Review of the Water Quality and Aquatic Ecology components of the Narrabri Gas Project Environmental Impact Assessment

by

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1. Introduction

I confirm that in preparing this report I have read the Expert Witness Code of Conduct under the *Uniform Civil Procedure Rules 2005* and I agree to be bound by it. The documents I have utilised in preparing this report are listed under the references section at the end of the report.

2. Chapter 12. Surface Water Quality & Appendix G4 Water Baseline Report

2.1 Methods

The EIS states:

> *"Methodology from ANZECC/ARMCANZ (2000) was used for the project to generate water quality baseline statistics for the purpose of impact assessment. The regional baseline water quality data that have been collected over several years for the project provide an understanding of water quality within the Namoi River and Bohena Creek (refer to Appendix G4). These data would be used as comparative (sic) during ongoing water quality monitoring throughout all project phases using trend analysis over time so that identified significant variance from the norm can be investigated.*
>
> *The method above was then interpreted for the purposes of impact assessment as described in Chapter 10. This method considers the sensitivity of the receiving environment (Bohena Creek for example) and when multiplied by a magnitude rating, determines likely impact significance." (Page 12.4)*

It is unclear what this means. ANZECC/ARMCANZ (2000) does not include a method to "generate water quality baseline statistics". It does, however, include recommendations on data collection at reference sites which specify "*a minimum of two years of contiguous monthly data …is required*" (ANZECC 2000 page 7.4-5). None of the data sets for either the Namoi River or Bohena Creek fulfil this criterion. While that is understandable for Bohena Creek which is not a perennially flowing stream, that is not the case for the Namoi River. The only data set provided which extends over 2 years is that for site 7511 which included only 12 sampling occasions over that period.

It is unclear what "*significant variance from the norm*" means. It seems to be phrased in pseudo-statistical language. Water chemistry in rivers is highly variable both spatially and temporally. Does the "norm" mean the mean (average) or the median or something else? The "variance" in statistics is a measure of the deviations of a set of measurements from the mean and is determined from the equation:

$$\sigma^2 = \frac{\sum(x_i - \mu)^2}{N}$$

I assume that what is meant here is a "significant difference" from the median or mean. It is unclear if that means a statistically significant difference. If so a power analysis would need to be conducted on the existing data to establish how many samples would need to be collected and analysed in order to establish that there was a statistically significant difference. From the data included in the tables here it is not possible to conduct such an analysis. To do such an analysis it is necessary to know the mean and standard error or standard deviation of the data set at a site. Using just the mean values for the 6 Namoi River sites (which will be an underestimation) and the maximum and minimum values (which will be an overestimation) for TDS and Calcium the number of samples necessary to detect a 25% change in either of those analytes, with 95% confidence, would be between 4 and 75 samples based on a power analysis conducted with SYSTAT software.

2.2 Statistical Analysis

> *"As new surface water quality data are collected, these will continue to be added to the dataset, which undergoes statistical analysis to ensure it is spatially and temporally representative such that is provides confidence when assessing trends in water quality analytes. This is important so that outlying data points or spikes can be identified during operational water quality monitoring that may flag potential issues.*
>
> *All field-based surface water monitoring data and laboratory results are captured in a centralised database. This methodology allows for automated trend analysis and comparison of data against baseline information and threshold values."* P 12-7.

Despite what is stated in the excerpt above, appendix G4 has no statistical analysis, and results are presented for various analytes together with minimum, maximum, mean and median values, and the number of samples. No explanation is given as to how the proponent intends to ensure the data is spatially and temporally representative, or how trends are to be detected. The data set is quite sparse, particularly in terms of temporal patterns, with the most frequent sampling apparently being once every two months. Certainly the data set is inadequate to ascertain patterns of change during high flow events, and the sampling frequency is totally inadequate to detect spills.

2.3 Summary on Namoi River

The Summary section (page 12-15) on the Namoi River is inadequate. There is no evidence to support the statement that "*a variety of chemical constituents are recognised as a product of activities within the greater Namoi Catchment, with the main source of total dissolved solids being agriculture and residential runoff*". There is no evidence of agriculture or residential runoff contributing to TDS.

