissions for carbon sequestration projects. Risk assessment provides the foundation for the MMV and closure plans and should be performed, reviewed and updated together as required to support the regulatory process.

Proponents should use comprehensive risk assessments to:

- identify adverse events
- assess the likelihood of adverse events
- understand the potential consequences of those adverse events
- understand the inherent safeguards in place through site selection (geology, natural systems, location of legacy wells, etc.)
- support closure and transfer of liability.

Risk assessment is an iterative activity that should inform project risk management activities including:

- guiding the development of a site-specific monitoring plan
- guiding the reduction of project risks to an acceptable\(^{44}\) level by describing the behavior of injected CO$_2$
- aiding in development of responses to mitigate non-conformance\(^{45}\)
- supporting closure and transfer of liability.

The working group has not identified a specific method to be used for risk assessments though different risk assessment methods are in use, appropriate methods will contain similar analytical elements and will identify similar threats and consequences for any given project. The project proponent should determine, in consultation with the regulator, the methodology appropriate to the project to ensure the risk assessment meets the requirements of the regulator. Regardless of approach and methodology, the risk assessment must contain a narrative that describes the logical thought process of the above risk assessment considerations for the carbon sequestration project.

The submission of a risk assessment will enhance the regulatory process for carbon sequestration projects as the site-specific risks, and how they are being managed, can be more thoroughly considered throughout the life of the project. MMV and closure plans are developed in response to risks identified and requiring the inclusion of a risk assessment as part of the regulatory process will enable the project proponent to communicate to the regulator and stakeholders the basis for the MMV and closure plans. The ongoing development of the risk assessment over the life of the project could be used as a tool to communicate sequestration performance and permanence of greenhouse gas reductions when applying for transfer of liability and transferring MMV infrastructure. Risk assessment is an iterative activity related to the development of the MMV and closure plans and is reviewed and updated in accordance with the MMV and closure plans.

\(^{44}\) Refer to the RFA Glossary of Working Terms for a discussion of acceptable risk (Appendix C).
\(^{45}\) Mitigation and remediation are also addressed by the Environmental Working Group (Appendix D8).
2. The Government of Alberta should endorse the following guidelines for risk assessments:
   • Risk assessments should be iterative, systematic, technically defensible, transparent and available to the public as integral to MMV and closure plans.
   • Modelling and simulations should be undertaken (as applicable on a site-specific basis) to evaluate and predict the behaviour of the sequestration complex and inform the risk assessment.
   • Records of risk assessments including all iterative updates and comparisons of predicted behaviour of the sequestered CO₂ with measured performance should be retained for the life of the project to support MMV plans and closure Certificate applications.
   • Non-technical risks specifically related to public acceptance of MMV plans, should be identified and addressed by project proponents.

The working group has identified general contextual documents that provide information and background on appropriate risk assessment methodologies and realistic considerations to be used within a carbon sequestration project risk assessment. The documents should be available on a dynamic list provided to a general audience. Documents the working group has identified include:

   • Canadian Standards Association, Z741: Geologic Storage of Carbon Dioxide.\(^{46}\)

3. The Government of Alberta should undertake a review of the Canadian Standards Association Z741: Geological Storage of Carbon Dioxide following its final publication. The review would inform the decision as to whether the standard, or part thereof, should be adopted by the province.

A review of the standard would identify similarities and differences between the standard and the principles, guidelines and requirements already in place in Alberta legislation (regulations, standards and directives). The final publication of the standard is expected in fall of 2012.

\(^{46}\) The Standard has been included on the list of contextual documents as it provides appropriate background and information on risk assessment of a carbon sequestration project regardless of the results of the review proposed in recommendation three.
D16. SITE CLOSURE

Author
Geology/Technical Working Group

Issue
The Geology/Technical Working Group has determined the subsurface criteria that must be achieved for projects to be granted a closure certificate.

Scope and Key Questions
The Geology/Technical Working Group has worked in collaboration with the Monitoring, Measurement, and Verification (MMV) Working Group to determine the elements that are important to demonstrate the safety and efficacy of sites for geological sequestration and the requirements for site closure.

Background
In Alberta, the Mines and Minerals Act provides that the Minister of Energy may issue a closure certificate upon a lessee meeting certain conditions including that the captured and sequestered CO₂ is behaving in a stable and predictable manner, with no significant risk of future leakage. Initial closure plans must be submitted when applying for a carbon sequestration lease and the plan must be updated every three years or 90 days prior to the date the lease is renewed.

In the United States, the cessation of injection marks the beginning of the post injection site care period which includes appropriate monitoring and other actions to ensure that the CO₂ is safely contained. Iterative dynamic modelling and monitoring results for the area of review are used to demonstrate stable and predictable CO₂ plume and pressure front behavior. The Director of the United States Environmental Protection Agency (US-EPA) may authorize site closure once it has been demonstrated that there is no longer a risk of endangerment to underground sources of drinking water.

