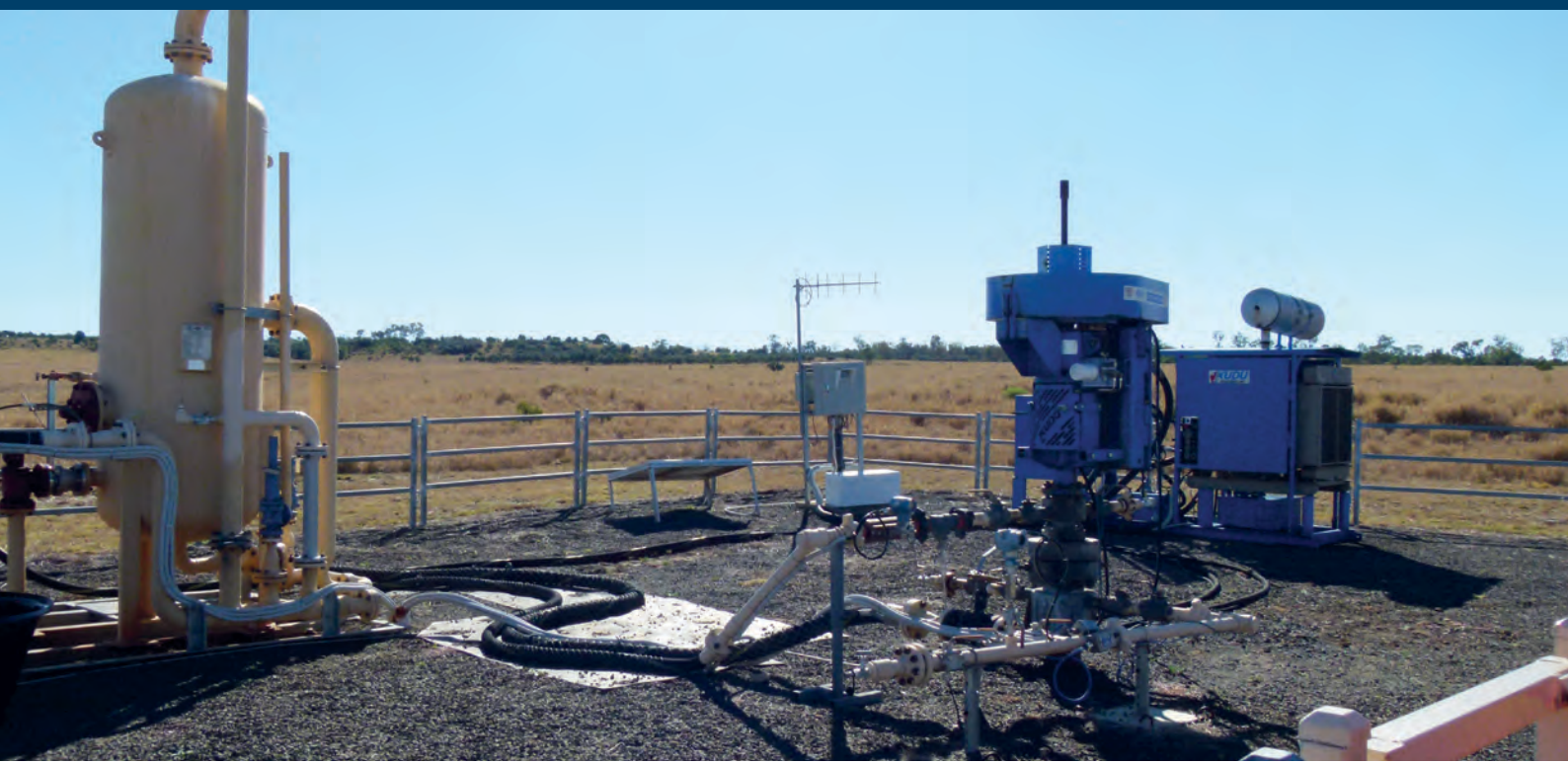

Coal seam gas in the Tara region:

Summary risk assessment of health complaints and environmental monitoring data

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For more information contact:

Executive Director, Health Protection Unit, Department of Health
PO Box 2368, Fortitude Valley, BC, 4006
Telephone: 3328 9310
Email: healthprotectionunit@health.qld.gov.au

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1. Introduction

The coal seam gas (CSG) industry has developed significantly in the Tara region over recent years. Its development has coincided with complaints from some residents alleging impacts on the health of themselves and family members. Various government and industry stakeholders have undertaken a range of initiatives that are relevant to assessing the potential for public health risks from the industry. This report provides a summary risk assessment based on the data obtained from these reports.

This summary risk assessment is framed on the following questions:-

1. What is known about the health complaints among residents in the Tara region?
2. What is known about the impacts of CSG activities on environmental factors that may affect the health of the community (environmental health determinants) in the Tara region?
3. What is the most likely relationship between the residents' health complaints and any documented impacts of CSG activities on environmental health determinants?

This risk assessment primarily takes a community-wide focus rather than focussing on potential health impacts that may be attributable to highly site specific factors e.g. a single property's dam contains poor quality water. Site specific issues should be assessed on a site-by-site basis. This assessment also does not address occupational health and safety impacts for CSG workers.

A range of information available to the Department of Health up to February 2013 was used for the assessment. As further information becomes available over time, it will require specific evaluation. That may necessitate amendment to this assessment.

2. Information sources

The following information sources were used for this risk assessment:

1. *The Darling Downs Public Health Unit (DDPHU) investigation into the health complaints relating to Coal Seam Gas (CSG) activity from residents residing within the Wieambilla Estates, Tara, Queensland–July to November 2012* (Appendix 1). Report dated January 2013 by Dr Penny Hutchinson, Public Health Physician, Darling Downs Public Health Unit.
2. *Health effects of coal seam gas – Tara* (Appendix 2). Report for the Department of Health dated 19 February 2013 by Dr Keith Adam, Specialist in Occupational and Environmental Medicine, Medibank Health Solutions Pty Ltd and Adjunct Associate Professor, The University of Queensland.
3. *Environmental Health Assessment Report – Tara Complaint Investigation Report* (Appendix 3). Report by ERM (Environmental Resources Management Australia Pty Ltd) dated January 2013 of QGC's (Queensland Gas Company) environmental monitoring at nine residential sites in the Tara Estates during July 2012. The report was provided to the Department of Health by QGC and used with QGC's permission. (Note: The ERM report comprises 784 pages. Appendix 3 of this report does not include Annex C and Annex D of the ERM report. Annex C comprises maps of the nine residential sites. Annex D comprises 717 pages of the raw analytical results used for the body of the report and photos, sampling and other details collected at the nine properties involved in the QGC monitoring program.)
4. *Wieambilla Estates Odour Investigation Results: July-December 2012* (Appendix 4). Report dated January 2013 by Environmental Monitoring and Assessment Sciences, Science Delivery Division, Department of Science, Information Technology, Innovation and the Arts (DSITIA) for the Department of Environment and Heritage Protection (DEHP).
5. *Submission on National Greenhouse and Energy Reporting (Measurement) Determination 2012 – Fugitive Emissions from Coal Seam Gas*. A submission dated 19 October 2012 by Dr Isaac Santos and Dr Damien Maher, Centre for Coastal Biogeochemistry, Southern Cross University, to the Department of Climate Change and Energy Efficiency. Accessed 17 January 2013 from the Southern Cross University website at http://www.scu.edu.au/coastal-biogeochemistry/index.php/70/
6. *Enrichment of radon and carbon dioxide in the open atmosphere of an Australian coal seam gas field.* A journal article by researchers from the Centre for Coastal Biogeochemistry, School of Environment, Science and Engineering, Southern Cross University, Lismore. It was published (as a Just Accepted Manuscript) in Environ. Sci. Technol. on 27 February 2013, DOI: 10.1021/es304538g.
7. A report dated February 2013 on noise monitoring at one site in the Wieambilla Estates by the Department of Environment and Heritage Protection (DEHP).

3. Health complaint data

This section reviews the two sources of clinical information about the health complaints made by residents in the Tara region. The intent is to understand the key clinical features of the complaints e.g. nature, prevalence, severity and reversibility. This is the first step in identifying whether any particular factor/s, in particular CSG industry emissions, might have a role in their causation or exacerbation.

