Groundswell Gloucester

# Exposing the Risks:

# Fundamental Flaws in AGL's application to frack CSG wells in Gloucester

**January 2014**

# Exposing the Risks:

# Fundamental Flaws in AGL's application to frack CSG wells in Gloucester (Review of Environmental Factors (REF))

These information sheets identify health, ecological, social, economic, financial and political risks that AGL is taking with its proposed Waukivory Pilot Project at Gloucester.

The risks are apparent from the many inaccurate statements and missing data in AGL's Review of Environmental Factors (REF) for the Pilot Project. Separately and together these weaknesses in the REF make the document a seriously inadequate and flawed assessment of the likely impacts of the Waukivory Pilot Project. The concerns raised in this document need to be addressed by both Government and AGL before a fair, comprehensive and credible consideration of the impacts of the Project is possible.

The risk sheets below need to be considered as a whole, not only as stand-alone documents. In many cases risks identified in each of the twelve Risk Sheets are linked to further details in other Risk Sheets, to provide a more complete context.

Risk Sheet 1 entitled *Discrepancies and Contradictions*, provides an overview of the many concerns community members hold regarding the critical and fundamental issues relating to social licence: *How accurate is AGL's information? Is the process transparent?*

AGL's documents and public statements include many contradictory statements. The rush to implement the Pilot Project, with its toxic chemicals and lack of proper water and health risk assessments suggests AGL is not taking concerns relating to community health, water, environment and water-reliant businesses seriously.

The other eleven Risk Sheets (2-12) identify specific concerns about AGL's proposed fracking operation and highlight many concerns that need to be addressed before a rigorous, credible and balanced assessment of the project can be made.

Information in this pack was gathered by community members of Gloucester and elsewhere. Together we share a deep knowledge and passion for the local ecosystems and community of the Gloucester valley. We represent the range of people living in a rural community: farmers, scientists, engineers, health workers, small business and tourism operators, tradespeople, parents, grandparents and family members.

We have consulted experts in the field on as many issues as possible; however some of the issues raised are based on our own understanding and interpretation.

Groundswell Gloucester is determined to ensure the well-being of the local environment which we depend on for our livelihoods, so that our children and others can enjoy healthy and prosperous lives in this valley. We feel a strong responsibility to protect the ecological, economic and social sustainability of our environment and our community.

## Contents



## Abbreviations

| | |
|---|---|
| CoP | Code of Practice for Coal Seam Gas Fracture Stimulation Activities |
| EIRP | Environmental Incident Response Plan |
| EMM | EMGA Mitchell McClennan |
| EPA | Environment Protection Authority |
| FSMP | Fracture Stimulation Management Plan |
| GDE | Groundwater Dependent Ecosystem |
| HHERA | Human Health and Environmental Risk Assessment |
| MSDS | Material Safety Data Sheet |
| NICNAS | National Industrial Chemicals Notification and Assessment Scheme |
| OCSG | Office of Coal Seam Gas |
| PB | Parson Brinckerhoff Consultants |
| REF | Review of Environmental Factors |
| SGMP | Surface and Groundwater Management Plan |
| SKM | Sinclair Knight Mertz - consultants |
| SRB | Sulphate-Reducing Bacteria |
| VWP | Vibrating Wire Piezometers |

**For further information:**


Julie Lyford 02 6558 1995
Jenni O'Neill 0432 144 338
Jeff Kite 02 6558 7436

# *Risk Sheet 1: Discrepancies and Contradictions*

**The issue:**
There are many contradictions within AGL's REF and between other public statements and documents and AGL assertions. AGL has also made comments that have been challenged by credible researchers and public commentators. Furthermore AGL has made commitments that don't appear to have been met.

These issues make it difficult for shareholders, government bodies and the community to know what is accurate and what is not – and what are the real risks arising from AGLs fracking proposal?.

The lack of accuracy and rigour with which AGL seems to be approaching fracking plans is a particular concern because, if approval to frack is granted, it is not clear how actively involved regulatory agencies will be in ensuring compliance with conditions. AGL is the only agency required to ensure compliance with Codes of Practice.

## Part 1: Contradictions and apparent inaccuracies in the REF

### 1.1.1. Contradictory chemical assessment

The REF chemical assessment is internally contradictory. It claims:
*"Human health and ecological assessment completed for all chemicals."* (Vol 7. p. 14).

Yet the report then states:

*"Only a small number of the chemical listed on the Australian Inventory of Chemical Substances (AICS) have been assessed in detail by the National Industrial Chemical Notification and Assessment Scheme (NICNAS) ….*

*None of the proposed chemicals in use for hydraulic fracturing have been assessed by NICNAS"* (p. 20).

Later it asserts:

*"Most of the available data relates to aquatic toxicity"* (p.29).

However, many of the Material Science Data Sheets (MSDS) show no data available for aquatic toxicity.

See Part 2 of this Risk Sheet for other contradictory public statements.

### 1.1.2. AGL downplays connectivity between coal seams and overlying water aquifers

AGL has repeatedly stated that they do not have a proper understanding of the nature and extent of connectivity at Gloucester:
*"The fracture stimulation and pilot testing program is also important to assess water production volumes and whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones." (REF ES.1)*
(Also see *Risk Sheet 4*)

Despite stating that connectivity is not known, for the Human Health and Ecological Risk Assessment, AGL justifies their determination of 'low risk' by suggesting there is no connectivity:

*"The underlying geology creates a hydraulic barrier between the target coal measures and the upper alluvial and naturally fractured rock aquifers."* (REF Vol 7: Human Health and Ecological Risk Assessment p. 23).

Implications:
The chemical (Health) risk assessment is invalid and may dangerously underestimate impacts on humans and the environment. .

**1.1.3. Fracking fluids in water bearing coal seams**

There is evidence in the Chief Scientist's report (among others) that a significant volume of fracking fluids (50-85%) will remain in the coal seam.
AGL says: "*Essentially, what goes down the well comes back up."* (REF Vol 5 Appendix D, Sect 2.4, p. 13)
(See Risk Sheet 5)

**1.1.4. Unsafe storage of flowback fluid**

AGL says: *"Flowback water is stored within lined ponds or aboveground tanks that are not affected by rainfall (including flooding)."* Vol 3 p. 97).

It is difficult to see any basis for this claim. With no flood study, no consideration of extreme rainfall data (such as 752mm which fell in February 1929), and no detailed specifications for ponds or tanks, AGL and regulators cannot begin to assess risk of failure.

**1.1.5. AGL underestimates flood risk**

*"The subject lots are not within flood planning area identified in the Gloucester LEP"* (REF Vol3 p 95).

This implies that Avon River doesn't suffer significant flooding. The fact is the Gloucester LEP did not cover flood risk areas except the immediate township of Gloucester and a full flood study has not been done. Historical reports of occurrences of major flooding are available.

AGL's own preliminary groundwater assessment 2010 acknowledges much of their project is on a floodplain:
*"Elevations within the Stage 1 Area…decrease to 110mRL…Avon River floodplain."* (SRK 2010: "AGL002 Gloucester basin hydrology study" p5)
*"The rivers and creeks within the Stage 1 GFDA are subject to flooding and water velocities in these rivers can be high after heavy rainfall"* (SRK 2010: p15).

Australians expect AGL and regulators to use quality technical research and data as the basis for design and assessment of environmental impacts. The experience in Queensland is that many recent floods exceeded design levels and caused open cut coal mines to fill with floodwaters and therefore needed to be pumped out into watercourses leading to significant environmental impacts. Increasingly, the 1 in 500 year flood is being used for urban and other project design relating to floodplains, rather than the 1 in 100 year flood.

AGL says that design is based in response to local residents' anecdotes:
*"Where possible, work sites have been situated above areas identified by landholders as being floodprone."* (Vol 3 p. 95).

It is difficult to understand why AGL was given approval in the first place to drill these wells on the floodplain. AGL's REF for that approval did not adequately address flooding.

**1.1.6. Lack of independent assessment and evaluation in the REF**

AGL says the application to frack:
*"…includes an independent environmental assessment and a comprehensive evaluation of hydraulic fracturing" (*Gloucester Gas Project Community Update October 2013).
Contradictions with this information:

*Consulting firm, EMGA Mitchell McClennan (EMM), did the environment assessment work. It is unclear how these consultants were deemed, or approved, as 'independent'. Were they approved by the Office of Coal Seam Gas (OCSG) or the Environment Protection Authority (EPA) as independent, or simply selected by AGL without reference to any third party?*

It is difficult to accept that the REF is a comprehensive, independent evaluation of hydraulic fracturing. The Fracture Stimulation Management Plan (FSMP) was written by AGL and compliance seems to be determined by AGL itself. It is highly inappropriate that compliance with the Code of Practice for Coal Seam Gas Fracture Stimulation Activities (CoP) is determined by AGL.

No detailed independent peer review of the REF is provided. A comparison with Dr Rick Evan's peer review of 2012 highlights the gap between a detailed examination and what is provided in the REF.

The Chief Scientist's first recommendation in her July 2013 report includes: "That the Government…insists on world best practice on all aspects and at all stages (exploration, production, abandonment) of CSG extraction" and that it sends "a clear message to industry that CSG extraction high performance will be mandatory; compliance with legislation will be rigorously enforced……"

Leaving AGL to monitor its own compliance with Codes of Practice is not consistent with this recommendation.

**1.1.7. AGL's commitment to properly 'consult' with the community?**

Access to the borehole logs for the exploration bores (gas wells to be fracked) WK11 – 14 was refused by AGL on the basis that it is "commercial in confidence information" for 2 years after drilling. It is unclear why such a request would be refused. (Email Nov 2013) The CoP encourages a high level of consultation with the community. However, the approval process for REFs and FSMPs does not allow for public submissions.

### 1.1.8. Air pollution emissions – VOCs and hydrocarbons from coal seams

*AGL's REF says:*
***"The project will result in emissions...principally methane, ...nitrogen oxides, carbon monoxide and volatile organic compounds (VOCs)."*** *(REF, Appendix C, p11).*
*Estimates of levels of emissions of VOCs (based on US figures) are tabled on p17.*

An AGL study notes:
"Free hydrocarbons were also described in coals...in the Gloucester Basin" (CSIRO literature review for AGL, 2011, p52).

***Contradictions in published AGL statements:***
While it is unclear in the following statement whether AGL is referring to air pollutants arising from fracking and flaring, or to extracted gas, AGL implies to readers that there is no issue with hydrocarbons or VOCs:
*"The natural coal seam gas does not contain heavy hydrocarbons or volatile organics such as benzene or toluene' (AGL head of community relations in letter to Gloucester Advocate 4 Dec 2013)*
If these chemicals are not in gas which is extracted, they are certainly in the produced water which is extracted with it.

### 1.1.9. Threatened species

Nine threatened species have been identified near the Pilot Project site with evidence of habitat and forage. Nests were found adjacent to McKinley's Lane and the area is part of a habitat corridor for the grey crowned babbler (GRL EIS p 4-273 to 276).

Where AGL reports on threatened species within a 10km radius, AGL refers to only a vague possibility of the occurrence of 2 threatened species – Grey-crowned babbler and Grass Owl: "Shrubs and juvenile Eucalypts in road reserves may provide habitat for the Grey-crowned babbler" (GRL EIS 4.3 P 85).

Note: The evidence in GRL's EIS reporting nests and positively identifying a habitat corridor was publicly available in August 2013. AGL's REF was published in October 2013.

### 1.1.10. Groundwater Dependent Ecosystems

"Two ecosystems are dependent upon groundwater within and surrounding the Site, namely riparian vegetation adjacent to Waukivory Creek and the Avon River, and stygofauna" (GRL EIS p. 4-146).

AGL says: "There are no known groundwater dependent ecosystems (GDEs) (apart from baseflow accessions) although there may be some uptake of shallow groundwater (from the alluvium) by native terrestrial vegetation on the floodplain." (REF P 11).

Implications:
AGL had previous information indicating the likely presence of GDEs (Evan's report). They also had access to GRL's EIS positively identifying the presence of GDEs. Failure to acknowledge groundwater dependent ecosystems is concerning. It also precludes

any baseline or comparative monitoring of these populations and inadequate risk assessment or mitigation measures. This is a significant issue as River Oak communities are fundamental to the health of watercourses like the Avon River and Waukivory Creek.

## Part 2 Contradictions and discrepancies in AGL's other published documents and comments

### 1.2.1. AGL attempts to reassure public, government and shareholders based on its record, yet there have been a number of inaccurate statements .

*"AGL has a strong record of safely using hydraulic fracture simulation…. mostly at Camden…."*
*"AGL has fracture stimulated 126 wells, including four in Gloucester and the process is well understood, carefully managed and monitored."* (Gloucester Gas Project Community Update October 2013; also in Gloucester Advocate ad 23 October 2013).
AGL says:
*"Our activities in the Gloucester region will be undertaken using the same safe, proven techniques we have used at our Camden Gas Project over the past 13 years"* (Gloucester Advocate article Nov 12 2013).

**Contradictions to this information:**
a) AGL did not develop Camden. http://www.agl.com.au/about-agl/how-we-source-energy/natural-coal-seam-gas/camden-gas-project/the-project

b) It is unclear how many of the fracked 126 wells were fracked since AGL assumed ownership and how many were fracked prior. However, AGL states that they have only fracked 4 wells in the Gloucester area. Presumably the other wells near Gloucester were fracked by Lucas/Mopolo.

c) AGL has not been operating at Camden for 13 years. AGL assumed ownership and operation in 2009. See above website.

d) It seems there is no evidence behind AGL's assertion that fracking has not impacted water resources. Dr Gavin Mudd, Senior Lecturer (Environmental Engineering) at Monash University, claims:

> *"AGL (and Sydney Gas before it) has conducted no scientifically valid ground water monitoring in ten years of operating the Camden gas project, having taken no baseline study at any point."* (p. 44)

Original source: Mudd, G M, 2010, Environmental and Groundwater Issues and AGL's Hunter Coal Seam Gas Project. Research Report for the Hunter Valley Protection Alliance, Broke, NSW, February 2010.

e) Air quality monitoring since 2008 does not show safe or compliant operation. Breaches were not disclosed in AGL reports.
*"In relation to our Rosalind Park Gas Plant, our Annual Environmental Performance Reports for the years ending 2008, 2009, 2010 and 2011 state that continuous monitoring of NOx, temperature, flow rate, moisture and oxygen was successfully undertaken in those years. <u>In all four reports, this statement is erroneous</u>. While monitoring was carried out during this time, that monitoring was not "continuous" due*

*to equipment limitations and breakdowns experienced during these years. AGL is working with the EPA to rectify this non-compliance. The EP Licence Annual Returns for the years 2008, 2009, 2010 and 2011 should also have identified this non-compliance."*
http://www.agl.com.au/about-agl/how-we-source-energy/natural-coal-seam-gas/camden-gas-project/environment

**1.2.2. AGL stated that studies to date make "Gloucester one of the most studied and understood water basins in Australia"** (Gloucester Advocate article November 12, 2013)

These comments are contradicted by AGL itself, even in its own published information, acknowledging there is a lack of information:
*"The location and distribution of relatively high and low permeability zones is poorly known at present."* (AGL's HHERA risk assessment p. 11).
(Also see Risk sheet 4)

This is also contradicted in other publications:
*"The extensive faulting, displacement of strata across faults, folded and discontinuous lithologies and lack of any fault seal analysis' (Ward & Kelly, 2013) makes understanding the hydrogeology in this area incredibly difficult."* (Sect 5.5.1.2, p. 44).
(Also see Risk Sheet 4)

**1.2.3. Despite acknowledging their lack of understanding of Gloucester's hydrogeology (above), AGL frequently states, or implies, that coal seams are isolated from overlying water aquifers.**

This assertion has been questioned many times, both in AGL's own reports and by external expert opinion.

Some relevant comments from AGL:

*a) "The underlying geology creates a hydraulic barrier between the target coal measures and the upper alluvial and naturally fractured rock aquifers."* (Human Health and Ecological Risk Assessment - REF for fracking 2013, p. 23)

*b) "Our six years of studies show that shallow groundwater aquifers are not connected naturally to the deep coal seam water bearing zones. Layers of rock act as barriers between shallow groundwater and deep groundwater."* (Gloucester Advocate Ad October 16, 2013 p. 3)

*c) "Results to date …indicate there is negligible connectivity between groundwater in deep coal seams and beneficial water resources in shallow aquifers and streams"* (AGL's Annual General Report 2013, p. 42)

*d) "Typically, there are 100s of metres of impermeable rock between shallow aquifers and coal seams"* (Presentation to Citibank Dec 2010).
http://www.agl.com.au/~/media/AGL/About%20AGL/Documents/Media%20Center/ASX%20and%20Media%20Releases/2010/December/GM%20Presentation%20to%20Citibank.pdf

e) AGL and their groundwater consultants Parsons Brinckerhoff (PB) seem to suggest that previous water monitoring data indicates a lack of connectivity:

"PB states that this bore shows 'negligible seasonal variation and no response to rainfall recharge"; implying negligible connectivity. (Evans, 2012, p22)"

*Evans challenges the analysis in e) and interprets AGL's data:*

*"This suggests there is hydraulic continuity laterally (and also possibly vertically)…and this hydraulic connectivity is not negligible"* (Evans, p. 19).

*"The results do not support a conceptual model of hydraulic isolation of interburden layers."* (Evans, p. 20).

*"These observations suggest that deeper confining units are responding to recharge relatively quickly, and are not hydraulically isolated units."* (Dr Rick Evans of SKM, in 2012).

**Further contradictions with above statements a) to e)**

AGL's study of 2010 already identified connectivity:
"Upward leakage may occur through fault zones" (SRK, 2010:24, in Evans, 2012, p37).

AGL's 2010 study also found that when drilling intersected a fault, connectivity increased by ten times. (SRK AGL002 2010: p24) The Waukivory Pilot wells intersect several large fault zones (FSMP p13). AGL refused to make data logs for these wells available.

The NSW Chief Scientist states (referring to the Gloucester basin):
*"This deep faulting has the potential to interconnect deeper coal seam aquifers with near surface fractured rock aquifers. 'The extensive faulting, displacement of strata across faults, folded and discontinuous lithologies and lack of any fault seal analysis' (Ward & Kelly, 2013) makes understanding the hydrogeology in this area incredibly difficult."* (Sect 5.5.1.2, p. 44).

And in a Background Paper on NSW Geology by Ward and Kelly, only 2 months before the REF was released, in August 2013, (referring to the Gloucester Basin)

*"However, the permeability and heterogeneity of the fault zones have not been studied. Future investigations will quantify the fault seal properties adjacent to coal beds from which the gas will be produced (SKM, 2012).* ***Until they are proven to be sealing faults, it is reasonable to assume that the fault zones would provide pathways of hydraulic connectivity from the coal measures to the near surface."***

**1.2.4. AGL implies that Dr Rick Evans supports fracking at Waukivory**

AGL has stated that the independent hydrologist, Dr Rick Evans, said the pilot 'should proceed as soon as possible'. (Gloucester Advocate 12.12.2013 and at AGL's 2013 AGM; see below)

**Contradictions to this statement:**

Any support Evans offers is, at best, significantly limited and/or qualified, as indicated below. His review of the Waukivory pilot program did not make any consideration of chemicals to be used or management of waste water. Evans stated that his

*"Review focuses on the risks associated with hydraulic changes to aquifer behaviour and does not consider any potential issues resulting from the use of chemical hydraulic fracturing fluids."* (Evans peer review 2012 p. 42).

Dr Evans calls into question AGL's impact assessment, which frequently says that siting the wells away from faults means potential impact is low:

*"Siting CSG wells away from faults is an important, but not necessarily sufficient control, to prevent the impact of faults acting as potential preferred pathways."* (p. 42).

There is a potential process for fracking to cause an interconnection of coal seams and the water table:

*"If the fracturing were to intersect a fault or fracture zone and where there was preferential flow along the fault or fracture zone. There are known faults in the Gloucester Basin so there is potential for this process to occur. AGL propose to investigate this process in the Waukivory Flow Testing program" p44.*

Evans also made recommendations regarding the location and number of monitoring bores that would be required to give useful data (p44.). We question whether the monitoring program in the REF adopted these recommendations and whether useful data will be gathered. See Risk Sheet 8.

### 1.2.5. AGL implies that Gloucester Council supported fracking in Gloucester as part of its water study, but fracking is not supported by Council.

At the AGL Annual General Meeting 2013, Jeremy Maycock (Chair):

*"In an endeavor to seek to provide yet more assurance to the community there, AGL recently agreed to fund another large scale water study for the whole area and do this through the Gloucester Council entirely at their discretion how they organize this and certainly completely independent from AGL. Now part of the scope of that study is to undertake hydraulic fracturing of four wells in a nominated part of the project and we have always been very transparent about that, it is just part of the scope of that work, and that is what is now proposed and the consents required to start that work are pending at the moment with the NSW Government."*

At the same meeting, Michael Fraser (AGL CEO) stated:

*"…just for the record, because there were a couple of comments there I wanted to set the record straight, that 'we had undertaken to do this study before proceeding with further work and we'd gone back on our word'. Just for the record, that isn't actually the case. This work… there is an independent water expert that was appointed by the community consultation committee again one of the forums that we communicate with the local community in.*

*That independent expert, Dr Rick Evans, recommended that this work should proceed as soon as possible to add further to the knowledge base and the understanding of water in the Gloucester Basin…*

*And also the agreement that we recently signed with the Gloucester Council, very specifically referenced that fact that this work would be undertaken, it would be made available to the local council, we're funding them having their own independent water expert, who will be able to review all of this data and for the benefit of the rest of our shareholders, buy the time we've finish all of this work and all of the studies, the Gloucester Basin from a water perspective will be the best understood basin in the Country."*
(Excerpts from transcript of AGL AGM 2013 recording)

In sharp contrast, Gloucester Council says:

*"Whilst Council was made aware of AGLs intention to frack wells in the Waukivory Pilot Project at the time we signed the agreement, Council in no way endorsed AGL's fracking plans" (*Gloucester Shire Council Media Release November 2013).

