Submission
No 385

INQUIRY INTO COAL SEAM GAS

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The Director
General Purpose Standing Committee No. 5
Parliament House
Macquarie St
Sydney NSW 2000

Dear Sir/Madam,

Submission to the Legislative Council for the Inquiry into Coal Seam Gas by Dr. Aharon Arakel of Sydney

(This submission includes Attachments 1 and 2)

With reference to the terms of the inquiry I, Aharon Arakel of Sydney provide the following observations and recommendations for consideration by your committee.

I have a PhD qualification in sedimentology and environmental geochemistry and since early 1990's I have been involved with many aspect of salinity issues and control measures from academic teaching and research to industry advice and development of innovative saline water treatment technologies. My involvement with Coal Seam Gas (CSG) associated water management efforts dates back to 2002 when I led a major project on behalf of one of current CSG-LNG developers in Queensland involving a comprehensive techno-economic evaluation of the options for desalination of CSG associated water and minimisation of residual waste brine through recovery of valuable products. This included the first and, up to now, only field trials undertaken in Australia testing innovative processes for recovery of valuable products from CSG associated water at a gas field near Roma, Queensland. As the Chief Technologist of Geo-Processors Pty Limited, operating from Sydney and Los Angeles, I have, during the past twenty years, lead or supervised over 80 projects for clients around the world from diverse industries - all seeking practical solutions for their operational salinity issues and/or saline pollution problems.

As indicated in my brief resume (Attachment 1), I have also actively participated in applied research focusing on development of an appropriate knowledge base on various aspects of salinity and salinity remediation. Therefore, I consider myself properly qualified and having long professional standing and personal interest in the subject matters covered by my submission.

Drawing from my experience and personal conviction that the CSG and farming industries can co-exist, under a stricter regulatory regime and with a greater government participation in sponsoring research for knowledge base development, I provide the following observations and recommendations under the terms of the inquiry for consideration by your committee. Please note although my observations have relevance to the broader subject matter of CSG associated water management, my recommendations are primarily for those terms of the inquiry listed in Table 1 and more specifically for alleviating the potential adverse impacts of brine generated from desalination of CSG water on surface water and soils.

Accordingly, my observations primarily relate to the issues and shortcomings associated with current NSW government strategies and policies and the sustainability of practices currently followed by CSG explorers and developers for managing brine generated from the desalination of produced water including CSG drilling

fluid. Building on these observations I have then made a number of recommendations for overcoming the current shortcomings under each specific term of the inquiry identified in Table 1. Additional complimentary recommendations are also included. For the ease of follow-up by readers and as much as practicable my observations and recommendations are cross-referenced in this submission.

Table 1. Terms of inquiry specifically addressed in this submission

Inquiry Reference Number	Definition of the Term
1a	Effect on ground and surface water systems
1e	Nature and effectiveness of remediation under the NSW Petroleum (Onshore) Act
1f	Effect on greenhouse gas and other emissions

PART 1. OBSERVATIONS

1A. General Observations

Daily we come across a wide variety of farming and community groups in New South Wales which express their concerns with the issues related to Coal Seam Gas (CSG) developments in our state particularly on the potential environmental, social and economic impacts as related to exploration and commercial development activities in farming and urban areas. There is also the question, more recently, of what to do with the massive volumes of the saline water brought up to the surface as a co-product of CSG production.

While these are real and genuine concerns we are also increasingly reading media articles by various interest group and statements by so-called water experts that are not based on facts and factual information on CSG associated water and management issues. This is a stern warning and a wakeup call; the lack of regulatory maturity in NSW plus the absence of a credible knowledge base for validating and defining the extent of CSG development impacts and hence the community concerns with CSG related water management practices can lead to poor decisions with undesirable economic outcomes for residents of NSW. There are obviously some risks involved with CSG development in NSW, as there is with all other natural resource development projects. However, from my long involvement with CSG industry, the risks with CSG development in NSW are manageable; the key shortcoming is the overwhelming need for a credible knowledge base so the environmental risks associated with CSG associated water handling can be identified, quantified and managed appropriately in a timely manner and in isolation from the current hype.