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3.1. DDPHU report

The Darling Downs Public Health Unit (DDPHU) report on health complaints is based on two sources of clinical data. First, it uses reports from GPs and hospitals in the Tara region in regard to clinical presentations by residents claiming adverse health impacts from CSG activities. Secondly, it uses clinical data obtained during follow-up interviews of people who attended local general practitioners (GPs) and hospitals or registered health complaints related to CSG activities with 13HEALTH (13 43 25 84). Some residents' complaints are included in both data sources. The data covers the period 4 July to 12 November 2012.

The primary purposes of the DDPHU report were determining the nature, prevalence and severity of the health complaints. It also considers aspects of the exposure of the affected residents to CSG activities (type, proximity and duration), as well as other exposures unrelated to CSG activities that could be relevant to the health complaints.

The report is based on information for 56 people from 11 families resident in the region. Symptoms were reported for 46 of these people. Two other individuals who registered complaints with 13HEALTH were excluded from the analysis as they were not residents of the region. A broad range of symptoms was reported. The predominant symptoms reported were headaches (34 people), sore, itchy eyes (18), nosebleeds (14) and skin rashes (11). Other reported symptoms with frequencies less than 10 people are detailed in Table 1 of the DDPHU report.

Nine individuals presented to local healthcare providers (total of 16 presentations). Reported symptoms included headaches, nosebleeds, skin rashes and generally feeling unwell. Clinical examination of these cases did not reveal any significant identifying findings. There was no clinical evidence of nosebleeds in those who reported this symptom. No hospital admissions that were attributed to CSG exposure arose from these presentations to local healthcare providers.

The predominant symptoms of headaches, eye irritations, nosebleeds and skin rashes are discussed in the DDPHU report. For this summary, the following key observations are drawn:

- Headaches – varying types described (dull ache and pounding); often worse at night in association with sounds of compressors from CSG wells; variable duration up to months on end; medications used ranged from simple over-the-counter analgesics to narcotic analgesics; some reports of related symptoms such as pins and needles. It is not evident that any of the headaches have been associated with a specific medical condition (e.g. migraine) or a specific diagnosis related to a toxic substance.
- Eye irritations – sore, itchy eyes experienced mainly when outside the home with symptoms settling when indoors.
- Nosebleeds – predominantly reported in children; several presentations to the local GP in the study period, however GP did not report any findings on clinical examination.
- Skin rashes – more commonly reported in children; one skin rash was identified by the DDPHU public health physician as a common skin condition that would be unrelated to CSG activities.

In regard to the period prevalence of complaints, the DDPHU report estimates that complaints were registered for approximately 3.7 per cent of the resident population in the Wieambilla Estates during July to 12 November 2012. This includes complaints registered by parents/carers for their children. Approximately 0.7 per cent of the resident population is reported to have attended the local GP clinic at Tara with symptoms described by the resident as being related to CSG activities. As an indicator of clinical severity, there were no hospital admissions attributed to exposure to CSG activities.

Following evaluation of the information obtained about the clinical complaints, the DDPHU report concluded that the investigation by itself was unable to determine whether any of the health effects reported by the community are linked to CSG activities. Reasons for this are explained in the DDPHU report.

In summary, the most that can be drawn from the DDPHU report is that it provides some limited clinical evidence that might associate an unknown proportion of some of the residents' symptoms to transient exposures to airborne contaminants arising from CSG activities. The clinical evidence does not indicate any specific or unique medical conditions that can be attributed to such exposure. Rather, it points more to transient (reversible) effects at most. The test of whether any of the symptoms could be attributed to exposure to CSG emissions lies in the assessment of the data from environmental monitoring. This is discussed later in this report. Of note, the reported symptoms can have many potential causes unrelated to CSG activities and, indeed, unrelated to any other specific environmental health factor.

3.2. Dr Adam's report

Dr Keith Adam was commissioned by the Department of Health to provide an independent expert opinion on the health complaints of residents in the Tara area with particular regard to the potential for the complaints to be linked to CSG activities. Dr Adam conducted clinics at Tara Hospital on 11–12 October 2012. The clinics were advertised locally by various means, but the level of awareness achieved among residents is not known. Anecdotal comment has been received that awareness levels were low. Attendance at the clinics was voluntary and comprised individuals and family groups. Dr Adam undertook telephone consultations for people who were unable to attend in person.

Participants included adults and children. Information was obtained in regard to 23 people in total. Direct participation involved 15 people in person and two by telephone. Three of these participated as individuals and the remainder comprised separate family groups. Among the family groups, there were a further six people who were unable to attend the clinics due to school or work commitments. However, it is understood that any concerns relating to them were raised on their behalf by other family members who attended or telephoned the clinics. Dr Adam commented on the relatively small number of residents who participated in the clinics. He was unable to determine whether this was due to limited publicity of the clinics or a lack of widespread interest in the clinics among residents.

Reported symptoms are detailed in the full report. The complaints mainly related to headaches, nausea and vomiting, nosebleeds, nose, throat and eye irritation, and some skin rashes and sores. These are similar to the symptoms discussed in the DDPHU report. There were reports of odours associated with irritation of the nose and throat. There also were reports of low frequency vibration. A commonly reported pattern was improvement in symptoms when away from the area and recurrence on return.

On clinical examination, some limited nasal inflammation was observed in several cases. Dr Adam did not observe any bleeding or crusting of the nasal mucosa (inner lining of the nose) that might be expected in association with recent nosebleeds. One rash was observed, which Dr Adam was unable to identify. Apart from those limited observations, the key outcome from the physical examinations was that Dr Adam was not able to find any objective evidence of the clinical conditions which were reported. He noted the absence of clinical findings would not be unexpected for complaints of headache or nausea.

Dr Adam commented that the circumstances of potential exposure described to him by attendees would, for the most part, be expected to represent relatively low level exposure. This was based on the distance between the homes of affected individuals and CSG wells. For comparison, Dr Adam commented that his review of peer-reviewed literature in regard to occupational exposure to CSG did not identify evidence of unique or substantial harm to employees in the industry. This is highly relevant as potential exposure among workers in the industry itself could be expected to be significantly higher than in a community setting among residents located up to many kilometres from CSG sites.

The key clinical conclusion that is drawn from Dr Adam's report is that his clinical interview and assessment of residents who attended the clinics was not able to identify any specific clinical condition or pattern that would point to an obvious relationship between the reported health complaints and exposure to chemicals or emissions involved in the CSG industry. He comments that he would expect exposure to potential CSG emissions to be low, given the distances between the affected residents' homes and CSG wells. He particularly noted that review of any environmental monitoring would be important to test his presumption that resident' exposure is low.

Dr Adam reviewed the ERM and DSITIA reports (Appendices 3 and 4 of this report) in regard to environmental monitoring data. His overall finding was that the results in those reports 'do not indicate any significant exposure which could account for the ongoing symptoms'. However, Dr Adam identified one criticism of the ERM report in regard to the air monitoring results where 'in some cases, the standard against which the results were being compared was less than the limit of detection of the analytical method'. He explained that this meant that 'it cannot be stated with certainty that the standard was not exceeded'. Further detailed discussion of this aspect is found in the Department of Health's assessment of the ERM report

(section 4.1.1 of this report). While noting this criticism, Dr Adam concluded, 'Despite this criticism, the testing provides comfort that despite testing for a wide range of substances, the vast majority were not able to be detected'.

The Department of Health's assessment of Dr Adam's report is that he was unable to identify a specific clinical disease or condition that clearly could be attributed to exposure to CSG emissions. The reported symptoms, if due in any way to CSG emissions, are more suggestive of intermittent exposure to low-level irritants and odours, rather than exposure leading to significant systemic toxicological effects. It appears clear the reported symptoms are rapidly reversible based on the reports that symptoms improved when residents were away from the area. As commented by Dr Adam, review of the environmental monitoring data is necessary to identify if there is any likely association. Apart from Dr Adam's review of available environmental data that is summarised in the preceding paragraph, further detailed review by the Department of Health follows in Section 4 of this assessment.