Mayor of Gloucester Shire, John Rosenbaum, said:

*"Fracking was not part of that independent water study. Our understanding is that AGL wishes to frack to increase its knowledge of the commercial viability of the resource, and to collect more data to help it meet conditions set out by the State and Federal Governments."*

*"Council has consistently informed AGL of community concerns regarding fracking. We are particularly concerned that fracking will proceed before a detailed scientific analysis of the risks it poses is undertaken through the Commonwealth Bioregional Assessment.*

*Until we have independent scientific advice that clearly states that fracking poses no risk to our community we will continue to oppose it*".

**6. Presentation of incomplete and questionable survey results to Gloucester council** on November 20 and subsequent media release on survey. AGL's press release on their survey results suggested 50% of respondents support or are unsure about AGL's CSG activities. The presentation to Council indicated only 13% supported CSG. In any case, it appears that questions were generalised to NSW, not specific to fracking or CSG in Gloucester. AGL has failed to release full details of survey questions asked and responses.
For debunking of the survey presentation to Gloucester council and the full presentation see: http://www.coal-seam-gas.com/australia/gloucester10.htm

**1.2.7. AGL continues to imply that fracking chemicals are small in volume and benign**

AGL says publicly that hydraulic fracture stimulation fluid consists "mainly of sand and water with a small amount of additives" - Gloucester Gas project newsletter October 2013.

AGL's other comments on fracking chemicals (renamed 'recipe') are available at: http://www.agl.com.au/about-agl/how-we-source-energy/natural-coal-seam-gas/gloucester-gas-project/the-waukivory-pilot

In fact, AGL plans to inject 20,000L of potentially toxic chemicals and constituents. See the following *Risk Sheet 2: Toxic Chemicals in Fracking Fluid* for information on chemicals and details of significant risk of harm.

**1.2.8. Chemical risk assessment not done**

AGL's Head of Gas Operations stated last year that all fracking chemicals have undergone an independent Human Health and Ecological Risk assessment for approval by EPA, NSW. (Gloucester CCC minutes June 28, 2012, p17)

In fact, chemical assessment is not done by the EPA, but by NICNAS. Yet, AGL's REF states:

*"None of the proposed chemicals in use for hydraulic fracturing have been assessed by NICNAS"* (p. 20).

Note: In the same meeting, AGL's Head of Gas Operations said:
*"If I was producing content that was deliberately misleading I would not have a job…AGL does not accept this at all."*

**1.2.9 AGL asserts that the Gloucester gasfield is an answer to a supposed gas supply crisis**

AGL continues to assert that there is a looming gas shortage in NSW that will drive up prices when in fact there is no such shortage as NSW consumers can purchase gas across State borders (just like any commodity) at prices equivalent to that paid in other Eastern States.

*"This proposal will add to the gas supply crisis that New South Wales is facing as existing supply contracts roll off between 2014 and 2017. This roll off of contracts will coincide with very substantial increases in demand for gas as LNG export projects come on line in Gladstone. The absence of multiple new sources of supply in NSW will add to substantial upward pressure on gas and electricity prices in the state."*
(AGL Media Release 19/2/2013).

**Contradictions with other information:**

The NSW Chief Scientist says:
NSW sources 95% of its gas interstate through the
*"NSW/Victoria interconnect system drawing gas from the Otway Basin, Offshore of Victoria."* (Chief Scientists Interim Report, p. 23).

This interconnect system can continue to meet demand. BHP says there is enough gas supply for Eastern seaboard for decades to come. "Bass Strait field still has a large amount of gas that's undeveloped….plenty of gas…indefinitely." SMH May 15, 2012.

The eminent Sydney Morning Herald senior economics writer, Ross Gittens, refuted the gas scarcity claim and wrote a feature article entitled 'Industry's coal seam gas campaign is a con', saying:

*"The gas industry is working a scam on the people of NSW, in collusion with other business lobby groups and federal and state politicians. It's trying to frighten us into agreeing to remove restrictions on the exploitation of coal seam gas deposits.... In truth, there will be no shortages of gas in any state, just a requirement to pay the higher, netback price...With the advent of fracking* and *access to higher prices, it's not surprising gas producers are desperate to extract as much coal seam gas as possible as soon as possible. But their argument that increased production in NSW could hold down NSW gas prices is economic nonsense"*
http://www.smh.com.au/comment/industrys-coal-seam-gas-campaign-is-a-con-20131008-2v63m.html

**1.2.10 AGL made a commitment to establish a methane monitoring program through a workshop with community, Government and Council involvement and to have it in place and 'robust' before fracking would commence (CCC 22/8/2013 p. 23).**

As far as we're aware, AGL has not held a workshop with the aim of designing a methane monitoring program and has not put a robust methane monitoring system in place. We are aware that AGL has undertaken a quick baseline survey as published with the CCC minutes. However, as we understand it, no permanent methane monitoring sites were established and a robust methane monitoring program has not been put in place. There are no details in the REF. AGL needs to provide an addendum to the REF describing their proposed "robust" monitoring program and make this available for review to the community (not just the CCC), Government and Council.

As we understand it, AGL has not undertaken any baseline monitoring of methane levels in surface water and groundwater across the Stage 1 area and its surrounds.

http://www.agl.com.au/~/media/AGL/About%20AGL/Documents/How%20We%20Source%20Energy/CSG%20Community%20News/Gloucester/CCC%20Minutes/2013/November/AGL%20CCC%20Minutes%20%20%2022%20August%202013.pdf)

**1.2.11. Tiedmans Site**

AGL irrigates produced water (coal seam water blended with fresh water) onto crops at its Tiedmans site. AGL stated that "in heavy rain falls, water is captured in a dam and recycled" (email from AGL Media Relations Manager to media representative, November 2013).

**Contradictions with this information:**

AGL's published design report shows that the catch dams overflow every time there is more than 25mm of rain.

This also calls into question the accuracy of AGL's statement that no 'irrigated water' would leave the Tiedmans irrigation site, as irrigation pumps are shut down in heavy

rain. The fact remains that after 25mm of rain, runoff from the site overflows into the Avon River system.
http://www.agl.com.au/~/media/AGL/About%20AGL/Documents/How%20We%20Source%20Energy/CSG%20and%20the%20Environment/Gloucester/Plans%20and%20Proposals/2013/May/Gloucester%20Soil%20Management.pdf (p. 11).

**1.2.12. Salinity and the Avon River**

a) Previous AGL reports (e.g. PB, 2012) suggested that groundwater was too brackish to support GDEs.

b) AGL also stated in a newspaper article (Gloucester Advocate, 10 April, 2013) that the Avon River catchment is "a known saline catchment" and that discharging AGL's "slightly salty water" would "actually improve the quality of the water in the Avon River Catchment".

**Contradictions with this assertion:**

a) Rick Evans (SKM 3/5/2012) comprehensively states that the potential for GDEs is evident and he disputes PB's assertions that groundwater is too brackish to support ecosystems; stating conclusively that EC levels are certainly capable of sustaining ecosystems (P 32 – 33).

b) The Gloucester Environment Group has been recording electrical conductivity (EC), a measure of salinity, in the river at three points since 2009. The aim was to provide a baseline that can be used to compare changes to salinity and other water quality parameters over time. The sampling site with the highest recorded EC is just to the south of Jacks Road.

With the river flowing, the highest recorded EC is 540 units (micro Siemens per centimetre) with an average over 18 samples between 2009 and 2013 of 355 units. This is a relatively small sample size but it is noted that Stratford Coal's data for 2011 for a similar site gives an average EC of 257 units.

The Australian Drinking Water Guidelines set the maximum salinity (measured as total dissolved solids) for fresh domestic drinking water as 500 milligrams per litre which is approximately 770 EC units, well above the recorded EC levels for the river.
The Avon River is therefore not saline but fresh. . However, now AGL use a figure of 150mg/L (about 230 EC units), as the emphasis is on there being sufficient fresh water in the Avon to dilute their saline produced water.

## External information relating to AGL and Contradictions and Discrepancies

Links to reports by news sources and other community groups (independent from Groundswell) of AGL's failure to operate safely:

Discharge of Contaminated Water, causing damage to pasture and other breaches
www.coalandgaswatch.org.au

1. AGL at Camden - May 2013
AGL investigated by EPA for failure to publish data from air monitoring program between Feb and May.

2. EPA fined AGL in March for failing to maintain equipment in a proper and efficient condition resulting in emissions of nitrogen oxides above levels permitted by licence.

3. Also under investigation for failing to continuously monitor for emissions of nitrogen oxides between 2009 and 2012 at Rosalind.
www.abc.net.au/news/2013-06-06/agl-breach/4738542

*4. 8 March 2013 - CSG equipment feeling the heat of underground water*
http://www.abc.net.au/rural/news/content/201303/s3711044.htm
Very hot underground water is melting equipment at a CSG exploration project in central west Queensland. Company hydrologist, John Ross, says underground water temperatures of over 80 degrees are being recorded in the wells at its pilot project north of Ilfracombe. "We've changed the pump types and we're looking at all of the circuitry, pump columns and other components and going for the highest quality equipment we can. Because it's quite a corrosive environment down there as well, as high temperatures."

5. A total of 53 environmental incidents at AGL operated sites were recorded in AGL's corporate incident reporting systems during FY2011, compared with 15 incidents recorded in FY2010. One of the incidents was rated as having a high potential risk (the overtopping of a dam at the Downlands Facility during the Queensland floods in December 2010). Other incidents included minor spills and leaks, administrative non-compliances and noncompliant air emissions. In addition to environmental incidents at AGL operated sites, during FY2011, a number of incidents occurred at the AGL-Arrow Energy Moranbah Gas Project joint venture, where Arrow Energy is the operator. Further information can be found in the 2011 Annual Report available at http://www.agl.com.au/about-agl/investor-centre/reports-and-presentations/annual-reports

*6. August 10, 2011 - NSW Gov't issues AGL with a formal warning after coal seam gas well blow-out - AGL*
https://www.google.com.au/#q=+http:%2F%2Fwww.kateausburn.com%2F2011%2F08%2F10%2Fnsw-govt-issues-agl-with-a-formal-warning-after-coal-seam-gas-well-blow-out
The NSW Government has issued AGL with an official warning following an incident during maintenance of a coal seam gas well at a site in Camden on 17 May 2011.

7. 17th May 2011, AGL was filmed by Channel 10 News venting the contents of a well clean-out (well maintenance workover) to the air near the Upper Canal carrying Sydney's back-up water supply and towards houses in Glen Alpine near Campbelltown.
http://scenichills.org.au/doc/SHA_Media_Release_240113_(9).pdf
There was a school nearby. In the following investigation, AGL was allowed to collect its own soil and water samples for analysis at an external laboratory and to later engage its own consultant to report to the EPA. The EPA later determined that AGL had not followed procedure but as there was no significant environmental harm it was given a warning. The reason for grass 'discolouration' where the contents had landed was never explained.

8. AGL alleged contract breaches.
http://www.abc.net.au/news/2013-12-05/agl-taken-to-court-over-power-contract-discounts/5136290
AGL taken to Federal Court by ACCC over power contract discounts allegedly eroded by price rises.

# *Risk Sheet 2: Toxic Chemicals in Fracking Fluid*

**The issue:**
AGL will inject approximately 20,000L of chemicals and constituents into water-bearing coal seams (REF Vol 5, Appendix B, Section 7.5, p31).

The stated volume of chemicals is only approximate and may be higher than that stated by AGL. Many of these chemicals have not been assessed for risks to human health and ecosystem health.

Some of the hazardous chemicals that AGL proposes to use are listed below. It is known that many of these chemicals can cause serious health impacts (see Risk sheet 12).

AGL's risk and impact assessments are based on the assumption that the chemicals will be isolated from our environment but there are many ways the chemicals may reach people and our environment, not least due to human error. Failure to acknowledge these exposure pathways means that their risk assessment is invalid and adequacy of mitigation and response measures cannot possibly be assessed by regulatory bodies.

**Risk 2.1: There are existing pathways for AGL's chemicals to move from coal seams into waterways and bores**

The nature of these pathways between coal seams and waterways is still not well understood and it is negligent to allow fracking to occur until these pathways are fully understood, potential risks identified and appropriate management plans in place.

AGL stated:
*"We want to do the flow testing program to see whether faults transmit gas or water". (AGL CCC minutes 20/2/2013 p13)*

Dr Rick Evans, a consultant to AGL, says that fracking has the potential to create new pathways for fluid to flow to the surface. Other reports show that existing bore holes can become conduits (see Risk Sheet 4: *Connectivity)*.

There have been thousands of bore holes drilled in the Gloucester basin and the majority of these are in the northern part of the basin. AGL has not provided evidence that they have identified all boreholes in the vicinity of the Pilot Study or risks associated with the boreholes becoming pathways for fluids. The hydrogeology in the area of the pilot program is highly complex and includes major faulting. (More details about these risks can be found in Risk Sheet 4: *Connectivity*).

**Risk 2.2: Fracking fluid pumped out of the coal seam will be stored in open dams or tanks on a floodplain, prior to transfer**

In the event of a flood or an accident hazardous fluid may spill over onto land and wash into our creeks and rivers during major rainfall and flood events. (For more detail see Risk Sheet 3: *Flooding at Test Site*).

**Risk 2.3: Long-term structural integrity of gas wells is not proven**

Together with numerous reports showing that gas wells are likely to fail in the long-term*, corrosion by Sulphate-Reducing Bacteria (SRB) is possible. When gas well casings corrode, contaminated water may flow into beneficial aquifers. (For more details see Risk Sheet 5: *Sulphate-Reducing Bacteria*).
* see, among others http://frackwire.com/well-casing-failure/,
http://www.slb.com/~/media/Files/resources/oilfield_review/ors94/0494/p04_18.pdf

**Risk 2.4: Use of toxic chemicals**

AGL has identified a list of toxic chemicals and constituents that are likely to be used as part of the testing program. These chemicals are known to cause a range of symptoms, from skin and eye irritation to genetic mutation. Together with exposure pathways identified above, AGL acknowledges airborne mists of fracking fluid may be emitted within 200m of homes (see Risk Sheet 11).

Biocide Tolcide PS75 – 450L is just one of the chemicals of greatest concern.
The Material Safety Data Sheet (MSDS) identifies this chemical as toxic to reproduction; sensitising, irritant; very toxic to aquatic life. The data sheet warns "avoid release into the environment". The nature of fracking is that this chemical will be forcibly injected into the environment.

For health impacts of the Tolcide alternative, BE7, and summaries of AGL's other toxic chemicals, see below.

***Contradictions in AGL's published information:***

**Contradiction 1. Connectivity between coal seams and overlying water aquifers**

Numerous studies indicate the likelihood of connectivity between Gloucester's coal seams and overlying water aquifers. (See Risk Sheet 4: *Connectivity*).

According to Dr Phillip Pells, a civil engineer who has spent four decades in geotechnical and groundwater engineering, a bore hole blow out in 2004 demonstrated how CSG activities in the Gloucester basin can cause connections between coal seams and the beneficial aquifers that the affected bore passes through.

AGL has repeatedly stated that they do not understand the nature and extent of connectivity at Gloucester:
*"The fracture stimulation and pilot testing program is also important to assess water production volumes and **whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones**." (REF ES.1)*
(Also see *Risk Sheet 10*)

Despite stating that connectivity is not known, for the Human Health and Ecological Risk Assessment, AGL justifies the use of the term 'low risk' by suggesting there is no connectivity:

*"The underlying geology creates a hydraulic barrier between the target coal measures and the upper alluvial and naturally fractured rock aquifers."* (REF Vol 7: Human Health and Ecological Risk Assessment p. 23).

**Contradiction 2. Use of toxic chemicals**

The REF shows large quantities of toxic chemicals will be used (REF Vol 7, HHERA, Appendix A).

Yet, AGL says publicly that hydraulic fracture stimulation fluid consists "mainly of sand and water with a small amount of additives" - Gloucester Gas project newsletter October 2013.

**Contradiction 3. Contradictory chemical assessment**

The REF chemical assessment is contradictory. It claims:
*"Human health and ecological assessment completed for all chemicals."* (Vol 7. p. 14).

Yet, the report then states:

*"Only a small number of the chemical listed on the Australian Inventory of Chemical Substances (AICS) have been assessed in detail by the National Industrial Chemical Notification and Assessment Scheme (NICNAS) ….*

*None of the proposed chemicals in use for hydraulic fracturing have been assessed by NICNAS"* (p. 20).

Later it asserts:

*"Most of the available data relates to aquatic toxicity"* (p.29).

However, many of the Material Science Data Sheets (MSDS) show no data available for aquatic toxicity.

**Contradiction 4. Who is doing the chemical risk assessment?**

AGL's Head of Gas Operations stated last year that all fracking chemicals have undergone an independent Human Health and Ecological Risk assessment for approval by EPA, NSW.

As shown above, chemical assessment is not done by the EPA, but by NICNAS and

*"None of the proposed chemicals in use for hydraulic fracturing have been assessed by NICNAS"* (p. 20).

Note: In the same meeting, AGL's Head of Gas Operations said:

*"If I was producing content that was deliberately misleading I would not have a job…AGL does not accept this at all."*

# AGL's toxic fracking chemicals

This information about toxic fracking chemicals that AGL proposes to use in the Pilot Project is derived from the REF vol 7 Appendix A.

AGL may **substitute Tolcide with BE7**: Known effects: Aggravated skin and lung disorders. Toxicity for inhalation, primary irritation, carcinogenicity not determined, caused mutations in bacteria and mammalian cells, very toxic to aquatic organisms. Mobility in water, soil, air not determined, degradability not determined, bio-accumulation not determined. Note: BE7 reacts with Hydrochloric acid, listed as another fracking fluid, to release chlorine gas. It reacts with certain metals to produce hydrogen gas. MSDS warns: avoid contact with metals.

**Acetic Acid**: Severe respiratory irritation, eye, skin, mouth, throat, stomach burns. Long-term erosion of teeth. Eco-toxicity not determined. No information available on Toxicity to microorganisms.

**BC140C**: Eco-toxicity not determined. Persistence and biodegradability no information available, bio-accumlative potential: no information available, mobility in soil no information available.

**Choline Chloride**: Human toxicity not determined – e.g. effects on reproduction, as a carcinogen, etc. not known. Eco-toxicity not known. Bioaccumulation not determined.

**FE2 (Citric acid)**: Not assessed by NICNAS. Toxicity to fish and algae not determined. Mobility in soil no information available. Warning: Prevent from entering waterways, or low areas. Scoop up and remove. Skin, eye, mouth, throat abdominal irritation… NOTE: concentration of citric acid in fracking fluid is 5991mg/L. Drinking water guideline is 15mg/L.

**GBW-30 Breaker**: Human Toxicity not determined. Bio-accumulation not determined. Chemical fate information: Not determined. Aus. AICS inventory not determined. Classification Xn – harmful.

**WG-36 Guar Gum**: Warning: Prevent from entering sewers, waterways, low areas. Eco-toxicity not determined. No information available on mobility in soil.

**Sodium Hydroxide** – caustic soda: May form explosive mixtures with strong acids. Warning: Prevent from entering sewers, waterways, or low areas. Causes respiratory, eye, skin, mouth, burns. Eco-toxicity not determined. Mobility in soil not determined.

**HAI-150E**: Known symptoms are respiratory, eye, skin irritation. Toxicology by ingestion not known.

# *Risk Sheet 3: Flooding at Site*

**The issue:**
Three of the four gas wells to be fracked are on a flood plain. Frequent flooding in the area is documented: 5 major floods between 1857 and 1893; 3 between 1957 and 1978 and catastrophic floods in 1929 and 1956. Photos from 2012 show road access near the site cut and floodwaters lapping at an AGL worksite.

The Rocky Hill EIS preliminary flood assessment shows that three of the existing wells are in the middle of the floodplain and well within the 1 in 100 year flood level.

**Risk 3.1: The fracking application (REF) does not contain a detailed flood study.**

No detailed flood study of the Avon River floodplain has been completed. AGL have acknowledged that there needs to be a detailed study as it has been agreed that this will be done as part of the GSC/AGL Gloucester Water Study. Until the detailed flood study is completed, we have no confirmation of flood area, depth, velocity speed of onset and duration.

**Implication:**
It is impossible for AGL to estimate potential damage to infrastructure or prepare a realistic emergency response plan without knowing what the nature of the flood emergency may be. It is impossible for regulatory bodies to determine the adequacy of flood procedures.

**Risk 3.2: Prior to transport in sealed water tankers, flowback fluid will be held in open dams or tanks on the floodplain, approximately 100m from the Avon River**

Without specific flood and rainfall data, it is impossible for AGL or regulators to assess the adequacy of these dams or tanks to withstand flooding. It is also impossible to determine at what level of flooding the flowback fluid will begin to overflow onto surrounding areas and into the Avon River.

**Risk 3.3: No specifications are given for open dams or tanks that will hold flowback fluid next to 3 of the gas wells**

Limited specifications are provided for one dam and give only an approximate capacity. It has a freeboard of 450mm and pumping will cease if this is reached. Without site-specific flood and heavy rainfall data it is not possible for AGL or regulators to determine if the freeboard is adequate to cope with maximum expected rainfall and avoid spillage. If the freeboard is reached, continuing rainfall means flowback fluid will spill over.

The suitability of the soil for dam construction has not been considered. Alluvial soils are frequently too soft and friable with too high a percentage of alluvial material. Without sufficient clay material to provide good binding and compaction, any earth dams would be high risk.
**Implication:**
Without specifications as to surface area, height, or wall construction it is impossible to assess the risk of flowback fluid spills.

**Risk 3.4: Gas wells inundated during flood events**

Specific procedures for securing gas wells during flood events are not provided. In any case, without data on onset speed, it is impossible to assess whether AGL will have enough forewarning to implement procedures. If manual onsite procedures are necessary, access to the wells may be cut by floodwaters.

**Contradictions in AGL's information**

1. "The subject lots are not within flood planning area identified in the Gloucester LEP" (REF Vol3 p 95).
This implies that Avon River doesn't suffer significant flooding. The fact is the Gloucester LEP did not cover flood risk areas except the immediate township of Gloucester and a full flood study has not been done. Historical reports of occurrences of major flooding are available.

AGL's own preliminary groundwater assessment 2010 acknowledges much of their project is on a floodplain:
*"Elevations within the Stage 1 Area…decrease to 110mRL…Avon River floodplain."* (SRK 2010: "AGL002 Gloucester basin hydrology study" p5)
*"The rivers and creeks within the Stage 1 GFDA are subject to flooding and water velocities in these rivers can be high after heavy rainfall"* (SRK 2010: p15).

