10 GROUNDWATER

10.1 INTRODUCTION

This chapter provides responses to submissions received on the draft environmental impact statement (EIS) related to groundwater of the Gas Field Component of the Queensland Curtis LNG (QCLNG) Project.

Where changes to the Project description, as detailed in *Volume 2, Chapters 7* and *11*, have impacted on groundwater, these impacts, and measures to mitigate impacts, are described.

10.2 RESPONSES TO SUBMISSIONS

A summary of the submissions received on groundwater of the Gas Field Component and a response to those submissions is provided in *Table 3.10.1.*

Table 3.10.1 Responses to Submissions on the Draft EIS

Issue Raised	QCLNG Response	Relevant Submissions(s)
QGC's impacts on groundwater may affect Xstrata Coal Queensland activities.	Refer to *Section 10.2.2.3*	18
Groundwater levels and quality will be altered by CSG extraction.	Refer to *Section 10.2.2.1*	7
Groundwater levels need to be closely monitored and information shared with underground coal gasification (UCG) companies as they rely on the maintenance of those levels for successful operation.	QGC has a groundwater monitoring program in place in accordance with the conditions of its Environmental Authority. Reports on the monitoring are submitted to the Department of Environment and Resources Management (DERM) as required under the conditions of the Environmental Authority.	39
Associated Water leakage from ponds may impact on groundwater and associated ecological values.	Refer to *Section 10.2.2.1 and Volume 3 Chapter 11 of the supplementary EIS.*	32
Metals, metalloids, inorganic and organic water quality parameters should be updated to include "moderate reliability" or "low reliability" trigger values, where appropriate, as provided in the ANZECC & ARMCANZ (2000) guidelines.	Refer to *Section 10.2.1.1*	32

Issue Raised	QCLNG Response	Relevant Submissions(s)
Discuss whether reinjection will mitigate potential impacts of Associated Water extraction.	It is not practicable to reinject Associated Water into the same aquifer as it is being extracted from. This would be counter-productive to the gas extraction process which relies on reduction in water pressure. Therefore reinjection will not mitigate potential impacts of Associated Water extraction. Reinjection is being considered as an associated water management measure (refer to sEIS *Volume 3 Chapter 11*).	32
Provide a summary of findings from any bore inventories conducted.	Refer to *Section 10.2.1.2*	32
The EIS should take a whole-of resource view of groundwater impacts. This should be based on a comprehensive hydrogeological conceptualisation taking into account potential impacts on other water users, future impacts on supplies and on environmental values.	QGC and its consultant believe that the draft EIS and its appendix on Groundwater Impact Study (GWIS) does present a ‘‘whole-of resource’’ view of groundwater impacts.	32
Present predicted groundwater drawdown cones graphically overlaid on the model domain so that extent and shape of drawdown can be readily assessed. Include estimated drawdown impacts from the proposed Santos’ Gladstone LNG project operations.	Refer to Section *10.2.2.1*	32
The Great Artesian Basin Resource Operations Plan (GAB) establishes a register of springs which support significant environmental and cultural values in the GAB area. There are a number of springs on the register located in the Surat North and Surat Management Areas. The EIS should list and map these springs and consider the potential impact of Project activities on them. Information should be provided that shows the source of groundwater in springs likely to be affected by the proposal. As springs occur 40 km from the northern boundary of the study area (Appendix 3.4, 4.4.6), and the modelled drawdown is apparent up to 60 km from the bores (*Figure D 11, Appendix 3.4*), it is reasonable that the impact on these springs should be fully assessed.	Refer to *Section 10.2.1.3*	32