Apart from the clinical and environmental aspects, Dr Adam's report also contains observations that are pertinent to the general on-going assessment and management of CSG issues. These relate to the following:

- residents' reported concerns are not exclusively about health impacts
- the level of coordination between government agencies and the CSG industry in regard to environmental monitoring and feedback to residents
- the need for a comprehensive communication strategy to regain community confidence
- residents' reports of noise/vibration impacts.

As these aspects are not directly related to the clinical aspects of the health complaints, they will be considered further in the discussion section of this assessment.

4. Environmental monitoring data

This section reviews three information sources on environmental monitoring activities that have been undertaken in the Tara region. The intent is to identify if any particular environmental health determinants have been measured at levels that could explain the symptoms that have been reported by residents. This is the second step in determining whether any particular factor/s, in particular CSG industry emissions, might have a role in the causation or exacerbation of the residents' reported symptoms. It is based on the fundamental principle that adverse health effects can occur only if there is exposure to hazardous agents at levels and durations sufficient to induce the adverse effect.

4.1. QGC Environmental Monitoring – ERM report

QGC commissioned environmental monitoring of air, water and soil at nine residential blocks in the Wieambilla Estates near Tara. Sampling was undertaken by SGS Leeder Consulting at various times across the nine blocks during 11 to 19 July 2012. Analysis and reporting of the results was undertaken by ERM. For purposes of this assessment, the report of QGC's environmental monitoring program is referred to as the ERM report.

The Department of Health was not involved in the design and implementation of the monitoring program or the laboratory analysis of the samples. The results in the ERM report are used in this assessment on their face value as presented in the report. The key findings in regard to air, water and soil are discussed separately.

4.1.1. Air monitoring

The ERM report indicates that air monitoring was undertaken at the nine residential lots at various times during 11 to 19 July 2012. The properties were sampled on various dates with the outcome that air sampling occurred on seven different dates (11, 12, 13, 16, 17, 18 and 19 July 2012). No sampling was reported for 14 to 15 July 2012 which were weekend days. Thirteen air samples were collected. A single sample was collected at five properties with two samples at each of the remaining four properties. The sampling forms in the ERM report appear to indicate that the individual sampling periods ranged from just over seven hours to almost 22 hours. Four sampling periods were less than 12 hours. However, this level of detail is not summarised explicitly in the ERM report. At two properties there were both day time and night time samples.

Sampling was undertaken with vacuum canisters. This method provides the average air concentration of analytes over the duration of the sampling period. It does not identify short-term peaks and troughs in air concentrations that may occur during the full sampling period for a particular sample. Sampling and analysis was done in accordance with the relevant Australian Standard. The samples were submitted to SGS Leeder, a NATA (National Association of Testing Authorities)

accredited laboratory, for analysis of:

- vacuum/pressure
- volatile organics
- total voc as n-hexane
- general gases (helium, hydrogen, methane, carbon dioxide, carbon monoxide and ethylene)
- sulphur gases.

ERM reviewed the laboratory quality assurance (QA) and quality control (QC) data and concluded the data were suitable for its intended use. Summary results are provided in Table 3 of the ERM report.

Section 7.1.3 of the report describes the screening criteria used by ERM to evaluate the results. The Australian National Environment Protection (Air Toxics) Measure (2004) (NEPM) was used as the primary criteria. However, as most of the 95 individual analytes reported by SGS Leeder are not included in the NEPM, the US EPA Regional Screening Levels (RSLs) for residential air were used as the secondary criteria. The NEPM and the RSL criteria represent air concentrations that are considered to be protective of human health over a lifetime of exposure at that concentration.

Table 7, Section 7.2.3 of the ERM report summarises the identified exceedances of the air criteria adopted for the report. The table indicates that the only exceedance related to the concentration of benzene in an overnight sample from one site. The specific concentration is not provided in the body of the report. However, review of the raw data indicates the reported result was 25 µg/m^3. The NEPM value is 10.3 µg/m^3 as an annual average. A second sample from the same property during day time was reported as <4.3 µg/m^3. The ERM report states the average of the two samples was below the NEPM value. As the two samples combined appear to have covered a 23.5 hour period without overlap, the 24-hour average would have been very close to the NEPM annual average value. However, it is not apparent to the Department of Health nor explained in the ERM report how an average less than 10.3 µg/m^3 was calculated given the individual values were 25 and <4.3 µg/m^3 respectively.

Apart from this single benzene result at one property, the ERM report indicates there were no other exceedances of the air quality screening criteria. The Department of Health considers this aspect of the ERM report needs significant qualification.

The air sample analyses comprised 95 discrete analytes which are listed in Table 3 of the ERM report. Of these 95 analytes, 49 do not have criteria listed in either the NEPM or the RSLs. Three, hydrogen, helium and carbon dioxide, are normal constituents of air and would not be expected to have NEPM or RSL criteria. Excluding carbon dioxide which was detected in all samples at typical concentrations in air (0.04 per cent except one sample at an unexpectedly low 0.02 per cent), the only positive detections (i.e. concentrations above the limits of reporting) for this group of analytes were:

- 31 µg/m^3 of cis-1,2-Dichloroethene at one site. The remaining 12 samples were reported as below the limit of reporting (<9.5 µg/m^3 or lower). This concentration is equivalent to approximately 8 ppb (parts per billion). In contrast, its odour becomes noticeable at approximately 17 ppm (parts per million) which is 2,000 times higher. Its occupational exposure standard is 200 ppm. The reported concentration would not be expected to be associated with any adverse effects.
- 0.44, 0.23 and 0.18 µg/m^3 of total VOC as n-hexane from sampling at two sites. The remaining 10 samples were reported as below the limit of reporting for the specific sample (<0.22 µg/m^3 or lower). This result relates to the mass of the total VOC (volatile organic compounds) in the sample expressed as its equivalence as just n-hexane, rather than as discrete substances. No specific comment can be made other than to state that these concentrations, if due to n-hexane alone, would not be expected to be associated with any adverse effects.

There were another 20 analytes where all concentrations reported for the 13 air samples were below the NEPM or RSL criteria. Two of these analytes, toluene and o-xylene, have criteria in both reference lists. For both, the reported concentrations in all samples were substantially below both criteria values. None of the results for these 20 analytes suggest exposure at levels that would be expected to be associated with adverse health effects.

Of the remaining 26 analytes, the ERM report shows the limit of reporting for each analyte in the 13 air samples was higher than the relevant NEPM or RSL criteria value (Table 3 of the ERM report). For many of these analytes, the relevant criteria value was two or more orders of magnitude (i.e. at least 100 times) lower than the limit of reporting of the respective analyte in the samples. In this situation, while the analysis report might indicate the analyte is below the limit of reporting (i.e. a measureable concentration was not detected), it can not be categorically stated that the concentration in the sample was also below the relevant criteria value. For these 26 analytes, it is possible that the air concentrations in some samples may have exceeded the reference criteria value i.e. above the criteria value but below the limit of reporting. It is impossible to identify which analytes or samples to which this important qualification might apply. It is equally possible that some, or even all, of these analytes were not present in the air at concentrations above the reference criteria or that they were even present at

any measureable concentration if a more sensitive sampling and analysis methodology had been used for the program. It may also be the case that none of these 26 analytes are even related to CSG activities in the area, so their presence, if any, could be unrelated to CSG activities. It would have been helpful for more detailed analysis to have been included in the ERM report given this dilemma brought on by reference criteria that are significantly below the limits of reporting of the sampling and analytical techniques used for the air sampling.

Despite these qualifications, it remains the case there was only one analyte in any of the 13 samples that demonstrably exceeded its reference criteria. This was the benzene concentration of 25 µg/m^3 in one of the two samples collected at one site. This result appears to relate to a 12-hour sample (approximately), whereas the NEPM reference value is an annual average of 10.3 µg/m^3. The 12 remaining benzene results were reported as <5.9 µg/m^3 or lower. Benzene is a confirmed human carcinogen and the NEPM reference value is based on limiting the risk of cancer to acceptable levels following lifetime exposure (nominally 70 years) to benzene. The second air sample (also approximately a 12-hour sample) at the same property was reported as <4.3 µg/m^3, meaning the 24-hour average for the property would have been approximately 13.5 µg/m^3. This average assumes the value of the second result (reported as <4.3 µg/m^3) is assumed to be half the limit of reporting (i.e. 2.2 µg/m^3). Using half the limit of reporting is a common method used to derive statistics for results which are below the level of reporting.

