UNSW SYDNEY

28 June 2018

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Narrabri Gas Project – Response to Submissions
Expert Review

This letter is to follow-up my previous advice regarding the Narrabri Gas Project, which was requested on behalf of the North West Alliance. I have now read the "Narrabri Gas Project – Response to Submissions" provided by Santos and can make the following brief observations.

Salinity of produced water

An issue raised by my submission was as follows:

> *The EIS describes the quality and management of produced water in Chapter 7. Somewhat unhelpfully, the salinity of the produced water is described in terms of electrical conductivity (in units of microSiemens per centimetre), rather than an actual salt concentration (in units of mg/L). It is stated that the average salinity is around 14,000 microSiemens per centimetre. The EIS states that "this level of salinity is approximately 30 percent of the salinity of seawater, which is around 50,000 microSiemens per centimetre".*
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> *The actual conversion from electrical conductivity to salt concentration in mass terms is dependent upon the precise chemical composition of the salt. Produced water from CSG wells is predominantly composed of sodium bicarbonate, whereas sea water is predominantly composed of sodium chloride. Consequently, the conversion from electrical conductivity to salt concentration is significantly different for the two saline solutions.*
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> *At 25^{o}C, 14,000 microSiemens per centimetre would equate to approximately 7000 mg/L sodium chloride, but would equate to approximately 14,000 mg/L sodium bicarbonate. On this basis, it is not accurate to state that the salinity is approximately 30 percent of the salinity of seawater. Seawater contains around 35,000 mg/L of salt, hence the produced water is approximately 40% the salinity of seawater.*
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> *I note that in previous personal discussions (in 2014) with Santos Water Management Leader, Glen Toogood, I was informed that the overall average salt concentration was expected to be 18,000 mg/L. On that basis, the salinity would be approximately 50% the salinity of seawater. In order to avoid this*

ambiguity, the EIS should simply provide the actual expected salt concentration –in mg/L- in Chapter 7.

A response is provided on Page 6-40 of the Response document, where it states:

Submissions requested clarification of the salinity of produced water. They requested salinity to be expressed in terms other than electrical conductivity. They also stated that produced water salinity stated in the assessment of around 9 g/L (14,000 microSiemens/cm) was lower than previously published estimates of salinity for Bibblewindi exploration at around 14.5 to 31 g/L with an average of 18 g/L.

> Electrical conductivity (EC) is considered to be an acceptable method of expressing salinity. Section 6 of the updated Water Baseline Report in Appendix D of this RTS contains water quality data from produced water collected at the existing water treatment facility at Leewood and salinity is presented in terms of electrical conductivity and total dissolved solids, with a break-down of the anions and cations constituting this salinity.
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> Table 6-1 of the updated Water Baseline Report provides for the Leewood produced water ponds the field measured TDS ranges from around 2,750 mg/L to 24,400 mg/L, with a mean of around 14,700 mg/L.

It is indeed helpful that this figure of 14,700 mg/L for mean salinity has now been provided. Given that seawater is around 35,000 mg/L, it should no longer be claimed that the mean salinity of the produced water is approximately 30% of the salinity of seawater. On the basis of the above figures, the produced water will be around 42% of the salinity of seawater.

Salt mass

A further issue raised in my submission was as follows:

In section 7.8.1 "Salt Volumes", it is stated that "produced water was heated in the laboratory to 180 degrees Celsius to simulate the thermal process used during water treatment. During heating, some salt in the produced water decompose, while the remainder become a solid salt product. After taking into account decomposition resulting from heating, the typical mass of salt produced is 11,700 milligrams per litre of water fed to the water treatment process".

The fact that the initial salt concentration (in mg/L) does not seem to be provided, makes it difficult to understand the mass balance for the above paragraph. However, it is clearly implied that some chemical change is understood to take place. In my opinion, this needs to be supported with some clear and balanced <u>chemical reactions</u>. In addition, the EIS needs to answer the following questions:

- *What salts are being changed and into what products?*
- *What is the mass loss of salt relative to the initial mass?*
- *How is that loss accounted for?*
- *Does this change produce gaseous products?*

A response is provided on Page 6-269 of the Response document, where it states:

Submissions queried the quantification of waste salt in the assessment.