2. Australians expect AGL and regulators to use quality technical research and data as the basis for design and assessment of environmental impacts. The experience in Queensland is that many recent floods exceeded design levels and caused open cut coal mines to fill with floodwaters and therefore needed to be pumped out into watercourses leading to significant environmental impacts. Increasingly, the 1 in 500 year flood is being used for urban and other project design relating to floodplains, rather than the 1 in 10 year level. It is difficult to understand why AGL was given approval in the first place to drill these wells on the floodplain. AGLs REF for that approval did not address flooding.

AGL says project layout is based in response to local residents' anecdotes:
**"***Where possible, work sites have been situated above areas identified by landholders as being floodprone."* (Vol 3 p. 95).

3. Without a full flood study, it is not possible for AGL or regulators to assess the capacity of open dams or tanks to avoid spillage in flooding or extreme rain.

AGL says:
*"Flowback water is stored within lined ponds or aboveground tanks that are not affected by rainfall (including flooding)."* Vol 3 p. 97).

It is difficult to see any basis for this claim. With no flood study, no consideration of extreme rainfall data (such as 752mm which fell in February 1929), and no detailed specifications for ponds or tanks, AGL and regulators cannot begin to assess risk of failure.

# *Risk Sheet 4: Connectivity of Coal Seams and Beneficial Aquifers*

**The issue:**
If there are pathways connecting coal seams to other aquifers, fracking chemicals, coal seam water and gas can contaminate shallow aquifers and rivers, potentially harming humans and animals.

**Risk 4.1: The nature of the connections between coal seams and shallow aquifers in the Gloucester basin are not well understood**

The role of faults in potentially becoming pathways for fracking fluids, coal seam water and gas is a particular risk in Gloucester because faults and fractures are common and associated structures are so complex.

*"The connectivity issue is more of a challenge as we do not know how to characterize it fully at this stage."* (p. 77, Sect 7.7 Comments from the Chief Scientist's review, July 2013).

With respect to the Gloucester Basin, the Chief Scientist states:

*"This deep faulting has the potential to interconnect deeper coal seam aquifers with near surface fractured rock aquifers. 'The extensive faulting, displacement of strata across faults, folded and discontinuous lithologies and lack of any fault seal analysis' (Ward & Kelly, 2013) makes understanding the hydrogeology in this area incredibly difficult."* (Sect 5.5.1.2, p. 44).

The lack of information is acknowledged by AGL:

*"The location and distribution of relatively high and low permeability zones is poorly known at present."* (AGL's HHERA risk assessment, p. 11).

AGL has repeatedly stated that they do not understand the nature and extent of connectivity at Gloucester:
*"The fracture stimulation and pilot testing program is also important to assess water production volumes and* ***whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones."(REF ES.1)***
(Also see *Risk Sheet 10*)

The highly fractured, discontinuous and irregular nature of the geology may be the reason AGL are having to frack the wells to get the flows of gas they want when horizontal drilling is likely to be cheaper and preferred in many locations.

**Implications:**

Without fully understanding the nature of the geology, AGL and regulators cannot predict where fracking chemicals and gas will go. No further fracking should occur until there is a full understanding of the geology, if that is, in reality, possible.

Economic implications for AGL's investors are that fracking will be necessary to release commercial volumes of gas but fracking is relatively costly both in terms of implementation and in reputational damage and consumer backlash.

**Risk 4.2: AGL's own data shows coal seams and aquifers are naturally connected**

The layers of "interburden" between the coal seams and aquifers do not form a sealing layer as AGL try to assert.

In the peer review by Dr Evans, he makes the following comments about one of the monitoring bores established for the Stratford flow testing:

*"This suggests there is hydraulic continuity laterally (and also possibly vertically)…and this hydraulic connectivity is not negligible."* (Evans, p.19).

And with respect to another:

*"The results do not support a conceptual model of hydraulic isolation of interburden layers."* (Evans, p. 20).

In fact, Evans' assessment of AGL's monitoring bore data states:

*"These observations suggest that deeper confining units are responding to recharge relatively quickly, and are not hydraulically isolated units" (Evans, 2012,* pp19-24)

AGL's consultants do not appear to have considered Dr Evans' analysis in their more recent reports on the conceptual model and water balance.

These indications of connectivity correspond with the most recent independent review of the Gloucester basin geology in a Background Paper on NSW Geology by Ward and Kelly, August 21013, (referring to the Gloucester Basin)

*"However, the permeability and heterogeneity of the fault zones have not been studied. Future investigations will quantify the fault seal properties adjacent to coal beds from which the gas will be produced (SKM, 2012). Until they are proven to be sealing faults, it is reasonable to assume that the fault zones would provide pathways of hydraulic connectivity from the coal measures to the near surface."*

**Implications**:
1. When large volumes of groundwater and gas are being extracted, **drawdowns in shallow aquifers may be considerably more** than predicted by AGL. This will impact on the current and future use of these aquifers and the health of associated groundwater dependent ecosystems.

2. The other concern is that AGL continue to push the line of negligible connectivity in the face of the very considerable evidence provided by Dr Evans, Dr Philip Pells and many others. AGL accepts the need for more detailed peer review of their conceptual model and water balance, which is part of the GSC/AGL Gloucester Water Study. This review may provide useful information as to the extent of the risks inherent in the Waukivory Pilot Program. Due process indicates AGL should not proceed until these studies are completed.

**Risk 4.3: Fracking and drilling may create new pathways between coal seams and water sources**

AGL'S report in July 2010 states that **drilling which intersected a fault increased hydraulic conductivity of the coal seam by 10 times**. (SRK AGL002 2010: p24)

Dr Rick Evans explains how new pathways between coal seams and water sources can occur:

*"if the fracturing were to intersect a fault or fracture zone and where there was preferential flow along the fault or fracture zone. There are known faults in the Gloucester Basin so there is potential for this process to occur. AGL propose to investigate this process in the Waukivory Flow Testing program"* (Evans, 2012 *p44.*)

In terms of reducing this risk sufficiently, Evans states:

*"**Siting CSG wells away from faults is an important, but not necessarily sufficient control, to prevent the impact of faults acting as potential preferred pathways**"*.p42

**AGL has not adopted the important control Evans recommended** - to site CSG wells away from faults. AGL's Fracture Stimulation Management Plan (FSMP) admits that the **Waukivory gas wells intersect several large fault zones. (FSMP p 13)**

This is particularly concerning because a thrust fault in the Waukivory Pilot Project site ends up in the shallow alluvium under the Avon river (AGL's REF SGMP p. 10).

This means that if the fault becomes a pathway for fracking fluids, gas, or coal seam water, they may flow up directly under the Avon and the aquifer that connects to it.

**Risk 4.4: Bore holes can provide a pathway for chemicals and gas to travel from coal seams to the surface**

Bore holes cross through all the layers of rock and water bearing zones (aquifers) depending on their depth and can provide an open pathway from one layer to the next if not constructed to the required standard or if affected by corrosion. During CSG testing activities in 2004, a borehole blew out, demonstrating how CSG activities can cause connections between coal seams and beneficial water sources. There are thousands of bore holes in AGL's exploration area in the Gloucester basin. The REF does not contain a detailed study on the locations of boreholes in the vicinity of the Pilot Program. This means it is impossible for AGL or regulatory bodies to assess whether boreholes will become conduits for contaminated water and gas. The possibility of inadequate plugging of boreholes is a grave community concern, particularly as there seems to be little regulatory inspection of works.

**Risk 4.5: Gas wells need to isolate gas and fluids from the layers of rock and aquifers (water zones) they pass through**

Like bore holes, gas wells cross through all the layers of rock and aquifers and if they are not sealed, can allow chemicals and gas into aquifers. The long-term integrity of gas wells has not been proven.*

AGL's REF does not consider the effect on gas well integrity of vibration associated with blasting by nearby coal mining and vibration induced by CSG activities.
* see, among others http://frackwire.com/well-casing-failure/,
http://www.slb.com/~/media/Files/resources/oilfield_review/ors94/0494/p04_18.pdf
Monitoring and managing the effect of Sulphate-Reducing Bacteria on gas wells is also not adequately considered. (See *Risk Sheet 6: Sulphate-Reducing Bacteria*)

**Contradictions in what AGL says about connectivity:**

As shown above there is ample evidence that coal seams and aquifers are connected. But AGL's health risk assessment is based on their assertion that:

*"The underlying geology creates a hydraulic barrier between the target coal measures and the upper alluvial and naturally fractured rock aquifers."* (HHERA p. 23).

Implications:

The health risk assessment is invalid and may dangerously underestimate impacts on humans and the environment.

AGL and their groundwater consultants Parsons Brinckerhoff (PB) seem to have interpreted previous water monitoring as indicating a lack of connectivity:

"PB states that this bore shows 'negligible seasonal variation and no response to rainfall recharge"; implying negligible connectivity. (Evans, 2012, p22)"
This is incorrect. Evans states:
*"It is apparent that the bore is responding to recharge. This response is particularly significant given that this is the deepest of the monitoring bores, and screen in one of the target coal seams."* (Evans, 2012, p 23).

Further examples of AGL's contradictory statements on connectivity are **in Risk Sheet 1: Discrepancies and Contradictions**

**See Appendix A** for Problems with meeting the requirements of the NSW Code of Practice for Coal Seam Gas Fracture Stimulation Activities (CoP)**.**

# *Risk Sheet 5: Management of Fracking Fluid*

**The issue:**
AGL plans to inject almost 20,000L of chemicals, mixed with water and sand, into coal seam aquifers and then pump it back up to the surface. It is then called 'Flowback water'. AGL acknowledges the toxicity of this contaminated water by stating the need to transport it in sealed tankers to licensed facilities.

**Risk 5.1: AGL is unclear about onsite storage of flowback fluid**

AGL's REF seems to make contradictory statements for how they will manage flowback fluid onsite. In some parts of the application, they say it will be in open dams or ponds, open tanks, contained tanks, lined and secure water storage, and/or one compartment of a dual compartment turkey's nest dam.

**Implications**:
AGL's risk assessments and impact statements are based on flowback fluid being isolated from the environment. Open dams and tanks are clearly not isolated from the environment so the risk assessments are invalid and cannot be assessed by regulators.

**Risk 5.2: Risk of flowback fluid spillage due to design of open dams or tanks impossible to determine**

AGL have acknowledged that they do not have enough information about where to site their infrastructure as a more detailed flood study is one of the projects being undertaken by the Gloucester Shire Council as part of the AGL funded Gloucester Water Study.

No specifications are given for open dams or tanks that will hold flowback fluid next to three of the gas wells. Specifications for one dam give only an approximate capacity. It has a freeboard of 450mm and pumping will cease if this is reached.

Without site-specific flood and heavy rainfall data it is not possible for AGL or regulators to determine if the freeboard is adequate to cope with maximum expected rainfall and avoid spillage. If the freeboard is reached, continuing rainfall means flowback fluid will spill over.

Without specifications as to surface area, height, or wall construction it is impossible to assess the risk of flowback fluid spills. On-site materials are to be used for construction but there is no data on the nature of these materials so it is impossible for AGL and regulators to assess their suitability for construction.

AGL acknowledges need for sealed tankers to transport flow back fluid. If sealing containers are necessary, then open dams or tanks are inadequate.

**Risk 5.3: Locations of dams/tanks**

Three wells are on a flood plain, with at least one approx. 100m from the Avon River (see *Risk Sheet 3: Flooding at Test Site*) and flowback fluid storage is to be within 25m of wells. Regulations allow gas wells as close as 40m from rivers. Note: Domestic septic tanks in Gloucester must be at least 100m from watercourses.

**Risk 5.4: Where will the flowback fluid end up?**

AGL's REF says it will go via sealed tankers to a licensed facility. AGL says the location has not been determined.

Implications: With no specific plan in place it is impossible for AGL or regulators to assess the feasibility of this plan.

**Risk 5.5: AGL says it can pump out flowback fluid and after a certain time between 90% and 100% of it will be removed**

*"The fluids used during fracture stimulation are recovered from the well through the flowback and dewatering processes. Essentially, what goes down the well comes back up."* (REF Vol 5 Appendix D, Sect 2.4, p. 13).

They suggest that **fluid coming after that will be called 'produced water', to be blended and used for irrigation.**

When fracking chemicals are injected into the coal seam, they will mix with existing coal seam water. The Chief Scientist's Interim Report (p58) stated that 50-85% of flowback fluid remains in the ground.

AGL has not provided evidence that removing all flowback fluid is possible. Their monitoring plans will not adequately demonstrate that all fracking chemicals have been removed prior to using pumped water for irrigation.

**Implications:**
If fracking chemicals remain in coal seam, they may end up sprayed onto crops at the Tiedmans site. Crops from this site have already been sold as fodder to beef or dairy farmers. Run-off from Tiedmans site overflows into the Avon River after 25mm of rain.

**Contradictions with AGL's information:**
As shown above, there is evidence from the Chief Scientist that a significant volume of fracking fluids will remain in the coal seam. Yet AGL says:
*"The fluids then flow back out of the well leaving the sand in place in the fractures."* (Gloucester Gas Project Community Update October 2013).

# *Risk Sheet 6: Sulphate Reducing Bacteria (SRB)*

**Risk 6.1: SRB exist in coal seam water and can affect the inside of steel casings in wells**

AGL acknowledges that SRB affects the inside of steel casings in wells (EIRP p7). SRB may exist and proliferate in gas wells for the life of the well and after capping and abandonment, affecting steel and cement.

Although the use of a biocide (in this case, Tolcide) is problematic for human and ecological risk, (see Risk Sheet 2), it is injected into the coal seam for its impact on reducing SRB. AGL seems to plan to inject the biocide only in the initial phase, and asserts all of it will be pumped out. (See Risk sheet 5). It seems there is potential for populations of SRB to proliferate and affect well integrity by corroding the steel and cement casing. AGL does not seem to provide details of monitoring to determine how efficient the Tolcide has been in depleting SRB. The need to monitor SRB levels to determine efficacy of biocides is highlighted here:
http://twinoxide.com.au/pdf/industryBiocides.pdf

If gaps open in the steel and cement casing, contaminated water and gas will be able to escape into surrounding formations including aquifers. The length of time it will take for this disintegration to occur is unknown, but farmers in Narrabri suggest disintegration has occurred within 10 years.

**Risk 6.2: Lack of testing of produced water for SRB**

With SRB potentially affecting well integrity and opening pathways for contaminated water and gas, monitoring SRB levels in perpetuity would seem necessary. It seems AGL has no ongoing monitoring plan for SRB levels. (SGMP Appendix D – p29 shows limited laboratory suites for water analysis).

AGL states that:

*"Shallow aquifers are protected by four barriers within the well construction: two steel and two cement barriers…Aside from the important environmental consideration, zonal isolation is important for gas production, as water migration form any other source will hinder gas production."* (Appendix B p. 15). See Risk Sheet 4.

**Implications:**

Separation between gas wells and aquifers is at risk. This means human health and environmental risk is much greater than the REF suggests. It is unclear how wells will be plugged after abandonment. We ask what effect SRB is having, and may have on other exploration wells and monitoring bores in the area.
Other implications are in production efficiency and potential ongoing commercial costs which may escalate. Corrosion is estimated to cost oil and gas industries in the US $100m per year
AWA: Page 7 – Associated problems
https://www.google.com.au/#q=http%3A%2F%2Fwww.awa.asn.au%2FuploadedFiles%2FThe%2520Sauce%2520Sept%25202009.pdf&undefined=undefined

For images showing disintegration and contamination, possibly within 10 years:
http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/?a=30043
http://www.cessnockadvertiser.com.au/story/1139619/turning-blind-eyes-on-coal-seam-gas-negative-points/

Potential for SRB and other bacteria to become resistant to biocides over time:
http://www.nacecalgary.ca/pdfs/NorthernPapers/Bacterial%20Survival.pdf

Risks with corrosion and biodegradable alternative:
http://cheserver.ent.ohiou.edu/paper-gu/a%20green%20biocide%20enhancer.pdf

# *Risk Sheet 7: Air Quality and Methane*

## Air Quality

Flaring is the burning off of gas from gas wells. It is done during flow testing as the gas company is not allowed to sell gas extracted under an exploration lease. Flaring may continue, 24 hours a day, for long periods. Flaring is known to release carcinogens and other toxic chemicals into the air:

*"Over 250 toxins have been identified as being released from flaring including carcinogens such as benzopyrene, benzene, carbon di-sulphide (CS2), carbonyl sulphide (COS) and toluene; metals such as mercury, arsenic and chromium; sour gas with H2S and SO2; nitrogen oxides (NOx); carbon dioxide (CO2); and methane (CH4) which contributes to the greenhouse gases."*
http://ntn.org.au/wp/wp-content/uploads/2012/04/NTN-CSG-Report-Sep-2011.pdf

On the issue of air pollution Southern Cross University researchers found a threefold increase in methane, and increases in carbon dioxide and radon levels in the air within the Tara gas project area.
(www.scu.edu.au/coastal-biogeochemistry/index.php/69)

**Risk 7.1: No onsite monitoring planned at nearby residences**

We are unable to locate in the REF specific plans for onsite monitoring at nearby residences for flaring and venting pollutants.

**Implications:**
AGL or regulators will have no way of knowing what impact flaring and venting are having on nearby families (as close as 500m); no indication of the need to modify procedures.

**Risk 7.2: No local baseline NO2 or CO data collected, despite proximity to homes**

For AGL or regulators to assess impacts on air quality, comprehensive baseline data is required. It would appear that no on-site air quality baseline data collection is presented in the REF. AGL has used baseline data for NO2 and CO from the EPA database - with the closest monitoring stations at Wallsend, Newcastle, Beresfield, Muswellbrook and Singleton. Climactic information was taken from Chichester Dam - 32km away and Taree Airport - 52.3km away.

**Implications:**

We question the use of data from distant monitoring stations to provide baseline information for Gloucester. Without an accurate local baseline, AGL or regulators cannot determine impacts.

**Risk 7.3: Modelling air impacts based on remote location, not on Gloucester**

AGL uses data from Windermere, near Bulga, and they note that this data was collected with a view to later lodging a frack application for Windermere. Why not monitor at Gloucester where an application is being lodged?

We question the accuracy of extrapolating data from Windermere to predict impacts in Gloucester where the topography and local wind patterns are completely different. Windermere is at the edge of the many times wider Hunter Valley. The Gloucester valley is markedly narrower, at 10km and hemmed in on both sides by mountains formations.
Airshed drifting patterns resulting from warm morning air rising from the plains, which are a feature of Bulga, are unlikely to occur in the Gloucester basin where the warming sun would be west of the CSG site and drawing the air westward form the site across the river and houses as the thermals rise over the mountains to the west. (Preliminary comments from a preliminary review by Dr Neville Hodkinson PhD, Singleton Shire Healthy Environment Group)

**Implications**:
Air pollution may actually travel much farther and in different directions than anticipated. Risk to residents may be much higher than AGL implies. Mitigation based on incorrect assumptions may not be adequate, exposing families to harm.

**Risk 7.4: Venting**

AGL concedes venting emits methane, nitrogen oxides, carbon monoxides and VOCs (REF Appendix C, p11) and say they will minimise the amount of venting. There doesn't seem to be specific information on how much venting will be done. There doesn't seem to be either collected or extrapolated baseline data for VOCs.

**Implications:**
Neither AGL nor regulatory bodies can assess risk of harm to people or animals, or demonstrate impacts during or post-venting.

## Methane

Methane can contaminate water through coal seam connectivity with aquifers (see *Risk Sheet 4: Connectivity*) or be released into the atmosphere. Air-borne methane emissions can occur through the same pathways or through improperly sealed infrastructure. Methane emissions reduce the volume of gas available for sale by the gasfield operator and have a global warming potential 21 times greater than CO2.

***Contradictions with published AGL statements:***

a) While AGL committed to designing, with the community, a robust methane monitoring program prior to fracking, as far as we aware, this has not occurred. We are aware that AGL has undertaken a short baseline survey of limited locations as published with the CCC minutes )
http://www.agl.com.au/~/media/AGL/About%20AGL/Documents/How%20We%20Source%20Energy/CSG%20Community%20News/Gloucester/CCC%20Minutes/2013/November/AGL%20CCC%20Minutes%20%20%2022%20August%202013.pdf).

However, as we understand it, no permanent methane monitoring sites were established and a robust methane monitoring program has not been put in place. There are no details of a monitoring program in the REF. AGL needs to describe their proposed "robust" monitoring program and make this available for review to the community (not just the CCC), Government and Council.

**As we understand it, AGL has not undertaken any baseline monitoring of methane levels in surface water and groundwater across the Stage 1 area and its surrounds.** Baseline and ongoing monitoring of methane should be addressed with SGMP. The lack of baseline monitoring appears to constitute a breach of the CoP.

**Implication:**

Without a robust and independently reviewed baseline and future methane monitoring program in the REF, neither AGL nor regulators can determine the extent of fugitive methane emissions. Neither party can adequately plan or assess management or mitigation responses.

Accurate information on sources of fugitive emissions may indicate locations where interaquifer connectivity has been created. We question why AGL or regulators would not ensure that this information is collected.

*b) Air pollution emissions – VOCs*
*AGL's ref says:*

***"The project will result in emissions...principally methane, ...nitrogen oxides, carbon monoxide and volatile organic compounds (VOCs)."*** *(REF, Appendix C, p11). Estimates of levels of emissions of VOCs (based on US figures) are tabled on p17.*

An AGL study notes:
"Free hydrocarbons were also described in coals...in the Gloucester Basin" (CSIRO literature review for AGL, 2011, p52).

***Contradictions in published AGL statements:***

While it is unclear in the following statement whether AGL is referring to air pollutants arising from fracking and flaring, or to extracted gas, AGL implies to readers that there is no issue with hydrocarbons or VOCs:

"The natural coal seam gas does not contain heavy hydrocarbons or volatile organics such as benzene or toluene'
(AGL head of community relations in letter to Gloucester Advocate 4 Dec 2013)
If these chemicals are not in gas which is extracted, they are certainly in the produced water which is extracted with it.