Under the European Union Directive, a condition for transfer of responsibility is that all available evidence indicates that the stored CO₂ will be completely and permanently contained. Technical criteria required include: conformity with predictive models; absence of detectable leakage for a minimum 10 year period; and evolution to long term stability.

Analysis Principles
The working group has reviewed requirements in other jurisdictions, publications, and the proposed Canadian Standards Association Z741: Geological Storage of Carbon Dioxide and the closure plan for one of the Alberta CCS projects.

A closure workshop with representatives from all working groups was held in January 2012, at which time the scope of the closure issue and the aspects each group would address were determined. Performance criteria for closure were developed by the MMV Working Group with input from the Geology/Technical and Regulatory Working Groups. The performance criteria for closure are included with the MMV issue recommendations, and the Geology/Technical Working Group has made recommendations for key terms in the performance criteria.

The recommended performance criteria for closure include, as appropriate:

- Sequestered CO₂ and affected fluids are conforming with project objectives and regulatory requirements as described in the project applications and approvals, and any applicable amendments to those approvals.
- There is no significant adverse effect of sequestered CO₂ or affected fluids to health, the environment, other resources (including but not limited to hydrocarbons, non-saline groundwater and pore space outside of the operator’s sequestration lease).

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47 As released for public review on October 27, 2011.
48 Where adverse effect is defined by the Environmental Protection and Enhancement Act to mean “impairment of or damage to the environment, human health or safety or property”.

• Sequestered CO₂ and affected fluids are adequately contained in the sequestration complex.
• Sequestered CO₂ has behaved in a predictable\(^{49}\) manner in conformance with subsurface modelling.
• Sequestered CO₂ is expected to continue to behave in a predictable manner and is trending towards stability.
• The project specific risk profile is decreasing and the risk of future leakage or adverse effects on health, the environment or other resources is acceptable.
• Decommissioning and abandonment have been completed as required by the respective regulatory agency.\(^{50}\)
• Surface reclamation has been completed to the extent possible, as agreed with the regulator for the post-closure period.

Evidence for closure should be demonstrated on a site-specific basis and should be provided by:
• Compliance with legislation (regulations, standards, directives), applications and approvals.
• Results and interpretation of data collected by activities under the MMV plan (a component of which is the evolution of the site-specific risk assessment).
• Simulations and modelling to support containment and predictability of the sequestered CO₂.
• Results and practices followed for surface reclamation.
• Results and practices followed for decommissioning and abandonment of wells not needed for future monitoring to support long-term isolation of the sequestered CO₂.

Project operators and regulatory agencies should communicate throughout the injection period to ensure that MMV and closure plans evolve as required. As a project progresses, a staged approach to reporting and the review of closure criteria will help ensure that time-sensitive data are collected when available and to the extent required by the regulatory agency. The regulatory agency and the project operator should agree how the project will demonstrate that:
• CO₂ plume behavior is in current conformance with predictive models.
• its future behavior can be predicted.
• the CO₂ plume is trending towards stability.

The parties should also agree how the evidence being collected supports these criteria.

Areas of Non-Consensus
None.

\(^{49}\) Refer to the RFA Glossary of Working Terms for a discussion of the term “predictable” (Appendix C).
\(^{50}\) Regulatory agency has been used throughout this document as a general term to describe Government of Alberta regulatory agencies and departments. A general term has been used when it is unclear which agency or department will be responsible for unique aspects of CCS. In addition, implementation of the Regulatory Enhancement Project (REP) recommendations may result in a single regulatory body for upstream oil, gas, and coal development in Alberta. The RFA has identified that further work is required to clarify regulatory roles and responsibilities for CCS.
\(^{51}\) The ERCB uses the term “abandonment” for its oil and gas-related activities. ERCB does not consider a well completely abandoned until the Surface Abandonment is conducted. From Directive 020 there are four cases for abandonment:
- Cased-hole well abandonment: The downhole abandonment of a completed or cased well
- Open-hole well abandonment: The downhole abandonment of an open-hole well after drilling is complete but before the rig is released
- Surface abandonment: The cutting off of casing string(s) and the capping of a well
- Zonal abandonment: The abandonment of a single pool completion within a cased hole or the downhole abandonment of an open-hole interval in a cased hole.
Recommendations & Conclusions

1. There is consensus that the current ERCB Directive 020 adequately addresses the conformance and containment requirements for abandonment of wells used for CCS activities.

In considering the well abandonment issue, the working group reviewed current ERCB requirements (Directive 020 – Well Abandonment) and found that testing, subsurface isolation and subsurface abandonment practices are adequate to ensure conformance and containment of wells used for the purpose of CCS activities; however, any applicable advances in abandonment techniques and practices should be incorporated into abandonment requirements for wells in the future.

