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12.0
Exceedance thresholds and determining response actions

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12.1 INTRODUCTION

QGC has systematically quantified and now is implementing monitoring programs for identified potential major risks in order to safeguard EPBC listed springs and the GAB. In this way, the company is then equipped to manage those risks and to develop plans and processes to avoid or mitigate unwanted impacts. The current modelling (GEN2 and QWC's regional model), combined with the early warning and trigger monitoring and the response strategies as described below, are designed to protect EPBC listed springs.

The following major issues have been addressed:

- i If Threshold Values for surface water quality and water environmental values are exceeded
- iia If Early Warning, Threshold Values or Trigger Limits for aquifer drawdown in relation to EPBC listed springs are exceeded
- iib Threshold Values for aquifer drawdown in relation to groundwater-producing bores are exceeded
- iic Threshold Values for groundwater contamination are exceeded
- iii Subsidence or surface deformation occurs which impacts on surface or groundwater hydrology
- iv Unforeseen emergency discharges.

This section describes QGC's response plans and processes that have and are being developed to manage potential surface and groundwater impacts from CSG water extraction. The plans build on the information outlined in the Stage 1 WMMP.

In addition, QGC will develop an Emergency Discharge Management Plan to manage the risk of unforeseen emergency discharges. This is discussed further in Section 14.11. The suite of measures and plans that have been put in place to manage potential CSG water extraction impacts are depicted schematically at Figure 42.

12.2 MATTERS CONSIDERED IN THE STAGE 1 WMMP

Condition 49h
Approach to minimise the impact from any exceedance through early warning systems

In the Stage 1 WMMP Plan QGC outlined mechanisms to avoid, minimise and manage risk of adverse impacts. Response actions and timeframes were developed for stimulations where:

- Threshold Values for surface water quality and water environmental values have been exceeded
- There are unforeseen emergency discharges.

Condition 52d:
For a response plan for unforeseen emergency discharges go to the Site Emergency Response Procedure – Kenya, Appendix T.1 and the Dam Safety Emergency Response Plan, Appendix T.2

Surface water considerations have now been incorporated into an overall Exceedance Response Plan which is outlined in the following sections. Unforeseen emergency discharges are discussed in Section 14.11 and are currently managed under QGC's Site Emergency Response Procedures and specific Dam Safety Emergency Response Plans (refer Appendix T.1 and Appendix T.2).

To date, these procedures and plans have been developed to manage the Kenya water storages. QGC commits to developing specific procedures and plans for the Windibri and Northern Water Treatment Plants and associated regulated water storages.