Neither the measured level of 25 µg/m^3, nor the estimated 24-hour average of 13.5 µg/m^3, is sufficiently high to be associated with acute impacts on health. The NEPM reference value (10.3 µg/m^3) is an annual average calculated to reduce the risk of cancer from a lifetime of exposure at that level. While that site can be calculated to have experienced a 24-hour average approximating the NEPM reference value on the day that testing occurred there, all other lots experienced results that were clearly below the NEPM reference value. The explanation of this single result is unknown, but the ERM report advises 'Benzene is not a compound that is found in CSG and this cannot be attributed to CSG activities but rather from a local source such as smoking, etc.'

In the context of a further 12 samples, including one at the same property, that are all reported as <5.9 µg/m^3 or lower, it is considered that this result is an outlier which is not reflective of the general ambient air quality in the area. It is likely there is a local explanation for the result, rather than it being explained by CSG or any other industrial activities impacting on the region's air shed. For example, it may relate to benzene emissions from sources such as petrol or smoking on the property in question near to where the sample was collected. These are given simply as examples of common alternative source of benzene which may explain this single outlier result.

Despite the qualifications the Department of Health places on the evaluation in the ERM report about the air monitoring results, it remains that the air monitoring did not identify any analytes at detectable concentrations that would be expected to be associated with adverse health effects of the type reported by residents. The air monitoring results outlined in the ERM report do not provide an explanation of the symptoms reported by residents of the area. However, the air monitoring program had important limitations. The total monitoring period was nine days, the methodology resulted in limits of reporting for some analytes that were substantially higher than reference air quality criteria and the monitoring was not designed to identify short-term peaks or troughs in air concentrations. It is considered a more strategic air quality monitoring program could be implemented to provide more useful information on the impacts of the CSG industry, if any, on ambient air quality in the region.

4.1.2. Water monitoring

Aspects of the ERM report concerning water relate to the same nine residential lots in the Wieambilla Estate. Samples were collected from potable drinking water sources (all nine lots) and ponds and surface water sites (five lots). The samples were analysed by SGS Leeder and compiled into the report by ERM. Over 90 chemical, physical and microbial parameters are included in the report (Table 1 of the ERM report). The water quality data were assessed against the health and aesthetic parameters of Australian Drinking Water Guidelines (ADWG) (National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC) 2011).

Table 1: Physical, chemical and microbial properties of water included in the ERM report

Property	Specific parameters
Physical Properties	pH, conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), Biological Oxygen Demand(BOD)
Cations/Anions	Sodium, potassium, calcium, magnesium, chloride, fluoride, carbonate (as $CaCO_3$), bicarbonate (as $CaCO_3$), hydroxide (as $CaCO_3$), sulphate (as SO_4^{2-}), total phosphorous, nitrate, nitrite, total nitrogen, cyanide Total anions, total cations, total alkalinity, Sodium Adsorption Ratio (SAR)
Metals (Total and dissolved)	Aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silica (SiO_2), silver, strontium, vanadium, zinc
Total Petroleum Hydrocarbons	C_6-C_9, C_{10}-C_{14}, C_{15}-C_{28}, C_{29}-C_{36} and Total C_6-C_{36}
PAHs (Polycyclic aromatic hydrocarbons)	3-Methylcholanthrene, 7,12-Dimethylbenz(a)anthracene, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Benzo(a)anthracene, Chrysene, Dibenz(ah)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene
Phenols	2,3,4,6-Tetrachlorophenol, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,6-Dichlorophenol, 2-Chlorophenol, 4-Chloro-3-methylphenol, 2-Methyl-4,6-dinitrophenol, 2-Nitrophenol, 4-Nitrophenol, Dinoseb, Hexachlorophene, *m & p*-Cresol, o-Cresol, Pentachlorophenol, Phenol
BTEX	Benzene, ethylbenzene, toluene, *m & p*-xylenes, o-xylene
Microbial	Coliforms, thermotolerant coliforms, faecal coliforms, *E. coli*, standard plate count

Assessing the suitability of water for use at the properties where samples were obtained requires the comparison of test results with the appropriate standard. According to the ERM report, all properties reported use of roof-harvested water for drinking and most household purposes. Two properties reported use of on-site ponds or surface water created by a dam for washing and bathing. The Department of Health recommends that the quality of water used for domestic purposes, other than toilet flushing and laundry, should be assessed against the ADWG. For all other uses, water is more appropriately assessed against the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Chapter 5, Guidelines for Recreational Water Quality And Aesthetics (ANZGFMWQ) (NWQMS, 2000). However, the ERM report has assessed all water against ADWG guidelines, distinguishing health from aesthetic criteria, without regard to the source or use of the water. The ADWG are generally a more conservative standard, and therefore exceedances for non-potable water use may not necessarily represent a health risk.

In addition, the ERM report in Section 7.2 summarises the results for dissolved metals, rather than total metals, the latter being more relevant to human health and generally more conservative. The following discussion refers to the data in Table 1 of the ERM report (*Summary of Water Analytical Results Environmental Health Assessment Report – 0181432*) using the analytical results for total metals.

Potable drinking water

The ERM report identified four physical or chemical parameters where the drinking water quality exceeded the ADWG: pH, aluminium, cadmium, and zinc. It is noted that the report identified an exceedance for lead at one site. In that case,

the reported result was equal to the guideline value and is therefore not considered an exceedance for this review. Four rainwater tanks were not within the ADWG guideline range (6.5–8.5) for pH (three were low at 4.5, 6.0 and 6.4, and one was elevated at 8.9). One rainwater tank exceeded the aesthetic guideline concentration for aluminium (reported as 0.022 mg/L; ADWG aesthetic guideline 0.02 mg/L). Two rainwater tanks exceeded the cadmium health guideline value (reported as 0.0023 mg/L and 0.0025 mg/L; ADWG 0.002 mg/L) and the zinc aesthetic guideline value (4.8 mg/L and 5.4 mg/L, aesthetic guideline 3 mg/L).

With the exception of cadmium, all reported exceedances were for aesthetic parameters. The ADWG suggests that untreated water, with no obvious sources of contamination, that does not meet aesthetic parameters should be assessed on historical data. Further investigation and corrective action would be recommended only if test results were outside normal operating limits. The exceedances reported for these aesthetic parameters were all slightly outside the guideline values and would not be expected to represent an immediate or long-term health risk. Therefore, based on the aesthetic chemical parameters, the drinking water supplies are fit for purpose, although some would benefit from pH adjustment.

In the case of the two samples where cadmium exceeded the guideline value, the results were marginal elevations of the ADWG health guideline value. The ADWG notes that the World Health Organisation (WHO) guideline value for cadmium in drinking water is slightly different (higher) at 0.003 mg/L due to rounding in the calculation. The reported results do not exceed the WHO guideline value. As the ADWG concludes that the difference between the ADWG and WHO guideline values is not significant, the drinking water supplies would also be considered fit for purpose based on the health chemical parameters. The ADWG notes that cadmium may be found in drinking water due to impurities in the zinc of galvanised pipes or in solders used in plumbing fittings. The occurrence of elevated zinc in the same locations as the two elevated cadmium results suggests that further investigation into the storage or plumbing of drinking water supplies at those locations may be worthwhile.

Although the ERM report included the results of five types of microbial testing, the ADWG includes a health guideline value for one, E.coli. Two rainwater tanks were reported to contain E.coli, but all tanks had some type of microbial contamination as demonstrated by the other testing. The presence of microbes is expected in both roof-harvested water and untreated surface water. Further microbial analysis would be needed to identify potential health hazards. In situations where infants, the elderly and immune-compromised (e.g. dialysis, HIV, cancer patients) may consume the water, it is recommended that roof-harvested water be boiled before drinking and for personal hygiene uses such as teeth cleaning. In addition, appropriate control measures should be used to manage the quality of this water, as provided in Guidance on the use of rainwater tanks (enHealth, 2010).