"(M)*ajor ions include sodium, chloride, and calcium, which reflect the dominant water type of the Namoi River*"(Page 12-15). In as far as it means anything, this statement appears to be incorrect. Converting the mean ionic concentrations from Table 12.1 to milliequivalents (mEq) gives 1.43 for each of Na and Ca (the two predominant cations). For chloride (the major anion measured) the mEq value is 0.9. The sums of the mEq values for anions and cations should be identical (since river water is electrically neutral). So the sum of the positive charges is about 2.86, but for negative charges is only 0.9, leaving a large component of the anions not accounted for. The sites tables in appendix G4 indicate quite high levels of sulphate (e.g site 7529 had 24mg/L = 0.54 mEq), but if that is representative that still only accounts for about 54% the anionic component. So what is the rest? Is it carbonate and bicarbonate? If so that has very significant implications for the "dominant water type" – and for the biota which occur in the river. If natural, it also means that maintaining the pH in the river is very important. It also means that the Namoi is very different to Bohena Creek which appears to be sodium and chloride dominated with lower pH.

2.4 Cause of High EC

The statement that "*The background electrical conductivity values may be attributed to agricultural and dryland cropping activities in which accumulated salts can be mobilised and discharged into surface water during rainfall events*" (Page 12-15) is incorrect. Indeed, we know that some western NSW rivers were at times too salty for humans and stock to consume when first encountered by Europeans, long before there were any substantial agricultural or dryland farming activities in the catchment.

2.5 Water Chemistry of Bohena Creek

There is far less data for Bohena Creek than for the Namoi River, partly because the creek is not perennial. The water chemistry data are quite variable. In order to detect a 25% change in conductivity with 95% confidence would require between 25 and 75 samples, and to detect the same level of change in calcium concentration would require between 35 and 150 samples. So far only 40 samples in total have been collected from this creek. In contrast to the Namoi River, the chloride in Bohena Creek accounts for 77% of the anionic component required to match the Na and Ca components. It is interesting that the ratio of Na/Ca in Bohena Creek is 3.17, indicating a predominance of Na, while that in the Namoi River is 1.11, indicating an approximate gravimetric equivalence.

It is most disturbing that the EIS makes no mention of the obvious chemical differences between the two water bodies. Differences in water chemistry may have substantial impacts on the biota of streams (molluscs, for example are favoured by high calcium levels such as the Namoi River), and on the impact of toxicants such as metals (which are more toxic in acidic, lower calcium streams such as Bohena Creek). However, this is not discussed under either water quality or aquatic ecology.

2.6 Need for Release to the Creek

According to Figure 12.2 on page 12.5 the treated water to be released to Bohena Creek during the peak years will amount to 418 ML each year for 2 years. That amounts to approximately 12% of the water produced. That amount of water would be utilized if an additional 100ha were to be irrigated or by a 65% increase in dust suppression usage. Should there be dry years, such as the period 2001-2004 there would be no flows in the creek, much less flows > 100 ML per day, so there would be no possibility to discharge and some other disposal route would need to be found. I note that zero flow years occurred for

40% of the years used as a basis for the design of the project (1995-2005), and that the period from 2005-2012 was excluded from consideration because it had "far fewer incidences of flow" (Managed Release Study p 22). That suggests that there may be far fewer opportunities to release water than is suggested by the earlier data. The fewer incidences of flow are attributed to a change in the rating curve, but the post-2005 rating curve is presumably the rating curve used currently. It would seem to be unnecessary to discharge to the Creek and preferable, therefore, to plan from the outset not to discharge any of the water extracted in the gas extraction process.

3. Chapter 16. Aquatic Ecology

Most of the details of the aquatic ecology work on which this section is based are included under the Managed Release Study and so are discussed below.

3.1 Aquatic Habitat

It is curious that the stream habitat structure is discussed on page 16.10 under "Riparian Habitat" with a different description being provided on page 16.11 under "Aquatic Habitat".

3.2 Water Quality

The discussion of water quality is very disappointing, as demonstrated by comments regarding turbidity, such as "*One reason for the high turbidity was the large volume of sediment suspended in the water column*". Yes, high turbidity is virtually always caused by high levels of suspended sediment, there are only two other possible factors, the nature of the sediment particles, and large volumes of organic particles. However, the comment that "*the high turbidity probably contributes to the low dissolved oxygen concentrations*" is incorrect. Low dissolved oxygen concentrations are primarily a product of the availability of organic material which is utilised by microorganisms, and a low re-aeration rate in the standing waters of the remnant pools.