Issue Raised	QCLNG Response	Relevant Submissions(s)
Volume 3, section 10.4.1, Environmental values, includes a Tier 1 Trigger Level of 10 per cent increase in physical or chemical parameters concentrations relative to statistically valid baseline values. However, deterioration of water quality is not always associated with an increase in water quality parameter concentrations – decreases may also be significant (e.g. decrease in pH). Further, a fixed 10 per cent variation from a "statistically valid baseline value" may not be appropriate as natural variation in some physical or chemical parameters may exceed a 10 per cent range. Additionally, a statistically valid baseline value may not be immediately available for the required parameters in the short-term (i.e. before sufficient data has been collected by the proponent for previously unmeasured parameters to develop a statistically valid baseline value). The development of trigger values should be based on the method prescribed in Section 7.4.4 of the ANZECC/ARMCANZ (2000) guidelines.	Refer to *Section 10.2.1.1*	32, 36
In *Volume 3, Section 10.5.2, p.17* the modelling prediction that CSG activities were unlikely to affect groundwater contribution to base flow and springs is based on an assumption that these springs are sourced from shallow water table aquifers. This assumption is not substantiated.	Refer to *Sections 10.2.1.3 and 10.2.2.1*	32
The purpose of Figure 3.10.6 is not explained. The figure is misleading because it wrongly relates extraction rights established in the water resource plan (WRP) to the projected production of Associated Water. These issues are dealt with under separate legislation.	Refer to *Section 10.2.1.4*	32
There must be an irrevocable guarantee that the LNG operations do not have any effect on the region's groundwater resources. The Tier 1 trigger level of 10 per cent reduction in drawdown or water quality is far too high and is not acceptable. A 10 per cent drawdown in the GAB aquifers would result in a massive loss in capacity of the GAB.	Refer to *Section 10.2.1.1*	36

10.2.1 Environmental Values

10.2.1.1 Trigger Values

The setting of trigger values for CSG operations is currently being negotiated between the CSG industry, including QGC, and the Queensland Government. The concerns of all parties in relation to drawdown effects are being taken into consideration in these negotiations. The aim of the trigger value is to set a level that provides indication that further investigation and where required management measures to be implemented to ensure there are no lasting negative impacts on the groundwater resources as a whole. The basis of monitoring and potential mitigations were outlined in *Volume 3, Chapter 10 Section 10.6.2* of the draft EIS.

In relation to the water quality levels the recommendation that the development of trigger values should be based on the method prescribed in *Section 7.4.4* of the Australia and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) guidelines, rather than an arbitrary 10 per cent, has been adopted by QGC. However, the ANZECC guidelines advise that in the absence of a suitable reference site (*Chapter 3 – Section 3.3.2.5*) default trigger values should be assigned for particular ecosystems (e.g. upland rivers, freshwater lakes, wetlands). The trigger values presented in the guidelines do not directly relate to the QGC Project area or the impacted environments (i.e. a confined GAB aquifer) in question.

QGC has therefore proposed that water quality trigger values be calculated using the 80th percentile of the Queensland DERM database water quality data for each aquifer, which represents the historical data collected across the "study area" and the specific environments to be monitored (and potentially to be impacted on).

However, the chosen guideline values from this approach will not reflect temporal and spatial anomalies. Therefore QGC still proposes that reference sites, or background monitoring locations, will be monitored to study the reliability of the assigned trigger values method due to the uncertainty in the data currently available.

The ANZECC guidelines state that the trigger values are an ''early warning'' mechanism to alert the natural resource manager of a potential problem. QGC still proposes that a second tier trigger level, as set out in the draft EIS, be implemented that would represent the stage at which some form of compensatory or remedial action is required to mitigate the risks posed by the changes to water quality.

10.2.1.2 Bore Inventory

Two bore inventories have been completed as part of the preparation work for a full-scale groundwater monitoring plan for the Project. The first bore inventory of 254 existing water bores was completed between 10 November 2008 and 6 February 2009. A follow-up bore inventory was completed, visiting 42 of the 104 original bores located within a 10 km radius of the tenement areas. Water level and water quality data have been collected on each occasion.

The quality of the data available as a result of the inventories is dependent on:

- data available for the bore in the DERM groundwater database
- data provided by the landholder during the field interview.

Landholders have not consented to the public release of the data they have provided and as such QGC is not able to provide the bore inventories as part of this sEIS.

QGC is preparing an Underground Water Impact Report (UWIR) in accordance with the requirements of Section 257 of the *Petroleum and Gas (Production and Safety) Act 2004 (Qld)* (P&G Act). This report combines the results from these inventories and any monitoring already undertaken by QGC. One of the aims of the UWIR is to present the trigger threshold for individual bores and aquifers in the area potentially affected by the exercise of underground water rights for the petroleum tenure.