Non-potable water

The analysis of water from ponds and surface water identified four physical or chemical parameters that were above the guidelines: total dissolved solids, aluminium, iron and total silica. The ERM report incorrectly identifies an exceedance of silver for one site in Table 6 (page 22 of report), whereas the summary data table (Table 1) and the laboratory reports in Annex D of the ERM report indicate that silver was not detected in any samples for this property. Two ponds had an elevated total dissolved solids result (reported as 640 and 1300 mg/L; both above the ADWG value of 600 mg/L, but only one was above the ANZGFMWQ value of 1000 mg/L). Three ponds had elevated concentrations of both aluminium (reported as 1.4, 0.94 and 2.7 mg/L; ANZGFMWQ guideline value 0.2 mg/L) and iron (reported as 1.3, 2.1, and 1.7 ; ANZGFMWQ guideline value 0.3 mg/L). One pond had an elevated concentration of aluminium (reported as 9.3 mg/L) and another had an elevated concentration of iron (reported as 0.57 mg/L). There is no ANZGFMWQ guideline value for silica in recreational water. However, three dams had silica concentrations (250, 380 and 640 mg/L) above the ADWG value of 80 mg/L. These values for aluminium, iron and silica are within the range expected for surface waters based on the soil composition in the area (and typical of western Queensland and New South Wales). Based on the physical and chemical properties, the pond water sampled was generally fit for purpose.

As with the drinking water, the surface water testing found microbial activity in all samples. All ponds had a standard plate count greater than 300 cfu/100mL, with four of the five ponds also showing E. coli activity, which is an indication of faecal contamination. Two ponds grossly exceeded the ANZGFMWQ guideline value for faecal coliforms (reported as 3,600 and 15,000 cfu/100mL; ANZGFMWQ value 150 cfu/100mL). Further microbial analysis would be needed to identify potential health hazards. Primary contact, such as swimming, bathing or other direct water-contact sports would not be recommended for these two ponds with high faecal coliforms. It should also be avoided in the other two ponds because of some evidence of faecal contamination. A water management program for the ponds should be strongly considered. Although the high bacterial levels observed in most of the pond water samples are an indication of a potential health hazard, such contamination is due to human and/or animal faeces rather than contamination by CSG water or other CSG emissions.

Schoeller diagrams

At the request of the Department of Health, ERM prepared Schoeller diagrams for each water sample (Annex E of ERM report). Schoeller diagrams provide a visual reference of the common ion profile of the water sample. CSG water has a distinctive common ion profile, comprising low concentrations of sulphate, calcium and magnesium, and high bicarbonate (Van Voast, 2003). This profile is useful in determining if a water source, particularly a groundwater source, has been impacted by CSG water. Based on the Schoeller diagrams and the chemical analyses provided, the water quality profiles at these nine residential sites did not match the expected profile of water that has been impacted by CSG water.

In summary, the evidence from the ERM report does not indicate that residents' reported health symptoms are due to CSG impacts on their supplies of roof-harvested water or dam water.

4.1.3. Soil monitoring

The soil monitoring component of the ERM report relates to soil samples taken from the same nine residential properties in the Wieambilla Estates at Tara. Eight properties had four samples taken. The remaining property had five samples taken. Sampling at five properties included the property's vegetable patch. For another two properties the samples included the 'garden'. The remaining samples were representative of surface soil generally on the respective properties. The samples were analysed for:

- pH
- moisture
- conductivity
- texture
- metals
- exchangeable metals
- total nitrogen
- total phosphorus
- total carbon.

From a human health perspective, the metal and pH analyses are relevant. The other analyses relate to soil fertility and plant growth considerations (Hamza, 2008). Metal analyses for all samples comprised aluminium, boron, calcium, copper, iron, magnesium, manganese, molybdenum, potassium, sodium, sulphur and zinc. Public health guidance on soil contamination is provided in the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM). In particular, health investigation levels (HILs) are outlined in Schedule B(7a) of the NEPM (EPHC, 1999). These were the criteria used in the ERM report to evaluate the soil results. The ERM report concluded that 'no constituents were reported in soil above health risk criteria'. The Department of Health considers this conclusion requires qualification.

Of the metals included in the analyses, HILs have been developed for only boron, copper, manganese and zinc. The other metals included in the analyses are not normally regarded as toxic soil contaminants and HILs have not been required for public health purposes. Of the metals included in the analyses that have an HIL, all reported concentrations were less than the relevant HIL for residential land.

However, the soil samples were not analysed for all metals that have HILs listed in the NEPM. Metals with HILs that were not analysed were arsenic, beryllium, cadmium, chromium (III), chromium (VI), cobalt, lead, inorganic mercury and nickel. These metals are of more relevance to public health considerations of soil contamination. It would have been preferable if analyses for these metals had been done for the soil monitoring program. However, there is no reason to expect that the background soil concentrations of these metals would increase significantly as they are not anticipated emissions of CSG activities.

In regard to pH, reported levels ranged from 4.8–6.7 (median 5.9). These levels would not be expected to pose a risk to health from direct skin contact with the soil.

In summary, the reported soil results are not remarkable from a public health perspective. They do not indicate any obvious impact from CSG activities in the area. It is considered that the reported soil results do not provide any evidence relevant to the symptoms reported by residents. The metals with Australian HILs which were not analysed are not considered likely explanations of the reported symptoms, nor is it expected that CSG activities in the region would be impacting on background soil concentrations of those metals.

4.2. Department of Environment and Heritage Protection environmental monitoring

4.2.1. Air monitoring – Department of Science, Information Technology, Innovation and the Arts Report

The Department of Environment and Heritage Protection (DEHP) initiated an odour sampling program in the Wieambilla Estate. It commissioned the Department of Science, Information Technology, Innovation and the Arts (DSITIA) to assist. The report (Appendix 4) outlines the methodology and results.

Two air monitoring methods were used. First, nine short-term (30–60 seconds) air samples were collected in evacuated summa canisters. The intent was to collect samples when odour was worst with the aim of determining peak levels of VOC volatile organic compounds. Four residents collected six samples, DEHP field staff collected two samples in the coal seam gas fields area and a control sample was collected by DEHP field staff in the Barakula State Forest some 38 kilometres north of Chinchilla. The samples were collected between 3 July to 6 December 2012. Secondly, monitoring to determine long-term average air concentrations of VOC was conducted at four locations in the Wieambilla Estate and a control location in Chinchilla. This sampling was undertaken for three weeks in the period 26 September to 16 October 2012. The results from this monitoring provide an indication of long-term average ambient air concentrations as opposed to the very short-term peaks from the summa canister sampling.

The results from the sampling were compared with relevant health-based ambient air quality criteria as outlined in the report. For four substances, occupational exposure guidelines were referenced as there were no available ambient air criteria.

The results of the summa canister sampling show that 3–7 VOC were detected in each of the nine samples. These detections represent very short-term peak levels (30–60 seconds) and none exceeded their short-term (1-hour) reference criteria. The majority of the results were substantially below the respective reference criteria. Acrolein was reported at 0.5–0.6 ppb in two residential samples and the Barakula State Forest control sample. Ontario and Texas have adopted 1-hour reference criteria of 2.0 and 1.6 ppb respectively. Neither was exceeded. The Ontario 24-hour criteria is 0.17 ppb and the Texas annual criteria is 0.066 ppb, but it would be incorrect to attribute concern to the 30–60 second results of 0.5–0.6 ppb given these raw values exceed those 24-hour and annual reference criteria respectively. Acrolein is an acute irritant, but as the exposure period decreases e.g. from 24 hours (or even annual) to just a few minutes, an acceptable exposure level increases. Thus, comparing the summa canister results for acrolein with 24-hour and annual average criteria is not appropriate. It also should be noted that the passive sampling over three weeks did not identify the presence of acrolein. In summary, the summa canister sampling did not identify any VOC contaminants at levels that would be expected to be associated with adverse health effects.