4. Appendix G3: Water Monitoring Plan

4.1 Absence of Water Quality Monitoring Design

On page 3-20 of the Water Monitoring Plan the proponents suggest that surface water quality monitoring will be conducted at 6 sites (4 on Bohena Creek and two on the Namoi River). No indication is given of the frequency of sampling. Would it be only during releases, or would it commence during periods of flow prior to releases? How frequently during the release? Would samples be taken on a single occasion, or weekly or daily? How many samples would be collected at each time, one, or five or ten? This appears to me to be totally inadequate as a monitoring plan. There is sufficient existing data to determine how many samples are needed to detect effects of identified sizes, so I would expect a discussion of the frequency and number of samples at the very least.

5. Appendix G1: Managed Release Study

5.1 Treated Water Quality

The assessment of the impact on the water quality of Bohena Creek of the treated water release at p33 is based on modelled predictions of the composition of the treated water. However, we are given little indication of the confidence limits of the model. Predicted concentrations of various components in the treated water are presented in Table 5.1 (p 34). The mean concentration of phosphorus is predicted to be 0.01 mg/L, but the maximum concentration will be less than 0.01 mg/L. The level of total nitrogen, a key nutrient potentially stimulating algal blooms in freshwater systems, cannot be calculated although the concentration of ammonia, a nitrogen-based compound, will be up to 50 µg/L. Predictions of the consequences of the released water for Bohena Creek depend on composition of the released water, but I have a low level of confidence in this modelling.

5.2 Aquatic Ecology and Stygofauna Assessment

Within the Managed Release Study documents, the section on macroinvertebrates is particularly weak. It is troubling that sites in Bohena Creek were compared with sites in the Namoi River (p 12) given that one stream is intermittent and the other is perennial, and that one is apparently sodium chloride dominated and the other calcium carbonate dominated – both factors which would lead to substantial faunal differences. The Namoi is not a suitable reference system for a BACI type design to detect any impact.

5.3 Indicative Invertebrate Taxa

The comment that "*the presence of Leptoceridae and Acarinae are indicative of severe to moderate impairment*" (p 29) is untrue. In fact impairment is characterised by the absence of intolerant taxa, not the presence of tolerant taxa. Both Leptoceridae and Acarinae occur, and may be abundant, at sites with as close as is possible to no human impact. We are told that "*Hydropsychidae, Telephleidae (sic) and Protoneuridae occurred in the Namoi River but not in Bohena Creek*"(p66 Aquatic Ecology and Stygofauna Assessment) which is perhaps not surprising in the case of the Hydropsychids since they are obligate passive filterers requiring flowing water to survive. I assume that "Telepheidae" is a mis-spelling of "Telephebiidae" throughout the document.

5.4 Water Quality, Electrical Conductivity (EC)

In the Aquatic Ecology and Stygofauna Assessment appendix of the Managed Release Study we are informed that:

> "*EC was within the recommended ANZECC range for all sites, although temporarily fell below the minimum at Nuable Creek and Middle Creek in Autumn and at Spring Creek in spring (Table 12)".*

The same point is made on Page 62.

In Table 12 the document claims that ANZECC (2000) included a recommended range for EC of 125-2200 µS/cm. This is a complete misunderstanding of the ANZECC document. The value of 125 µS/cm is not a lower limit trigger value, but rather an upper limit for lowland streams in the eastern highlands of Victoria which have naturally low conductivity, as ANZECC states "*Low values are found in eastern highlands of Vic. (125 µScm^{-1}) and higher values in western lowlands and northern plains of Vic (2200 µScm^{-1})*".

