Integrity of Wells in the Nearshore Area Gippsland Basin*

Todd Goebel¹, Barry Nicholson¹, and Nick Hoffman¹

Abstract

The CarbonNet Project is seeking CO₂ storage sites in the nearshore area of the Gippsland Basin that provide permanent and safe storage for 25 to 125 Mt of CO₂. The integrity of legacy or existing wells (which may include abandoned, production, injection, mineral/water bores, and Measurement, Monitoring, and Verification (MMV) wells) is recognised around the world as one of the most significant operational risks to CO₂ storage projects. The number of wells and quality of completions can vary significantly in different basins and jurisdictions. Furthermore, the drilling and completion requirements for onshore and offshore wells are subject to various regulatory, industry and operator standards and practices. The Gippsland Basin has been an active oil and gas production province since the 1960's and there is a reasonable database of well data and parameters to assess well integrity. In the nearshore area of the Gippsland Basin, the integrity of twelve (12) wells has been assessed and risks identified. The assessment was based on existing documentation lodged with the regulator under Australia's comprehensive offshore petroleum legislation. The assessment concludes that the risk of leakage from the twelve (12) legacy wells reviewed is low, even though the primary purpose of the completion was to secure the wells in a petroleum context. Ultimately for any CO₂ storage project, there is a requirement to demonstrate how to safely monitor legacy wells in an Australian context to show they are not potential leakage pathways and to outline plans for remediation of wells if they are shown to have problems. Options are explored for completion and monitoring of future petroleum wells and other boreholes to avoid any new risks.
Integrity of Wells in the Nearshore Area
Gippsland Basin

Todd Goebel, Lead Reservoir Engineer

September 2015
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Outline

- Introduction
- CarbonNet Project Background
- Area of Study
- Database of Wells
  - Wells of Interest
  - Well Assessments
- Risk Assessment
- Risk Register and Action Plan
- Summary of Conclusions
Introduction

- Wells present a risk for CO$_2$ storage (or any injection or production project) as potential leak paths

- The number of wells and quality of completions varies significantly and accordingly, the level of risk they pose

- It is important to understand the prior history of each basin proposed for CO$_2$ storage

- Conduct careful examination of the state of records, and make careful and objective risk assessments based on observable facts and documented evidence
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CarbonNet Project Background

- The CarbonNet project is an initiative of the Victorian State Department of Economic Development, Jobs, Transport and Resources (DEDJTR)

- The objective is to establish a large scale, multi user CCS network in the Gippsland Region of Victoria, Australia

- Investigating the feasibility of sequestering up to 5Mtpa of CO$_2$ in the nearshore area (3-15 nautical miles) of the Gippsland Basin
The CarbonNet Project

Source & Capture options

Traralgon
Sale
Longford
Pipeline
Concept Route Only
Nearshore Injection areas under investigation

Offshore Gas Fields
Offshore Oil Fields
A portfolio of potential injection sites is being assessed, targeting the Cobia and Halibut subgroups of the Latrobe Group.

Three sites have demonstrated the fundamental suitability requirements for the storage of 25 - 125Mt of CO₂.

Injection is planned for a 25 year operational period.
CarbonNet Project Background

A comprehensive review of the legacy wells in this area was achievable for two key reasons:

1. Australia has a comprehensive open-file data system where petroleum data is released after a time period of 3-5 years

2. Gippsland Basin is an existing petroleum province with a large amount of information:
   - Available data (wells and seismic surveys)
   - Well completion reports, scientific papers about the oil and gas accumulations, their reservoirs and seals, basin stratigraphy, depositional setting and tectonic history
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Database of Wells