1B. Current and Proposed Practices for Management of CSG Brine Effluent and Drilling Fluid in NSW

From the point of concern with respect to potential adverse impacts of CSG associated water on surface water and soil systems it is critically important that certain facts, figures and technical issues are identified so that they can be openly and rationally discussed and assessed in order to identify their causes and then recommend possible solutions.

Below I have provided a brief outline of a number of largely untold facts and technical issues that will need constructive discussion for a better understanding of the technical issues surrounding saline-alkaline waste water management. From my experience, these technical issues that have direct impacts on water or wastewater management in new resource industries need to be clearly understood at the earnest in the

context of the scale of resource development, before appropriate regulatory regimes for risk mitigation can be implemented. Otherwise, the sustainability of a large-scale resource development (whether CSG or shale gas) would remain questionable thus adversely affecting such industry achieving its full commercial potential while sustaining manageable environment impacts.

In the context of this inquiry, this submission addresses only the issues related to CSG brine and CSG drilling fluid as defined below.

> *"CSG brine"*, referred to hereunder, is the concentrated reject from the membrane based desalination of CSG water. Review of CSG brine from existing and projected desalination facilities indicates that such brine will be variably saline and alkaline and thus would require either safe disposal or treatment for beneficial use.
>
> *"CSG drilling fluid"* means water generated during exploration well drilling or well-field development activities. This effluent is commonly saline and alkaline making it redundant for direct disposal or reuse in drilling, unless it is first treated.

The issues with sustainable management of CSG drilling fluid, particularly in prime land areas, are therefore significantly different from that of CSG brine, as discussed separately below.

1B (i) CSG Brine

<u>Projected Volumes and Salt Load Implications</u>

Because of the sheer volume of saline-alkaline groundwater co-produced during CSG production, reverse osmosis (RO) desalination is the preferred and probably the only viable means for reducing the volumes of such water. Therefore, regardless of the end use options, such water has to be desalinated and consequently the brine generated from RO desalination processes will be a ubiquitous feature of future CSG production operations in Australia. This is reflected in all CSG development companies having already or being in the process of establishing large scale RO desalination facilities to service their CSG production sites.

To give an indication of the scale and salt load of CSG brine production, it is estimated by the Queensland government (Queensland Government CSG Water Discussion Paper, 2009) that if only the CSG projects in the Surat Basin progress to their full commercial stage, some 25 gigalitres per year of associated water would be generated over the life of projects (i.e., next 25 years). Based on the indicative salinity level of the associated water (about 2 g/L) the Surat Basin operations alone are expected to bring to the surface approximately 50,000 tonnes of salt per year that needs safe disposal. CSG brine is expected to comprise between 10-30% of the original volume of water (2.5 to 7.5 gigaliters) introduced to the desalination systems, and will include upwards of 99% of the original mass of salts brought to the surface.

In the case of CSG resources in NSW the associated water is expected to be relatively more saline than the Queensland resources due to a higher degree of natural fracturing within the coal seams and the more saline nature of the associated groundwater aquifers. Consequently when assessing the environmental and operational impacts of CSG brine management practices it would be critically important that both volumes and salt loads are considered as part of assessing the water and salt balances. This highlights the issue raised earlier with the lack of a public access to relevant information base as presently most of useful information

including those on projected salt load generation through the life of CSG projects are held by the CSG developers and presumably not independently verified by peer review.

