Submission to Victorian Parliamentary Enquiry into Unconventional Gas.

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Background and qualifications

I am a hydrogeologist with over 22 years of experience with the last 16 years being based in Gippsland. Until recently, I was employed with a large engineering and environmental consultancy and have worked on many groundwater management projects for a variety of mainly public sector organisations. Much of my experience has been centred on the groundwater resources of Gippsland.

Preamble and disclaimer

The paper below focuses on unconventional gas in Gippsland. The paper does not take a stance either for or against unconventional gas but rather argues for rational debate around the science and presents my own views on the risks and potential impacts. These views, in no way, represent those of any employer or client that I have worked for. Although I have had some involvement in the recent Victorian Water Science studies into unconventional gas, the views presented below do not in any way represent the outcomes of these studies and instead, are based on publicly available information and personal experience.

The Science of Unconventional Gas in Gippsland

1. Communicating the science

The impacts of unconventional gas are technically complicated and site specific. Although interstate and international studies can provide some insight into potential Victorian impacts, actual impacts are dependent on the specific mining processes being proposed and site specific geological and hydrogeological features.

Although there has been significant State and Federal expenditure on understanding the science of unconventional gas in Victoria, very little, if any, of this information has been released to the public. Instead, community attitudes have been shaped by the media, interstate experiences and local information presented by community groups such as 'Lock the Gate'. There has not been any serious government attempt to provide the community with unbiased, evidence based science around the process and potential impacts of unconventional gas. Consequently, there is a relatively low level of community understanding around unconventional gas as evidenced by the 43% of respondents to a recent Government run consultation process indicating they were 'undecided' or 'don't know' when asked whether they support the development of an on-shore natural gas industry (The Primary Agency, 2015).

There have been several government public consultation processes to understand community, local government and industry attitudes to unconventional gas including those recently reported in The Primary Agency (2015) and the various opportunities to input to the current parliamentary enquiry into unconventional gas. While these opportunities are applauded, how can a community be expected to understand, evaluate and provide an informed opinion on a complicated topic such as

the merits or otherwise of unconventional gas in Victoria without at least some evidenced based information on the predicted impacts? To ensure a proper rational debate, the Government should release all the available studies on potential impacts prior to seeking the community's views.

The Victorian Government has just completed a series of studies into the potential impacts of unconventional gas in the Otway and Gippsland Basins (see: http://onshoregas.vic.gov.au/science-studies/about-the-water-studies). However, the results of these studies have not been publicly released and it is disappointing that the public does not have the opportunity to digest this information before the closing date for submissions to the Victorian Parliamentary Enquiry into Unconventional Gas.

2. Comments on the potential impacts of unconventional gas in Gippsland

In Gippsland, the types of unconventional gas being targeted include coal seam gas (CSG) and tight gas. There are significant differences between the target units and extraction process for CSG and tight gas:

- **CSG (eg Ignite Energy):** Targets narrow coal seams within the Latrobe Group Aquifer (also known as the Traralgon Formation) at the base of the Tertiary sequence of sediments in the Gippsland Basin. The process of CSG extraction involves depressurising the brown coal seams through extraction of groundwater until gas is liberated. Given the coal seams are largely contained within a sandy, gravel and silt sequence, dewatering the coal seams is also likely to result in depressurisation of the aquifer as a whole.
- **Tight gas (eg Lakes Oil):** Targets the Cretaceous aged bedrock below the Latrobe Group Aquifer. Gas liberation is achieved through increasing the permeability of the bedrock by fracking or horizontal drilling. Unlike CSG, significant dewatering of the formation is not needed.

The above differences in target units and extraction processes are likely to result in different scale and types of impacts. Therefore, it is important to review the impacts of these activities separately. Unfortunately, community debate on unconventional gas in Gippsland often lumps the impacts of these two activities together which is a gross over simplification of reality.

2.1 Potential impacts of CSG

Of the four key practice areas identified by the National Harmonised Framework for Natural Gas derived from Coal Seams (SCER, 2013), the issue of water management stands out as being the most critical risk for future CSG development in Gippsland (the others being well integrity, hydraulic fracturing and chemical use) . In particular, the large volumes of groundwater that will need to be extracted from the coal seams of the Latrobe Group Aquifer to liberate the contained gas has the potential to impact groundwater users in the Latrobe Aquifer itself, groundwater users in overlying aquifers and connected surface water features.