10.2.1.3 Groundwater Sources

The major river systems associated with the QGC Project area include the Moonie and Condamine rivers, transecting through the Central and South East Development Areas. Groundwater contribution to streamflow, or base flow, typically accounts for a significant fraction of total flow volume in major rivers and streams. Baseflow can sustain streamflow volumes long after rainfall events, or throughout dry seasons, and is therefore critical to the maintenance of aquatic ecosystems in rivers and streams in many Australian environments. Baseflow can occur as springs discharging into a river or stream, or as diffuse influx of groundwater through banks and bed sediments.

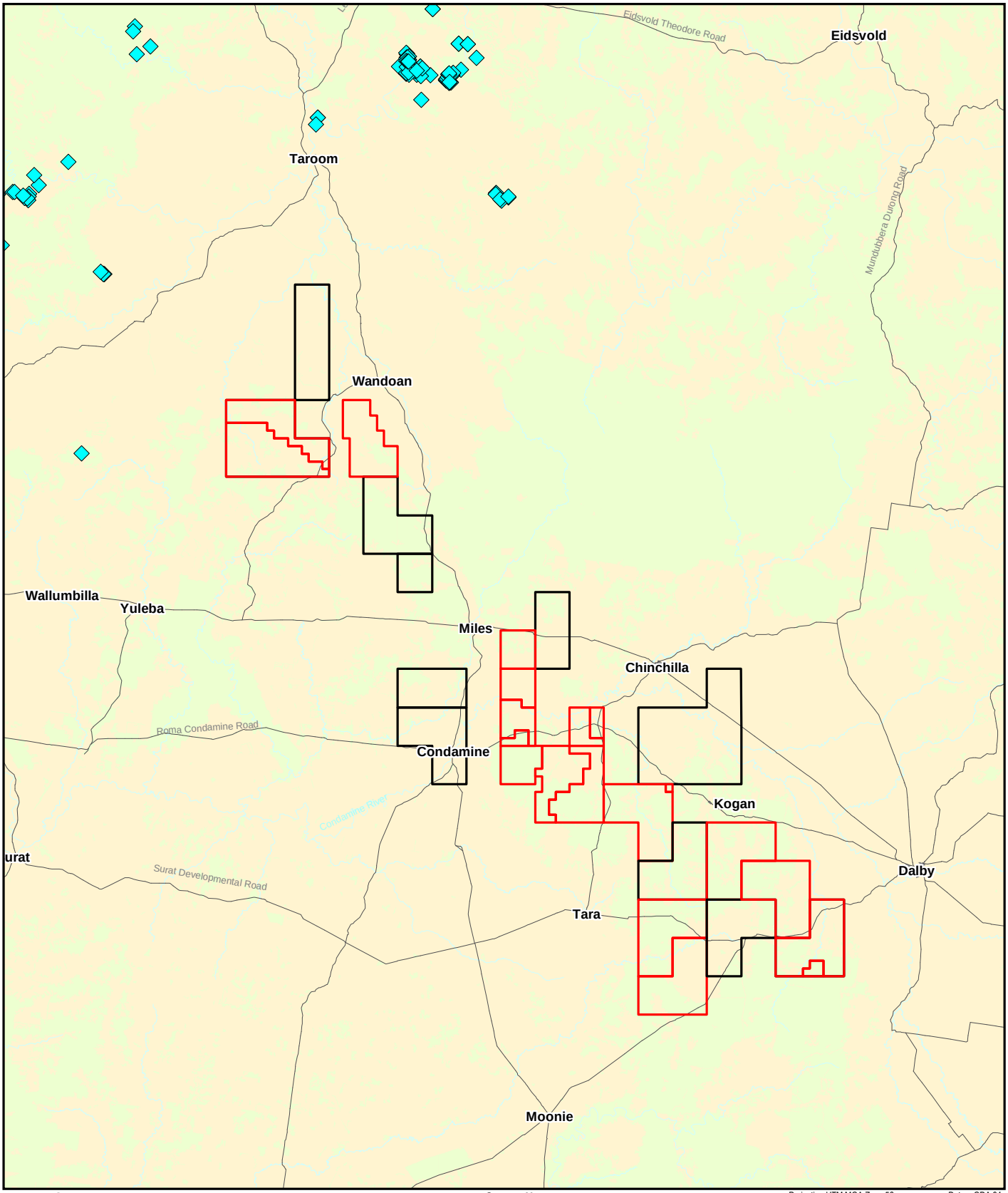
No springs were identified in the Project area although there are some springs within 30 to 50 km of the Project area. There are no known mound springs within the footprint of the CSG Fields, including the potential area of influence of CSG depressurisation activities (refer to *Figure 3.10.1*). At 30 to 50 km the predicted drawdown in the Springbok Sandstone aquifer (Injune Creek Group), Hutton and Precipice aquifers is anticipated to be negligible.