> As noted in Section 7.1 of the EIS, the average salinity of produced water generated during exploration and appraisal activities within the project area to date from the Maules Creek Formation and Black Jack Group is around 14,000 micro Siemens per centimetre. It is important to note that the produced water varies by seam and location across the project area.
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> To determine the volume of solid salt product the project would generate, laboratory work was undertaken to imitate the Leewood water treatment process (explained in Section 6.2.1 of Chapter 6 of the EIS), using conditions likely to achieve a similar level of decomposition. Specifically, the produced water was heated in the laboratory to 180 degrees Celsius to simulate the thermal process used during water treatment. During heating, some salt in the produced water decompose, while the remainder become a solid salt product. After taking into account decomposition resulting from heating, the typical mass of salt produced is 11,700 milligrams per litre of water fed to the water treatment process. This factor has been used to determine the estimated salt production rate, and subsequently, its volume and weight.

However, this response is really just a repeat of what was already stated in the EIS. The concerns I express above do not appear to have been addressed in the Response to Submission. It remains unclear how salt from produced water at a mean of 14,700 mg/L becomes only 11,700 mg per litre of (unconcentrated) produced water. No answers are apparent to the questions which were asked. Consequently, I find it difficult to accept, without further explanation, that the final mass of salt following brine treatment will be significantly less than the total mass of salt extracted from the coal seam. If mass loss is assumed to occur as a consequence of gaseous emissions, these emissions should be clearly stated and quantified.

Disposal of Waste Salt

A further issue raised in my submission was as follows:

> *In Chapter 28 "Waste Management", it is stated that 430,500 tonnes of salt are projected to be produced over the 25 year life of the project.*
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> *I understand that this 430,500 tonnes of salt would be disposed of at a licensed landfill facility. The operation of the licensed landfill facility appears to be outside the scope of this EIS. However, it is appropriate to consider the lifecycle impacts of all products produced from the proposed CSG operation. Salt-filled landfills are subject to a number of potential hazardous events, which effectively compound the environmental risks that flow from the CSG operation.*
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> *One potential hazardous event involves the failure of the landfill liner and seepage of saline water (leachate) to groundwater and surface water. There are measures that are normally proposed to be in place to manage this risk, but these measures will not completely eliminate the risk. Importantly, the lifespan of this salt storage will need to be properly considered. Salt does not biodegrade in the environment and has an infinite environmental residence time. Consequently, salt storages will need to be maintained on a permanent basis (decades or longer) or until the salt is re-mined and removed from the facility. Failure to do so will*

guarantee that the salt will eventually contaminate the local environment including groundwater and surface water. Unless satisfactory measures are in place to manage this risk over many decades (or longer), the risk is not managed.

A further important potential hazardous event is that of flooding, which can impact an open landfill monocell (one that is still in the process of being filled) and well as the existing stock-piles of salt, being prepared for landfill (or being prepared to be transported to the landfill site). These stock-piles will be relatively uncontained, and therefore, much more prone to causing environmental contamination during flooding or large wet weather events.

Due to the very long-term nature of some proposed salt landfill operations, the likelihood of contaminating groundwater and surface water over the long term is considerable. The responsibility for managing these risks over the long term will likely be inherited by future generations.

A response is provided on Page 6-270 of the Response document, where it states:

Submissions queried the measures that would be in place to monitor the potential impacts of produced salt once it is disposed. They stated that produced salt and contaminants therein would pose a risk if leaching into surface water and groundwater including rain or flood events. They stated that the lifecycle risks of salt disposal should have been considered in the assessment to ensure the salt is managed appropriately on a permanent basis.

> The Waste Assessment presented in Chapter 28 of the EIS was undertaken in accordance with the Secretary's environmental assessment requirements for the project. As stated in Chapter 31 (Project commitments) of the EIS, waste salt would be disposed of at an appropriately licensed facility in accordance with regulatory requirements.
>
> Licensed facilities that manage waste are required to ensure appropriate storage and management of the waste to prevent environmental impacts. This can typically involve measures such as the application of a barrier system and stormwater diversion works.
>
> The licenced landfill facilities operate under Environment Protection Licences issued pursuant to the NSW *Protection of the Environment Operations Act 1997*.

I take this response to imply that lifecycle risks have indeed been considered, but that other aspects of those lifecycle risks (ie, during and after waste disposal) are considered elsewhere. In my opinion, this segregation of assessments for individual project components is not ideal. Not having the full life cycle assessment of the project environmental impacts prevents the ability to properly appreciate the 'big picture' in terms of what impacts must be ultimately endured as a consequence of the project proceeding.

I hope you will find these comments to be helpful,

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