In considering the site abandonment issue, the Geology/Technical Working Group worked with the MMV Working Group to define the performance criteria for closure (See Analysis Principles above) and concluded that these criteria cover the technical requirements from the perspective of the Geology/Technical Working Group.

2. The Government of Alberta and its regulatory agencies should require that interim and final closure plans include assessment of all the wells that have penetrated the sequestration complex within the area of review to ensure that the evolution of the CO₂ plume or pressure front over the life of the project has not introduced leakage pathways that were not anticipated.

The initial assessment of existing wells carried out during the site selection process may predict that a particular well in the Area of Review will not be affected by proposed CCS operations. However, the movement of the CO₂ plume inside the sequestration complex during the operational phase may be different from that predicted by the model because of uncertainties in subsurface conditions, modelling techniques, and changes in operational plans. This may increase the likelihood that existing wells previously identified in the site selection stage that were not expected to be impacted by the project could be reached by the plume of injected CO₂ and may become potential leakage pathways. Additional monitoring or confirmation for abandonment according to existing regulations at that time may be required. In addition, new wells may be drilled during the life of a CCS project that will penetrate the sequestration complex, introducing potential new leakage pathways. Both existing and new wells need to be addressed in the closure plans.

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52 Area of review is the surface area within which there is risk (associated with potential events with adverse effects) to public health and safety, to the environment or to the exploitation of natural resources due to the CO₂ plume expansion and pressure build-up. After commencement of injection the operator has the option of updating the Area of Review with each submission of the interim closure plan as the uncertainty on plume expansion and/or pressure elevation should be reduced by ongoing conformance monitoring (see Glossary of Working Terms (Appendix C) for further details).

53 Recommendations for site selection address the initial assessment of existing wells in the sequestration complex within the Area of Review.

54 Licensees of third-party petroleum and natural gas wells penetrating the sequestration complex retain perpetual liability for well abandonment and site reclamation.
D17.  SITE SELECTION

Author
Geology/Technical Working Group

Issue
The objective of this assessment is to review the current regulatory requirements, identify best-in-class processes that would enhance Alberta’s regulatory regime, recommend necessary changes, and confirm the processes and resources necessary to implement a carbon capture and sequestration (CCS) regulatory framework that will be a cornerstone of a robust, efficient and effective system for large scale capture, transport and geologic sequestration of CO₂ in Alberta. As such the Geology/Technical Working Group has addressed key issues including determining what objectives are important to demonstrate, and what characteristics are important elements in selection of a CO₂ sequestration location.

Scope and Key Questions
The scope of this document is limited to the various frameworks or methods that will determine the geologic and engineering criteria required to determine a suitable carbon sequestration site. To consider a CO₂ geological sequestration technically feasible, three major parameters were considered to be essential:

- The sequestration complex must have sufficient storage volume capacity to sequester all the volume of CO₂ requested in any application for geological sequestration.
- The characteristics of the injection zone(s) in the sequestration complex must be such that sufficient injectivity from wellbore(s) is possible to store CO₂ at the rate that it is supplied from capture facilities.
- Seals of the sequestration complex must ensure suitable containment of all injected and displaced fluids.

Background
The Energy Resources Conservation Board (ERCB) has been regulating the disposal, storage, and injection of fluids into underground geologic formations in Alberta for many years, and in particular with respect to carbon dioxide (CO₂) for more than 20 years. The ERCB has processes in place to provide effective regulation of these activities, including the more than 50 schemes involving acid gas (H₂S and CO₂) disposal and CO₂ (CO₂-EOR) currently operating in Alberta.

ERCB Directive 056 – Energy Development Applications and Schedules and Directive 065 – Resources Applications for Oil and Gas Reservoirs sets out the key application requirements for projects with respect to CO₂ injection in underground geologic formations for the specific cases of acid gas disposal and of CO₂ enhanced oil recovery (CO₂-EOR).

Directive 065, Unit 4 sets out requirements and procedures for making an application to the ERCB for approval of disposal of fluids containing CO₂. Unit 4 sets out application requirements specific to acid gas disposal (CO₂ is classified as acid gas). In addition to conforming to the directives, ERCB requires approval for the sequestration or disposal of any fluid or other substance to an underground formation through a well.
Regulatory Framework Assessment

The Geology/Technical Working Group reviewed the following main documents to make recommendations for the site selection issue:

- *Oil and Gas Conservation Act* (R.S.A. 2000, ch.0-6) s.39(1)(d)
- Carbon Sequestration Tenure Regulation (April 2011)
- Directive 056: Energy Development Applications and Schedules (September 2011)
- Directive 065: Resources Applications for Oil and Gas Reservoirs (August 2010)

**Analysis Principles**

The approach for proper site selection should be tailored to the unique characteristics of each site (site-specific or case-by-case basis) and its management should be informed by a site-specific risk analysis in order to reduce uncertainties and enhance site understanding through iterative data collection and analysis throughout the entire life of the project. These recommendations therefore promote a risk-based approach for site selection.