Recharge springs are typically situated within the recharge zones of the eastern margin of the GAB according to Habermehl and Lau (1997). Although a few recharge springs are identified 40 km from the northern boundary of the study area, based on modelling results, this distance is far enough that impacts are not likely to be noted. Nonetheless, as a precautionary measure,

monitoring of the main aquifers will occur between the CSG operational areas and the locations of these springs in accordance with QGC's groundwater monitoring plan. The purpose of this monitoring would be to enable additional mitigation measures to be implemented if monitoring of these bores detected any impacts in excess of the predicted scenario.

10.2.1.4 Water Use

QGC recognises that extraction of water in relation to CSG production, which is controlled by the *Petroleum and Gas Act (Qld) 2004*, is covered under different legislation to groundwater allocations which are given under the *Water Act 2000*. *Figure 3.10.6* in the draft EIS was intended to assist DERM, when drawing up the Environmental Authority conditions, in assessing the extent of CSG water extraction compared to the ''general reserve'' limits set by government to protect the overall resource. The figure has been amended (refer to *Figure 3.10.2*) to demonstrate the rate of extraction as a result of CSG production against the current government extraction limits under the *Water Act 2000*.



Legend:

- Gas Fields - PL & PLA
- Gas Fields - ATP
- Great Artesian Basin springs

Source Note:

1:250,000 Topographic vector copyright Geoscience Australia

Mining Tenement Information copyright State of Queensland (Dept. Mines and Energy)

Projection UTM MGA Zone 56 Datum GDA 94

0 10 20 30 40

Kilometres

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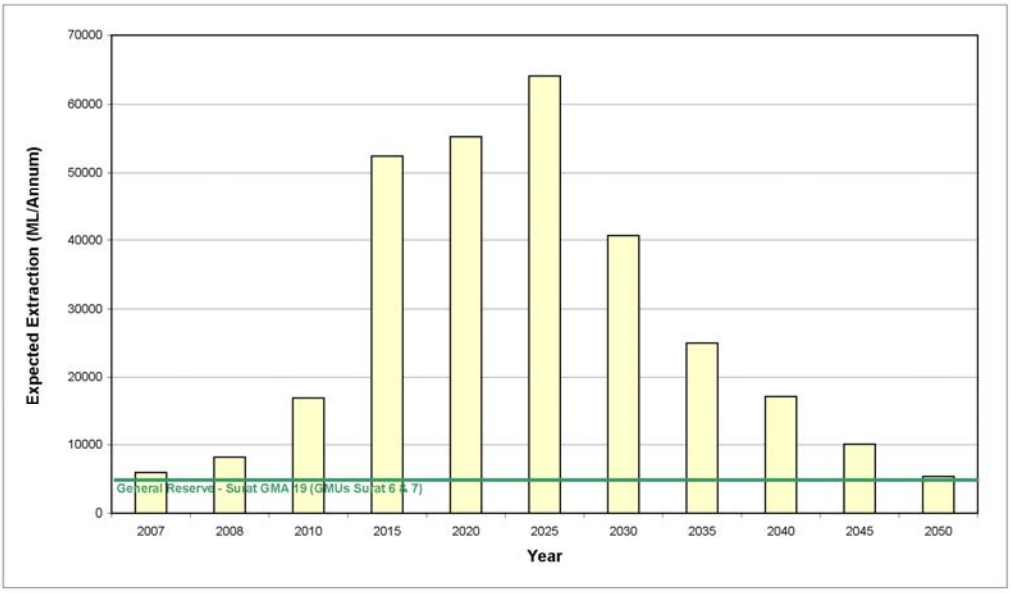
QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