# *Risk Sheet 8: Water Monitoring – Useful Data?*

**The Issue:**
We question whether the monitoring program as described in the REF is comprehensive or robust enough to gather useful data.

The apparent inadequacy of the water monitoring program casts doubt on AGL's assertions that gathering useful water data is an aim of the Waukivory pilot. The proposed water monitoring plan needs to be peer reviewed by an independent expert with established technical knowledge of CSG operations.

**Background Information:**

The 4 wells that are to be fracked and flow tested have the following depths:
Waukivory 11 (WK 11) - 1103 metres
Waukivory 12 (WK12) - 755 metres
Waukivory 13 (WK13) - 1103 metres
Waukivory 14 (WK14) - 1014 metres

Access to the borehole logs for the exploration wells was refused by AGL on the basis that it is "commercial in confidence information" for 2 years after drilling. It is unclear why such a request would be refused.

The REF states that "several large fault zones intersected by the Waukivory pilot wells have been confirmed by image logs acquired as part of the logging of the wells. These image logs allow accurate identification of the location of faults and their dips. Zones were selected for fracture stimulation located away from these faults." Appendix B, Vol 5, FSMP Sect 2.4 p13.

It is clear from this and other information in Risk Sheet 4 (Connectivity of Coal Seams and Beneficial Aquifers) that the hydrogeology in the area of the pilot study is highly complex.

The REF states that "The objective of a dedicated groundwater network and associated monitoring program is to protect the shallowest beneficial aquifer…." And "This additional groundwater monitoring will provide:

- A better understanding of groundwater flow paths and the connectivity of aquifers and deeper water bearing zones (under actual flow testing conditions);
- An improved conceptual model of groundwater flow (in an area of substantial thrust faulting); and
- More definitive proof of connectivity (or lack of connectivity)…..to better inform the community and regulators…" Vol 5, App D, Surface Water and Groundwater Management Plan (SWGMP) Sect 6.2, p25.

The design of monitoring programs for the fracking and flow testing of exploration wells is very specialised and should be undertaken by an expert, experienced hydrogeologist. As indicated below, from what we understand, it would seem that the proposed monitoring program is very inadequate. A detailed peer review is necessary. It seems logical, and more in line with reasonable caution, to delay even designing a pilot program until an expert hydrogeologist is contracted by the Gloucester Shire

Council, as proposed for the GSC/AGL Gloucester Water Study. This expert hydrogeologist will also be doing detailed peer reviews of AGL reports. "Hydrogeological Conceptual Model of the Gloucester Basin", June 2013, "Water Balance for the Gloucester Basin", July 2013, and "2013 Gloucester Groundwater and Surface Water Monitoring – Annual Status Report", October 2013. This will provide the reviewer with an excellent background to review the design of the Pilot Program including its proposed monitoring program.

## Risk 8.1: Number and location of monitoring bores

According to Sect 6.2, p. 27, AGL has drilled 5 designated monitoring bores for the testing program. The screened intervals are: WKMB01 47 – 53 m, WKMB02 52 – 61m and WKMB03 200 – 209m. WKM04 is screened at 335 – 347m and will be fitted with a Vibrating Wire Piezometer (VWB). WKMB05 is approximately 1000m deep and, as we understand it, it will be fitted with geophones during fracking and then have a VWP fitted for the flow testing. The screen interval has not been provided.

Figure 1 in the SGMP, p36 shows the location of the exploration wells to be fracked and the designated monitoring bores. WKMB01 and WKMB04 are located about 330 metres west of WK11 while WKMB02 and WKM03 are about 100 m east of WK11.

**Issue 1: Will the monitoring program provide useful information on connectivity, including the effect of the thrust fault?**

In Dr Rick Evans' discussion of the Waukivory Pilot Program he notes that:

*"AGL propose to investigate this process in the Waukivory Flow Testing program by monitoring a series of 8 designated monitoring bores either side of a known thrust fault for a period before and after hydraulic fracturing of the four proposed exploration wells"* (AGL email dated 13th March 2012, in Evans, 2012 p44).

However AGL has only drilled 5 designated monitoring bores for the testing program. The number or monitoring bores to be used is significantly less than Dr Evans was advised in March 2012. Having only 4 monitoring bores clustered in the vicinity of the fault appears completely inadequate.

Two of the 5 bores have a screened interval of about 50 – 60m, one is screened at about 200m and the fourth at about 350m and will be fitted with a VWP. To have the deepest monitoring interval at 350m seems completely inadequate to monitor the impacts of fracking and flow testing exploration wells that are 750 to 1100 deep.

Except for the one deep bore close to WK13, there are no other designated bores close to the other 3 exploration holes. To run such an expensive testing program while collecting such a limited amount of information is very difficult to understand. It would also seem that very limited data can be collected to assist in quantifying parameters that could be used in the 3D numerical modelling for the rest of the Stage 1 gasfield.

**Issue 2: Will the monitoring program show drawdown in aquifers**?

**No information will be provided on water table variations for the alluvial aquifer**. As a minimum, water table monitoring bores should be added to the two nests of bores.

Some information will be provided by the 2 designated shallow monitoring bores about changes in water levels in the fractured rock aquifer that they are screened in. The deeper bores may show changes in potentiometric heads in the aquifers or coal seams they are screened in.

There are four private bores within 2.6km of the pilot wells (600m, 2.6km, 1.5km, 1.8km) but AGL are not planning to monitor them. (SWGMP, p26)

We question why AGL would not take the opportunity to monitor impacts in these bores. We note that AGL are planning to monitor 3 Gloucester Resources Ltd bores that are screened in the shallow alluvium. However no information is given on the location of these bores so it is difficult to assess the benefit of monitoring these bores.

As we understand it only one well will be tested at a time. To really stress the system so that possible connectivity and drawdown is properly assessed, it would seem appropriate for all 4 exploration wells to be flow tested at the same time or at least for combinations of the bores to be tested at the same time. We understand that it is likely that AGL will wish to operate these wells if Stage 1 goes ahead. Impacts would need to be carefully monitored to avoid permanent damage to groundwater dependent ecosystems.

**Risk 8.2: Monitoring time insufficient to give useful data?**

There is no clear indication of what baseline information has been collected in the monitoring bores. WKMB04 was not operational when the REF was lodged and WKMB05 was still being drilled (October 2013).

If AGL wishes to gather useful information, they need to get a baseline of water levels in monitoring bores, against which impacts can be measured. It would seem appropriate that an absolute minimum of 12 months monitoring should be collected prior to the testing occurring. Monitoring bore WKMB05 was only being drilled when the REF was lodged (October 2013). This bore is the only one placed at a depth of 1000m. As it is the only one at the lowest coal seam, adequate data from this well very important.

This is another reason to delay the pilot program.

**Risk 8.3: Repeating questionable design**

AGL says the Waukivory Pilot is based on Stratford pilot testing:

"*Particularly Stratford pilot testing program. The resulting significant level of experience gained from previous projects has resulted in a high level of confidence in accurately predicting any potential associated impacts to groundwater systems…*

*The proposed methods to manage or mitigate impacts to groundwater have been derived from past project experience. This water management plan and the dedicated monitoring proposed is considered to be sufficient to identify any potential impacts."* (SGMP pp. 23-24).

However, Dr Evans, in his review of previous work by AGL in 2012, was highly critical of the groundwater investigations undertaken and the conclusions drawn by the consultants, including those associated with the Stratford Flow Testing.

AGL's own report challenges the usefulness of the Stratford monitoring:

Just one example is: *"It is not possible from the existing data to determine unequivocally the cause of the ...declining trend in groundwater in 7 of the (15) shallow monitoring bores."* Water Balance 12 July 2013 – PB, p. 23).

This assessment by PB also did not review the comments and conclusions made by Dr Evans in his peer review.

This suggests that the REF monitoring plan is based on the Stratford monitoring, which could not explain the water levels behaviour in 7 out of 15 bores. Yet the Stratford pilot project had far more designated monitoring bores than have been drilled for the Waukivory pilot.

We question the repeated use of an inadequate monitoring approach.

### Risk 8.4: No plan for management and mitigation of impacts

One purpose of the pilot is to determine the "possibility of any impacts to shallow aquifers" (p. 24), indicating AGL recognises this is a risk. We would expect that if impacts should occur, adequate and independently assessed management and mitigation measures are designed and ready.

However AGL says:
"Management and mitigation measures are not proposed as part of this pilot testing program unless shallow aquifers less than 75m are definitely impacted…" (p. 24).

**Risk 8.5: Monitoring of equipment failures?**

AGL expects some of its monitoring equipment to fail.

*"It is proposed to install pressure transducers in each well so as to monitor the drop in hydrostatic head…These are sensitive instruments that sometimes fail under the changeable pressure conditions…if [they] fail during the pilot test, the test will continue without this data."* (Appendix D, SGMP, p. 26).

**Implications:**
Measurement of heads and for some information, the rate of change in head, is fundamental to the information obtained by such a pilot study. If the equipment fails, this important information will not be gathered.

# *Risk Sheet 9: Groundwater Dependent Ecosystems and Threatened Species*

Note: This Risk Sheet identifies our perception of contradictions between published data and information in AGL's REF. It is not a survey of GDEs or Threatened Species near the pilot site. There may be other GDEs and Threatened species not mentioned here.

**9.1 Groundwater Dependent Ecosystems**

Recent ecological assessment undertaken for the Rocky Hill Mine (within 10km of Waukivory Pilot) Environmental Impact Statement (EIS) identifies groundwater dependent ecosystems:

**"Two ecosystems are dependent upon groundwater** within and surrounding the Site, namely riparian vegetation adjacent to Waukivory Creek and the Avon River, and stygofauna" p. 4-146.

This identification of GDEs concurs with Dr Rick Evans who comprehensively states that the potential for GDE is evident; stating conclusively that EC levels are certainly capable of sustaining ecosystems (SKM 3/5/2012 p 32 – 33).

a) Riparian vegetation:

GRL EIS 4-271 states presence of Community 3 HU598 River Oak Riparian Woodland of the North Coast and Northern Sydney Basin.

The CMA identifies the River Oak as a groundwater dependent ecosystem (highest likelihood ranking - 'high probability'). (Appendix 1 p 59 from "Risk assessment guidelines for groundwater dependent ecosystems: Volume 3 – Identification of high probability groundwater dependent ecosystems on the coastal plains of NSW and their ecological value, June 2012)

The Rocky Hill EIS states a number of times (eg section 11.6) that the riverine vegetation consists mainly of "River Oak, Cabbage Gum and Broad-leaved Apple. River Oaks are understood to be similar to River Red Gums and these species are likely to rely on groundwater from underlying formations." This is a highly significant comment, as although River Oak communities in the region are not threatened, they play very important roles in all riverine systems where they occur. They provide key habitat in rivers where riverine vegetation has already been impacted by clearing. They also greatly assist with bank stability. The deaths of the River Oaks as a result of low groundwater levels and reduced flows recharging the alluviums, could have a devastating impact on stream stability and the riverine ecosystems including aquatic ecosystems. (http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/?a=29905, October 2013)

b) Stygofauna:
"4 individuals from 3 taxa" found in the coal groundwater system. GRL EIS p4-306 states. The presence of stygofauna in aquifers and coal seams in the Gloucester basin was identified in GRL's EIS but is not acknowledged by AGL.

**Contradictions with AGL's REF**

AGL says:
"There are no known groundwater dependent ecosystems (GDEs) (apart from baseflow accessions) although there may be some uptake of shallow groundwater (from the alluvium) by native terrestrial vegetation on the floodplain." REF P 11.

**Implications:**

AGL had previous information indicating the likely presence of GDEs (Evan's report). They also had access to GRL's EIS positively identifying the presence of GDEs. Failure to acknowledge groundwater dependent ecosystems seems to indicate a lack of rigour. It also precludes any baseline or comparative monitoring of these populations and inadequate risk assessment or mitigation measures. This is a serious failure as River Oak communities are fundamental to the health of watercourses like the Avon River and Waukivory Creek.

### 9.2. Threatened and vulnerable ecological communities within 10km of the Waukivory site

Nine threatened species have been identified near the pilot site, with evidence of habitat and forage. Nests were found adjacent to McKinley's Lane and the area is part of a habitat corridor for the grey crowned babbler GRL EIS p 4-273 to 276

"One Threatened Ecological Community listed under the TSC Act is present within the study area. The location, structure, habitat and species composition of the dry rainforest community (community 4) indicates that it constitutes the Vulnerable Ecological Community (VEC) *Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions.* GRL EIS p4-269

**Contradictions in AGL's REF:**

Where AGL reports on threatened species within a 10km radius, AGL refers to only a vague possibility of the occurrence of 2 threatened species – Grey-Crowned Babbler and Grass Owl: "Shrubs and juvenile Eucalypts in road reserves may provide habitat for the Grey-crowned babbler" 4.3 P 85.

NOTE: The evidence in GRL's EIS reporting nests and positively identifying a positive habitat corridor was publicly available in August 2013. AGL's REF was published in October 2013.

Implications: By not properly acknowledging the existence of threatened species and ecological communities near the pilot site, no valid risk assessment or impact statement can be made or assessed by regulatory bodies.

# *Risk Sheet 10: Rationale for Fracking*

There are two stated purposes for fracking:

**10.1. To see how much gas will come out of these wells**
"The purpose of fracture stimulation and pilot testing is to identify potential gas resources by testing the composition, flow rate and volume of gas in target coal seams." (REF ES.1)

**Issues:** The composition, flow rate and volume of gas are variable from one well site to another. It seems likely that the productivity of the four Waukivory wells will not give any certainty as to the productivity of future production wells. At least 12 exploratory wells have already been fracked in the Gloucester basin. If fracking these 12 wells has not already given sufficient information to extrapolate to the whole of the basin, we question how fracking an additional four wells will provide any more analysis of the size of the resource.

**10.2. To see whether the deep coal seams are connected to shallow aquifers**

The fracture stimulation and pilot testing program is also important to assess water production volumes and **whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones."** (REF Executive Summary p.1)

Paul Ashby, the general manager of commercial development at AGL's upstream gas business, made a similar statement:
*''[The] biggest fear that people have, that we will somehow have a connection from this deeper well location up to the surface and that is why we have those surface water bores because that is where all the beneficial aquifers [are] … down deeper than that there are sealed layers that make sure there is no interaction between that shallow water and the deep water and we want to make sure that that is actually the case,'' Ashby told a radio station.'*
(To frack or not to frack, Michael West SMH Published: October 17, 2013 - 8:04AM)

**Issues:**
AGL is admitting here that coal seams may be connected to shallow aquifers, i.e. fracking fluids, coal seam water and gas may migrate from the coal seams into our water resources (see Risk Sheet 4). In any case if this is a goal of the pilot we do not believe AGL can achieve it, for two reasons. Firstly, the geology of the basin is so complex that it is unlikely that connectivity in one area will be the same as in another. Secondly, AGL's groundwater monitoring program for this pilot program appears to be far too limited to provide sufficient robust information on the connectivity between coal seams and aquifers (see Risk Sheet 8).

**Contradictions with AGL's own information:**
AGL's human health and ecological risk assessments are based on the assumption that there is no or negligible connectivity. Their own admission that connectivity is unknown means the risk of impacts on human and environmental health is much greater than AGL suggests (see Risk Sheet 2).

**10.3. The fracture stimulation and pilot testing program is also important to assess water production volumes** and whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones." ES.1

**Issues:**
AGL is acknowledging here that they are uncertain about how much contaminated water will need to be disposed of.

**Implications:**
Planning and assessing whether holding dams and treatment procedures are adequate cannot be done with satisfactory certainty. In any case, if AGL could not collect reliable data on water production volumes during the previous fracking of 12 wells, we question whether they will be able to do so through the current pilot.

**10.4. Additional rationale is:**

"Doing nothing carries consequences for energy supply in the Hunter region and in NSW. …..South Australia's Cooper Basin…predicted to decline in a few years time" (REF. Vol 4. p 29)

Contradictory information:
The NSW Chief Scientist says:
NSW sources 95% of its gas interstate through the *"NSW/Victoria interconnect system drawing gas from the Otway Basin, Offshore of Victoria."* (Chief Scientists Interim Report, p. 23).

This interconnect system can continue to meet demand. BHP says there is enough gas supply for Eastern seaboard for decades to come. "Bass Strait field still has a large amount of gas that's undeveloped….plenty of gas…indefinitely." SMH May 15, 2012. (Also see Risk sheet 1)

**Contradictions in information:**
1. Pricing - AGL says without Gloucester gasfield, NSW will pay higher prices. (Gloucester Advocate 20 June 2012)

The Chief Scientist Interim Report says that rising prices will be a direct result of excess supply linking Australia to the export market; QLD will be able to get international pricing – meaning gas suppliers [including AGL?] will expect the same price to supply domestically. Chief Scientist Interim report P 23.

2. Environmental sustainability
AGL suggests that coal seam gas is clean (Gloucester update distributed November 2013). Greenhouse Gas Emissions: It has been conservatively estimated that the proposed activity and the flaring of natural gas from the Waukivory Project will involve the emission of about 65,000 tonnes CO2-e" (REF Quick reference guide p 3).

"Methane has a global warming potential, defined by the Intergovernmental Panel on Climate Change (IPCC), as 21 times that of carbon dioxide." (Chief Scientist Interim Report P91 10 Fugitive Emissions and Air Quality).

See Risk Sheets 2, 3, 4, 5 and 7 for other examples challenging that notion of 'clean'.

# *Risk Sheet 11: Inadequate Environmental Incident Response Plan (EIRP)*

**Risk 11.1: Contractor Training (EIRP p8)**
Specific plans for contractor-developed EIRP not shown. Specific plans for contractor training not shown. **It is unclear who will be responsible for any incidents that may arise.**

**Risk 11.2: Incident Classification (EIRP p15)**
No category for damage to underlying aquifers.

**Risk 11.3: Release of gas is listed as a serious incident. (EIRP p15)**
Despite the 'serious' ranking, there seems to be no specific plan for how to monitor the release of gas. (See Risk Sheet 6: Air Quality and Methane) There is no response or specific plan to remediate damage. There is no mention of release of gas in the Hazard Risk Register (Appendix A).

**Risk 11.4: Risk of cross-contamination of aquifers underrated**
Item 3. "Low permeability aquitard layers exist between shallow beneficial aquifers and target coal seams." (See *Risk Sheet 4: Connectivity* for challenges to this statement)

Even if this statement was proven, any level of permeability, even 'low' as suggested in Appendix A, Item 3, means there is connectivity. The fact that 'low permeability' has not been proven indicates that the real risk is much higher than the Hazard Register indicates. But more of a concern for fracking is the several fault zones intersected by the pilot wells. Without a detailed fault seal analysis, the Chief Scientist's report says it is reasonable to assume that the fault zones would provide pathways of hydraulic connectivity from the coal measures to the near surface.

**Risk 11.5: Mitigation no 6. "monitoring changes in flowback chemistry"**
The adequacy of the monitoring requires scrutiny. For example, what change in flowback chemistry would indicate a risk and initiate a response? What specific response is indicated?

**Risk 11.6: Mitigation no 8. "faulting is mapped…zones selected for stimulation are away from faults"**
We question the assertion that fracking away from faults mitigates risks inherent in fracking in a faulted area. Dr Rick Evan's review (2012) states interconnection of coal seams and the water table can occur:

"if fracking intersects a fault or fracture zone and there is preferential flow along the fault or fracture zone. There are known faults in the Gloucester Basin so there is potential for this process to occur."p44.

In terms of reducing this risk sufficiently, Evans states:

*"Siting CSG wells away from faults is an important, but not necessarily sufficient control, to prevent the impact of faults acting as potential preferred pathways*".p42

**In any case, AGL has not adopted the important control suggested - to site CSG wells away from faults. The wells they intend to frack intersect with "several" fault zones (FSMP p 13).**

**Risk 11.7: Item 4. Changes to groundwater levels**
While the risk includes "changes to groundwater pressure and levels; or surface water levels and flow", there is no mitigation in the mitigation column other than "Groundwater monitoring program". (See Risk Sheet 7 for inadequacies in monitoring program) **There is no response given (action to be taken) should changes in groundwater levels occur.**

***Risk 11.8: Item 7,8,14. Air pollution***
AGL admits these potential effects: "fine and fluid mists may blow into the atmosphere", "Offsite dust impacts" and also "greenhouse gas emissions".
These risks seem to relate to vehicle emissions, road dust and escaping fracking fluids in the form of mists. They state that as the nearest residence is 200m from the site, the risk is mitigated. This assertion is not supported by any data. There is no supporting data to show which direction mists will blow with prevailing wind or how far the mist could blow (see Risk Sheet 7).

There is no item in the Appendix for air pollution relating to flaring. There doesn't seem to be any mention of flaring throughout Volume 7 of the REF. (See Risk Sheet 7)

There seems to be no item in the Appendix for fugitive emissions of methane and airborne toxins, which experience suggests can leak into air and surface water along the length of faults that subcrop near the surface and through bores (see *Risk Sheet 4 Connectivity*).

**Risk 11.9: Item 11 SRB effect on steel integrity**
While AGL states corrosion by SRB is potentially corrosive to well structure (p7), SRB is not listed as a Risk in Appendix A. The EIRP only relates to short-term issues. There are no mitigation measures listed and no monitoring of the effect of biocides on SRB over time is included. There is no response plan for this issue. (See *Risk Sheet 6 SRB*).
The need to monitor SRB levels to determine efficacy of biocides is highlighted here:
http://twinoxide.com.au/pdf/industryBiocides.pdf

**Risk 11.10: Item 18 "Interaction with unrecorded wells that have not been properly plugged and abandoned, causing connection with other subsurface layers or surface"**
(see Risk Sheet 4 Connectivity)
Mitigation for this issue is that wells within 600m will be properly plugged and abandoned. Issue: To what degree of certainty can AGL or regulators confirm that all bores have been located? No mapping of unregistered bores is available in this document. Is 600m an adequate radius? There is no indication of what 'properly plugged' means and no technical specifications.