- 1562 wells in the basin
- 811 wells with basic geological data
- 546 wells with relevant log data
- 49 wells are located in the focus area considered by CarbonNet for CO$_2$ storage
- 14 wells are relatively close to sites that CarbonNet has assessed for offshore CO$_2$ storage
<table>
<thead>
<tr>
<th>Well Name</th>
<th>Operator</th>
<th>Spud Date</th>
<th>Total Well Depth (mKB)</th>
<th>Well Depth Subsea (m)</th>
<th>Formation Potentially Exposed to CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amberjack-1</td>
<td>BHP</td>
<td>4th May 1990</td>
<td>1750 m</td>
<td>-1729.0 m</td>
<td>Halibut</td>
</tr>
<tr>
<td>Broadbill-1</td>
<td>Lakes Oil</td>
<td>17th Jan 1998</td>
<td>1345 m</td>
<td>-1314.3 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Golden Beach-1A</td>
<td>Burmah</td>
<td>3rd May 1967</td>
<td>2905 m</td>
<td>-2892.8 m</td>
<td>Halibut</td>
</tr>
<tr>
<td>Golden Beach West-1</td>
<td>Woodside</td>
<td>11th Sep 1965</td>
<td>2290 m</td>
<td>-2278.1 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Kyarra-1A</td>
<td>Australian Aquitaine</td>
<td>16th Feb 1983</td>
<td>1280 m</td>
<td>-1249.5 m</td>
<td>Halibut</td>
</tr>
<tr>
<td>Palmer-1</td>
<td>Esso</td>
<td>12th Aug 1981</td>
<td>1723 m</td>
<td>-1702.0 m</td>
<td>Halibut/T2</td>
</tr>
<tr>
<td>Perch-1</td>
<td>Esso</td>
<td>13th Mar 1968</td>
<td>2867 m</td>
<td>-2857.5 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Perch-2</td>
<td>Esso</td>
<td>11th Feb 1985</td>
<td>1321 m</td>
<td>-1300.0 m</td>
<td>Halibut/T2</td>
</tr>
<tr>
<td>Perch-3</td>
<td>Esso</td>
<td>10th Oct 1989</td>
<td>1301 m</td>
<td>-1258.7 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Perch-4</td>
<td>Esso</td>
<td>1st Feb 1995</td>
<td>2052 m</td>
<td>-1247.0 m</td>
<td>T2/Cobia</td>
</tr>
<tr>
<td>Salt Lake-1</td>
<td>Woodside</td>
<td>12th Apr 1970</td>
<td>1670 m</td>
<td>-1620.7 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Tommyruff-1</td>
<td>BHP</td>
<td>20th May 1990</td>
<td>1550 m</td>
<td>-1529.0 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Wasabi-1</td>
<td>Apache</td>
<td>14th Feb 2008</td>
<td>2313 m</td>
<td>-2274.0 m</td>
<td>Halibut/T2/Cobia</td>
</tr>
<tr>
<td>Wyralla-1</td>
<td>Australian Aquitaine</td>
<td>16th Apr 1984</td>
<td>1160 m</td>
<td>-1139.0 m</td>
<td>Halibut/Cobia</td>
</tr>
</tbody>
</table>
For most of these wells, the likely target for CO$_2$ injection is the Cobia Subgroup or the underlying Halibut Subgroup.
Well Assessments

- All wells in the Gippsland Basin have been completed to petroleum industry standards of the period

- Competent completions across the Lakes Entrance Formation topseal

- Deeper intervals have been completed in a less systematic manner and some of the intraformational seals that could be of value for storage may have been compromised

- In most cases, good data is available but for certain wells, the documentation is less complete

- The path the CO$_2$ plume takes depends on injection well location and the CO$_2$ may come into contact with existing petroleum exploration wells that have been plugged
Well Abandonment Details vs Formation Tops

- Golden Beach-1A
- Golden Beach West-1
- Salt Lake-1
- Broadbill-1
- Wyrallah-1
- Tommyruft-1
- Kyara-1
- Perch-2
- Perch-3 (oil)
- Perch-4 (oil)
- Perch-1
- Palmer-1
- Wazabi-1
- Amberjack-1

- Cobia Reservoirs
- U. Halibut Reservoirs
- Middle Halibut Reservoirs
- Lakes Entrance Seal
- T2 Seal

- Bridge Plug
- Casing
- TD
- Uncemented Casing
- Open Hole
- Cement Plug
- Producing oil zone

Data not complete
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Risk Assessment Criteria Matrix

- Each well was assessed for the **likelihood** and **consequence** that if a CO$_2$ plume encounters a well, CO$_2$ could migrate out of the primary storage reservoir into the upper reservoirs or to the surface, impacting the public or environment.

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Consequence Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 – Insignificant</td>
</tr>
<tr>
<td>A</td>
<td>The consequence is almost certain to occur in most circumstances</td>
</tr>
<tr>
<td>B</td>
<td>The consequence is likely to occur frequently</td>
</tr>
<tr>
<td>C</td>
<td>Possible and likely for the consequence to occur at some time</td>
</tr>
<tr>
<td>D</td>
<td>The consequence is unlikely to occur but could happen</td>
</tr>
<tr>
<td>E</td>
<td>The consequence may occur but only in exceptional circumstances</td>
</tr>
</tbody>
</table>
Risk Assessment Findings

- The risk of a CO$_2$ plume encountering a well and migrating out of the primary storage reservoir into the upper reservoirs or to the surface, impacting the public or environment was judged to be low to very low in all wells.