In the case of the passive sampling, all results, with the exception of a single benzene result reported for one residence were well within relevant reference criteria. That sample was reported as 0.6 ppb, whereas the other four samples were all reported as <0.17 ppb. The DSITIA report identifies three reference criteria for annual average exposure to benzene. These criteria are 3 ppb (the Queensland EPP Air), 1.4 ppb (Texas) and 0.13 ppb (Ontario). Thus, the reported result of 0.6 ppb meets the Queensland and Texas reference values, but exceeds the Ontario reference value. Previous comment was made in this summary assessment in regard to a single benzene result in the ERM report. In comparison to the other four passive sampling results, including three from within the Wieambilla Estate, this single result of 0.6 ppb at one residence appears to be an outlier. For further comparison, the Air Quality Bulletin for South-East Queensland dated October 2012 (the most recent monthly report available online) shows that monthly maximum 24-hour benzene levels at the Springwood site in Brisbane ranged from 0.9–1.3 ppb during November 2011 to October 2012 (DSITIA, 2012). The annual average level at Springwood for 2011 (the most recent year for which an annual average has been reported online) was 1.1 ppb (DERM, 2011). Thus, the result of 0.6 ppb reported for one residence, while higher than the other four results, is still lower than typical ambient air concentrations reported for benzene at the long-term monitoring site for South-East Queensland at Springwood. As discussed previously in regard to the ERM report, it is considered this pattern of results of a single higher result at one property is more likely to be explained by a very local source of benzene rather than a generalised impact on ambient levels within the Tara region. In any case, the reported concentration of 0.6 ppb is not sufficiently high to be associated with acute health effects such as those symptoms reported by some residents in the area.

The DSITIA report does not indicate unacceptable short-term or longer term air concentrations of VOC. The monitoring data do not show air contaminants at concentrations that would be expected to be associated with adverse health effects. It is feasible that some contaminants may have been detectable as transient odours, but the reported concentrations from both monitoring methods do no suggest that exposure would pose likely risks of adverse health effects.

4.2.2. Noise monitoring

DEHP undertook noise monitoring at a single residence in the Wieambilla Estate from 31 July 2012 to 6 December 2012 due to concerns by residents regarding low frequency noise. Low frequency noise is normally considered to be noise with a frequency range of 10 Hz to 200 Hz (Leventhall, 2003). Noise measurements were recorded approximately ten metres from a residential house using two logging sound level meters. Noise measurements were recorded as A-weighted, C-weighted and linear sound pressure levels. Linear 1/3 octave noise levels from 6.3 Hz to 20 kHz were also recorded. Assessment of the noise monitoring data by DEHP was limited to three time periods identified by the resident as causing noise impacts and two other randomly chosen time periods for comparison.

Environmental noise is normally composed of a complex mixture of many different frequencies which may include discrete frequencies and broad frequency ranges. To enable noise to be expressed in a simple manner which accounts for the importance of different frequency components, different frequency weighting networks have been defined. The A-weighting is the most commonly used and approximates the response of the human hearing system. It filters out the low frequency components which, at the same level, the hearing system does not respond to as well as the mid and high frequency components. C-weighting is also commonly used where filtering of only very high or very low frequencies is required. The difference between the A-weighted and the C-weighted levels gives an indication of the amount of low frequency noise present (Berglund, Lindvall and Schwela, 1999). If the difference exceeds 20 dB further investigation is generally required.

The measurements were taken by DEHP to check compliance with the low frequency noise requirements in the Environmental Authority PEN100020207 for the QGC Kenya Central Coal Seam Gas Processing Facility and not specifically for assessing health impacts. DEHP concluded that 'while low frequency noise was detected, the level was not high enough to result in a breach of the conditions in Environmental Authority PEN100020207'. However, it was acknowledged in the DEHP report that the level of the low frequency noise had the potential to result in annoyance, even though it did not breach the conditions in the environmental authority.

Annoyance is generally accepted as being one of the major effects of exposure to environmental noise. Berglund, Lindvall and Schwela (1999) defined annoyance as '*a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them*'. The level of annoyance from low frequency noise depends on the level and duration of the noise and also on non-acoustical factors such as the individual's noise sensitivity, fear with respect to the source, attitude towards the source and perceived control over the situation (van Kempen, Staatsen and van Kamp, 2005). Other health related effects of low frequency noise include stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep (Casella Stanger, 2001). Sensitisation to low frequency noise often occurs over time, resulting in the person becoming more aware of the noise and not being able to shut it out or get used to it. Other people may not be able to hear the low frequency noise as it may be close to or below their threshold of hearing and/or its importance may be underestimated (Moorhouse, Waddington and Adams, 2005). Berglund, Lindvall and Schwela (1999) noted that 'a large proportion of low frequency components in noise may increase considerably the adverse effects on health'.

The noise monitoring undertaken by DEHP was at just one location in the Wieambilla Estate, but it identified periods where the difference between the C-weighted and A-weighted sound levels exceeded 20 dB. This indicates that low frequency noise may be a problem. DEHP was unable to identify the source of the low frequency noise, but assumed in its report it was coming from the QGC Kenya Central Coal Seam Gas Processing Facility due to its location relative to the monitoring site. It is feasible that some headaches reported by some residents may be due to low frequency noise. However, low frequency noise does not provide an explanation for other commonly reported symptoms of eye irritation, nosebleeds and skin rashes.

If concerns continue in the community about low frequency noise, additional assessment by DEHP and/or industry stakeholders may be required even though the conditions in the environmental authority are being complied with at the one site where noise monitoring was undertaken. This would be needed to determine if low frequency noise is a significant issue across the area and if noise mitigation measures are required.

4.2.3. Water monitoring

This assessment is based on roof-harvested and dam water supplies that are potentially used for drinking and other household purposes. These are the potential sources of residents' exposure to water that may be relevant to their health complaints. DEHP advised it had very little water monitoring data that would be relevant to this aspect of the assessment of the residents' health complaints. It is considered the data in the ERM report from the QGC monitoring program is sufficient to assess the impacts of CSG activities on residents' roof-harvested and dam water supplies, and any potential links to residents' health complaints.

4.3. Southern Cross University research on fugitive methane, carbon dioxide and radon

Two documents based on research from Southern Cross University, Lismore, were reviewed.

The first was a submission to the Department of Climate Change and Energy Efficiency in October 2012. It relates to a new mobile method for measuring fugitive methane and carbon dioxide emissions in a CSG setting. It is understood the method and results have not been published in a peer-reviewed publication to date. The data described in the document are taken on their face value for the purposes of this assessment.

Methane and carbon dioxide measurements were recorded serially over a wide land area in a CSG area, including the Tara region, for comparison with similarly collected measurements in non-CSG areas to the south of Tara, including northern New South Wales. Methane concentrations in the CSG area ranged from <2 ppm [~1.77 ppm] (parts per million in air) to a peak of 6.89 ppm. In the non-CSG areas, concentrations ranged from 1.78–1.94 ppm. Carbon dioxide concentrations ranged from 388–541 ppm in CSG areas, with non-CSG areas recording concentrations of 390–423 ppm.

Methane has two relevant properties in regard to human health from direct exposure:-

1. Methane is a simple asphyxiant if its concentration in air is high enough to cause a sufficient reduction in the inhaled oxygen concentration. In this circumstance, symptoms from lack of adequate inhaled oxygen can occur. The oxygen concentration of the atmosphere's dry air is normally reported as 20.95 per cent (~209 500 ppm). The peak reported methane level of 6.89 ppm would have a negligible impact on this normal oxygen concentration and no impact on human health from direct exposure.

2. Methane is an explosive gas at concentrations of 5-15 per cent (~50 000-150 000 ppm) in air. The peak level measured is over 7 000 times lower than methane's lower explosive limit.

Carbon dioxide is produced as a waste by the body during normal cellular respiration. It is excreted by exhalation during respiration. The concentration of carbon dioxide in exhaled air is approximately 4-5 per cent (40 000–50 000 ppm) compared to its typical concentration in inhaled air of approximately 0.04 per cent (~400 ppm). Inhalation of up to 541 ppm carbon dioxide, the peak level reported in the CSG area, is of no clinical significance.

The data reported by the Southern Cross University researchers in their submission to the Department of Climate Change and Energy Efficiency is relevant to considerations of total fugitive greenhouse gas emissions from CSG deposits and activities undertaken to collect CSG resources. However, the reported results have no bearing on the specific health complaints of residents in the Tara region.