Project	Queensland Curtis LNG Project
Client	QGC - A BG Group business
Drawn	Mipela
Approved	CDP
Date	02.12.09
sEIS Volume 3 Figure	S3.10.1
File No:	QCO2-T-MA-00135
Revision	Supplementary

Title **Tenements in relation to Great Artesian Basin springs.**

Figure 3.10.2 Extraction of Water from the Walloon Coal Measures



10.2.2 Potential Impacts

Volume 3, Chapter 10 of the draft EIS presents a discussion of the regional hydrogeology around the Project in an attempt to assist the assessment process and develop a meaningful model to assess potential impacts. The six primary regional units discussed in the EIS include:

Quaternary Alluvium

- Shallow (including the Shallow GAB aquifers)
- Intermediate (including the Mooga and Gubberamunda Sandstones)
- Walloon (including the Walloon Coal Measures (WCM) and Springbok Sandstone)
- Hutton (Hutton Sandstone)
- Precipice (Precipice Sandstone).

The potential impacts of depressurisation were assessed through the development of a regional conceptual groundwater model, supplemented by the development and application of an idealised numerical groundwater model of the region. The model was used to estimate the potential magnitude of drawdown in the six units above on a whole-of-resource basis as a result of CSG operations.

Modelling results indicated that extraction of groundwater for the purpose of CSG recovery from the WCM could induce inter-formational transfer of groundwater from the basal sandstone unit of the Springbok Sandstone and limited inter-aquifer transfer from the Precipice and Hutton formations. The modelling predicted that QGC's CSG activities were unlikely to affect the

Intermediate unit, or affect the groundwater contributions to baseflow and springs.

10.2.2.1 Groundwater Resources

The groundwater modelling predicted that QGC's CSG activities were unlikely to affect the groundwater contributions to baseflow and springs. Groundwater modelling predictions indicate that groundwater aquifer depressurisation resulting from inter-formational flow does not measurably impact on the shallow groundwater systems within the Project area. This is due to the significant distance between the resources and the CSG wellfields and/or the minimal degree of potential impact predicted where the aquifers (e.g. the Springbok Sandstone) outcrop/subcrop.

Precautionary monitoring and management of the key aquifers will be implemented as part of the Groundwater Monitoring Management Plan (GWMP). In the unlikely event that groundwater monitoring results indicate that the aquifers monitored are being unduly impacted (i.e. Tier 1 trigger values) by QGC CSG extraction activities, further targeted assessment of those aquifers and their likelihood of causing adverse impact to the shallow aquifer systems which support GDEs will be carried out.

If the groundwater monitoring results identify a cause-and-effect relationship, either in terms of a significantly reduced recharge or a degradation of water quality to the potentially impacted GDEs, remedial measures would be implemented (e.g. supplementation of recharge water).

10.2.2.2 Drawdown Cones

There is evidence of fault and fold zones in the CSG development area that are believed to structurally separate the three major development areas (Central Development Area, South East Development Area and North West Development Area). On this basis it was determined that the development areas would largely be hydraulically separated and this was the basis of the modelling carried out. This has not been tested in practice and only ongoing monitoring will provide evidence of this hypothesis.

The groundwater model developed for the EIS was a conceptual model based on the data currently available to QGC. It is not possible at this time to "present predicted groundwater drawdown cones graphically overlaid on the model domain so that extent and shape of drawdown can be readily assessed" as some of the available data are unverified as stated in the draft EIS. Detailed site-specific hydraulic conductivity, k, data for the various aquifers is not available in the public domain, and at this stage QGC has only measured k data in the Walloons Coal Seams. As such QGC believes that the overlaying of drawdown cones could be highly misleading.

10.2.2.3 Cumulative Impacts

While the model provides a representation of aquifer behaviour in the NWDA region, it does not directly take into account the cumulative impacts which

might result from groundwater extraction or dewatering associated with neighbouring CSG, UCG or coal mining activities in the same region. The exact details of these proposed activities are not currently known and as such have been treated here in a qualitative manner based on the inferred impacts presented by the proponents for each project.

Wandoan Coal Project

The Wandoan Coal Project (WCP) proposes 15 pits within the currently defined tenements with the maximum depth of open pit mining anticipated to be approximately 80 m below ground level (mbgl). With current pre-mining water levels measured at between 22.5 and 41.1 mbgl, mining is inferred to penetrate some 38.9 m and 57.5 m into the water table (PB, 2008).