2.1.1 Existing impacts from Latrobe Aquifer groundwater extraction

The targeted area for CSG in Gippsland is located geographically between two mining activities already impacting the Latrobe Group Aquifer:

- **Off-shore oil and gas extraction**

The target unit for on-shore CSG continues off-shore and is the source unit of the Bass Strait oil and gas fields. The off-shore gas and oil extraction process involves pumping significant quantities of groundwater along with the oil and gas resulting in dewatering of the Latrobe Group aquifer both off-shore and on-shore. Groundwater levels in the Latrobe Group Aquifer, as monitored in a series of State Government bores, has shown a consistent and steady decrease in groundwater levels of between 0.5 to 1.0m per year over the last 30 years across the whole of the Gippsland Basin stretching from the Yarram area in the south-west to the Bairnsdale area in the east.

- **Coal mining in the Latrobe Valley**

Although the coal being mined in the Latrobe Valley is from a younger set of coal seams much shallower than the Latrobe Group Aquifer, significant volumes of groundwater are pumped from the Latrobe Group Aquifer to maintain mine integrity. Without this dewatering, upward pressures from the Latrobe Group Aquifer have the potential to cause buckling of the mine base as the mining process unloads the geological profile above the aquifer. Groundwater pumping of the Latrobe Group Aquifer has resulted in a significant area of reduced groundwater levels in the aquifer stretching from the Latrobe Valley as far east as the Sale.

The drawdown of groundwater levels in the Latrobe Group Aquifer from the above activities has effectively joined resulting in a significant regional drawdown in the aquifer.

The behaviour of the Latrobe Aquifer to significant depressurisation from coal mining and off-shore gas and oil extraction activities provides very useful information on the hydraulic properties of the aquifer and connection to overlying aquifers. In effect, these activities provide a 30 year experiment on the response of the Latrobe Group Aquifer to sustained pumping. Such responses can be used to provide an indication of the potential impact of further depressurisation from future CSG activities. The main observations from the current and historical pumping from the aquifer are:

- The aquifer has strong horizontal hydraulic connection as evidenced by the relatively consistent decline in groundwater pressures observed across the region;
- The Latrobe Group aquifer has greatest vertical connection to overlying aquifers in the area of the Balook Formation which occurs as a narrow band extending from the Yarram area in the south to Bairnsdale in the east (see Figure 1). Monitoring data shows that groundwater pressures in the Balook Formation in the Yarram area and north have been declining by approximately 0.5m/year in response to a decline of approximately 1.0m/year in the underlying Latrobe Group Aquifer.
- Vertical interaction between the Latrobe Group and overlying aquifers is likely to be restricted in areas where the Latrobe Aquifer is overlain by marine deposits of the Gippsland Limestone and Seaspray Group (see location of marine sediments in Figure 1). Studies have shown that these marine deposits have low permeability and are likely to restrict vertical flow (eg Goldie-Divko et al, 2010).
- The most impact on groundwater users occurs in the Yarram region where both the Latrobe Group Aquifer and the overlying Balook Aquifer are relatively close to the surface and are used extensively for irrigation. A financial assistance package was provided to groundwater

irrigators in the region in 2009 to help with costs associated with adjusting to lower groundwater levels. Groundwater users in the Longford region who have deep bores tapping the Latrobe Group Aquifer are also impacted (Esso-BHP Longford Gas Plant and a vegetable grower).

- In the Latrobe Valley to Sale region, groundwater monitoring data indicates that a naturally upward flowing groundwater system from the Latrobe Aquifer to shallower aquifers has now reversed and is now a downward flowing system. There is some speculation that this may have resulted in the Latrobe River now losing water to groundwater which would have otherwise historically gained groundwater. A similar process is also speculated for the Tarra River area north-west of Yarram where shallow basalts on the edge of the Strzelecki Ranges are thought to be hydraulically connected to the laterally equivalent Latrobe Group Aquifer. It should be noted that although there is some evidence to support these speculations regarding reduced river flow, they have not been definitively proven and remains an area requiring further investigation.