Risk based approaches direct attention towards the most significant risks (probability of an event occurring multiplied by the severity of consequences). Adopting a risk-based approach to site selection provides the proponent(s) with more flexibility in the project design. Levels of acceptable risk should be defined on a case-by-case basis for each project through an interactive dialogue between project proponent(s) and the regulatory agency.

The working group believes that an operator may benefit from an independent assessment of a geologic sequestration project prior to submission of applications for tenure and/or permitting. For example, Shell Canada Energy engaged a consultant to conduct an external review of the Quest project with the collaboration of a panel of experts. Executives from Shell found the resulting technical input to be helpful during the ERCB hearings on the project. Such reviews may not be needed in the future as the industry matures and both operators and regulatory agencies gain experience with large-scale CCS operations.

**Areas of Non-Consensus**

None.

**Recommendations**

1. The Government of Alberta and its regulatory agencies should adopt general site selection criteria and the ERCB should review the requirements that apply to CCS to ensure that they adequately reflect the overarching objectives of adequate storage volume capacity, sufficient injectivity, and suitable containment.

Proponents must demonstrate that the sequestration complex has adequate storage volume capacity, sufficient injectivity, and suitable containment. The working group believes that adopting general criteria for site selection will assist proponents in demonstrating achievement of these objectives, and that these criteria will contribute to the acceleration of CCS activities in the province and greater public acceptance of CCS projects. Examples of parameters for which criteria should be developed include pressure regime, faulting and fracturing intensity, thickness of injection zones, protection of groundwater, etc.

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55 Containment in this recommendation is defined as “Retention of injected CO₂ and affected fluids within the sequestration complex” (see Glossary of Working Terms (Appendix C) for further details).
The ERCB requirements for fluid injection/disposal generally reflect the overarching objectives noted above. However, the Geology/Technical Working Group has identified several specific items that should be assessed; these are:

- The term fracture pressure (FP) needs to be clarified. The maximum bottom hole pressure (BHP) should not simply be limited to 90 percent of the formation fracture pressure.\(^{57}\) The current rule leaves room for interpretation of the “fracture pressure”. For example, if FP was clearly defined as the Fracture Extension Pressure (FEP), which is less than the fracturing pressure FP, it would safeguard against opening existing fractures when the BHP exceeds the formation minimum compressive stress. Therefore, the maximum BHP should consider the fracture extension pressure and the formation minimum compressive stress.

- As required by the regulator, the geo-mechanical modelling should include assessment of the integrity of the seal(s) in the presence of temperature-induced stress changes, considering that the injected CO\(_2\) stream most likely will be at a lower temperature than the initial temperature of the sequestration unit and overlying seal(s).

- Operators should be required to determine the seal fracture pressure and the pressure that seal(s) will experience over the life of a CCS project due to the pressure front.\(^{58}\) Suitable predictive modeling/monitoring would be required to cover this eventuality.

- Operators should be required to determine the capillary entry pressure of the seal(s) and to demonstrate that this pressure will not be exceeded anywhere within the sequestration lease over the life of the project.\(^{59}\)

- Scheme assessments for all existing wells falling within the area of review\(^{60}\) and penetrating the sequestration complex should be reviewed. The current Directive 65 requirement for assessing the impact of wells\(^{61}\) is based on a single injection well with a radius of influence of 1.6 km. This requirement is intended to regulate acid gas disposal operations, but is not applicable to CCS activities due to the large CO\(_2\) injection volumes and the associated pressure fronts.

- Operators should be required to evaluate the likelihood and potential impact of induced seismicity. The Government of Alberta, with the assistance of third party expertise as necessary, should provide guidelines to operators on determining the likelihood of fault activation/reactivation if faults exist in the sequestration complex for which tenure is requested or granted.

This list is not exhaustive. As ERCB Directives come up for regular review, or as new issues are otherwise identified, requirements related to CCS site selection should be re-assessed in the context of the overarching objectives.

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57 ERCB Directive 051 (Section 8.1) limits the BHP to the lesser of 90 percent of formation fracture pressure or the pressure at which hydraulic isolation logging was conducted.

58 In addition, analysis should be completed at the shallowest structural trapping point in cases where a significant column of CO\(_2\) could accumulate in a structural trap, so as not to create fracture(s) or open any existing fractures in the seal(s) at the top of the column. If CO\(_2\) is trapped in a structure where a large column can accumulate, the buoyancy effect could give rise to a pressure at the top of a column of CO\(_2\) which could exceed 90 percent of the fracture pressure at that point while still complying with the injection well maximum BHP requirement. The injected mass of CO\(_2\) must be small enough to ensure the fluid pressure at the shallowest point of a column of CO\(_2\) anywhere within the sequestration lease does not exceed 90 percent of the fracture pressure (or any updated rule related to the first bullet in Recommendation 1).