The proposed WCP is likely to draw down local water levels by between 40 m and 60 m within the WCP tenement and common tenement areas held by QGC. Furthermore, this dewatering effect will induce a limited halo of drawdown outside the WCP tenements and again this will impact QGC tenure areas locally. It is considered that this effect will be largely indistinguishable from the CSG extraction when considered in relation to the impacts of the key aquifers (where present).

UCG Tenement in the Wandoan area

Cougar Energy and Cockatoo Coal hold tenements adjacent to QGC tenements in the vicinity of the NWDA. The underground coal gasification proposed mining area targets the Macalister Coal Seam which lies between 150 m and 300 m depth in this area. UCG operations create some drawdown effect but not to the same extent as occurs for CSG extraction. UCG activities could therefore impact on groundwater drawdown and water quality within and adjacent to the UCG defined tenement areas. The depressurisation of groundwater piezometric levels arising from UCG operations may potentially affect QGC tenements, however, it is expected that this would be negligible compared to the CSG activities. It is expected that the level of drawdown would be in the same order of magnitude as that predicted by the QGC modelling but that the effect may be over a slightly greater area (however no specific information on these impacts is available at this time).

UCG operations target coal seams at deeper depth than the proposed WCP open pit depth and may impact on groundwater levels at tenement boundaries common to both UCG and CSG.

Other CSG Development

In relation to cumulative effects of other CSG production, particularly the Santos Gladstone LNG project, QGC does not have access to any other CSG operator's groundwater impact modelling output, and is not able to assess mutual interference effects. The publicly available data in the Santos EIS is not sufficient to provide meaningful results at this stage. Based on the hydrogeology studies carried out by Golder for the draft EIS, QGC believes interference effects between QGC and the Santos Surat/Bowen basin

activities will not be significant due to the distance which separates these fields, approximately 100 km. It is anticipated that the interference effect between QGC and Arrow and Origin CSG fields will be considerable but of the order (with respect to the magnitude of drawdown) of that predicted in the EIS. This impact will however potentially be felt over a more extensive area, i.e. the ''halo'' will potentially be broader.

10.3 CHANGES TO PROJECT DESCRIPTION

10.3.1 Impacts

Since the original modelling of QGC's tenements for groundwater impacts QGC has acquired further tenements in the north-west as a result of the purchase of ATP 768 and PL 171. While these tenures were included in the draft EIS they were not included in the groundwater modeling. Re-modelling of the north-west drawdown area has been carried out during the supplementary study period to incorporate these additional tenements. The same methodology as that described in the draft EIS was applied, however, the depressurisation zone was moved 10 km to the north-east to reflect the increased area. The findings from this study (refer to *Appendix 3.2*) found that:

- Drawdown in the Springbok Sandstone is predicted to range between less than 0.5 m up to an expected maximum of 2 m at 1.8 km from the edge of the depressurisation area (i.e. boundary of the tenements). Recovery of the Springbok Sandstone aquifer is predicted to commence 75 years after groundwater extraction terminates.
- The predicted maximum drawdown in the Springbok Sandstone in the NWDA is less than the CDA and SEDA.
- The predicted maximum drawdown in the Gubberamunda, Hutton Sandstone and the Precipice Sandstone is insignificant.

These findings are the same as those predicted for the NWDA in the draft EIS and thus the increased area of the NWDA has had no impact on the overall drawdown and depressurisation predictions.

In relation to water quality in the NWDA the modelling concluded that inter-formational flow induced by CSG depressurisation would be unlikely to cause significant groundwater quality changes regionally within an aquifer or between aquifers. Although the aquifer water quality may vary within an aquifer, this variation is too small to cause significant changes if inter-aquifer flow occurs. Other users of the water are therefore unlikely to be impacted.

As stated in the draft EIS, incorrect bore design and poor bore construction techniques have the potential to increase the risk of inter-aquifer flows, pressure loss and water quality degradation. However, the risk of inter-aquifer flows arising from bore design or poor bore construction techniques was considered to be very low.

10.3.2 Mitigation

As the findings of the revised modelling found no change in impact from the original modeling, no additional mitigation measures are proposed.