Management Issues

Considering the direction of the CSG industry development in NSW, it is generally assumed that the volume of CSG water and thus desalination brine from NSW operations would be less than that projected for Queensland in the coming years. However, what is not said is that regardless of the volumes involved the brines from the desalination processes will be highly alkaline and made up of sodium carbonate and bicarbonate mixed with sodium chloride salt. It is known from literature that the management of the environmental impacts of such brines is substantially more complex than that of ordinary desalination brines. Consequently, considering the volumes involved the cost of management of such brines will be significant as their safe disposal will either involve deep well injection or where injection option is not available require brine treatment for volume reduction and conversion to solids before final disposal in purpose built landfill facility. As discussed below, one approach for reducing the cost of brine disposal will be through the recovery of valuable products from the brine; this approach is one of the preferred options proposed by the Queensland Government along with deep well injection, where possible.

Another untold story relates to the limitations with the scope and availability of brine management options regardless of the costs involved. Overseas literature on this subject matter (see Attachment 2 for example) clearly indicates that options available for sustainable management of RO brine, whether from municipal or other industrial sources, are limited and can be summarised as listed in Table 2.

The following additional notes provide supplementary information on the issues associated with the brine disposal options listed in Table 2.

Table 2. Brine disposal options and limitations thereof

Disposal Option	Limiting Factors in NSW
1. Direct land application	• Impossible because of volumes involved, high salinity and sodicity impacts and current regulatory constraints • Loss of a resource
2. Direct discharge to waterways and wetlands	• As above
3. Blending with sewage effluent for disposal	• Impossible because of volumes involved and reduction in beneficial use of sewage effluent
4. Evaporation, infiltration and retention ponds	• Highly undesirable and already banned in Queensland and NSW
5. Volume reduction by enhanced evaporation systems and impoundment	• Highly undesirable because of impacts on surrounding environment and significant risk associated with CO2 gas release • Past history of failures in the U.S. and Middle East • Multiplying effect on concentration of toxic contaminants

6. Thermo-mechanical evaporation and crystallisation	• Technically feasible but with significant carbon footprint and high costs of pre-treatment
7. Deep well injection	• Technically feasible and cost effective where favourable hydrogeology is available • A risky option particularly in areas without deep well injection history • Requires tight monitoring to ensure structural integrity of the injection system • Loss of a resource
8. Comprehensive treatment of CSG brine for beneficial use and waste minimisation	• Removes a large cost component related to landfilling of solid residues • Offers opportunity to offset treatment costs through product recovery • Requires market development for the generated products

Brine Impoundment:

CSG brine is commonly alkaline and characterised by elevated concentration of dissolved ions of sodium, chloride and bicarbonate. Consequently, once stored in a pond (whether called storage or evaporation ponds) the alkaline brine will be subject to evaporation and bicarbonate decomposition leading to the release of CO2 gas to the atmosphere thus exacerbating the environmental impacts of brine storage practices.

Equally important is that, through time, such ponds will progressively lose their evaporative capacity (because of increasing salinity), thus extra land will be required to address the reducing usefulness of evaporation ponds. Consequently, through time, the land needed to set up such ponds and costs involved in their construction and operation will be significant, if not prohibitive. There is excellent Australian experience and literature available on this subject matter from the salt interception schemes in the Murray-Darling Basin.

My experience indicates that unless the CSG brine is subjected to thermal volume reduction processes there is little chance that solid salts can be formed and extracted from the storage ponds in a form for beneficial use or direct safe disposal. Conventional salt harvesting may be feasible but this will require substantially larger land area to set up purpose-built evaporation and crystalliser ponds; this is not a preferred option on both economic and environmental grounds and evaporation ponds have been banned in both NSW and Queensland.

Enhanced evaporation systems (EES) have been mooted by some companies as a measure for brine volume and pond size reduction. Some trials have been conducted in NSW by a CSG developer; however, from substantial overseas experience (U.S.A., Israel, and Middle East) it appears that EES has major limitations including but not limited to scale of application and prohibitive operating costs. There is plenty of good public domain literature to support these observations. Apart from technical/operational issue the main concern my perspective is the enhanced release of CO2 gas from impoundments, which is unsustainable on

both environmental and economic grounds. [Recommendation 7]

All these issues with CSG brine are untold to the public; this is reflected in the little passive reference to brine management issues and solution options in the environmental impact statements of the Queensland CSG developers. Statements by some government authorities that there is currently no solution for management of CSG brine are also not helpful as without knowing about technologies and practices employed in other industries, or at least showing interest in finding solutions for the good of people and environment, such statements can only be considered as overstatement.