Implications:

1. It is impossible for AGL or regulators to assess risk or adequacy of mitigation.

# *Risk Sheet 12: Health Impacts*

The 2km Buffer Zone for CSG Mining was introduced in NSW because of health impacts that CSG exploration and mining can have. The premature granting of AGL's conditional license by the previous government means the people of Gloucester are excluded from the protection of the 2km buffer zone that other communities receive. The population within AGL's exploration area (PEL285) is over 6300 people so even for an exploration activity covering a small surface area, many people will live in the potential impact zone. AGL does not deal with this issue in their REF.

***Issue 1:*** **How many people live within 2km of the gas wells?**
The whole of the Forbesdale estate (33 homes), part of the Avon valley estate, individual farms and homes along Bucketts Way, plus the homes on land owned by mining companies within the area. This amounts to almost sixty homes, which equates to nearly 200 persons.

***Issue 2:*** **What is the medical evidence according to Australian health experts?**
220 submissions were sent to the Chief Scientist on this subject, including from Australian Medical Association, Doctors for the Environment of Australia, Public Health Association and the National Toxics Network. They conclude in a joint statement that

**"...Unconventional Gas Mining poses multiple serious threats to human health and the environment..."**

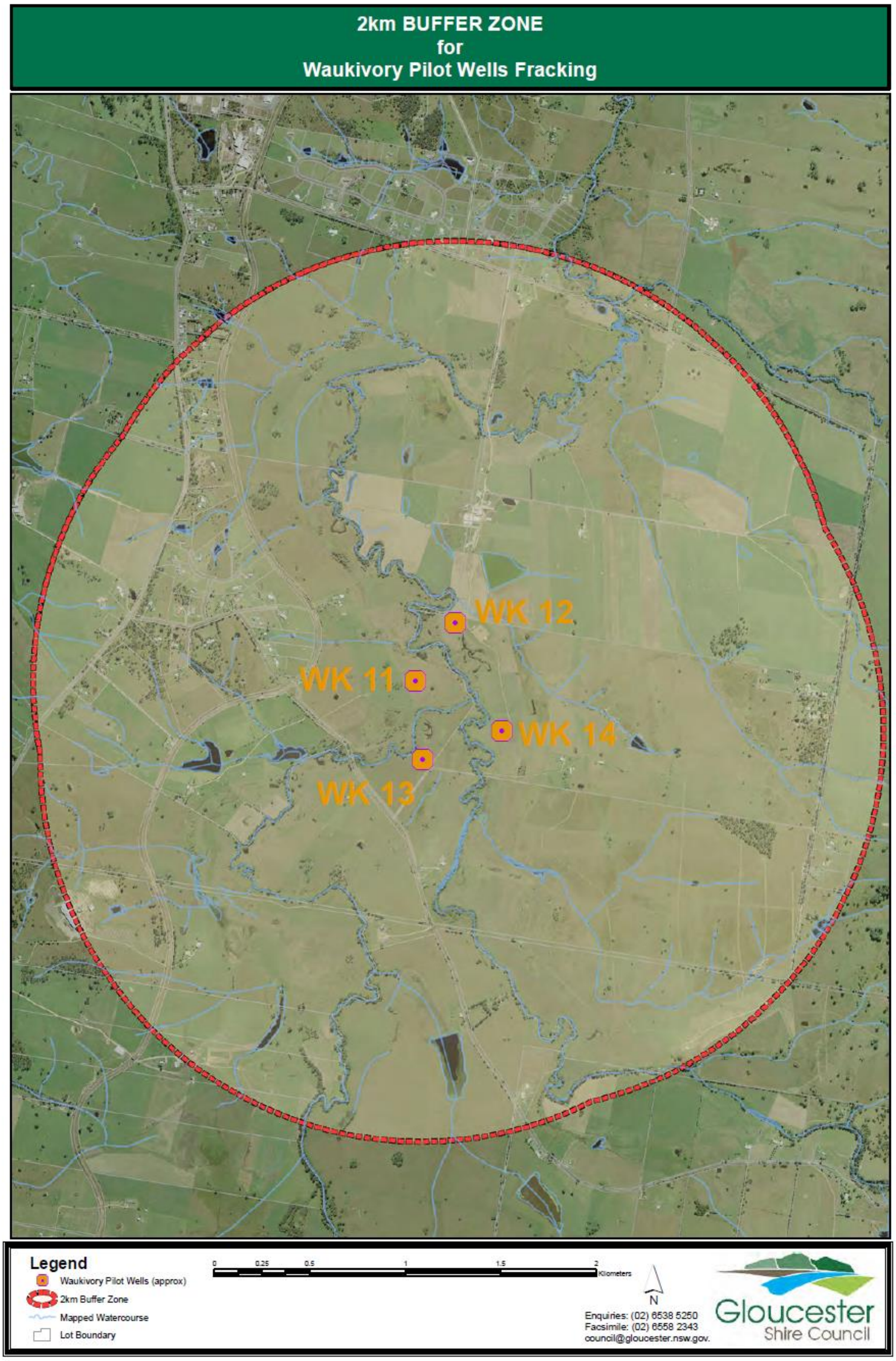
The numerous health risks from hydrocarbons, heavy metals, radioactive material, fracking chemicals etc polluting air, surface water and ground water and the risks from explosion all point to this project being grossly inappropriate in such a populated area. The health damage to a similar but less heavily populated rural residential community at Tara, Qld is graphically described in the report "Symptomatology of a Gasfield" by Dr Geralyn McCarron. She particularly is appalled at the **apparent neurotoxic effects on children.**

**The Australian Medical Association stresses that Health Impact Assessments should be essential for such projects.**

AGL has expressed no intention to complete one for Gloucester. (See *Risk sheet 7* for AGL's failure to collect basic air quality data).

If this apparently dangerous project is still considered essential for AGL, they should fund independent and comprehensive baseline health monitoring so that assessment of future impacts is possible and post a bond of many millions to compensate the people of Gloucester should they experience the kinds of health impacts reported by other communities living near gasfields, as well as the 75,000 water users downstream.

Comprehensive reports on fracking and health:
http://www.tai.org.au/content/fracking-good-your-health


2km BUFFER ZONE
for
Waukivory Pilot Wells Fracking
WK 12
WK 11
WK 14
WK 13
Legend
Waukivory Pilot Wells (approx)
2km Buffer Zone
Mapped Watercourse
Lot Boundary
0
0.25
0.5
1
1.5
2
Kilometers
N
Enquiries: (02) 6538 5250
Facsimile: (02) 6558 2343
council@gloucester.nsw.gov.
Gloucester
Shire Council

# Concluding Statement

We believe that AGL's application to frack four CSG wells in Gloucester (REF) contains inaccuracies and contradictions. It is inadequate in regard to water monitoring and assessment; risk assessment and response planning; lacks a health impact statement and is reliant on previously challenged data. .

AGL has acknowledged their lack of understanding of the geology of their project area both explicitly and by implication through agreeing to fund independent water studies. It is simply unacceptable for AGL to attempt to frack before they have an adequate understanding of the hydrogeology and the damage they may cause to human health and the environment, as well as to local and regional businesses which rely on clean water, soil and visual amenity.

We call on the NSW Government to reject AGL's proposal to frack at Gloucester on the grounds that the REF does not adequately meet the mandatory requirements of the Code of Practice for Coal Seam Gas Fracture Stimulation Activities.

We call on the NSW Government to publish all Departmental responses to the REF.

We call on the NSW Government to place a moratorium on all coal seam gas exploration until the Chief Scientist's recommendations relating to adequate regulatory rigour are implemented.

We call on AGL to cease all CSG exploration in the Gloucester Basin until all of the following are complete:

1. Independent review of the Review of Environmental Factors and implementation of all recommendations.

2. All pending water studies with independent reviews and implementation of the recommendations of:

    a. Chief Scientist's review into CSG
    b. Gloucester Council's joint review of water studies
    c. Bioregional Assessment of whole Gloucester basin.

3. Comprehensive Health Impact study:

    a. Baseline health screening and ongoing monitoring system for all residents within 2km of gas wells and infrastructure including pipelines
    b. Independent Enquiry into existing health concerns in Tara and Camden
    c. Independent review of International Research into health impacts
    d. Compensation agreements in place for future impacts for local residents and downstream users.

4. Robust, independent baselines and monitoring systems for airborne pollutants and methane levels in water sources.

5. Research and modelling into interaction between coal mining and CSG and impacts of seismic activity – both natural and induced - on well integrity.

6. Specific, independently reviewed plan for management, treatment and disposal of flowback water and produced water for both pilot and production activities

7. Development of appropriate compensation agreements for drop in property values for all landholders within 5km of gas wells and associated infrastructure.

Appendix A

## Commentary: Problems with meeting the requirements of The NSW Code of Practice for Coal Seam Gas Fracture Stimulation Activities (CoP)

**Note:** On 21 November, 2013 the Victorian Government extended its ban on fracking until at least July 2015.

A preliminary comparison of The Code of Practice for Coal Seam Gas – Fracture Stimulation Activities (CoP) and AGL's REF has identified these apparent issues:

- We note that the CoP was published in September 2012. According to k) in the Preliminary of the CoP: "This document will be reviewed 1 year after commencement…" This is not AGL's problem, but as far as we know, the regulator has not reviewed the CoP.

- Mandatory – under CoP 1.2 a), "if the sensitivity of potentially affected environmental, land use or community features significantly increases" FSMP must be reviewed. Community sensitivity has certainly increased greatly.

- Mandatory – under CoP 1.2 g) "the FSMP is a public document and may be published by the department…." Then why is there no pubic submission period for FSMPs which are part of a REF?

- Mandatory – under CoP 3.2, "design….. must be described in the FSMP….must incorporate…..:
  c) identification …..the extent of natural fracturing
  d) determination of geological stress fields and areas of faulting
  f) modelling of the likely fracture propagation field, including extent and orientation".

- Mandatory requirements, Sect 4.2 for Risk assessment does not specifically require consideration of flooding. This should certainly be a requirement for this project. AGL refer to their "Flood Management Plan" 4 times in the REF, but it appears from our searches that they chose not to include it in the REF. This is very surprising considering that 3 of the 4 wells are on the flood plain and, as far as we can tell, their flowback water will be stored in open top steel containers or turkey nest dams on the floodplain.

AGL's FSMP states:

- Section 2.4 p13 "To identify faulted areas prior to drilling, AGL conducted a 3D seismic survey to assist in well placement. This allows AGL to place wells away from high angle vertical faults and only intersect low angle faults."

- It goes on to say "The several large fault zones intersected by the Waukivory pilot wells have been confirmed by image logs acquired as part of the logging of the wells. These image logs allow accurate identification of the location of faults and their dips. Zones were selected for fracture stimulation located away from these faults."

- And again "As a further mitigation for fracture stimulation treatments to migrate up faults, real-time pressure monitoring will occur throughout the program...." And AGL will … .use "geophones in a nearby monitoring well".

These statements by AGL together with the requirements of the CoP raise many concerns:

- They confirm that the geology is incredibly complex in the area of the pilot study.

- AGL has not provided a detailed description of the faults and fractures in the area of the pilot program, but we know there are at least "several large fault zones intersected by the Waukivory pilot wells….".

- As far as we are aware, AGL has not published information on the outcome of their 2D and 3D seismic surveys. So there is no mapping of the faults available to the public. We understand that the 3D surveys identify the location and dip of faults. One would assume that they the depth of the faults is also critically important information in order to direct the fracture stimulation away from them.

- The FSMP is required to include a description of the "….areas of faulting..." but this has not been done.

- The FSMP is required to describe the modelling of the likely fracture propagation field, including extent and orientation. This has not been done. They have said that the data collected will be 'incorporated to refine future fracture modelling.' It is very unclear whether to proposed monitoring program will really assist with this (See Risk Sheet 8).

**Appendix B**

# *AGL's Addendum*

**The issue:**
AGL posted an addendum to the REF in response to requests from regulatory bodies to address issues in the REF. The Preferred Activity Report (PAR) does very little to alleviate any of the concerns of Groundswell Gloucester. In fact in some areas, it only leads to a greater level of concern.

**The AGL addendum is cross-referenced with our risk sheets and with Appendix C Tiedmans Trial Critique here:**

**Risk Sheet 2: Toxic Chemicals in Fracking Fluid**
Risks identified in Risk Sheet 2 have not been addressed.

**AB 2. 1 EPA requirement not met**
The EPA identified the need for an assessment of:

"additive toxicity risks to surface waters due to potential combinations of undiluted chemicals related to handling, storage and mixing methods;
assistive/antagonistic effects in made-up fracture fluid, taking into account the quality of source water, in particular if sourced from existing dams containing CSG exploration water; (Addendum p2)

AGL declined to conduct an assessment of synergistic or antagonistic effects of mixtures of chemicals as it is too difficult:

"The HHERA assesses individual chemicals in the fracture fluid. Synergistic or antagonistic effects of mixtures of chemicals in hydraulic fracture stimulation have not been assessed as such an assessment is extremely complex as not only the chemicals included in the mix need to be taken into account, but also chemical and physical interactions with substances present in the geologic strata where the fluids are applied." p22

**AB 2.2 Inadequacy in flowback fluid plans**
AGL is inconsistent in statements about flowback fluid, which at some point AGL will determine is 'produced water' and use it to irrigate crops (also see AB5.3).

AGL still has not identified in detail, how it will differentiate between flowback water and produced water. Simply using an EC value is not acceptable, particularly when the Chief Scientist's July report states that 50 to 85% of flowback water may be retained within the coal seams (see Risk Sheets 2 and 5).

Addendum Section 2.6: "Water storage is required for flowback water, which is expected to occur immediately after the fracture stimulation program (and may flow back for several weeks or months),…." This is not consistent with AGL's assurances that flow back water will be evacuated and become produced water soon after fracture stimulation is completed.

**Risk Sheet 3: Flooding at Test Site**

It would appear that AGL are still not taking flood risks seriously. It is appalling enough that AGL was granted approval to construct three of the four wells on a floodplain in the first place. Now they are showing on Figure 2.2 and 2.3, that the 100m x 100m pad for WK 13, which is where the “water staging point” (i.e. fracking chemicals and produced water storage) will be located, is immediately adjacent to the Avon River and the turkey nest dam is indicatively shown just inside the fence close to the river.

**AB 3. 1 No detailed flood study**

No detailed flood study has been provided. AGL has completed modelling based on a preliminary flood assessment conducted for the Rocky Hill Mine EIS. No new information is presented to alleviate concerns of design capacity to withstand major flooding.

**AB 3. 2 Inadequacy of data and flowback fluid storage**

There will now be one open dam for storage of flowback fluid, rather than one at each gas well. The freeboard for this dam has been increased from 450mm to 500mm, to potentially withstand the 1 in 100 year flood level. The adequacy of this for design is still questionable. In addition, there is still no data on extreme rainfall so it is still not possible for regulators or AGL to determine adequacy of the freeboard to withstand spillage.

**Risk Sheet 4: Connectivity of Coal Seams and Beneficial Aquifers**

**AB4.1 Inadequacy in meeting OCSG requirement on beneficial aquifer impacts**

OCSG asked AGL to “assess depressurization of the alluvium, shallow rock and also the potential for impacts on groundwater levels at the outcrop areas.”

PB did modelling, found in Addendum Vol 2 – Appendix C – Groundwater Modelling, including the consideration of faulting in Pilot Study area. It was a very brief study that suggested that water table lowering was negligible after 24 months of pumping from coal seams. There is minimal information provided – a three page written report plus three figures. This modelling and the associated report is completely inadequate and does nothing to allay concerns about the impacts of depressurisation and water table drawdown.

The modelling does not relate to the requirements of the CoP re the modelling of 'likely fracture propagation field, including extent and orientation'."

As incomplete as it seems to be, the modelling is also questionable in terms of validity of its data and therefore its conclusions. The modelling relies, at least partially, on data from Parson’s Brinkerhoff Consulting report which PB asserted showed low connectivity between coal seams and aquifers. This assertion has been comprehensively challenged by Dr Rick Evans, Dr Philip Pells and by a previous AGL report commissioned through SRK (See Risk Sheet 4). Reliance by the modeller on comprehensively challenged data would indicate that the modelling provided in the addendum is invalid.

It is understood (Gloucester Shire Council, pers comm) that all approvals are now completed for Dr Rick Evans and Sinclair Knight Mertz (SKM) to be contracted to the GSC to provide consulting services and detailed peer reviews. This will include review of three of the fundamental reports, two of which are referenced for this modelling and being used as a basis for the basin numerical modelling by AGL. It is planned that Dr Evans will commence this work in the near future as part of the GSC/AGL Gloucester Water Study which is funded by AGL.

The two reports, as referenced in the letter on modelling in Addendum Vol 2 Appendix C are:

- Parsons Brinckerhoff (2013a) *Hydrogeological Conceptual Model of the Gloucester Basin*, Report PR_7266, dated June 2013
- Parsons Brinckerhoff (2013b) *Water Balance for the Gloucester Basin*, Report PR_7296, dated July 2013

The third report Dr Evans will be reviewing is AGL's most recent annual report on water monitoring for 2013. Due process requires that these three reports should be subject to detailed peer review before the pilot study commences. We acknowledge that Dr Evans showed some support for the need for the flow testing at the Waukivory the pilot site. However it would appear that Dr Evans previous terms of reference specifically did not include full consideration of the likely impacts of fracking (See Risk Sheet 1 for review of Dr Evans' comments on the Waukivory Pilot).

It is deeply concerning that AGL would provide regulators with such a broad brush modelling exercise that must use very limited data in the area of the pilot program, some of which is based on AGL reports (eg PB 2012) shown to have major shortcomings by Dr Evans and others.

**AB4.2 Information on Faults**
AGL continues to acknowledge that they have insufficient knowledge of faulting in the area. This would indicate that neither AGL nor regulatory bodies can satisfactorily assess risk inherent in the Waukivory fracking pilot with current information. (Also see AB10.1)

AGL references to faults are given below:

- Hydrological Conceptual Model of the Gloucester Basin by PB June 2013
  - 4.3.4 Geological setting – Faulting
  - 5.5.1 Influence of faulting on groundwater flow – Faulting and groundwater
  - 5.5.2 Influence of faulting on groundwater flow- Fault investigations
  - 6.3.3 Groundwater flow – Role of faults

- Hydrological Investigations of one strike-slip fault in the Northern Gloucester Basin was undertaken by PB, August 2013. We have not been able to locate this report. It has not been peer reviewed and in any case only relates to only one fault. The Pilot program intersects several faults and the Stage 1 area intersects many, many more. See Risk Sheet 4 for discussion of differences between faults and dubiousness of extrapolating data from a single fault to others.

- 3D Seismic Investigations - No report available to the public

While there is some useful information in the mentions of faulting in reports noted above, together they confirm how little is known about faults (Also see AB10.1, below).

This confirms that the extent to which AGL or regulators can determine the risk and likelihood of fracking fluid, produced water and gas migration is questionable at best.

**Risk Sheet 5: Management of Fracking Fluid**

**AB5.1. Continued high risk of flowback fluid spills**
Little additional information is provided to show that flowback fluid stored in the open dam on the banks of the Avon River is not at risk of spilling over during flooding or extreme rainfall, or in dam failure such as has occurred elsewhere in NSW and Queensland in coal/CSG operations.

"The height of the sides of the dam will be a minimum of 500 mm above the 1 in 100 year annual exceedance (sic) probability (AEP) flood level……"

The standard approach adopted by AGL to plan and design water storage dams is to approach a construction contractor such as the NSW Government owned Soil Conservation Service to undertake a design and construction plan for the dam."……." The double lining will cover the outside of the dam which will provide erosion protection in a flood event."

A quick search of the Soil Conservation Service (SCS) website indicates that it would have the capability to do this work although it does not provide any examples where this has been done for the coal/CSG industry and certainly not on a floodplain. It is mainly involved in works associated with returning degraded soil to farmlands to be used for sustainable agricultural purposes as well as the construction of earth dams for farm water supplies. It is noted that the SCS's website states that: "The percentage of clay, silt and sand present in soil is crucial to the construction of earthworks such as dams."

Given this stated "standard approach adopted by AGL" and according to AGL, the imminent start of construction that is proposed, it would be appropriate for AGL to provide an appropriately detailed design for the turkey nest dam for consideration by the regulators, including:

- a geotechnical investigation at the actual proposed location of the t/s dam;
- detailed design and drawings including the dam cross-section;
- the proposed source of soil to be used for embankment construction (as the soil on the floodplain is likely to be very unsuitable);
- the AEP flood probability levels at the base of the earth dam;
- estimated velocities of floods around the embankment;
- proof that the lining material can withstand expected upward pressures at the base of the dam during flood events; and
- Proof that lining materials on the outside of the dam can be used to withstand major flooding events.

**AB 5.2 Inadequate Mitigation for flooding and flowback fluid spillover**
Mitigation for spillover is that:
'Weather will be monitored and in the event of a flood pumping will cease and any flowback water levels will be decreased through transportation to appropriate facilities" p25.

AGL's approach to avoiding problems associated with severe weather events is highly questionable. Such events can occur with very little warning. Without a detailed flood study, necessary lead time to enact any response is unknown. Even if sufficient lead time was available, the likelihood of water tankers being able to reach the turkey's nest dam in order to be pumped out also seems fraught with difficulties, with access cut by floodwaters or trucks becoming bogged on a very soggy floodplain.

The fundamental problem is still that it should not be necessary to construct a turkey-nest dam directly adjacent to the Avon River because these wells should never have been drilled on the floodplain. No matter what mitigations AGL may come up with, this is the wrong place for a pilot program involving fracking and flaring.

**AB5.3 Continued lack of detail in extraction of fracking fluid**
No convincing new information is provided on how AGL will determine that 100% of fracking fluid will be returned. Reliance on salinity measures to show that the water abstracted is now produced water is inadequate. There still seems to be no analysis for remnant traces of chemicals and constituents, prior to flowback water being renamed 'produced water' and irrigated onto fodder crops. (Also see AB2.2)

**AB5.4 Continued lack of detailed information on fate of flowback fluid (fracking chemicals)**
According to Section 2.7.2, AGL will transport "flowback water by truck for lawful disposal at an appropriate facility". Again, why is it that AGL still have not determined where this disposal facility is located?

**Risk Sheet 6: Sulphate Reducing Bacteria**

**AB6.1 Continued inadequacy relating to SRB**
There seems to be no new mention of SRB in the Addendum, but we note that AGL says Tolcide is the most hazardous chemical and is a 'short kill bactericide and degrades rapidly in the environment'. p39.