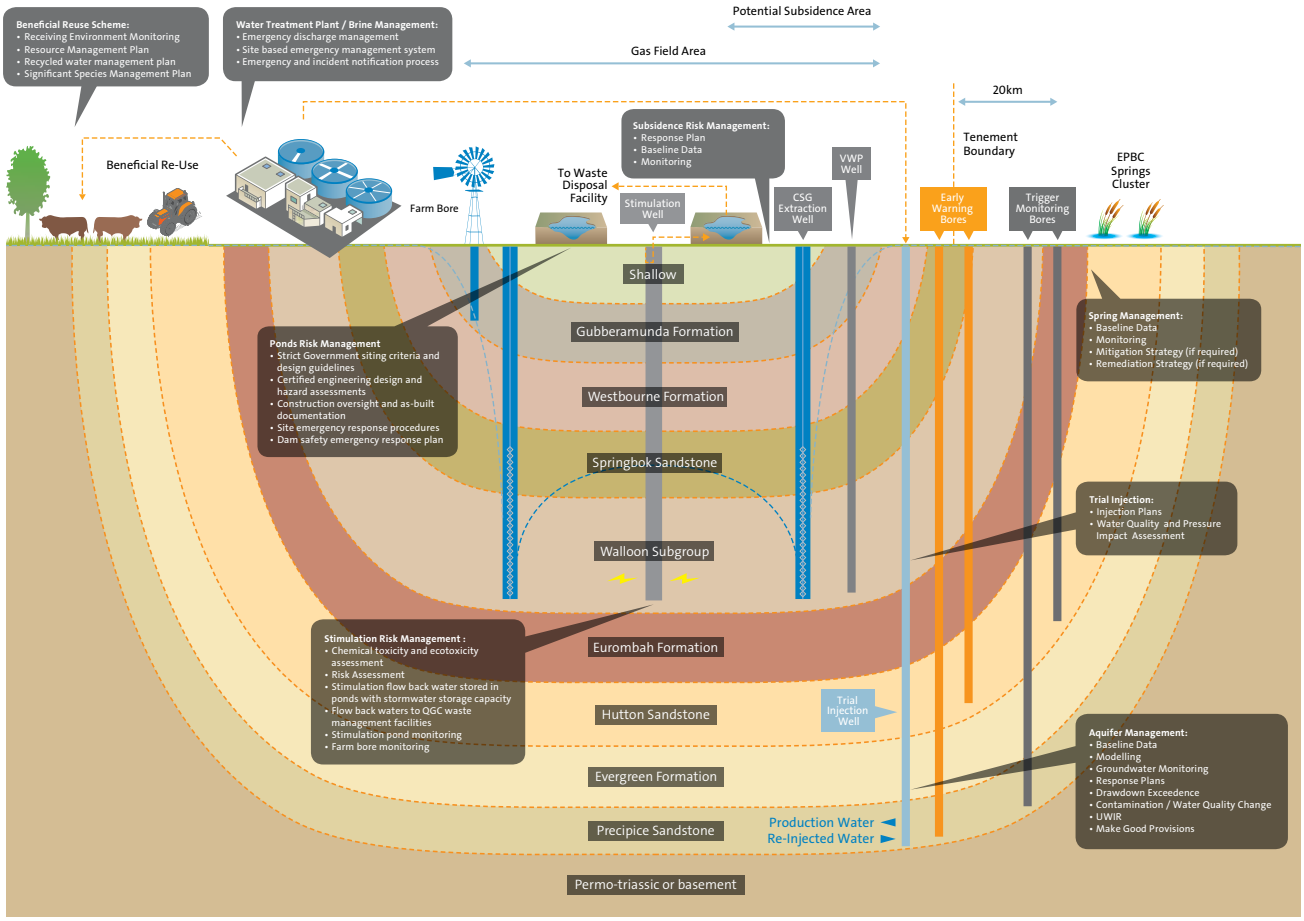


Figure 42 – QGC management systems of potential CSG water extraction impacts

12.3 EXCEEDANCE RESPONSE PLANS

Draft Exceedance Response Plans for scenarios are presented at Appendix U and include:

- Response Plan i — If Threshold Values for surface water quality and water environmental values are exceeded
- Response Plan ii — If Early Warning, Threshold Values or Trigger Limits for aquifer drawdown in relation to EPBC listed springs are exceeded
- Response Plan iib — Threshold Values for aquifer drawdown in relation to groundwater-producing bores are exceeded
- Response Plan iic — Threshold Values for groundwater contamination are exceeded
- Response Plan iii — Subsidence or surface deformation occurs which impacts on surface or groundwater hydrology.

12.4 APPROACH TO DEVELOPING EXCEEDANCE RESPONSE PLANS

Conditions 72 and 73: Initial notification to Minister of threshold breaches and response actions within 10 business days of QGC's awareness of exceedance.

Exceedance Response Plans will be activated following the initial notification to the Minister. Each Plan is built around a two-phased Critical Review Process with reporting to SEWPAC at key times (see Figure 43). Where necessary, a Mitigation Plan would be identified and implemented as a separate third phase.

In each case under Phase 1, a desktop review and written report must be prepared and submitted to SEWPAC within a nominated number of days of the exceedance and address the following:

- Verification of the exceedance. The verification process will depend on the type of exceedance. In the case of a water quality exceedance this would at least involve a re-analysis of the sample exceedance and (in the case of a surface water exceedance) a resampling at the relevant discharge location.
- Processes that may have contributed to the exceedance. Confirm if there is a link to CSG activities. If not, advise and close out.
- Likelihood of continued exceedances without further action
- Management options to avoid future exceedances
- Any additional monitoring required to confirm the significance and duration of the exceedance
- Any other changes recorded by the relevant monitoring program
- Statement about potential effects on the receiving environment and the need for further investigation and assessment.