A shortcoming which appears to contribute to this very issue is the lack of experience by company and government scientific/technical advisors on aspects of CSG brine hydrochemistry and little reference to overseas experience with management of such brine [Recommendation 10]. This appears to be at odds, particularly in Queensland, where a preferred option is for treatment for beneficial use of CSG brine.

Failure to actively seek sustainable solutions has the potential to turn brine management into a major bottleneck for the CSG industry in achieving its full commercial potential in New South Wales and potentially elsewhere in Australia. There are several examples from Southwest U.S.A., where the implementation of inland municipal desalination projects have been delayed or even curtailed because of challenges with brine management (see Attachment 2).

Deep Well Injection:

As indicated in Table 1, where favourable hydrogeological conditions exist, deep well injection can be an attractive means for safe disposal of saline waters including CSG brine. However, in areas without deep well injection history it requires significant sophistication on the part of operator to comply with regulatory requirements. In the U.S. deep well injection in some states requires a redundancy of 100% backup capacity. Considering that alkaline CSG brine will potentially require substantial use of chemicals for pre-treatment to avoid corrosivity, scaling and adverse fluid-rock interactions that could clog the pores, it is expected that such redundancy will be also necessary in the case of Australian CSG industry.

Considering the sensitivities surrounding groundwater aquifers in NSW, if deep well injection was permitted as an option for brine disposal then tight monitoring requirements would be necessary to ensure the structural integrity of the permitted injection systems. Of particular importance will be the need for continuous monitoring and expert review of the performance of injection wells to provide evidence for absence of vertical migration avenues from injection zone. [Recommendation 2].

1B (ii) CSG Drilling Fluid

Regardless of the method of exploratory drilling (vertical, horizontal or combinations thereof) CSG drilling fluid is invariably saline and alkaline, turbid, high hardness and may be characterised by elevated concentration of dissolved metals and organic contaminants. It may also include the remnants of chemicals used for enhanced fracturing of coal seams. However, considering the prevalence of inherited fracturing of the seams in NSW coal basins and elevated salinity of associated water (compared with Queensland counterparts) it is expected that the use of chemicals for hydraulic fracturing in NSW would be limited and at best site-specific.

The water quality issues, as described above, can substantially reduce the usefulness and the scope of direct reuse of CSG drilling fluid. Consequently, CSG explorers may need to frequently utilize externally sourced fresh to brackish water with low Total Suspended Solids (TSS) and hardness for augmenting the in-situ saline to alkaline water lost during drilling. This practice is potentially unsustainable in NSW for the following reasons:

- The volume of fluid generated from individual exploration wells and well development fields would be significant in volume warranting onsite treatment for recycle/reuse
- Drilling fluid can be treated for recycle/reuse using existing technologies
- In the case of NSW, considering higher salinity nature of CSG water, pond storage of saline and potentially contaminated drilling fluid would be a highly undesirable practice
- Pond storage of drilling fluid leads to evaporation and further concentration of potentially toxic contaminants making the water redundant for beneficial use unless extensively treated at higher costs

As treatment of drilling fluid for reuse in exploration drilling and well field development is a common practice overseas it should be strongly encouraged and if necessary enforced through legislation in NSW to minimise the potential impact on the environment. [Recommendation 5].

1C. Beneficial Use of CSG Brine

Whereas the beneficial use of brine has been mooted by few CSG companies, Commonwealth and state legislations currently appear to be too lax to compel the companies to proactively pursue the opportunities for investment in brine treatment technologies for waste minimisation. This unfortunately applies right across many industries in Australia producing brine effluents are wasted through land discharge; although the West Australian government has recently introduced measures with potential for the State's mining and mineral processing industries taking more active interest to wastewater minimisation through application of appropriate technologies.