5.5 River snail *Notopala sublineata*

On page 72 the document cites NSW DPI (2007) as a source for a statement that this species has "*not been collected for more than 15 years in natural environments*". The DPI document does comment that "*Over the last decade living specimens have only been recorded from water supply irrigation pipelines*", but this does not appear to have been intended as a definitive statement. The species has been detected in irrigation pipelines because it is a pest in those locations, where it may block the pipeline. It has not been detected elsewhere, but it has rarely been sought. DPI (2007) note that "*There have been no extensive dedicated surveys for the river snail in NSW. However, some survey work has been done as part of a postgraduate research project at Macquarie University*". There are very few freshwater malacologists in Australia, so there are very few people looking for freshwater snails, and since most aquatic invertebrate surveys (such as the one conducted here) only identify taxa to the level of family, it is not surprising that the species has not been detected. Given that there is an historical record of the species from this area I would have expected that the proponent would have conducted a targeted survey for the species conducted by an appropriately experienced freshwater invertebrate specialist.

6. Appendix C of Appendix G1: Aquatic Ecology and Stygofauna Assessment

6.1 Macroinvertebrate Assessments

It is stated in sections 4.24 and 4.3.4 that SIGNAL scores from Bohena Creek indicate pollution or poor condition. On page 47 "*SIGNAL scores below 4 indicate severe pollution, or poor condition*" and on page 66 "*These scores are indicative of high to moderate levels of disturbance*". SIGNAL scores, and most other indicators, need to be interpreted by a specialist with some expertise in the field. Taxa with high SIGNAL scores are generally those intolerant of low concentrations of dissolved oxygen. In flowing waters oxygen concentrations are maintained by the entrainment of oxygen through the turbulent flow. When flow ceases, the pools remaining in non-perennial streams generally contain high loads of organic material, in the form of terrestrial plant litter which has fallen into the stream. Microbial processing of this material consumes oxygen, and water temperatures are often higher than during flow periods, which also reduces dissolved oxygen concentrations, and there is less oxygen diffusion into the water because of the reduced level of turbulence. Consequently, even in non-perennial streams without human influence the fauna tends to be dominated by taxa which are tolerant of low dissolved oxygen concentrations, and which have low SIGNAL scores. Examples include air-breathing taxa such as Corixidae, Notonectidae, Nepidae, Dystiscidae, Veliidae and Culicidae, as well as species which have mechanisms, such as blood pigments, to assist them in living in low oxygen environments such as some Chironomidae and oligochaets. All of these occurred in the pools of Bohena Creek and lowered the SIGNAL score. However, in these circumstances they are not necessarily indicative of pollution or other anthropogenic disturbance, but simply that the stream had ceased to flow, and they were the taxa able to survive in the remnant pools.

7. Executive Summary

The executive summary states (p ES 16) that:

> The project's Water Monitoring Plan would be implemented to monitor the managed release, including upstream and downstream water chemistry, hydrology and toxicity assessment.

However, as noted above there is insufficient information provided to indicate that the monitoring plan would be effective, or even to assure us that the proponents are aware of what is required to effectively detect and monitor for environmental impacts.

8. Conclusion

In general I found the components of the report dealing with water quality and aquatic ecology below the standard that I would expect.

From the point of view of surface water quality, chapter 12, on water quality, and the supporting appendices G1 and G4, are extremely disappointing. Data collection has been inadequate, the "statistical analysis" is superficial in the extreme, the interpretation is shallow and unscientific, and the documents are replete with vague and meaningless reassurances such as "*It is assumed that treated water temperatures at the point of release would be as close to Bohena Creek ambient temperatures as possible"* (Managed Release Study p13). If that is the criterion, treated water can be released at any temperature the proponent wishes, simply by stating that is wasn't possible to cool the water any further. I would expect that a competent management plan would specify a numerical goal, such as released treated water being within 2°C of the temperature in Bohena Creek. Again, in regard to the released water, the proponent states it would "*target a SAR similar to Bohena Creek if long duration releases are required*" (Managed Release Study p 82). It is unclear what "similar" means - within 5%? 10%? 20%?

The results, and implications of the water quality work do not seem to have been considered by those conducting the aquatic ecology work, and there has been no targeted search for the snail *Notopala sublineata*.

There has not been adequate consideration given to the design of post-impact monitoring, and the number of samples, and sampling frequency, which would be required, just as there has not been adequate consideration given to the sampling design for water quality in the existing work.

References

ANZECC (2000). Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council. October 2000.

DPI (2007) Recovery plan for the endangered river snail (*Notopala sublineata*). NSW Department of Primary Industries.

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