Phase 2 is enacted where the conclusions of the desktop review identify an unacceptable risk of an adverse or significant effect on the receiving environment, and/or SEWPAC also concludes from the report that further investigation is required. The timeframe for Phase 2 depends on the specific exceedance but could vary from three to six months.

Phase 3 would involve the implementation of further mitigation measures. Specific mitigation measures will depend on the type of exceedance. Indicative mitigation measures for each exceedance type are outlined below.

An outline of the generic response action approach is shown at Figure 43.

Response action process

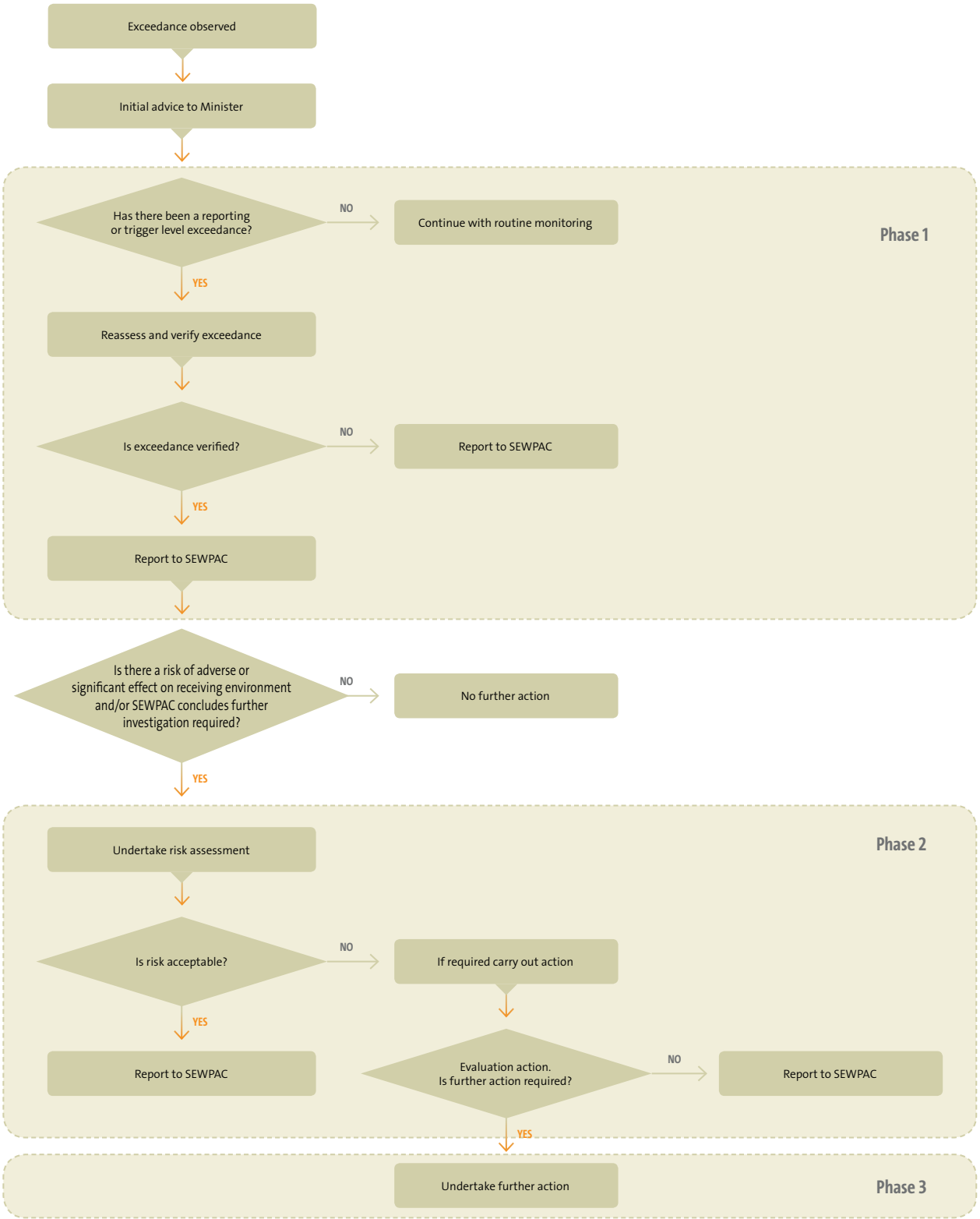


Figure 43 – Outline of QGC generic methodology for a response action

12.5 THRESHOLD VALUE EXCEEDANCE

12.5.I THRESHOLD VALUES FOR SURFACE WATER QUALITY AND WATER ENVIRONMENTAL VALUES ARE EXCEEDED

The response plan is based on dealing with exceedance scenarios that could occur in surface water bodies associated with:

- The approved discharge of treated CSG water to Chinchilla Weir
- Surface water flows downstream of the beneficial re-use scheme on the Condamine River
- The yet-to-be-approved treated water discharge from the Northern Gas Fields Woleebee Creek Treatment Plant to Glebe Weir on the Dawson River
- Where the monitoring results of release points at Chinchilla Weir, downstream of Condamine River BUA area and Glebe Weir indicate an exceedance of the investigation and reporting Trigger Limit, for listed toxicants. As a design preventative measure, QGC will employ continuous in-line monitoring of treated CSG water that will be used for beneficial re-use. Therefore, an exceedance can only occur if:
    - The WTP does not work properly, and
    - The instrumentation fails at multiple points, and
    - No remedial actions are undertaken.

Only in-specification water (i.e. meeting Queensland and Australian Government approval conditions) will be discharged to the Chinchilla and Glebe Weirs. All out-of-specification water will be redirected to raw water ponds for re-treatment. Treated water quality will be monitored by in-line sampling of produced water for key parameters such as pH and TDS with weekly compository laboratory analysis for major ions and trace elements.

QGC's in line monitoring system will include alarms for when key water quality indicators such as TDS or pH reach target management action levels. Response actions will depend on the nature of the alarm and may include, for example, immediate recirculation. If subsequent monitoring indicates that Threshold Values for surface water quality or water environmental values have been exceeded, then a phased response action process would be initiated. The Phase 1 investigation is to identify the root cause of the failure and to create the required improvements to prevent re-occurrence. Phase 2 is a tailored program aimed at understanding the impact of the exceedance which could lead to Phase 3. Phase 2 investigations could include further monitoring and a ecotoxicological risk assessment.

Specific Phase 3 mitigation measures could include:

- Development and implementation of an incident management process
- Modifications or repairs to treatment plant units such as RO membranes
- Review of beneficial re-use practices (e.g. irrigation application rates at the Condamine River scheme).

12.5.2 THRESHOLD VALUES FOR AQUIFER DRAWDOWN AT EPBC LISTED SPRINGS ARE EXCEEDED

Threshold Values for aquifer drawdown have been developed (Section 12.6.1) for geological strata that:

- Are primary source aquifers for EPBC listed springs
- Are strata from which groundwater is extracted for domestic use, stock watering, irrigation, industrial usage or town water supply.

In the case of EPBC listed springs under its Australian Government EPBC approval conditions, QGC has responsibility for the surveying of spring clusters at Scott's Creek, Dawson River 8 and Cockatoo Creek. Federal approval responsibility is shared with Origin Energy at Cockatoo Creek and Origin Energy and Santos at Scott's Creek and QGC is in the process of developing commercial arrangements with the other proponents for spring monitoring and management.

Under the UWIR spring management strategy, QGC will be responsible for monitoring the Dawson River 8 spring complex with APLNG taking responsibility for Scott's Creek. Under the UWIR there is no requirement for QGC to monitor the Cockatoo Creek Springs. QGC will formerly request endorsement of this approach from SEWPAC.

12.6 DEFAULT DRAWDOWN LIMITS

12.6.1 DERIVATION OF DRAWDOWN LIMITS

In February 2011 SEWPAC instituted a default drawdown threshold for all aquifers of 0.2 m as a precursor to the drawdown thresholds set in line with Condition 49(a).

QGC interprets the requirement for drawdown limits to apply to those aquifers which are primary source aquifers to EPBC listed springs.

The Klohn Cripper Berger reports for QWC have identified the Hutton and Precipice Sandstones as the primary source aquifers for the Surat Basin EPBC listed springs. This would remove the requirement to define spring-related default drawdown limits for the Mooga, Gubberamunda and Springbok Formations and the Walloon Coal Measures. QGC recommends relying on the Queensland Water Act 2000 definitions for consolidated rock strata to apply to these formations.