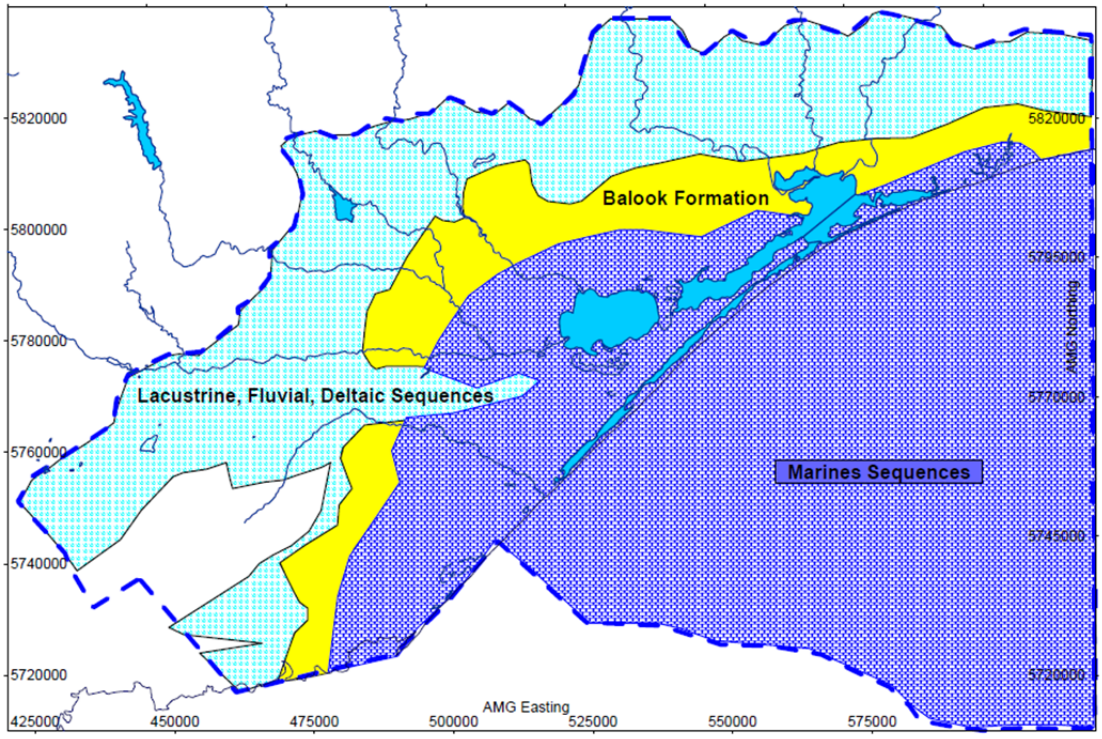

Figure 1: Units overlying the Latrobe Group showing the location of the narrow band of the Balook Formation (from Schaeffer, 2008)

Depressurisation of the Latrobe Group Aquifer also has the theoretical potential for compacting of the overlying clay layers resulting in land subsidence. However, despite theoretical studies predicting subsidence, recent surveys using the latest satellite levelling techniques showed no measureable subsidence along the Gippsland coast between 1992 and 2011 (DEPI, 2014). Subsidence around the coal mines has long been measured and monitored and was again measured in recent satellite survey at approximately 30mm/year near Morwell (DEPI, 2014).

2.1.2 Potential future impacts from CSG extraction from the Latrobe Group Aquifer

Depending on the location of development and based on the historical behaviour of the Latrobe Group Aquifer to sustained pumping, in my opinion, the most vulnerable assets to impact by groundwater extraction for CSG development are:

- Groundwater users extracting from the Latrobe Group Aquifer and overlying Balook Aquifer including the groundwater based irrigation activities in the Yarram area and the smaller number of groundwater users in the Longford region;
- Surface water features which cross the outcropping and sub-cropping basalts north-west of Yarram on the edge of the Strzelecki Ranges which are thought to be hydraulically connected to the laterally equivalent Latrobe Group Aquifer;
- Surface water features overlying areas where the Balook Formation (and to a lesser extent, the Latrobe Valley Coal Measures) may vertically transmit further declines in the underlying Latrobe Group Aquifer.

Less vulnerable assets are those above the marine deposits of the Gippsland Limestone and Seaspray Group such as the Gippsland Lakes and the Boisdale Aquifer in the Giffard area. Furthermore, there is no evidence to suggest that the Boisdale Aquifer in the Giffard area has been significantly impacted by historical declines in the underlying Latrobe Group Aquifer with groundwater levels mainly being influenced by changes in rainfall. Therefore, the significant thickness of Seaspray Group aquitard separating the Latrobe Group Aquifer from the overlying Boisdale Aquifer is likely to restrict the impacts on the Boisdale Aquifer from CSG extraction.

The above observations are based on a particular conceptualisation of the hydrogeology of the area and need to be tested through numerical modelling of the system taking into account the particular location of development and the likely additional groundwater extraction rates and volumes. It is critical that any numerical modelling of the system adequately characterises the current and historical decline in Latrobe Aquifer groundwater levels prior to simulating the impacts of additional groundwater extraction.