The problems identified in Risk Sheets 2 and 6 are confirmed here: that Tolcide should not be released into the environment in any case, but also that its efficacy in controlling the corrosive impact of SRBs may be short-term and this efficacy is not being monitored.

**Risk Sheet 7: Air Quality and Methane**

**AB7.1 Continued absence of monitoring of air pollutants at residences**
No new information seems to be provided on collecting local baseline data near residential homes, despite 50 homes being within 2km of the fracking site. No new information is provided of any ongoing monitoring plans.

**AB7.2 Continued inadequacy in Methane Monitoring**
We note the mention here of 2 methane emissions monitoring points at the outcrop of the Roseville coal seam (p25). We maintain that this is grossly inadequate, as there are many more potential points at which methane may escape, both through natural formations, induced connectivity, and from gas field infrastructure.

## Risk Sheet 8: Water Monitoring: Useful Data?

There is a distinct pattern in AGL's publications, including in the addendum, of "talking up" their monitoring program. For a large project such as the proposed Stage 1 gasfield, with a pilot program located within a water catchment, their water monitoring program is very limited and definitely needs to be reviewed by an independent hydrogeologist such as Dr Evans.

While reference is made in the addendum to water monitoring that was not presented in the original REF, it seems there are no changes to the monitoring program surrounding the pilot area to indicate that the issues identified in Risk Sheet 8 will be addressed.

### AB8.2 Inadequate monitoring in the Avon River

A plan to conduct surface water monitoring of the Avon River is presented in the Addendum, but it seems that the monitoring has not begun. Flows in the Avon River vary dramatically across a 12 month period so unless baseline data is collected for at least a bare minimum of 12 months, it is highly unlikely that valid comparisons of the natural state of the river and the impacted state will be possible.

### AB8.3 Inadequate monitoring and response to drawdown

AGL states that if drawdown occurs in shallow aquifers an 'adaptive management approach will be used to prevent environmental harm'p34. There are four problems here:

1. Identification of drawdowns may not be possible considering the inadequacy of baseline monitoring.
2. If significant drawdowns occur, environmental damage may have already occurred; ie naturally available water levels have been impacted.
3. When stage 1 is fully commissioned, AGL could use all four exploration/production wells operating at the same time.
4. There is no detail in terms of what 'adaptive management' might mean so regulators cannot possibly assess the adequacy of such management. If depressurisation/drawdown problems do occur, the monitoring program will give very little information to enable adaptive management to be applied.

### AB8.4 Inadequate baseline data

Again AGL tries to overstate their baseline monitoring by saying; "Groundwater level and water quality data in the broader monitoring network have been collected since January 2011, representing 35 months of baseline data." Only two samples over 35 months does not constitute even a minimal baseline. Also questionable is the baseline for the 3 designated monitoring bores near the pilot program. At least two of the monitoring bores directly surrounding the pilot site were not operational as of October 2013. In addition, we understand that one monitoring bore has recently failed and been decommissioned. Whether reliable data has been collected from this bore is questionable. It is unclear whether this monitoring bore will be replaced with another. If it is, then we presume a significant delay will be necessary so that adequate baseline data can be collected from the replacement monitoring bore.

**AB8.5 Inadequate and inappropriate monitoring locations**
In the numerical modelling provided in the addendum, as problematic as it is, AGL suggests impacts will be localised. While this statement is questionable in itself, if it is correct, then long-term, verifiable baseline data and subsequent monitoring in the vicinity of the wells is paramount. Relying on only broader basin baselines and modelling is not appropriate and will not allow AGL or regulators to determine impacts, as required by the CoP.

**AB8.6 Inadequate number of bores**
In Section 2.7.4: AGL continues to claim: "There is a substantial groundwater monitoring network across the Gloucester Basin with 45 AGL groundwater monitoring bores installed for baseline and ongoing monitoring of the GGP. There are four in the immediate vicinity of the Waukivory Pilot……"

When the size of the Gloucester Basin is considered as well as the number of aquifers, aquicludes and coal seams, this number of monitoring bores is definitely not substantial. As we understand it, one of the four monitoring bores referred to here, has failed and this happened well before the PAR was submitted. Also, their only deep monitoring bore which will have "multiple VMPs", will only be available for water monitoring after the fracking has been completed on all four wells.

**Risk Sheet 9: Ecosystems and Threatened Species**

**AB9.1 Continued inadequacy in identification of ecosystems and threatened species**
Issues identified in Risk Sheet 9 do not seem to be addressed in the addendum. AGL now acknowledges the Weeping Lilly Pilly but asserts risk is low due to known low permeability described by PB 2013. Again, AGL is repeating a PB finding:-
"Imply recharge to deeper hydrogeological units via vertical or lateral seepage is very slow" (PB 2012) - that has been refuted in their own peer reviewer's 2012 report by Dr Rick Evans (see Risk Sheet 4).

Indeed, AGL again confirms that low permeability is not proven as indicated by their own rationale for the pilot – to determine permeability (see Risk Sheet 10). It seems that the risk to the acknowledged Weeping Lilly Pilly and other unacknowledged ecosystems remains.

There is still no acknowledgement or assessment of a number of threatened species.

**Risk Sheet 10: Rationale for Fracking**

**AB10.1 No additional rationale is given**
One mention of a previously acknowledged rationale is confirmed in the numerical modelling letter:
"The exact nature of the thrust fault in the areas of the Waukivory Pilot is not known and is one of the main reasons for conducting the pilot" p 2/3.

This is further confirmation by AGL that they do not understand the connectivity of coal seams and beneficial aquifers or the extent to which faulting may increase connectivity, meaning risk assessments based on an assumption of low permeability cannot be validated.

**Risk Sheet 11: Inadequate EIRP**

11.1 No new information seems to be given that improves the adequacy of the EIRP.

**Risk Sheet 12: Health Impacts**

12.1 No new information seems to be given addressing health impacts.

**Appendix C Tiedmans Trial**

Groundswell Gloucester has serious concerns about the Tiedmans "Trial". As explained in Appendix C, it seems to be more a way to dispose of produced water during the pilot testing stages rather than an authentic, well designed, trial.

**AB.C1 no plan given for a portion of produced water**

Section 2.2: "AGL proposes to re-use a portion of the produced water for irrigation of crops at the Tiedmans property….". What does AGL propose to do with the other "portion"?

**AB.C2 Lack of contingency plan**

"On 5 November 2013, AGL lodged an application with the OCSG requesting an extension of the approval granted for the Tiedmans Irrigation Trial for another 24 months from July 2014." AGL is awaiting an approval to extend their irrigation trial at Tiedmans. Their application to extend the trial was lodged on November 5 with the Office of Coal Seam Gas. There is no opportunity for independent community comment on this application (see Appendix C).

AGL states that if the Tiedmans trial does not continue, produced water from the Waukivory pilot will be held until the Stage 1 gasfield becomes operational. In the interim, the risk of extreme weather causing overflow of the produced water remains. In any case, it seems AGL has a surprising and unseemly level of confidence that regulators will be satisfied that the conditions of approval for the Stage 1 gasfield will be met. We also do not share AGL's confidence that the Stage 1 gasfield will be commercially viable in the face of a lack of social licence amid growing community concern.

**AB.C3. Excerpt from REF Addendum relating to Tiedmans Trial**

2.7.3 Produced water re-use options

As described and assessed in the REF, beneficial re-use of produced water is the preferred option. The full range of produced water re-use options considered for the preferred activity is described in Section 2.8.7 of the REF.

Given the relatively small volumes of produced water expected from the preferred activity, the only viable options are:

- drilling water, hydraulic fracture stimulation water required for future pilot testing programs;
- livestock stock water; and
- irrigation.

The Waukivory Pilot will utilise the water management plan on the Tiedmans property which was approved by DTIRIS-DRE in 2012. An application for the extension of the Tiedmans Irrigation Trial approval is currently pending with the OCSG to extend the period within which works under this approval may be undertaken. This strategy involves blending the produced water generated from flow testing programs with fresh water sources and irrigating. The results from the current pilot irrigation at the Tiedmans property (the Tiedmans Irrigation Trial) demonstrate that produced water from pilot wells can be beneficially re-used for the irrigation of crops.

The three options listed are inadequate.

- The Commonwealth approval requires consideration of re-injection of the produced water into groundwater systems so this should be tried as an option.
- Reverse osmosis to reduce the pollutants in the water should be tried so that the water can be used safely for crop irrigation, stock water or environmental flows.
- The concept of using the untreated produced water for livestock water is a new concept that is not sensible given the chemical composition of the water.

To suggest that "the results from the current pilot irrigation at Tiedmans (in above excerpt) demonstrate that produced water from the pilot wells can be used beneficially for the irrigation of crops" is not a statement that can be supported by any facts.

- The trial has only operated for 8 months and only 2 irrigations have been tested
- The soil results from these irrigations are inconclusive at best and indicate potential soil salinity increases
- The trial design is actually flawed and will not be able to prove anything about reuse
- Test results from the fodder are not yet available to indicate the level of heavy metals taken up by the plants from the irrigation water

We question this mention of an application to extend the trial. We urge authorities to consider the information and respond in detail to Appendix C and actively and transparently consult with community groups and independent experts before considering whether or not the Tiedmans trial extension is approved.

**Review of additional, new risks raised by the Addendum:**

**AB13.1 Risk in Drilling under the Avon River**

Additional risks are evident in the planned underbore drilling of the Avon River Section 2.6.2:. AGL plans to bore horizontally under the Avon River for a distance of 80m in order to construct an underground pipeline to carry fracking fluids and coal seam water from gas wells to the holding dams on the other side of the river. While HDD is a well-known technology for putting pipes under roads, railway lines etc., there appears to be risks in doing this in alluvial plains under creeks.

The second and third paragraphs on P17 talk about; "….high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. " and "The bentonite content of the drilling fluid is critical for drilling boreholes through rock."

Although no information is provided about the ground conditions at the river crossing, one would expect that there will be alluvial soils, both near the surface and down to the maximum depth proposed of 4 metres or 2 metres below the river bed. It would be unlikely that there is any solid "rock" as stated above. There is a distinct possibility of relatively unconsolidated soils which would cause considerable problems for HDD using bentonite. The possibility of water ingress and bentonite loss could be high. It is noted that AGL state that:

"The depth of underboring will be more than 4 m below the bed of the Avon River as shown on Figure 2.6." while the, HDD – Fluid Management Plan, Appendix A, Section 5 on Safeguards states that "There will be a minimum of 2m cover below water courses.

Watercourses will be monitored by an observer for visual triggers such as changes to turbidity or other visible disturbance to in the unlikely event that a breakthrough occurs ." Besides the inconsistency on depth, the concern about possible breakthrough is clear.

Again, AGL should provide more information about actual soil conditions rather than have their consultants do what appears to be a desktop study. It may be necessary to sleeve the water pipe under the Avon River in this situation.

**AB13.2**

**Section 2** and Figures 2.3 to 2.5: It is unclear as to why the Office of Coal Seam Gas (OCSG) is still being provided with "indicative" locations of pilot wells and "conceptual" site layouts when, according to AGL, the start of this pilot program is imminent.

**AB 13.3**

AGL declines to monitor with passive diffusion bag samplers as per NOW's recommendation.

**AB13.4**

A determination of whether the Waukivory Pilot had sufficient impacts to be assessed under the EPBC Water Trigger was completed by AGL. This self-assessment is not provided.

**Appendix C**

# Problems with AGL Tiedmans Irrigation Trial Design - Summary

AGL promote the Tiedmans trial as a 'first in NSW' for using blended water produced during CSG extraction to irrigate crops. The AGL "Fact Sheet: Gloucester irrigation trial" describes how 70ML of produced water is blended with 100ML of fresh water and then applied to 12ha of fodder crops with a spray irrigator. Four different soil management treatments have been applied and two crop types are grown on these in 16 plots. A range of soil and water testing is undertaken at 6 month intervals.

The first problem in the design is that the soil data is averaged across all the 16 plots so there is no possibility of analysing for treatment differences. One reason for this is that there is only 1 sample site per plot (0.77ha in size) and this is absolutely insufficient to get an accurate measurement for any of the properties being tested. Only half of the plots are tested for soil moisture so this data is meaningless.

The second problem is that only one grade of water salinity is used across the whole area irrespective of the soil treatments or crop type. Therefore, it is not possible to look at any differences in the soil or plant reactions to the amount of salt being added through the irrigation water.

The third problem is that irrigation water is applied to all plots at the same time regardless of differences in soil moisture content. The 'trail' reports talk a lot about irrigating to maintain a soil moisture deficit but this is meaningless when the data is not analysed separately for the various treatments. When all plots are irrigated some will be already saturated and others will be dry. This will impact on runoff and plant growth.

The fourth problem is that the treatments are very intrusive because the slots are 200mm wide at 1500mm centres across the plot and 0, 300, 650 and 900mm deep. A mixture of organic matter, lime, gypsum and zeolite is then buried in these slots and spread across the surface. This means that there are large trenches of varying depths in the plots and these trenches will allow irrigation water and rainfall to move into the subsoil to varying amounts. This difference is not being measured in the design. In fact there is no information in the reports as to whether the sampling site is near a slot, in a slot or up to 600mm from a slot. Again this means that the data from various plots cannot be compared and is probably the reason why AGL is averaging the data across the whole area even though this makes the measurement meaningless.

The fifth problem is that all lucerne plots are harvested on a common dates and all triticale/sorghum plots are harvested on a common date. Therefore, any advantages of irrigating to maintain a given soil moisture content in order to maximise plant growth is lost. Any interactions between soil moisture, soil salinity and plant growth are also lost due to the poor design and unsatisfactory data analysis.

The sixth problem is that there are significant changes in soil characteristics and surface slope across the site and within plots. It is therefore entirely inappropriate to have only 1 soil sampling site per plot. There needs to be at least 5 and probably 7 sample sites per plot if any meaningful data is to be obtained.

The seventh problem is that the 'trial' is only designed to operate for 2 years while the Waukivory wells are tested. In the first 6 months it was only possible to irrigate with blended water on 2 occasions and therefore only a very small amount of salt has been added to the soil at this stage. In a fully operational gas field it will be necessary to dispose of saline water for 20 years which means that a 2 year demonstration is inappropriate and will lead to incorrect assumptions about environmental impact.

The eighth problem is that the calculations of runoff in the trial area are incorrect. This means that in a 1:100 year rainfall event there will be substantial pollution of the Avon River by processed water leaving the 'trial' site because the emergency catch dams and pumps will not be adequate to handle the volume.

This is not a trial in the sense that meaningful data will be obtained to assist in the development of a produced water management strategy in 2014. It is simply a process for disposing of the produced water from the Waukivory Pilot wells when they are fracked and tested over the next 2 years and the environmental safety of this process is flawed and cannot be tested.

**Appendix D**

# AGL Tiedmans Irrigation Trial Fundamental Design Problems

## *This is not a Trial but an Area to dispose of Produced Water*

### Trial Objectives

There is not one report by Fodder King or AGL that clearly sets out the purpose and design of this 'Trial'. It is necessary to review documents from 2011 to 2013 to understand what is currently happening on the site and then the current situation is different from the trial design that was approved by DRE.

The report by Fodder King to AGL (October 2012) says in section 2.1

*"The Stage 1A area is the trial irrigation area that is the major focus of the Soil Quality Monitoring and Management Program. This area will have intensive monitoring of soil, water and crops, and application, after blending, of most of the produced water for irrigation.*

*"The Stage 1A area is about 22ha in total of which 12-15 ha is planned to be irrigated using a linear move irrigator. Crop types are expected to be lucerne, forage sorghum, oats and selected pasture types."*

*"The Stage 2 area is approximately 15ha. These areas are unlikely to be irrigated during the early stages of the irrigation activities and will only be used if irrigation application rates on the Stage 1A and Stage 1B areas are less than anticipated."*

So this project by Fodder King on behalf of AGL is about getting rid of Produced Water not experimenting with or trialling different water rates or salinities and the impact of these rates on the soil or environment. Stages 1B and 2 will only be irrigated if there is too much water for Stage 1A.

Section 3.2 says *"the objectives of the Stage 1A Irrigation Trial are to:*

> *a) Derive information on the performance of using blended water and improved soils to maximise the beneficial use of produced water. This trial will provide support data for the preparation of the Gloucester Project Extracted Water Management Plan;*
>
> *b) Provide information to optimise the design of a water treatment and storage system to match the beneficial re-use system; and*
>
> *c) In order to minimise the overall 'footprint' of the project on the surrounding landscape the trial is aiming to achieve blended water application rates in the range of 3-5 megalitres/hectare/year."*

Objective (a) is about "maximising" the use of produced water but it will not provide data on this because there is only one rate of blended water application across all treatments and only at one salinity level for any irrigation event. Because there are no variables in quality or quantity of water application there can be no analysis to maximise beneficial use.

Objective (a) says that data will support the preparation of the Extracted Water Management Plan but that Plan will be developed in early 2014 which is well before the trial is completed 2015 and even before any realistic data can be collected.

Objective (b) is about "optimising" design of treatment and storage but this is not a variable in the trial so there will be no data for such optimisation to be considered.

Objective (c) is about minimising the "footprint" so it is about getting the Produced Water on the smallest area without really exploring options. For example, there is no variation of the water quality or quantity applied to the various crops or soil treatments so the concept of minimisation is not logical.

Objective (c) is to "achieve blended rates" of 3-5 ML/Ha/yr of blended water containing 2000mg of salt per litre, that is applying 6-10 tonnes of salt per hectare per year. However, there is no variation of applied salinity rates across treatments so there can be no interpretation of treatment effects on water demand.

These Objectives are further confused by Section 3.3 that says *"the objectives of the Stage 1B and Stage 2 areas are to:*

> *a) Allow for the irrigation of the lowest salinity irrigation water stored in the holding dams to provide improved pasture for stock grazing across the property (which is the traditional land use);*
>
> *b) Provide additional irrigated land area (to the intensive Stage 1A area) in the early stages of irrigation so that "air space" can be provided in the holding dams for the blending of the more brackish produced water that is in storage."*
>
> *"The remainder of this Soil Quality Monitoring and Management Program focuses on the Stage 1A irrigation trial area where between 50 and 60 ML of produced water is expected to be irrigated."*

In this section (3.3) Objective (a) appears to irrigate with undiluted water and not blended water.

In this section Objective (b) is about getting produced water out of the storage dam onto the soil to enable clean water from the river to be added for dilution of the salt in the produced water.

The last sentence in this section says that 50-60 ML of produced water is to be applied to the 12 ha of irrigated land in Stage 1A. Unfortunately the report does not indicate the salinity of this water or the period over which it will be applied. However, other information in the report suggests that the period is 2 years and the salinity of produced water is up to 8000mg/L. This would mean that up to 480 tonnes of salt will be applied to 12 ha or 40T/ha over the 2 years. Section 3.2 of the report says "*blended water application rates in the range of 3-5 megalitres/hectare/year."* That is up to 5ML/ha/yr of water with 2tonnes/Ml of salt which means up to 10 tonnes salt per hectare per year. The numbers in the various reports are not consistent.

By contrast the Water Management Plan (AGL 2012) states in section 4 that "*for this irrigation proposal, maximum irrigation rates are likely to be 4-6 ML/ha and the irrigation water quality will not exceed 3000 µS/cm, and for the main trial area the target is to use a blended water* *mix with a salinity between 1500 and 2000 µS/cm.*" In this case up to 6ML/ha at 3T/ML is an application of 18 T/ha of salt.

FK Report 2 (August 2013) has different figures for irrigation of Stage 1A as extracted below.

between 100 and 180 megalitres (ML) of blended water will be irrigated across this area during the trial period.

This means 100ML to 180ML over 12 hectares in 2 years which is 4.25 to 7 ML/ha and up to 14T/ha of salt; different to the previous report.

There is a serious lack of consistency in the information presented by AGL and its advisors in reports to Government. It is no wonder that the public is confused and concerned; and this is only for salt so a similar problem exists for all the heavy metals and other pollutants.

## Soil Characteristics

The Fodder King Report 2012 (FK 2012) states in Section 4.2 that the soil of the area is a Brown Sodosol as shown below.

***4.2 Baseline Data***

Previous investigations by Fodder King (FK) (2011) have characterised the soils within the Stage 1A irrigation area. Existing soils within the Stage 1A irrigation area are described as clay loam and classified as Brown Sodosols. The soil samples were analysed for a standard chemical suite

Brown Sodosols are so named because they are saline at depth. Victoria Resources Online describes such soils as follows: "the surface is a shallow sandy loam or sandy clay loam, poorly structured, slight to moderately alkaline, low salinity and non-sodic; the subsoil is a deep poorly structured (sodic) medium to heavy clay, strongly alkaline and increasing salinity with depth". "Salt content is usually low to moderate in surface soils and high (greater than 1.0 dS/m) in subsoils. If these soils frequently become waterlogged, salinity levels may increase at shallow depths. The subsoil salinity is likely to restrict growth of salt sensitive species (legumes) from 50 cm below the soil surface." (http://vro.dpi.vic.gov.au/dpi/vro/wimregn.nsf/pages/natres_soil_balrootan_undulated_sodosol)

These soil characteristics and problems for the site are confirmed by the "average" data presented in Appendix 1 of FK 2012 and some extracts are copied below. The trial site soil is certainly saline at depth so the concept of adding more salt in blended irrigation water is not logical. Unlike a typical Sodosal, the soil at the Tiedmans site is very acidic and no explanation is given for this in any of the reports.