Brine minimisation through recovery of valuable products will, at a minimum, remove a large cost component related to landfilling and reduce the risks and liabilities associated with storage and disposal of brine. In addition, the beneficial use of CSG brine as a resource provides other advantages including offsetting of the treatment costs, opportunity for achieving zero discharge outcomes, significant carbon and physical footprint reduction and generating regional industry and employment opportunities. Further, there exist technologies that can create high value industrial chemicals and minerals, that are commonly used and currently imported by some Australian industries, from large volume low-value salts. The opportunities for import replacement are abound and the NSW government should take a proactive approach towards investing in opportunities where job creation and productivity level can be positively impacted.

It is evident that to make the CSG industry compatible with other industries, particularly farming, in NSW there is an overwhelming need for a paradigm change at both industry and government levels from waste disposal to resource recovery. The NSW government should promote this notion through investment in identification and assessment of technologies and practices that enable adoption by industry for sustainable management of saline effluents, including CSG brine. [Recommendation 9]

The fact is that the potential impacts of CSG brine on soil and water environments leave no room for complacency and the stakeholders in the CSG industry should also proactively seek technology based

solutions for brine minimisation through beneficial use. This needs allocation of research funds and in-house resources from the NSW government combined with appropriate legislation, if the CSG industry in NSW is to fully realise its development potential for the benefit of people of NSW and environment alike. [Recommendation 9]

1D. Current Status and the Need for Development of a Knowledge Base

There is an overwhelming need for a publicly accessible credible knowledge/information bank for productive discussion on CSG water quality issues and informed decision making on management options. The following provides an overview of the two key drivers for such a dire need:

Poor Quality of Professional Advice

It appears that the near absence of a credible knowledge base on CSG water management issues for reference by the public (and probably CSG companies) is partly a reflection of the poor quality of advice being provided by the ever-increasing number of consultants to the government and CSG water sector.

From my understanding, a consultant with appropriate experience on the subject matter should be able to support his/her client in early and thoughtful planning of a water management strategy, and particularly in developing a risk register and assessing the mitigation of these risks. Obviously each project is unique and has its own site specific requirements and constraints but CSG brine management has serious environmental, operational and cost issues common to all CSG projects. Unfortunately, the failure of consultants to CSG developers to identify the issues of brine management and its inter-connectivity with scale and whole life cycle impacts is evident in publicly available EIS reports for CSG developments.

Considering the importance of the success of CSG industry to the wealth generation and prosperity in of NSW there is an overwhelming need for a shakeup of the environmental consultancy industry to bring up the quality of output and performance commensurate with industry and community expectations. Right now, we are facing a key challenge, namely that of CSG brine management which has the potential to delay the operations and productivity of the CSG projects in Australia. It is critical to support the CSG developers and regulators in NSW in identifying the water issues early in the project at the planning stage rather than as a regulatory afterthought. For this very reason, the consultants should move away from a conservative approach of serving their clients (rather than providing their client with a professional and ethical service), taking stock of appropriate scientific and technical information bases, and thus developing a multi-disciplinary capacity for responding to broader issues that their clients and the Community are facing with. These are clearly some of the missing values from current consulting practices in the CSG field.

In summary, there are too many cooks providing poor quality professional advice to such an important industry sector. This, to me, is like playing with fire with potential to bring this important industry to its knees, and thus needs to be rectified promptly. [Recommendation 10].

The Fundamental Requirements

Considering the limitations with the options for sustainable management of CSG brine and the compounding effect of the inadequacy of publically available information on the nature and potential impacts of CSG brine and drilling fluid, there is an overwhelming need to develop a credible knowledge base. There has to be a central repository of information easily accessible by community and industry as a basic requirement for productive discussion of the environmental issues and for informed decision making. This has been done

overseas (see Attachment 2) and from my previous experience a similar approach can be implemented in Australia at NSW level with the Commonwealth funding support. [Recommendation 10].