The second document was an article published on 27 February 2013 (as a Just Accepted Manuscript) in Environmental Science and Technology. The aim of the study was to assess whether atmospheric radon-222 and carbon dioxide concentrations were elevated within a coal seam gas field. The study hypothesises that radon-222 may be used as a marker to indicate the presence of other gases released as fugitive emissions from coal seam gas extraction activities. The study involved measuring radon-222 and carbon dioxide concentrations at five locations inside (three sites) and outside (two sites) a coal seam gas field over a 24-hour period. The study reported a three-fold increase in maximum radon-222 concentration inside the gas field compared to outside of it.

The study was not conducted to collect data for the purposes of a health assessment and the authors do not express any health related concerns about their findings. As noted in the report, the radon-222 concentration varied throughout the 24-hour period. At the control location outside of the gas field, the average radon-222 concentration was 3.5 Bq/m^3 (approx), and the maximum was 8.5 Bq/m^3 (approx). At the location within the gas field where the highest radon levels were measured, the radon-222 concentration was an average of 7.7 Bq/m^3 (approx) and a maximum of 26 Bq/m^3 (approx).

For comparison:

- UNSCEAR (1993) reports an average radon concentration in outdoor air of 10 Bq/m^3
- ARPANSA (2012) reports that the average concentration of radon in Australian homes is about 11 Bq/m^3
- The recommended action level for radon-222 in indoor air is 200 Bq/m^3, and for workplaces it is 1 000 Bq/m^3 (ARPANSA, 2002). These action levels are set at levels where it may be useful in deciding whether any countermeasures need to be taken to reduce or avoid exposure. All of the radon-222 concentrations observed during the study are well below the levels at which action needs to be considered.

The average concentrations of radon-222 observed during the study are similar to natural background levels and do not raise concerns about adverse health effects. The results do not explain the symptoms reported by the residents.

Similarly, the carbon dioxide levels reported in the paper (average 24-hour levels of ~390 ppm at the control site up to ~467 ppm near the centre of the gas field) are of no clinical significance from direct exposure. These results do not explain the symptoms reported by the residents.

5. Discussion

The fundamental issue underlining this assessment is the concern among some residents in the Tara region that various symptoms they have experienced are related to CSG emissions. The intent of this assessment is to evaluate current information on the health complaints and environmental health determinants with a view to determining, as best as is possible, whether there is any likely association between CSG emissions and the complaints. If a likely association can be identified, measures to address any putative factors can be investigated and implemented. Alternatively, if a likely association can not be identified, greater assurance can be given to the community that emissions from the CSG industry are not considered to be having adverse health impacts.

Review of the two reports dealing with the clinical aspects of the complaints does not reveal clear evidence associating reported symptoms with CSG emissions. The most prevalent reported symptoms are headache, transient (reversible) eye irritation, nosebleeds and skin rashes. All of these are common medical complaints generally, as reflected by the following data.

- WHO (2012) reports an estimated 47 per cent of the adult population suffered a headache at least once within the last year and 1.7–4 per cent of the world's adult population have headache on 15 or more days every month.
- Various surveys of the prevalence of skin conditions in Australia have been reported (Marks, Plunkett, Merlin et al, 1999). These data show that the prevalence of self-reported skin disease, including eczema/dermatitis, is significant in the Australian community generally:
  - The national health survey by the Australian Bureau of Statistics in 1989–90 found 12.7 per cent of the population reported a disease of the skin and subcutaneous tissue within the previous two weeks.
  - In 1996-97, the School Skin Survey of 2491 children in urban and rural Victoria found 54 per cent of school children aged four to 18 years were reported by themselves or their parents as currently having at least one of the following common skin conditions, such as acne/pimples, eczema/dermatitis, tinea/ringworm, and warts/papilloma. In particular, in the context of the skin rashes reported by Tara residents, eczema/dermatitis was reported by the students or parents in 15.6 per cent of children in that survey.
  - The Maryborough Skin Health Survey in 1997–98 was a computer-assisted telephone interview survey in Maryborough, Victoria of 1457 adults aged 20 years and over. It found 27 per cent of people self-reported one or more skin conditions over the previous two weeks and 59 per cent self-reported at least one skin condition over the previous six months. In regard to self-reports of dermatitis/eczema in particular, the prevalence was 25.5 per cent in the previous two weeks and 12.6 per cent in the previous six months (excluding the previous two weeks).
  - The Tiny Tots Survey in 1998–99 of 1116 pre-school children aged from birth to five years found 49 per cent were reported by their parents to have skin disease. For eczema/dermatitis, the reported prevalence was 29.4 per cent.
- In regard to eye irritation:
  - A cross-sectional prevalence study compared residents near a chemical waste site at Kingston (south of Brisbane) and a control site at Beenleigh (Dunne, Burnett, Lawton et al, 1990). Chronic eye irritation in the previous six months was reported by 34 per cent of the Kingston respondents (n=257) and 11 per cent of the Beenleigh respondents (n=105).
  - A report by NSW Health (2003) states that the prevalence of eye, nose and throat irritation in the community is difficult to quantify. It cited a study of 2060 Danes in whom the prevalence of work-related irritation of the eyes, nose and throat was 16 per cent, whereas 7 per cent of subjects reported having irritation at home.
- In regard to nosebleeds, lifetime incidence in the general population is estimated at 60 per cent, though fewer than 10 per cent seek medical attention. Peaks in incidence occur in children under 10 years of age and adults older than 45 years of age (Medscape Reference, 2011; NICE, 2011).

The complaint data in the DDPHU report suggest the overall period prevalence of complaints of specific symptoms within the

total resident community is low compared to these comparison prevalence data for headaches, skin rashes and eye irritation. As the reference data for nosebleeds relate to lifetime incidence, a direct comparison can not be made. The data in the DDPHU report also suggest that complaints are generally of low clinical severity as complaints relatively rarely (~17 per cent of complainants) have resulted in attendance at the local GP or hospital for assessment or treatment and there have not been any hospital admissions reported. It is recognised that the complaint data might be affected by under-reporting for various reasons. However, the overall impression from the health complaint data is that the reported symptoms do not reflect a distinct or unique clinical pattern within the Tara region of increased symptoms over what reasonably could be anticipated in any community setting.

There are many potential causes of each symptom. For a specific factor/s to be a common cause of these symptoms, whether CSG-related or not, there would need to be exposure at levels sufficiently high to induce effects. For example, various hydrocarbon chemicals in air can induce headache or irritate the eyes, but these effects are not seen until exposure levels exceed a threshold for each particular substance or mixture of substances. Different substances and mixtures have different threshold levels for different clinical effects. In regard to skin rashes, there are many substances that can cause skin irritation or damage to the extent of inducing an observable skin rash e.g. dermatitis, but this typically requires direct skin contact usually with the substance in liquid or solid form. The skin is an effective barrier with the capability to resist damage from potential hazards unless the exposure is sufficient to breach its normal defensive mechanisms. For the combination of headache, eye irritation, nosebleeds and skin rashes to be caused by associated agents, presuming an origin from CSG activities, it is considered there would need to be significant exposure to the agent/s and such exposure would be expected to be evident from environmental monitoring data that was comprehensive in scope. Nosebleeds could be a potential consequence of mucosal damage due to chronic nasal irritation. However, the evidence from the clinical assessments does not indicate that such damage has occurred in individual cases. No significant nasal mucosal damage has been reported and no recent bleeding sites were observed following clinical examination. Also, if clinically significant nasal irritation from airborne irritants was occurring to the extent of inducing mucosal damage and bleeding, it would be likely to be associated with irritant effects on other parts of the respiratory tract (both upper and lower), but this is not reflected in the complaints.

The DDPHU report discusses other factors that could be relevant to some symptoms. For example, exposure to smoke from domestic wood heaters and open fires, if sufficiently high, could cause symptoms such as headache and eye irritation. However, typical exposure to smoke from domestic wood heaters and open fires generally would not be expected to be associated with nosebleeds or skin rashes. Similarly, microbiological contamination of rainwater sources used for drinking purposes might be relevant to some symptoms such as nausea and vomiting. However, there is no obvious link between microbial water contamination and other symptoms such as long-term headaches, nosebleeds and transient eye irritation that is worse when outside the residence. It is important to note that most of the dam water samples reported in the ERM report indicate microbial contamination, including faecal contamination from human and/or animal sources. This could be relevant for some symptoms reported by some residents (e.g. nausea, skin rashes, eye problems) if residents at such sites use these water sources for direct recreational contact or other purposes.