*Extract from FK 2012 Appendix 1*

Average n = 16

| Depth | ECe | EC (1:5) | pH | NO2 | NO3 | Org-C | K | Ca | Mg | Na | Al | ECEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | dS/m | dS/m | CaCl2 | mg/kg | mg/kg | % | meq/ 100g | meq/ 100g | meq/ 100g | Meq /100g | meq/ 100g | meq/100g |
| 0 - 10 | 0.50 | 0.06 | 4.65 | <0.1 | 4.1 | 3.15 | 0.43 | 3.32 | 3.82 | 0.39 | 0.16 | 8.1 |
| 10 - 20 | 0.58 | 0.07 | 4.46 | <0.1 | 2.2 | 1.27 | 0.32 | 2.54 | 6.66 | 0.78 | 0.26 | 10.6 |
| 20 - 30 | 0.64 | 0.08 | 4.35 | <0.1 | 2.6 | 0.62 | 0.39 | 2.07 | 10.73 | 1.49 | 0.50 | 15.2 |
| 30 - 40 | 0.77 | 0.10 | 4.40 | <0.1 | 2.1 | 0.51 | 0.42 | 1.54 | 11.91 | 1.82 | 0.46 | 16.2 |
| 40 - 60 | 1.29 | 0.14 | 4.62 | <0.1 | 2.9 | 0.38 | 0.37 | 1.29 | 12.50 | 2.29 | 0.47 | 16.9 |
| 60 - 80 | 2.47 | 0.19 | 4.81 | <0.1 | 2.1 | 0.27 | 0.37 | 1.46 | 11.92 | 2.64 | 0.41 | 16.8 |
| 80 - 100 | 2.89 | 0.16 | 4.90 | <0.1 | 2.4 | 0.25 | 0.34 | 0.82 | 11.69 | 2.80 | 0.39 | 16.0 |
| 100 - 120 | 3.73 | 0.17 | 5.09 | <0.1 | 2.0 | 0.26 | 0.29 | 0.73 | 11.19 | 2.71 | 4.54 | 19.5 |

The Appendix also contains the minimum and maximum values for the soil properties and this indicates a range of about three fold for each tested characteristic. This is a very large variation across the site that is not accounted for in the trial design. There has been no attempt to apply the various amelioration rates to the variation in soil properties across the experimental area. All plots receive the same chemical treatment; it is only the depth of slotting that varies but again this is not based on any inherent soil test results.

Minimum

| Depth | ECe | EC (1:5) | pH | NO2 | NO3 | Org-C | K | Ca | Mg | Na | Al | ECEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | dS/m | dS/m | CaCl2 | mg/kg | mg/kg | % | meq/ 100g | meq/ 100g | meq/ 100g | Meq /100g | meq/ 100g | meq/100g |
| 0 - 10 | 0.3 | 0.04 | 4.18 | 0.1 | 1.2 | 1.77 | 0.26 | 2.13 | 2.43 | 0.08 | 0.03 | 5.4 |
| 10 - 20 | 0.2 | 0.03 | 4.2 | 0 | 1.1 | 0.52 | 0.16 | 0.94 | 2.98 | 0.28 | 0.01 | 5.5 |
| 20 - 30 | 0.3 | 0.04 | 4.02 | 0 | 1.6 | 0.33 | 0.23 | 0.63 | 6.04 | 0.63 | 0.07 | 9.4 |

Maximum

| Depth | ECe | EC (1:5) | pH | NO2 | NO3 | Org-C | K | Ca | Mg | Na | Al | ECEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | dS/m | dS/m | CaCl2 | mg/kg | mg/kg | % | meq/ 100g | meq/ 100g | meq/ 100g | Meq /100g | meq/ 100g | meq/100g |
| 0 - 10 | 0.80 | 0.08 | 4.95 | <0.1 | 6.8 | 6.34 | 0.76 | 6.00 | 5.17 | 0.87 | 0.65 | 10.9 |
| 10 - 20 | 1.70 | 0.22 | 4.72 | <0.1 | 3.7 | 4.55 | 0.71 | 4.62 | 11.20 | 1.53 | 0.57 | 17.3 |
| 20 - 30 | 1.10 | 0.15 | 4.73 | <0.1 | 3.9 | 0.92 | 0.65 | 3.57 | 16.50 | 2.98 | 1.57 | 22.2 |

## Soil Amelioration

The soil at the site is not suitable for irrigation with saline water and Fodder King has advised AGL to ameliorate the soil as indicated below (FK 2012). The trail contains the following soil treatment at four depths of placement within slots dug into the soil:

### 5.1 Stage 1A Trial Irrigation area

The Stage 1A trial area will entail deep amelioration of soils over four treatment depths. The composition of the ameliorant to be incorporated into the irrigation area is shown in Table 2.

**Table 2: Composition of ameliorant and loading rates**

| Material | Required application rate (Tonnes/ha) |
|---|---|
| Gypsum | 4 |
| Lime | 8 |
| Composted Feedlot Manure | 50 |
| Zeolite | 5 |

The ameliorant has been designed to improve the water holding capacity, infiltration rate, nutrient retention and organic matter content of existing site soils. Required application rates to create a productive soil were based on recommendations in FK (2011) – the Baseline 1 study. The ameliorants will act to increase soil pH (currently acidic), increase Cation Exchange Capacity (CEC – currently low), decrease soil Exchangeable Sodium Percentage (ESP – currently high) and increase organic matter (currently low), all of which were noted as limiting factors to irrigation of crops. The ameliorants are expected to alter existing soils in such a way as to buffer the deleterious impacts on soil structure and soil quality in view of estimated irrigation loads and water quality.

The slots in the soil for the amelioration treatments are not adequately described in the Report Section 4.3 (FK 2012) because the depth of the four treatments is not defined. FK 2013 states that the slot depths are 0, 600, 950 and 1200mm.

### 4.3 Soil Amelioration

Deep slotting was designed for the specific purpose of improving acid-sodic soils down to depths of as much as 1.3 metres. The preliminary soil testing for Tiedmans indicated that they are acidic as well as being sodic, and therefore candidates for this type of treatment.

Deep slotting enables the thorough physical mixing of soil ameliorants such as organic matter, lime and/or gypsum into sodic soils at depths greater than 300 mm, which makes it a suitable match with deep rooted crops. A typical deep slotting example is provided in Figure 2 and is based on the average soil profile derived from the core sampling done within the trial plot area.

Figure 2 from FK 2012 is copied below and indicates that the slots are 200mm wide and spaced at 1000mm intervals across the surface but FK 2013 says the slots are 1500mm apart. Therefore, 12% of the soil is dug up and the ameliorant mixture is buried. This would not result in a "thorough mixing of soil ameliorants' as stated in the paragraph copied above. There will however be subsoil brought to the surface and this is not a good practice on Brown Sodosol soils.

The treatment or composition of the two top layers (135mm and 100mm) in Figure 2 cannot be understood due to lack of information. Section 8 of FK 2012 (reproduced below) provides some more information on this and suggests that the soil removed from the slots and the top 235mm are mixed with the ameliorants; then some of this mixture is put back into the slots and the remainder is spread across the surface at depths varied according to the depth of slots. The soil profile that results from this amount of physical and chemical change will be very complex in both the vertical and horizontal direction. This means that representative sampling will be complicated and require a large number of replications to avoid the bias of the slots.

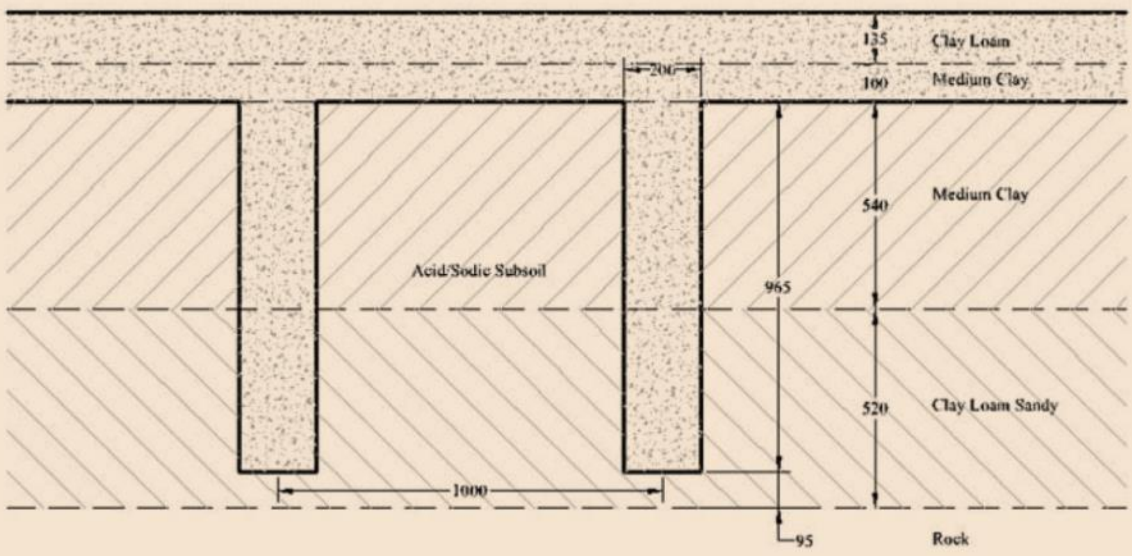



***Figure 2: Sample Deep Slotting Cross Section based on Stage 1A Profile Logs***

## 8 Soil Amelioration and Rehabilitation Plans

The existing soil in the Stage 1A area is a clay loam classified as a Brown Sodosol (FK, 2011) which will be ameliorated toward a Brown Dermosol (CSIRO Australian Soil Classification) prior to any irrigation activity. Each of the slotted profiles will have the ameliorated soil inserted and will also be incorporated across the top 24 cm of the entire area. Figure 8 and Figure 9 show

To suggest that the applied treatment process will ameliorate an existing Brown Sodosol toward a Brown Dermosol prior to any irrigation activity is a nonsense idea.

- Firstly, only about 12% of the soil volume is treated so most of the soil profile has not been altered;
- Secondly, the ameliorates will not significantly change the soil properties in the (maximum) period of 6 months between their incorporation into the soil and the first irrigation; and
- Thirdly, the CSIRO soil classification terminology and practice is not designed for such artificial situations.

The amelioration treatments will have very different affects across each of the plots in both time and space due to the;

- incorporation process and its inherent variability,
- small amount of soil actually 'treated', vertical change will be a lot quicker than any horizontal change,
- variability in the original soil properties, and the
- time taken for the complex chemical and physical processes to operate at varying moisture contents introduced by the various slot depths and the subsequent irrigations with water and consequential introduction of other chemicals.

All of the variability factors discussed above mean that the measurement of change in a 2 year trial will be problematic and sampling would need to be far more comprehensive than is occurring in this 'trail'.

These factors are further complicated by the fact that extra amounts of lime (1.75 to 3.5 t/ha) were added to various plots prior to irrigation based on an inadequate set of Baseline 2 soil acidity results (FK 2013 section 4.5). The samples were taken to 100mm depth and there is no explanation for this depth despite incorporation of ameliorants to 235mm. There is no discussion as to why the plots varied or why the various amounts of lime were added. This is inadequate reporting.

## Soil Sampling

The following diagram (Fig 4) is from FK 2012 and shows the location and number of sampling sites.

> These sites in Figure 4 were selected in order to:
>
> - enable comparisons with the baseline soil sampling locations (CS1 – CS16);
> - cover the general contour (differences in elevation) and expected drainage within the irrigation area;
> - maintain the high sampling density of 1 sample/0.77 hectares; and
> - have one sample point in each trial plot.

The first dot point is not a reasonable assumption because the variability across the site is so large (FK Annex 1 copied above). A statistical comparison is not possible with such a small sample size.

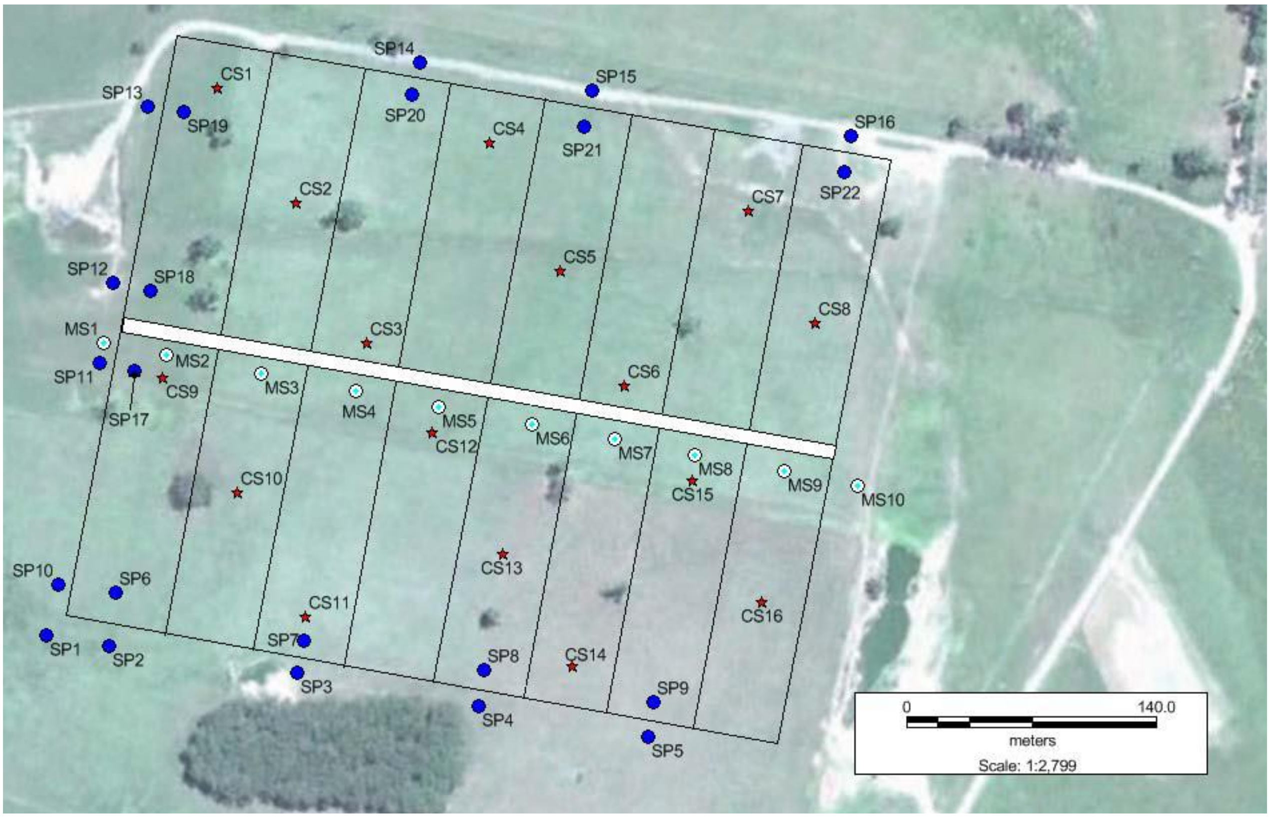
The second point is not acceptable because the soil surface has been substantially changed due to the trenching process and incorporation of large amounts of 'ameliorants'. FK2013 Appendix 1 (reproduce here on the next page) indicates that there is a height difference of >10m across the site and can vary by 3-5m in any plot with different slope gradients within various plots.

The third point is incorrect because 1 sample per 0.77ha is not a high density of sampling for such analysis due to the very variable nature of the soil and its characteristics. This variability is demonstrated by the data presented (pages 3 - 4 above) from Annex 1 of FK 2012 that shows the minimum to maximum variations are three fold for many characteristics. There should be at least 7 and preferably 9 sample sites for each plot in order to adequately account for within treatment variation. The location of sample points in relation to the amelioration slots is critical to data interpretation but this is not discussed in FK 2012.

Point four is not true. There is not a sample point for soil moisture or groundwater in each plot. Given the large surface gradient differences, and therefore runoff differences within the plots, there should be at least 7 and preferably 9 sample sites for each plot. The moisture difference at various horizontal distances from the slots will be very large and there will also be interactions between depth of slots and distance.

As presented in Figure 4, the soil sampling sites (CS) are somewhat on the contour lines (mapped in Sheet 01A of Annex 1 FK 2013) but this means they bear no relationship to the soil moisture sampling points (MS) and therefore no possible cause and effect relationships can be analysed between soil moisture and any other soil property. Similarly, there is no analysis possible of any relationship between soil moisture (MS) and groundwater (SP) because of the large spatial differences between sampling sites.

In summary, the soil sampling regime is entirely unacceptable for this type of trial due to the very large inherent soil variability and the non-uniformity of amelioration changes over time and space.

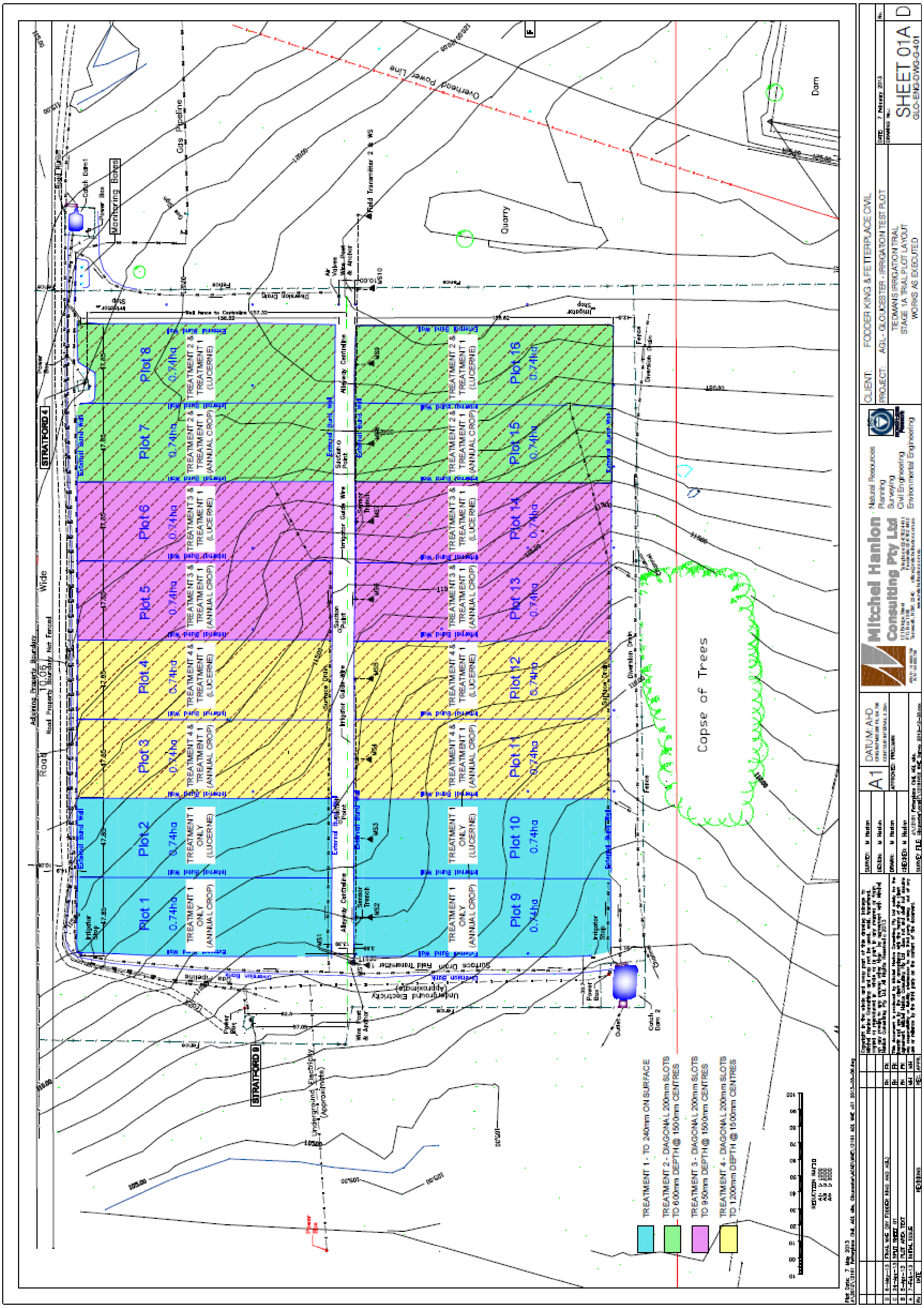



***FK Report 2012 Figure 4: Stage 1A Trial Irrigation Area showing location of soil sampling site (CS), shallow*** *groundwater samplers (SP, piezometers) and soil moisture sensors (MS)*

Section 8 of FK 2012 concludes with the following statement that is very difficult to comprehend.

> By altering the soil characteristics and physical attributes the soil becomes more receptive to irrigation and as such the soil will be 'pre-habilitated'. Consequently, any subsequent measures that may be required to rehabilitate the soils resulting from the blended water quality profile are expected to be minimal.

The only interpretation of this can be that the soil is being used as a massive 'sink' for up to 10T salt/ha/yr.


Plot 1
Plot 2
Plot 3
Plot 4
Plot 5
Plot 6
Plot 7
Plot 8
Plot 9
Plot 10
Plot 11
Plot 12
Plot 13
Plot 14
Plot 15
Plot 16
0.74ha
Copse of Trees
Quarry
Dam
Gas Pipeline
Overhead Power Line
Monitoring Bores
Road
TREATMENT 1 - TO 240mm ON SURFACE
TREATMENT 2 - DIAGONAL 200mm SLOTS TO 600mm DEPTH @ 1500mm CENTRES
TREATMENT 3 - DIAGONAL 200mm SLOTS TO 950mm DEPTH @ 1500mm CENTRES
TREATMENT 4 - DIAGONAL 200mm SLOTS TO 1200mm DEPTH @ 1500mm CENTRES
Mitchel Hanlon Consulting Pty Ltd
CLIENT: FODDER KING & FETTERPLACE CIVIL
PROJECT: AGL - GLOUCESTER - IRRIGATION TEST PLOT
TEDMANS IRRIGATION TRIAL
STAGE 1A TRIAL PLOT LAYOUT
WORKS AS EXECUTED
SHEET 01A
GLO-ENG-DWG-G-401

## Collection of runoff

Section 5.1 of FK 20011 discussed how the required volume of the Catch Dams was determined but the calculations completely misuse the Rational Method because of how the rainfall intensity was calculated for the plots. A correct interpretation and calculation of rainfall intensity for the Rational Method formula involves the determination of a 'time of concentration' as discussed in the following extract from http://www.nrm.qld.gov.au/land/management/pdf/c6scdm.pdf .