59 The capillary entry pressure to CO\(_2\) (displacement pressure) determines the quality of the seal as a flow barrier for CO\(_2\). If the seal is CO\(_2\) wettable and capillary entry pressure is exceeded then CO\(_2\) can enter the seal pore space and potentially flow through the seal. This may also have relevance for accelerating geochemical alteration of the seal(s) which could impact other properties of the seal(s).

60 Area of review is the surface area within which there is risk (associated with potential events with adverse effects) to public health and safety, the environment or to the exploitation of natural resources due to the CO\(_2\) plume expansion and pressure elevation (see Glossary of Working Terms (Appendix C) for further details).

61 Licensees of third-party petroleum and natural gas wells penetrating the sequestration complex retain perpetual liability for well abandonment and site reclamation.
D18.  SURFACE ACCESS

Author
Regulatory Working Group

Issue
Ensure that surface access rights for necessary CCS activities are sufficient.

Scope and Key Questions
The working group is examining activities that require surface access for a CCS project as well as reviewing the current processes for gaining surface access. From this, recommendations can be made that address potential regulatory gaps to ensure appropriate access provisions are in place that will facilitate the safe and effective implementation of CCS projects in Alberta. Issues related to compensation to landowners for surface access are out of scope.

Background
Most CCS activities that require surface access fall under similar provisions as for oil and gas activities. CCS activities will require surface access for monitoring, measurement, and verification (MMV) activities to ensure that CO₂ is contained and behaving in a predictable manner.

The Carbon Capture and Storage Statutes Amendment Act 2010 made changes to surface access in that the addition of Section 13.2 of the Surface Rights Act enables the Surface Rights Board to issue a right of entry order (ROE) to an operator in order to conduct required monitoring, measurement and verification specified in an approved MMV plan. Currently, an ROE order may be granted for conducting MMV activities in respect of the surface of the land for drilling or operating a well, necessary installations at or pipelines to or from that well and public roadway or other public way to give the operator access to the lease site. There is uncertainty as to whether the Act will grant access beyond the surface lease site.

No provisions exist to enable the Government of Alberta to also gain surface access to conduct MMV activities following the transfer of liability.

Analysis Principles
• Review of the Alberta’s current process of gaining surface access. Gathered input from MMV Working Group around the need for surface access for MMV activities during pre-operation stage, and operation stage.
• Review Alberta’s current process of gaining surface access during the post-closure phase. Gathered input from Environmental Working Group around the need/look of surface reclamation during the closure and post-closure stage.

Areas of Non-Consensus
None.

Recommendations
1. The Surface Rights Act should be amended to enable the Surface Rights Board to grant an operator a right of entry order (ROE) for any land within the carbon sequestration lease or evaluation permit boundary in order to conduct required MMV activities as outlined in an approved MMV plan pursuant to Part 9 of the Mines and Minerals Act.
The purpose of MMV is to address health, safety and environmental risks, evaluate sequestration performance and provide evidence for closure. Certain MMV techniques cannot provide complete data if access cannot be gained to key areas.

Conducting MMV activities is imperative in order to demonstrate conformance and containment of stored CO₂. Although the majority of surface access required for MMV activities will be to the areas overlying and surrounding the plume, some activities could require gaining transient surface access to all areas within the sequestration lease to deploy the required MMV techniques.

2. All necessary legislation should be amended to enable the Government of Alberta to gain surface access in order to conduct MMV and reclamation activities after transfer of liability.

The Government of Alberta, after transfer of liability, may need to perform MMV activities and remEDIATE and reclaim land.

3. There is consensus that the current process for obtaining access for pre-operation activities is adequate. Specific surface access provisions for pre-operation activities are not required.

Pre-operation activities would be conducted under an evaluation permit which includes an approved MMV plan. This means that a Right of Entry Order may be granted for those activities if necessary. The current process for obtaining surface access prior to the issuance of an evaluation permit, which requires coming to an agreement with the land owner through direct negotiation, is considered appropriate by the working group and no changes were suggested.
D19. SURFACE RECLAMATION

Author
Environmental Working Group

Issue
There is an existing regulatory framework in Alberta for surface reclamation associated with oil and gas facilities. It is anticipated that this framework will form the basis for the reclamation of CCS facilities. The CCS Regulatory Framework, however, may include expectations for long-term monitoring on CO₂ storage sites. Such expectations may impact the nature and requirements related to surface reclamation.

Scope and Key Questions
As Alberta has a well-established regulatory framework related to surface reclamation, the Environmental Working Group focused on CCS considerations and what, if any, modifications are required to the existing reclamation framework to accommodate CCS activities. Specific approaches for mitigating CO₂ leakage or other forms of contamination if required as part of a reclamation plan will not be included in this review.