- High standards of protection applied to the Lakes Entrance Formation regional petroleum seal.

- The alternative risk proposition that *Intraformational* CO$_2$ storage at the well may be compromised by completion quality was not evident for all wells.
Risk Assessment Findings

- Concluding assessment of risk and risk management for intraformational storage at the fourteen wells of interest.

- Five of the fourteen wells provide a low risk for intraformational storage of CO₂.

- A further two currently-producing wells are expected to be abandoned in the future and to meet all relevant high quality P&A standards (hence, not pose a future risk).

- For the remaining seven wells, mitigation includes avoiding the stratigraphic levels at potential risk, or avoiding some wells entirely that have a likely chance of encountering the CO₂ plume.
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<thead>
<tr>
<th>Identified Risks</th>
<th>Analysis &amp; Evaluation</th>
<th>Further Actions</th>
<th>Post-mitigation Risk level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intraformational</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ storage at the well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>will be compromised by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>completion quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amberjack-1</td>
<td>2</td>
<td>E</td>
<td>L</td>
</tr>
<tr>
<td>Broadbill-1</td>
<td>3</td>
<td>D</td>
<td>M</td>
</tr>
<tr>
<td>Golden Beach West-1</td>
<td>3</td>
<td>C</td>
<td>H</td>
</tr>
<tr>
<td>Golden Beach-1A</td>
<td>2</td>
<td>E</td>
<td>L</td>
</tr>
<tr>
<td>Kyrra-1</td>
<td>3</td>
<td>D</td>
<td>M</td>
</tr>
<tr>
<td>Palmer-1</td>
<td>2</td>
<td>D</td>
<td>M</td>
</tr>
<tr>
<td>Perch-1</td>
<td>2</td>
<td>E</td>
<td>L</td>
</tr>
<tr>
<td>Perch-2</td>
<td>2</td>
<td>E</td>
<td>L</td>
</tr>
</tbody>
</table>

**How to manage the risk:** 
- Avoid contact with Plume unless better documentation can be inspected.
- Avoid contact with Plume at Halibut/T2 level. Top Cobia is OK.
- Monitor during injection.
- Avoid contact with Plume unless better documentation can be inspected.
- Avoid storage at Halibut/T2 level. Top Cobia is OK.
- No action required.

**How to reduce this risk:** 
- Seek additional paper records / Ensure not contacted by CO₂ at this location.
- Seek additional paper records / Plan storage to avoid CO₂ at this level – i.e. assume that plume will rise to top Cobia.
- Check for detailed full WCR.
- No action required.

**Risk Level:**
- L (Low)
- M (Moderate)
- H (High)
- V (Very High)
## Risk Register and Action Plan cont’d

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<thead>
<tr>
<th>Identified Risks</th>
<th>Analysis &amp; Evaluation</th>
<th>Further Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Intraformational</em> CO₂ storage at the well will be compromised by completion quality</td>
<td>Consequence (L, 2, 3, 4, or 5)</td>
<td>Risk level (L, M, H, or VH)</td>
</tr>
<tr>
<td>Perch-3</td>
<td>2</td>
<td>C-D</td>
</tr>
<tr>
<td>Perch-4</td>
<td>2</td>
<td>C-D</td>
</tr>
<tr>
<td>Salt Lake-1</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>Tommyruff-1</td>
<td>3</td>
<td>D-C</td>
</tr>
<tr>
<td>Wasabi-1</td>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>Wyrallah-1</td>
<td>2</td>
<td>E</td>
</tr>
</tbody>
</table>
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- None of the fourteen wells analysed present any significant risk of leakage through the Lakes Entrance Formation, demonstrating that the regulatory intention of aquifer and resource protection is being achieved.

- Objectives for completion and abandonment of the wells have been met satisfactorily and to acceptable oilfield standard and practices of the period.

- Some of the completions undertaken for petroleum and aquifer purposes do not offer the level of desired protection for future CO$_2$ storage at an intraformational level at some specific sites.

*(Future petroleum well completion and abandonment requirements may require additional intervals to be fully cemented, additional wellbore plugs to be included, and for CO$_2$-resistant materials to be considered).*
Conclusions cont’d

- CarbonNet has modified its plans to avoid the stratigraphic levels at risk or to avoid some sites entirely where any probable CO\textsubscript{2} plume might reach the well.

- Overall, there is negligible risk of CO\textsubscript{2} rising to near-surface levels where it might present a risk to the environment or the general public.
Thank You

Todd Goebel, Lead Reservoir Engineer

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