> **6.3 Rainfall intensity**
>
> The average rainfall intensity for a design storm of duration equal to the calculated 'time of concentration' (tc) of a catchment is estimated using IFD (intensity, frequency, duration) information for the catchment.
>
> The catchment 'time of concentration' is the time estimated for water to flow from the most hydraulically remote point of the catchment to the outlet. The Rational Method assumes that the highest peak rate of runoff from the catchment will be caused by a storm of duration just long enough for runoff from all parts of the catchment to contribute simultaneously to the design point.
>
> The 'time of concentration' is calculated by summing the travel times of flow in the different hydraulic components. Those components may include overland flow, stream flow and/or flow in structures. Several flow paths may need to be assessed to determine the longest estimated travel time, which is then used to determine rainfall intensity.

The calculation in Section 5.1 uses a rainfall intensity of 11.7mm/hr which from the Report Table 4 page 10 is the average rainfall intensity for a storm lasting 24hour with a 1:100 year return period. That is, the FK 2012 report is suggesting that the time of concentration for the plots is 24hours and this is not correct.

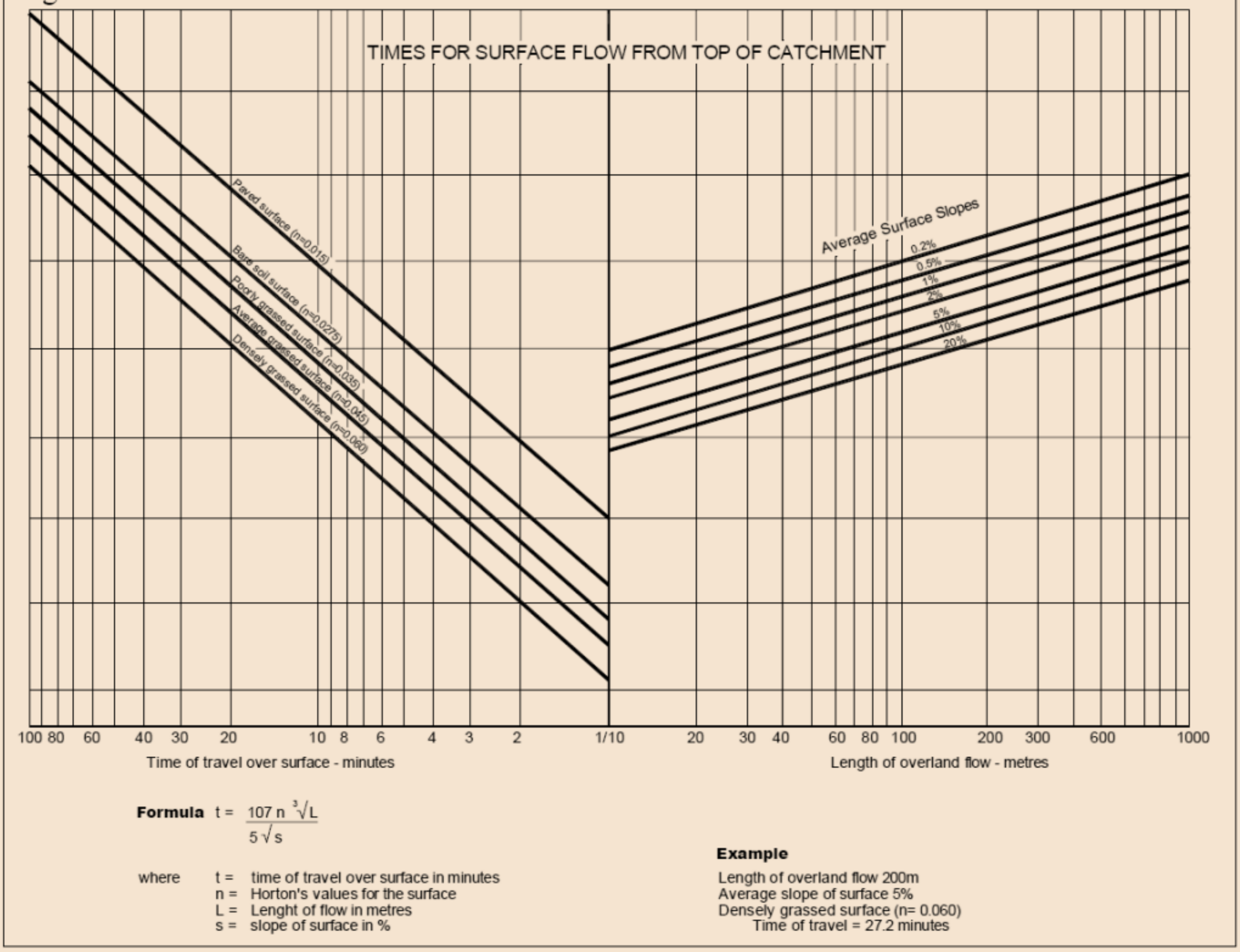
The above quoted nrm.qld.gov.au reference also provides a table (labelled Table 6.3) for calculating the time of concentration of plots and it is copied below.

Measurements for the plots at the Stage 1A site are 47m by 156m (FK 2013) so it can be estimated that the maximum length of overland flow will be about 160m. The land slope is approximately 2% and the surface is a moderately covered pasture. Therefore, the time of concentration for each plot would be about 22 minutes. The runoff is then channelled to the catch dam over a maximum distance of about 400m with a time of concentration of about 10minutes because at this stage it is channelised flow and has a greater velocity (say 0.7 m/s). This gives a total time of concentration of about 32 minutes for the trial area.

From the data in FK 2012 Table 4 the 32 minute rainfall intensity would be 100mm/hr for a 1:100 year rainfall event. That is, a depth of 100/2 or approximately 50mm total rain in the 32 minutes that the furthest runoff took to reach the catch dam. With a runoff coefficient of 0.2 used in the FK 2012 report this means that total runoff for the 12.32 ha will be 123,200m$^2$ x 0.2(coefficient) x 0.05m (rainfall) = 1232m$^3$ of water. This is 4 times the 310m$^3$ volume of runoff which the FK 2012 report calculates. The catch dams will overflow in a 1:100 year rainfall event and discharge polluted water into the surrounding land and watercourse

The pump on the catch dams has a capacity of 26L/s = 26/1,000 x 60 x 60 $m^3$/hr = 93.6 $m^3$ so it will take 3 hours to empty the dams and in the meantime 900$m^3$ of polluted water will have escaped.

Figure 6.3 Travel time for overland flow




The whole calculation of volumes for the catch dams is flawed due to an incorrect use of the Rational Method. The FK 2012 report on page 11 contains the following paragraph that is meaningless.

> The pump rate is not designed to empty the catch dams at a rate equal to the runoff rate from a large storm event. It is designed to capture the "first flush" from the irrigation area based on a 1 in 1 year event (24.9 mm in 1 hour, refer Table 4). This is important because any excess overflow during large storm events (such as 11.7 mm/hr over 24 hours) will have similar characteristics to overland flow from natural surrounding areas. This will be monitored by the salinity loggers in the catch dams.

The concept that the "first flush" will be the only runoff that contains salt is also flawed. During a 1:100 year rain event, salt will be mobilised throughout the 32 minute rainfall period and all 1232m$^3$ of runoff water will be polluted. Therefore, all 900m$^3$ of water escaping from the 'trial' area will be polluted.

If the trial is about disposing of saline and polluted water in an environmentally safe and sustainable process then any runoff containing contaminants needs to be contained before it reaches the land or water bodies. The concept that "excess overflow during large storm events … will have similar characteristics to overland flow from natural surrounding areas" is false as the natural areas will not have been sprayed with polluted water via irrigation. This lack of logic adds to the poor design of the project to dispose of produced water from test wells.

## Results after the first 6 months

Fodder King Compliance Report 2 (FK 2013) provides information on the soil testing at the completion of irrigating with "blended water" in the period 1st April to 39th June 2013. Crop growth and plant health were also monitored but no harvesting of fodder occurred during the period.

The FK report also provides information on the treatments actually applied as follows:

> Due to the selection of a centre feed linear move irrigator as the method for applying irrigation water, each treatment and crop combinaton was split evenly on either side of the centreline of the linear irrigator, resulting in 8 plots (Plots 1-8) under the northern leg of the irrigator and 8 plots (Plots 9-16) under the southern leg of the irrigator.
>
> This accommodated the need for 2 crop types and 4 treatment depths on either side of the cart track.

This is a major design fault as the water requirements of the various crops sown (see below) will vary substantially at any time of the year. A realistic design would have enabled the amount of irrigation water to be varied between plots to allow for the variable soil and crop treatments.

> The crop types being trialled for the 18 month trial are:
> - Perennials (lucerne) – 8 plots x 4 treatment depths
> - Annuals - 8 plots x 4 treatment depths
>   - winter forage cereals, eg oats, barley, triticale
>   - followed by summer forages, eg millet, forage sorghum
>
> The winter annual chosen for the period April to October 2013 was triticale.

In this 'trial' the water requirement is calculated from the average soil moisture data across all 16 plots so there is no allowance for different soil amelioration effects, crop requirements, evaporation rates due to plant height or density, or soil surface slope and its effect on infiltration. There is no ability in this 'trial' to assess soil treatment or crop type differences or interactions between these and/or soil moisture. The use of 8 treatments and 2 replications is at best wasted and at worst it makes it impossible to sensibly interpret the data.

During the reporting period 16% of the water received by the trial area came from blended water while 84% came from rainfall. See Table 3.1.

**Table 3.1 Rainfall and irrigation for the period – Stage 1A**

| Units | Rainfall for the period | Irrigation for the period | Total |
|---|---|---|---|
| **Mm** | 205.8 | 39.0 | 244.8 |
| **Megalitres** | 24.7 | 4.66 | 29.36 |
| **%** | 84 | 16 | 100 |

Irrigation of blended CSG water occurred in late April - May 2013 only. The DID, cumulative DID and soil moisture indicated that during this time was the only opportunity to irrigate. Approximately 4.66 ML of blended CSG water was applied to the Stage 1A area during the period.

Therefore, there were only 2 irrigations in the reporting period (30th April 8mm and 7th May 31mm). This was because rainfall was reasonable and evapotranspiration was low during the period meaning that the Daily Irrigation Deficit (DID) was above zero indicating that the soil could not absorb more water without saturating the root zone and/or creating runoff.

## *Irrigation water quality*

The following information on water quality is extracted from FK 2013.

Table 3.2 summarises water quality of the blended CSG water prior to irrigation to Stages 1A and 1B

**Table 3.2: Water quality of the blended CSG water prior to irrigation**

| Parameter | Units | Value |
|---|---|---|
| Electrical Conductivity (EC) | µS/m | 1380 |
| pH | no units | 9.28 |
| Chloride (Cl) | mg/L | 218 |
| Sodium (Na) | mg/L | 200 |
| Sodium Adsorption Ratio (SAR) | - | 14.5 |
| Adjusted SAR | - | 4.4 |
| Total Alkalinity | mg $CaCO_3$/L | 303 |
| Bicarbonate Alkalinity ($HCO_3$) | mg $CaCO_3$/L | 194 |
| Carbonate Alkalinity ($CO_3^-$) | mg $CaCO_3$/L | 109 |
| Calcium Carbonate Saturation Index | - | 9.4 |
| Hardness | mg $CaCO_3$/L | 36 |
| Aluminium (Al) | mg/L | 0.04 |
| Boron (B) | mg/L | 0.16 |
| Calcium (Ca) | mg/L | 6 |
| Copper (Cu) | mg/L | 0.002 |
| Fluoride (F) | mg/L | 0.2 |
| Iron (Fe) | mg/L | 0.54 |
| Magnesium (Mg) | mg/L | 5 |
| Manganese (Mn) | mg/L | 0.009 |
| Nitrate nitrogen ($NO_3$) | mg/L | <0.01 |
| Total Phosphorus (P) | mg/L | 0.39 |
| Orthophosphate ($PO_4^{3-}$) | mg/L | <0.01 |
| Potassium (K) | mg/L | 160 |
| Sulfur (S) | mg/L | 27 |
| Zinc (Zn) | mg/L | 0.012 |
| Total Dissolved Solids (TDS) | mg/L | 924 |
| Total Organic Carbon (TOC) | mg/L | 14 |

This list does not contain all of the heavy metals such as cadmium, chromium, boron and arsenic that are included in other AGL ground and surface water testing. It is important to test for these as they are taken up from the soil by crops such as triticale. Nor is there any testing for hydrocarbons and BTEX chemicals.

The blended water had an EC < 1500 µS/cm which was the mixing-model design objective for water quality prior to irrigation. The elevated pH (9.3) is of minor concern to site soils at these EC values as the pH can be attributed to carbonate interactions in the blended water. The blended irrigation water had elevated sodium and low calcium and magnesium and this has the potential to cause problems in association with the high alkalinity. The blended irrigation water was generally low in nutrients (nitrate and ortho-phosphate) however at a pH of 9.3 all phosphorous was in the bound form. Adjustment of the pH to around 7.5 would eliminate any alkalinity issues and release phosphorous for crop assimilation. Sodium, nutrients and Total Organic Carbon (TOC) values will be discussed further in section 3.5 with respect to mass balance results and potential impacts on site soils.

For unexplained reasons the FK 2013 report provides information on a mass balance for sodium (Na) rather than for salt which would be better related to electrical conductivity as measured. Unfortunately Table 3.3 states the mg of Na applied per kg of soil to a depth of 333mm. This is nonsense as the 333mm is a very artificial depth with no physical, practical or logical basis. There is no process in this trail of determining what soil characteristics are changing with in the slots or at various widths and depths from the slots. There is no possible basis for suggesting that the soil will be equalising across its entire mass.

3.5.1. Stage 1A

The mass of soil in Stage 1A was calculated as:

11.94 ha = 119,400 $m^2$ x 0.333 m (average treatment depth) x 1200 $kg/m^3$ (bulk density of the soil)

= 47,712,240 kg of soil in Stage 1A.

Table 3.3 provides a summary of mass balances for sodium, nitrate nitrogen, total phosphorous and total organic carbon

**Table 3.3: Summary of mass balances for sodium, nitrate nitrogen, total phosphorous and total organic carbon**

| | Dam WQ | Irrigation | Total Applied | Site soil mass | Total Applied |
|---|---|---|---|---|---|
| | (mg/L) | (ML) | (mg) | (kg) | (mg/kg) |
| **Sodium (Na)** | 200 | 4.66 | 932,000,000 | 47,712,240 | 19.5 |
| **Nitrate nitrogen ($NO_3$)** | 0.01 | 4.66 | 46,600 | 47,712,240 | 0.001 |
| **Total Phosphorus (P)** | 0.39 | 4.66 | 1,817,400 | 47,712,240 | 0.038 |
| **Total Organic Carbon (TOC)** | 14 | 4.66 | 65,240,000 | 47,712,240 | 1.367 |

This is absolutely meaningless information. The use of average treatment depth for soil mass is nonsense.

For example, 19.5 mg/kg of sodium has been applied during the period. Soil analysis over this period (discussed in Section 4) indicated that Na ranged from approximately 75 mg/kg (10cm depth) to 375 mg/kg (at 40 cm depth). Coupled with excess rainfall and saturated soils the 19.5 mg/kg applied during this period is not likely to significantly increase sodium in the soil profile.

The last sentence above is unbelievable. Firstly, the rainfall was not excess; the table below from FK 2013 indicates that rainfall was 8mm above average which is about 4%. Secondly, there should be information on the actual sodium change in the profile over depth not a statement about it being “not likely to significantly increase” or even decrease.

Table 6.1 - Key weather and irrigation information

| Key information | April | May | June | Total for the period |
|---|---|---|---|---|
| **Rainfall** | | | | |
| AGL weather stn | 52.0mm | 61.6mm | 92.2mm | **205.8mm** |
| Bureau of Meteorology Gloucester Post Office | 61.6mm | 55.8mm | 59.4mm | **176.8mm** |
| Mean monthly rainfall at Gloucester Post Office | 77.3mm | 68.0mm | 68.4mm | **213.60mm** |

The FK 2013 Report on Baseline 3 data for January to June 2013 only presents average values over the 16 plots for Stage 1A and some extracts are copied below on page 15. Pages 3-4 contain extracts of the Baseline 2 data. The Report also has some brief comments on trends in soil properties as copied below.

4.7. Key findings – Baseline 3 (irrigated soils) vs Baseline 2 (pre-irrigated soil)

The changes in average values between Baseline 3 and Baseline 2 are shown in Attachment 4. In addition, Baseline 3 is compared against Baseline 1 (parent soil) values.

**Salinity (Ec)**

As discussed in Report 1, the salinity 'spike' resulting from the use of compost and the mixing of layer 3 of the parent soil has subsided. Further decreases are expected to be reflected in the Baseline 4 results.

**Sodium and Exchangeable Sodium Percentage (ESP)**

The sodium values have decreased. As a result the exchangeable sodium percentages have also decreased and currently sit at a desirable level of less than 6% to 80cm depth. See Figure 4.1.

The comments are hard to follow as different soil depth ranges are used and in some cases different units are used. It is unacceptable to include gratuitous comments such as "further decreases are expected" without any explanation.

The implication above is that salinity (EC) has decreased over the time period. However the average EC for 1-10cm depth in Baseline 2 was 0.06 dS/m and for Baseline 3 in 2013 it was 0.32dS/m. This is a substantial increase over the period so the statement in the 2013 report is incorrect. For the minimum value data presented the increase is fourfold from 0.04 to 0.17dS/m in the surface soil. For the maximum value data presented the increase is sevenfold from 0.08dS/m in 2011 to 0.59dS/m in 2013. Therefore, according to the data in the report Annexes, there is an increase in surface soil salinity, as measured by EC, during the time when saline irrigation water was applied

In 2012 the Baseline 2 sodium value in the 0-10cm layer was 0.39meq/100g as an average of the 16 sample sites and the value in 2013 for Baseline 3 was to 0.558 meq/100g. This is an increase; not a decrease as stated in the Report section 4.7. The minimum value for sodium in Baseline 2 was 0.08 meq/100g and in Baseline 3 (2013) it had increased to 0.32 meq/100g.

The problem with all of these results is that the sample size is inadequate and the volume of saline blended irrigation water has been too small to cause any meaningful change in any direction.

Some Baseline 3 Soil Test Results from FK 2013

| AVERAGE N = | Depth cm | EC (1:5) dS/m | pH CaCl2 | NO3 mg/kg | Org-C % | K meq/100g | Ca meq/100g | Mg meq/100g | Na meq/100g |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 0-20 | 0.32 | 6.64 | 44 | 3.1 | 0.961 | 14.875 | 5.661 | 0.558 |
| 12 | 20-40 | 0.30 | 6.02 | 29 | 2.1 | 0.688 | 10.448 | 6.588 | 0.665 |
| 12 | 40 - 60 | 0.25 | 5.31 | 24 | 1.7 | 0.549 | 6.913 | 7.275 | 0.788 |
| 8 | 60 - 80 | 0.20 | 4.80 | 18 | 1.2 | 0.435 | 5.363 | 8.495 | 0.955 |
| 4 | 80 - 100 | 0.14 | 4.24 | 8 | 0.6 | 0.270 | 2.210 | 10.520 | 1.295 |
| 3 | 100 - 120 | 0.25 | 4.29 | 6 | 0.4 | 0.235 | 1.845 | 9.730 | 1.340 |

| Maximum N = | Depth cm | EC (1:5) dS/m | pH CaCl2 | NO3 mg/kg | Org-C % | K meq/100g | Ca meq/100g | Mg meq/100g | Na meq/100g |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 0-20 | 0.59 | 7.04 | 88 | 5.21 | 2.36 | 23.00 | 10.50 | 0.90 |
| 12 | 20-40 | 0.57 | 6.98 | 79 | 4.07 | 1.55 | 18.60 | 10.00 | 0.97 |
| 12 | 40 - 60 | 0.52 | 6.92 | 62 | 3.18 | 1.38 | 15.60 | 11.40 | 1.08 |
| 8 | 60 - 80 | 0.28 | 6.95 | 45 | 1.88 | 0.64 | 13.90 | 12.50 | 1.40 |
| 4 | 80 - 100 | 0.14 | 4.43 | 12 | 0.70 | 0.28 | 2.35 | 12.50 | 1.50 |
| 3 | 100 - 120 | 0.36 | 4.44 | 11 | 0.46 | 0.25 | 2.20 | 11.50 | 1.51 |

| Minimum N = | Depth cm | EC (1:5) dS/m | pH CaCl2 | NO3 mg/kg | Org-C % | K meq/100g | Ca meq/100g | Mg meq/100g | Na meq/100g |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 0-20 | 0.17 | 6.13 | 17.4 | 1.97 | 0.4 | 10.3 | 3.14 | 0.32 |
| 12 | 20-40 | 0.13 | 4.42 | 8.4 | 1.02 | 0.23 | 5.04 | 3.12 | 0.35 |
| 12 | 40 - 60 | 0.11 | 4.33 | 2.8 | 0.62 | 0.19 | 2.36 | 2.28 | 0.34 |
| 8 | 60 - 80 | 0.13 | 4.05 | 2.3 | 0.46 | 0.23 | 1.79 | 3.13 | 0.45 |
| 4 | 80 - 100 | 0.13 | 4.05 | 2.9 | 0.5 | 0.26 | 2.07 | 8.54 | 1.09 |
| 3 | 100 - 120 | 0.14 | 4.14 | 2 | 0.39 | 0.22 | 1.49 | 7.96 | 1.17 |

| Standard Deviation N = | Depth cm | EC (1:5) dS/m | pH CaCl2 | NO3 mg/kg | Org-C % | K meq/100g | Ca meq/100g | Mg meq/100g | Na meq/100g |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 0-20 | 0.13 | 0.26 | 21.2 | 0.87 | 0.57 | 3.92 | 1.94 | 0.18 |
| 12 | 20-40 | 0.13 | 0.86 | 22.2 | 1.05 | 0.35 | 4.41 | 2.41 | 0.19 |
| 12 | 40 - 60 | 0.12 | 1.02 | 18.0 | 0.81 | 0.34 | 4.26 | 2.79 | 0.25 |
| 8 | 60 - 80 | 0.05 | 0.98 | 15.4 | 0.51 | 0.14 | 3.93 | 2.74 | 0.28 |
| 4 | 80 - 100 | 0.01 | 0.27 | 6.5 | 0.14 | 0.01 | 0.20 | 2.80 | 0.29 |
| 3 | 100 - 120 | 0.16 | 0.21 | 6.3 | 0.05 | 0.02 | 0.50 | 2.50 | 0.24 |