Background
The key question for this issue is: will CO₂ capture and storage projects have similar or different effects on land surfaces as compared to more conventional oil and gas such as natural gas well sites and pipelines? There has been no indication that the type of equipment required for the injection and storage of CO₂ or CO₂ pipelines will create surface disturbances that differ from those created by current natural gas well sites and pipelines. As such the reclamation requirements would be the same and will continue to evolve over time.

The Environmental Protection and Enhancement Act (EPEA) requires that lands disturbed by oil and gas activity must be reclaimed to equivalent capability.

Equivalent land capability means that the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical (EPEA Conservation and Reclamation Regulation 115/1993).

Reclamation certificates are issued pursuant to EPEA and liability will be assumed by the Crown for the land surface after 25 years from the time of issuance of the reclamation certificate. The Public Lands Act also requires land to be restored to equivalent capability following the completion of any activity on public land. Alberta Environment and Sustainable Resource Development manages the certification process for private land and manages the process for public land.

In the case of a surface disturbance due to pipeline construction, the site must be fully reclaimed and meet the equivalent capability test.

In reviewing other jurisdictions it has been determined that Alberta has existing regulations for surface reclamation for both injection well sites and pipelines that are scientifically and technically sound. These regulations undergo regular review and are updated as required by technological and scientific advances.
Analysis Principles

The working group reviewed the current requirements for surface reclamation under EPEA and the Public Lands Act. The differences between current projects and CCS projects and how these differences impacted current requirements for surface reclamation were discussed.

Areas of Non-Consensus

None.

Recommendations and Conclusions

1. With regards to surface reclamation for CCS the Environmental Working Group recommends that:
   - CO₂ injection site reclamation follow the current physical and technical requirements for upstream oil and gas projects;
   - CO₂ pipeline site reclamation follow the current physical and technical reclamation requirements for pipelines, and;
   - operators remain accountable for site reclamation to the extent possible, while allowing for required infrastructure to remain in place where necessary for long term monitoring activities.

Alberta’s existing surface reclamation requirements under the Conservation and Reclamation Regulation for both injection well sites and pipelines are scientifically and technically sound and there is no evidence that CCS injection wells and pipelines will cause surface disturbances that differ from those currently created by well sites or pipelines.
D20. TENURE PROCESS

Author
Regulatory Working Group

Issue
Determine the information requirements a project operator must satisfy to acquire a sequestration tenure agreement (evaluation permit and sequestration lease) for pore space and communicate application process and expectations to stakeholders.

Scope and Key Questions
The working group is reviewing the existing tenure process for sequestration tenure agreements. This process was compared to that for Crown minerals, specifically petroleum and natural gas tenure. From this, recommendations can be made that address potential regulatory gaps and ensure proper application and issuance of sequestration tenure agreements.

Background
The tenure process is the method whereby Alberta Energy issues Crown held rights, or grants access to Crown lands, on behalf of the province. The Crown declared ownership of pore space in Section 15(1) of the Mines and Minerals Act and will be responsible for the disposition of pore space for CCS. Currently, the Crown grants access to pore space through the mechanisms outlined in the Carbon Sequestration Tenure Regulation as well as section 54(5) of the Mines and Minerals Act. The regulation specifies the requirements an applicant must satisfy in order to obtain pore space tenure for CCS purposes.

Companies can apply for either an evaluation permit or a sequestration lease. The term of the evaluation permit is 5 years from the term commencement date. The term of the sequestration lease is 15 years from the term commencement date. Each type of agreement holds an obligation as prescribed in the Carbon Sequestration Tenure Regulation.

Analysis Principles
The working group examined existing regulatory requirements to obtain carbon sequestration tenure as well as for Crown mineral rights.

Areas of Non-Consensus
None.

Recommendations

1. It is recommended that all requirements for acquiring a sequestration tenure agreement and information on pore space be accessible to industry and the general public through the Alberta Energy’s commodity website.
There is currently no information on pore space or the acquisition of pore space (sequestration tenure agreement) on the Alberta Energy website. The lack of clarity could result in inconsistent and inadequate applications. Publishing pore space information and the requirements for acquiring a sequestration tenure agreement on the Alberta Energy commodity webpage will clarify the application process and expectations as well as provide guidelines to stakeholders.

The pore space information should be easily accessible through one avenue, the Alberta Energy website.

2. Sequestration tenure applications submitted to Alberta Energy’s Tenure Branch should be subject to review by the Crown Mineral Disposition Review Committee (CMDRC).

The CMDRC reviews, at the department’s request, all surface restrictions affecting Crown mineral rights (i.e. petroleum and natural gas, oil sands, ammonite shell and metallic and industrial minerals) to consider the possible effects of mineral exploration and development activities on the environment within and adjacent to the requested rights prior to leasing them. The CMDRC may recommend that lands be withdrawn from disposition, or that the proposed disposition be granted with or without special terms and conditions.