PART 2. RECOMMENDATIONS IN RESPONSE TO THE TERMS OF THE INQUIRY

The following recommendations are made with reference to specific terms of the inquiry outlined in Table 1. As indicated earlier, these recommendations are primarily to assist the commission and CSG industry with identifying timely resolutions for the CSG brine management issues, dubbed by many in the field as a key stumbling block facing the industry in NSW. I request consideration of these recommendations as part of the measures that the Commission may recommend to NSW Government for overcoming current shortcomings with state planning processes and policy options to protect our communities and the environment.

<u>Inquiry Item 1a – Effect on ground and surface water systems</u>

Recommendation 1. Permitting for deep well injection of CSG brine to include well defined monitoring requirements to ensure structural integrity of the injection systems. Monitoring of injection wells shall be performed by CSG developers and review of performance of injection wells shall be undertaken by an independent expert to verify the absence of vertical migration from injection zones.

Recommendation 2. Where impoundment of CSG brine is allowed, it should be a temporary measure and include a clearly defined plan and timetable for removal of brine to an off-site wastewater treatment facility. The impoundment should be properly designed, constructed and operated under licensing arrangement with the state government and incorporate an operation plan with a well defined monitoring strategy, similar to guidelines for CSG brine impoundment in Queensland. Only one impoundment of agreed size and depth should be allowed for each well field.

Recommendation 3. Unless beneficially used or injected to deep wells, landfilling of solid residues (with less than 5% moisture) obtained from thermal volume reduction of CSG brine should be the ultimate destiny of CSG brines generated from desalination of CSG associated water.

Recommendation 4. A landfill site should only be located at CSG well sites and the CSG developer shall be fully responsible for risks and liabilities associated with operation of a landfill site for the whole life cycle to closure. Landfilling should be specifically for disposal of solids produced by the CSG operators. Only one mono landfill of agreed specifications should be allowed for each well field.

Recommendation 5. CSG exploration drilling should not be permitted unless the explorer has a well defined strategy and plan in place for treatment of drilling fluid for reuse/recycle of the treated water or otherwise for safe disposal. No impoundment should be allowed for the storage of untreated CSG drilling fluids.

<u>Inquiry Item 1e – Nature and effectiveness of remediation under the NSW Petroleum (Onshore) Act</u>

Recommendation 6. CSG developers to submit pond closure and salinity remediation strategies with their development proposals for approval, similar to a scheme recently introduced in Western Australia for mine development plans.

Inquiry Item 1f – Effect on greenhouse gas and other emissions

Recommendation 7. The use of enhanced evaporation systems for CSG water or brine volume reduction should be forbidden in NSW.

Additional Related Recommendations

Recommendation 8. The NSW government should, as a matter of principle, actively promote and encourage by legislation the need for CSG companies to implement a brine management strategy in earnest as an integral part of the process of defining and implementing a sustainable, long-term water management plan.

Recommendation 9. NSW Government to promote and contribute financially to investigative projects aimed at finding sustainable technology-based brine solutions including but not limited to:

- Establishment of an expert scientific advisory committee to advise the Government on water quality monitoring, pollution control and areas of research concentration
- Establishment of a research funding program (similar to Water Resource and Research Foundation of USA) to promote independent research on water quality monitoring methods, brine management technologies and publication of public interest technical and management reports
- Develop and maintain a central repository of CSG related water quality and management information for easy access by community and industry alike
- Finance the establishment and operation of a research institute to undertake research into environmental, economic and social impacts of CSG in NSW and co-finance projects for demonstration of appropriate technologies for CSG water management
- As a priority action the NSW government should commission a detailed CSG water management options study in collaboration with CSG developers and concerned community groups

Recommendation 10. NSW Government to develop a Scientific Integrity Policy so as to promote scientific ethical standards, transparent public communications, the use of advisory committees and peer review within the consulting industry. This may require the establishment of a registry of state consultants with appropriate qualifications for advising the government agencies on mining and CSG water management aspects.