Review of the reports dealing with environmental monitoring of air, water and soil did not identify evidence of exposure to potential emissions from CSG emissions that could be anticipated to be associated with adverse health effects within the residential community. In particular, there were no air monitoring data that indicated exposure to CSG emissions that would be likely to be associated with the most commonly reported symptoms of headaches, eye irritation, nosebleeds or skin rashes. The air monitoring data in the ERM report has limitations such as detection limits for some analytes exceeding reference criteria, sampling covered a limited time period and the sampling methodology related to average levels over the sampling period rather than potential short-term peaks. Given these limitations, it is feasible that short-term peaks in levels of some airborne contaminants might explain some complaints relating to reversible eye irritation, headache and odour. However, the short-term (summa canister) air monitoring outlined in the DSITIA report did not reveal any air concentrations of VOC that might be expected to be associated with adverse health effects. In the absence of any specific monitoring data showing exposure to unacceptable air concentrations of any contaminants, it is not possible to link reported symptoms to the CSG activities or any other source. Similarly, there were no results in the water or soil sampling that can associate the reported symptoms with emissions produced by CSG activities.

As mentioned in Section 3.2, Dr Adam made a number of observations that were unrelated to his clinical assessment of the residents who participated in his clinics. First, potential health effects were not the only concern of residents. Residents also reported environmental concerns and distress about the CSG companies being able to establish wells without necessarily securing the agreement of all stakeholders. This latter point, if correct, could be a significant cause of distress which could impact on the overall health and well-being of disaffected residents. The potential mental health effects of such impacts may need further evaluation and response within the affected community.

Secondly, Dr Adam commented about whether there has been adequate coordination between government agencies and

CSG companies that have undertaken environmental monitoring, and the feedback of such information to residents. The Department of Health recognises this concern. This assessment is one step to providing a consolidated point of feedback in regard to residents' health complaints and available environmental monitoring data. However, this observation needs to be considered into the future in regard to the overall governance of the CSG industry from a community perspective.

Thirdly, Dr Adam commented on the importance of a comprehensive communication strategy to ensure that the community is kept well informed with a view to regaining community confidence. He commented on the importance of a single organisation or agency being responsible for overall coordination.

Finally, Dr Adam commented on the complaints of noise and vibration, particularly at night. He is uncertain of the potential cause/s, but speculated about the possibility it may be related to high-pressure piston pumps. The Department of Health agrees with Dr Adam that this issue may warrant further investigation by relevant regulatory authorities and industry stakeholders to ensure that community noise and vibration from CSG activities is maintained within acceptable limits.

6. Conclusions

Based on the clinical and environmental monitoring data available for this summary risk assessment, a clear link can not be drawn between the health complaints by some residents in the Tara region and impacts of the local CSG industry on air, water or soil within the community. The available evidence does not support the concern among some residents that excessive exposure to emissions from the CSG activities is the cause of the symptoms they have reported.

The air monitoring provided to the Department of Health was sufficient to assess whether the reported symptoms were related to CSG activities. However, the available data were insufficient to properly characterise any cumulative impacts on air quality in the region, particularly given the anticipated growth of the industry. It is necessary to assess those impacts according to health-based standards which are relevant to long-term exposure.

Noise and vibration from CSG activities were common complaints. The DEHP report on its community noise investigation at one site showed that low frequency noise did not exceed the relevant environmental authority. However, there was acknowledgement that the levels could be a source of annoyance. A potential consequence in some people of noise annoyance can be headache, which was the most reported symptom. Conversely, noise annoyance would not explain other commonly reported symptoms such as eye, nose and throat irritation, nosebleeds or skin rashes. If concerns continue in the community about low frequency noise, additional assessment by DEHP and/or industry stakeholders may be required to determine if noise mitigation measures are required.

Whilst no emissions from the CSG activities are apparent that can explain the reported symptoms, the DDPHU report identified the issue of solastalgia. This term describes the distress that is produced in people by environmental change in their home environment. Negative effects can be exacerbated by a sense of lack of control over the unfolding change process in a person's normal environment (Albrecht, Sartore, Connor et al, 2007).

7. Recommendations

a. The CSG industry is predicted to expand significantly throughout Queensland. Given the level of community-wide concern with CSG expansion, it is recommended that relevant government agencies establish mechanisms to ensure a coordinated response to community and social aspects identified in this report. For example, a community reference group drawn from CSG areas may assist in the identification of health, community and social concerns at a community level and in the development of appropriate responses.

b. The Department of Communities, Child Safety and Disability Services take a lead role in advising on community support initiatives that can be implemented in areas where there are significant concerns about the impacts of CSG development.

c. Regular, timely and accurate information be provided to communities in CSG areas in relation to health, community and social concerns, including the feedback of information on environmental monitoring activities.

d. That a strategic ambient air monitoring program be established by DEHP to monitor overall CSG emissions and the exposure of local communities to those emissions. This could be based on consolidation of existing air monitoring undertaken by DEHP and industry, with supplementation where insufficient data exists. This would allow improved identification of any current and future impacts of CSG activities on ambient air quality. The Department of Health would provide health-based guidance on the design of the program and participate with other agencies in the review and

reporting of results. Key elements to include are:

- identification of analytes that are known or reasonably likely to be associated with CSG activities
- identification of relevant health-based reference criteria for each analyte prior to determining sampling and analysis methods. these should include short-term and/or long-term criteria (i.e. criteria for short-term peaks and longer term averages) as appropriate for each specific analyte
- use of sampling and analysis methods that will achieve limits of reporting that do not exceed the health-based reference criteria for each analyte.

e. Noise and vibration have been identified as significant concerns among residents following assessment of their health complaints. If concerns continue in the community about low frequency noise, additional assessment by DEHP and/or industry stakeholders may need to determine if noise mitigation measures are required.

f. Future health clinics related to CSG concerns may be indicated for residents in the Tara region and elsewhere. Community input should be sought in regard to the nature, location, frequency and timing of such clinics. Given the identification of mental health concerns relating to the impacts of the CSG industry on some residents in the Tara region, future clinics should include specific expertise on mental health aspects. Relevant Hospital and Health Services in CSG areas should be involved in the planning and resourcing of such clinics within their areas.

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9. Appendices

Appendix 1:

The Darling Downs Public Health Unit (DDPHU) investigation into the health complaints relating to Coal Seam Gas (CSG) activity from residents residing within the Wieambilla Estates, Tara, Queensland—July to November 2012.

Report dated January 2013 by Dr Penny Hutchinson, Public Health Physician, Darling Downs Public Health Unit.

Appendix 2:

Health effects of coal seam gas – Tara.

Report for Queensland Department of Health dated 19 February 2013 by Dr Keith Adam, Specialist in Occupational and Environmental Medicine, Medibank Health Solutions Pty Ltd, and Adjunct Associate Professor, University of Queensland.

Appendix 3:

Environmental Health Assessment Report – Tara Complaint Investigation Report.

Report by ERM (Environmental Resources Management Australia Pty Ltd) dated January 2013 of QGC's (Queensland Gas company) environmental monitoring at 9 residential sites in the Tara region during July 2012.

Appendix 4:

Wieambilla Estates Odour Investigation Results: July–December 2012.

Report dated January 2013 by Environmental Monitoring and Assessment Sciences, Science Delivery Division, Department of Science, Information Technology, Innovation and the Arts (DSITIA) for the Department of Environment and Heritage Protection (DEHP).

10. Acronyms

ADWG	Australian Drinking Water Guidelines
ANZGFMWQ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
CSG	Coal seam gas
DDPHU	Darling Downs Public Health Unit
DEHP	Department of Environment and Heritage Protection
DSITIA	Department of Science, Information Technology, Innovation and the Arts
ERM	Environmental Resources Management Australia Pty Ltd
EPHC	Environment Protection and Heritage Council
GP	General practitioner
HIL	Health investigation level
NATA	National Association of Testing Authorities
NEMP	National environment protection measure
RSL	Regional screening levels
US EPA	United Stated Environmental Protection Agency
VOC	Volatile organic compounds
WHO	World Health Organization