The working group believes the CMDRC should follow the same processes for CO₂ sequestration tenure agreements as they do for other Crown mineral rights.
D21.  WELL CONSTRUCTION

Author
Geology/Technical Working Group

Issue
The objective of this assessment is to review the current regulatory well construction, operation, and abandonment requirements, identify best-in-class processes that would enhance Alberta’s regulatory regime, recommend necessary changes, and confirm the processes and resources necessary to implement a carbon capture and storage (CCS) regulatory framework that will be a cornerstone of a robust, efficient and effective risk management system for large scale capture, transport and geologic storage in CO2 in Alberta.

Scope and Key Questions
A properly designed and constructed injection well is essential to maintain integrity from the injection period to beyond the point when the well has been permanently plugged and abandoned. Specific well construction materials and methods will be required to ensure integrity of CO2 injection wells.

Background
The initial reaction of the work group is that the current acid gas well construction requirements are appropriate for large scale CCS injection wells. The history of acid gas injection in Western Canada shows the efficacy of the regulations even though they may be reviewed and revised. There is a long history that this process can be undertaken successfully within the framework of existing regulations. Following a thorough review, the working group concluded that moving from acid gas injection to commercial scale CCS projects will result in more CO2 injection wells but often with similar volumes of CO2 injected per well. As a result, a commercial scale CCS project will increase the foot-print, but not exceed current levels of operating parameters and/or experiences relating to existing well integrity standards.

Analysis Principles
The decision making process is detailed in the Terms of Reference approved by the Geology/Technical Working Group. When addressing an issue, the tasks for the working group include examining it in an Alberta context, reviewing requirements from other jurisdictions, identifying and retaining contractors if required, preparing a work plan and developing recommendations.

Alberta has a regulatory structure dealing with acid gas (CO2 /H2S) disposal wells. There are two main ERCB Directives that outline the requirements for an acid gas/CO2 injection well and these directives were analyzed to determine their appropriateness for CO2 injection:

- Directive 051: Injection and Disposal Wells – Well Classification, Completions, Logging, and Testing Requirements – Clarifies completion, logging, testing, monitoring, and application requirements for injection and disposal wells. Specifies procedures and practices designed to protect the subsurface environment, including all usable groundwater and hydrocarbon-bearing zones. CO2 injection wells are classified as Class III wells. Directive 51 is one of a series of directives currently being reviewed by the ERCB.
- Directive 056: Energy Development Application and Schedules – the requirements and procedures for submitting a license application to construct or operate any petroleum industry energy development that includes facilities, pipelines, or wells.
Other directives applicable to CO₂ well design and integrity that were investigated include the following:

- Directive 008 – Surface Casing Depth Minimum Requirements
- Directive 020 – Well Abandonment
- Directive 065 – Resources Applications for Oil and Gas Reservoirs
- Directive 009 – Casing Cementing Minimum Requirements
- Directive 010 – Minimum Casing Design Requirements

**Areas of Non-Consensus**

None.

**Recommendations and Conclusions**

1. Classification of CO₂ injection wells needs to be more specific and indicate the concentrations of other components at which a well will be classified as Class IIIa. All Class IIIa wells should be evaluated against the same criteria regardless of purpose.

The working group reviewed the proposed revisions to Energy Resources Conservation Board (ERCB) Directive 051 regarding well classification and feels that the revision should consider all the various components and the concentration of CO₂ / H₂S at which a well will be classified as Class IIIa. The injectate may be a continuum of gases including H₂S, CO₂ as well as other gases (e.g. SO₂).

2. The proposed ERCB requirements for surface casing and for cementing the surface casing and the next external casing string from the base of well (casing shoe) to the surface in conjunction with other casing and cementing measures may be adequate for the purposes of CCS. However, if additional casing strings are used, the combined casing strings must isolate all formations from the base of the well to the surface.

These requirements should be applicable to all Class IIIa wells (new wells and conversions). However, the proponent may propose a modified well completion which will be reviewed by the ERCB using a performance-based approach as is the current practice. The reasons for a modified well completion may include:

- Differences in the age, construction and prior use of conversion wells (for example, existing wells may be suitable for conversion to injection in an Enhanced Oil Recovery scheme using the current risk-based assessment practice).
- A need to implement special MMV technology (such as a downhole fluid sampling apparatus, e.g., U-tube assembly).
- A need to obtain fluid samples that have not been contaminated by cementing.
The proposed ERCB Directive 051 revision was reviewed and it was determined that the proposed requirements for surface casing and for cementing the surface casing and the next external casing string (from the casing shoe\textsuperscript{62} up to the surface) in conjunction with other casing and cementing measures may be adequate for the purposes of CCS. The protection of saline groundwater is further addressed by the Regulatory Working Group as part of the competition with other resources recommendations (Appendix D\textsuperscript{6}) if used for industrial purposes.