2.1.3 Groundwater licensing

Under current arrangements, any company wanting to extract groundwater from the Latrobe Group Aquifer for the purpose of CSG extraction would need to purchase groundwater licences from other existing users. This is because the volumes of current groundwater licences has reached the limit set for the aquifer as defined by the 'Permissible Consumptive Volume'. It could be argued that much of the potential impacts discussed above could be avoided because there is no net increase in groundwater allocation. However, there are two caveats to this:

- Some of the willing sellers of existing licenses are likely to be using only part or none of their licence. So even though there is no net increase in allocation, there could be a net increase in usage (ie sleeper licences are effectively activated);
- The location of the groundwater extraction is likely to change thus changing the type and scale of impact. This change could be either positive or negative and under the current licensing arrangements, needs to be evaluated before a license transfer is granted by the licensing authority (Southern Rural Water).

None-the-less, the current caps on groundwater licences in the aquifer and the process for granting a license transfer provides some protection to the sustainability of the aquifer and impacts of extraction on other aquifers and surface features. Therefore, this paper argues strongly for maintaining the current licensing system with no concessions to the CSG industry.

2.2 Potential impacts of tight gas

Relative to CSG development, tight gas extraction has a greater emphasis on increasing hydraulic permeability through fracking and/or horizontal drilling and a lesser emphasis on extracting groundwater to liberate gas. Therefore, of the four key practice areas identified by SCER (2013), the main risks are centred on well integrity, chemical use and hydraulic fracturing and less on water management.

The target unit for tight gas in Gippsland is the buried bedrock of the Strzelecki Group which underlies the Gippsland Basin. Unlike the target for CSG where groundwater is contained within the poor spaces between sand, silt and gravel grains, groundwater in the bedrock is contained within joints and fractures within the rocks. The extent to which gas extraction from tight gas wells could cause impacts on overlying aquifers largely depends on their hydraulic connection to the bedrock. Due to the significant depths required to investigate, very little is known about the hydraulic properties of these buried rocks and their connection to overlying aquifers such as the Latrobe Group Aquifer. However, where these units outcrop in the Strzelecki Ranges, they are generally considered to have a low permeability and a poor aquifer. The buried rocks are similarly likely to have poor permeability.

In my opinion, the risks of extracting tight gas from the deep bedrock units of the Strzelecki Group is significantly less than those of CSG extraction due to the likely poor permeability of the target unit and the significantly lower groundwater extraction volumes required. However, an important caveat to this statement is that any activities to increase permeability in the gas zones through horizontal drilling and/or fracking need to be undertaken to the highest industry standards. Also, test and production wells should be constructed to the highest industry standards with all intercepted aquifers appropriately sealed to avoid well integrity issues.

3. Conclusions and recommendations

The main conclusions and recommendations from this paper are:

- There has been a lack of evidenced based science available to the community of Gippsland to allow a rational and informed debate on the merits or otherwise of unconventional gas development in Gippsland.
  Recommendation: That the results of all Victorian Government studies into the impacts of unconventional gas be immediately released to the public.
- The process and impacts of proposed coal seam gas and tight gas development are different and should not be lumped together.
- The impacts of sustained groundwater extraction from the Latrobe Group Aquifer for off-shore for oil and gas extraction and on-shore coal mine dewatering provides important insights into the potential impacts of coal seam gas extraction from the Latrobe Group. The impacts suggest that the most vulnerable assets to future CSG extraction are:

- groundwater users extracting from the Latrobe Group Aquifer and overlying Balook Aquifer;
- surface water features which cross the outcropping and sub-cropping basalts north-west of Yarram; and,
- surface water features overlying areas where the Balook Formation (and to a lesser extent, the laterally equivalent Latrobe Valley Coal Measures) may vertically transmit further declines in the underlying Latrobe Group Aquifer.

Less vulnerable assets are those above the marine deposits of the Gippsland Limestone and Seaspray Group such as the Gippsland Lakes and the Boisdale Aquifer in the Giffard area.

Recommendation: That the above potential impacts be tested by numerical groundwater modelling. Any groundwater model should adequately simulate the current and historical declines in groundwater levels in the Latrobe Aquifer and the differences in hydraulic properties in the overlying aquifers (eg the significant difference between permeability of the Seaspray Group and Balook Formations).

- The current caps on groundwater licences in the Latrobe aquifer and the process for granting a license transfer provides some protection to the sustainability of the aquifer and impacts of extraction on other aquifers and surface features.

  Recommendation: That CSG companies are required to comply with current groundwater licensing arrangements in the Latrobe Group Aquifer.
- The risks of extracting tight gas from the deep bedrock units of the Strzelecki Group are likely to be significantly less than those of CSG extraction due to the relatively poor permeability of the target unit and the significantly lower groundwater extraction volumes required. However, it is critically important that the highest industry standards are followed for well construction, fracking and horizontal drilling.

  Recommendation: That the highest standards are enforced for fracking, horizontal drilling and well construction in any tight gas developments.

4. References

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