The United States Environmental Protection Agency (EPA) requires a continuous long string casing cemented to surface for its Class I hazardous wells and is requiring this configuration for Class VI wells. The ERCB in its revised Directive 051 is proposing that Class IIIa wells will require cementing to surface for both the surface and the next casing string run. An Alberta study has concluded that cementing external casing to surface is a key factor in reducing the incidence of general well failures including surface casing vent flow and casing leaks. Alberta regulations allow the use of a production liner (fully cemented) which may be beneficial in certain applications.

In cases where fluid sampling is required as part of monitoring, cementing does not need to occur within the formation zones targeted for sampling. If the injection zone or zones are cemented and fluid sampling monitoring is required, cement will reduce the capacity for monitoring. The signature of injected CO\textsubscript{2} may be lost due to the geochemical reactions between cement (alkaline) and CO\textsubscript{2} (acidic) which can result in the precipitation of carbonates. There may be other chemical interactions occurring between the cement and the formation fluids that affect the fluid composition. This should be assessed when well conversions (e.g., injection to monitoring) are planned and MMV programs established.

Bachu and Watson\textsuperscript{63} reported that according to ERCB, as of 2006, there were 79 injection wells in Alberta; 48 of these were for AGD, and 31 were for CO\textsubscript{2} injection. Of these 79 wells, 57 were converted and only 29 of the injection wells were fully cemented to the surface. Some of these wells may have been granted approval prior to implementation of ERCB Directive 051 (1994). Directive 51 requires annual testing and if failures are detected, they must be repaired immediately. The most common detected problems in injection wells are tubing failure and packer failure.

3. ERCB directives adequately cover material selection, casing and well head pressure requirements.

Directive 010 details the minimum casing design requirements. The directive includes information and requirements on various design criteria including burst and yield strengths, alternative design methods and casing wear considerations. Licensees must also follow Directive 010 appendices to select the proper material specifications for all wells, using partial pressures of H\textsubscript{2}S and CO\textsubscript{2}, as well as design factors, to determine the appropriate material specifications. When selecting materials, the Licensee must consider current and anticipated future environments, specifically the potential for use of the well in H\textsubscript{2}S or CO\textsubscript{2} service. Directive 051 limits the maximum injection pressure to 90 percent of fracture pressure\textsuperscript{64} of zone or 90 percent of the maximum pressure at which hydraulic logging was conducted. An analysis of injectate phase behavior through a range of temperatures and pressures must be included in a Directive 065 application. Maximum reservoir pressures and reservoir type (i.e. depleted, open, and closed) will be addressed as a site selection sub-issue.

\textsuperscript{62} The casing shoe is placed at the end of the casing
\textsuperscript{63} S. Bachu and T.L. Watson, Review of failures for wells used for CO\textsubscript{2} and acid gas injection in Alberta, Canada, Energy Procedia 1 (2009) p. 3536
\textsuperscript{64} Directive 051 does not detail whether it is referring to fracture initiation, propagation or closure pressure.
4. There is a consensus that current and proposed acid gas regulations adequately address the integrity and hydraulic isolation of well construction and testing requirements for new CO₂ repository wells.

The proposed Directive 051 update will prescribe many of the requirements and detail the required frequency for hydraulic isolation and casing inspection logging. Monitoring requirements for the storage complex are being addressed by the Monitoring, Measurement and Verification (MMV) Working Group (Appendix D9).

Directive 065 has minimum monitoring requirements for acid gas wells including the measurement and reporting of:

- maximum wellhead injection pressure
- injection rate and cumulative volume
- continuous monitoring of injection well tubing and casing (annulus)
- corrosion protection of injection well
- hydraulic isolation logs

5. ERCB directives provide adequate guidance for the abandonment of CO₂ injection wells. A best practices review should be undertaken to determine whether acid resistant cement should be required.

The ERCB is in the midst of a number of directive re-writes. There are a number of differences between the suspension and abandonment requirements for acid gas and CO₂ injection wells.

The current Directive 013 requires that CO₂ injection wells with no volumetric activity for the last six months be classified as medium risk, while acid gas wells with no activity over the same duration are considered in a high risk category. Both risk categories require the operator to install a packer and a tubing plug or bridge plug when suspended. High risk wells must also cap the plug with eight linear metres of cement.

The objective of a well abandonment described in Directive 020 is to cover all non-saline groundwater and to isolate or cover all porous zones. Directive 020 (Section 5) considers zones where acid gas has been injected as level-A intervals. Acid resistant cement is not a prescribed requirement. However, Level-A intervals undergo a more detailed review process and have more stringent abandonment requirements.

Directive 13 – Well Suspension and Directive 20 – Well Abandonment are currently up for review by the ERCB.
APPENDIX E.
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