This approach is being adopted by QGC and other CSG proponents through the development of a common industry approach to spring monitoring and response and takes into consideration the methodology presented in the proposed EPBC Spring Groundwater Monitoring Strategy outlined in Geoscience Australia's Draft Final Report 'Guidance for the Combined Proponent Approach to Monitoring Potential Groundwater Impacts From Coal Seam Gas Activities to EPBC Springs in the Surat Basin – November 2012'. The common industry approach is outlined in Section 12.6.4 and the full proposal is provided in Appendix Q. This includes the use of dedicated monitoring bores in the primary source aquifers that serve as Early Warning Monitoring Installations and Trigger Monitoring Points for groundwater pressure and quality. These dedicated monitoring bores have groundwater pressure trigger levels that will cause a range of response actions depending on the drawdown observed or the deviation of the observed drawdown with the predicted drawdown.

In line with Condition 49(d) and 52(c)(vi) and in line with the approach recommended by GA, QGC has developed a set of early warning indicators, Threshold Values and Trigger Limits. These are presented in Section 12.6.5.

12.6.2 DISCUSSION ON DEFAULT DRAWDOWN LIMITS

As shown in Section 3.2.1, in the regions where QGC operates there is limited baseline groundwater level data as of today. While production remains only in the Chinchilla to Miles area, the initial monitoring locations include a set of nested bores in Gubberamunda, Springbok, Eurombah, Hutton and Precipice Formations and VWPs in Springbok and WCM at the Woleebee Creek Block south-west of Wandoan. In 2013, these will be augmented by Early Warning Monitoring installations for the Dawson River 8, Dawson River 2, Dawson River 6, Boggomoss and Prices spring complexes on Cassio Block (about 25 to 30 km north-west of Wandoan) (Figure 46). Following industry engagement, the Early Warning Monitoring installations for the Scott's Creek Springs will be installed by one of the other proponents (APLNG, Santos). In 2013, QGC will also install Trigger Monitoring Point bores in Hutton and Precipice Formations at a location about 20 km from the northern and western tenement boundaries (towards the Dawson River 8/other Dawson River/Cockatoo Creek and Scott's Creek Springs complexes). Further information on Early Warning Monitoring and Trigger Monitoring Points is presented in Table 20 and Figure 46.

For aquifers not related to EPBC listed springs, the drawdown thresholds are proposed in line with Queensland's Water Act, being:

- 5 m for the Mooga Aquifers (excluding existing trends or oscillations)
- 5 m for the Gubberamunda Aquifers (excluding existing trends or oscillations)
- 5 m for the Springbok Aquifers (excluding existing trends or oscillations).

It is accepted that these thresholds may be varied, subject to sufficient expert evidence. QGC is evaluating new data from installed monitoring bores to better assess the appropriateness of these thresholds. Throughout the Surat Basin, groundwater levels vary due to natural and groundwater use causes such as:

- Barometric effects of ± 0.1 m fluctuations (and up to ± 0.5 m) for confined aquifers
- Earth tides of ± 0.05 m due to gravitational effects of the moon and other celestial bodies
- Earthquakes. The Christchurch NZ earthquake caused up to a 5 m permanent (up to April 2011) change in groundwater levels in the area and the March 2011 earthquake in Japan a 0.3 m change in deep aquifers in the USA
- Seasonal factors of 0.5 m to several metres. Linked to rainfall and streambed infiltration recharge events, can produce wide variations; and loading and unloading due to seasonal shallow 'aquifer' weight changes.
- Conventional groundwater use for domestic, town and community water supply, agricultural and farm use and industrial purposes currently taking place in all target aquifers in and proximal to QGC tenements. This would include coal mining targeting the WCM. Limited observation bore data shows considerable variation around a long-term decline of 0.25 m to 0.5 m a year.

It is critical to establish existing clear baselines of groundwater level fluctuations and to identify existing trends. QGC's GEN2 model shows that in the next three years CSG water extraction will have minimal drawdown in overlying and deeper aquifers potentially in hydraulic connection with EPBC listed springs – as shown on drawdown plots for Precipice and Hutton Sandstones (refer Figures 44 and 45). These minimal drawdowns in overlying and deeper aquifers were also reported by QWC from their modelling.

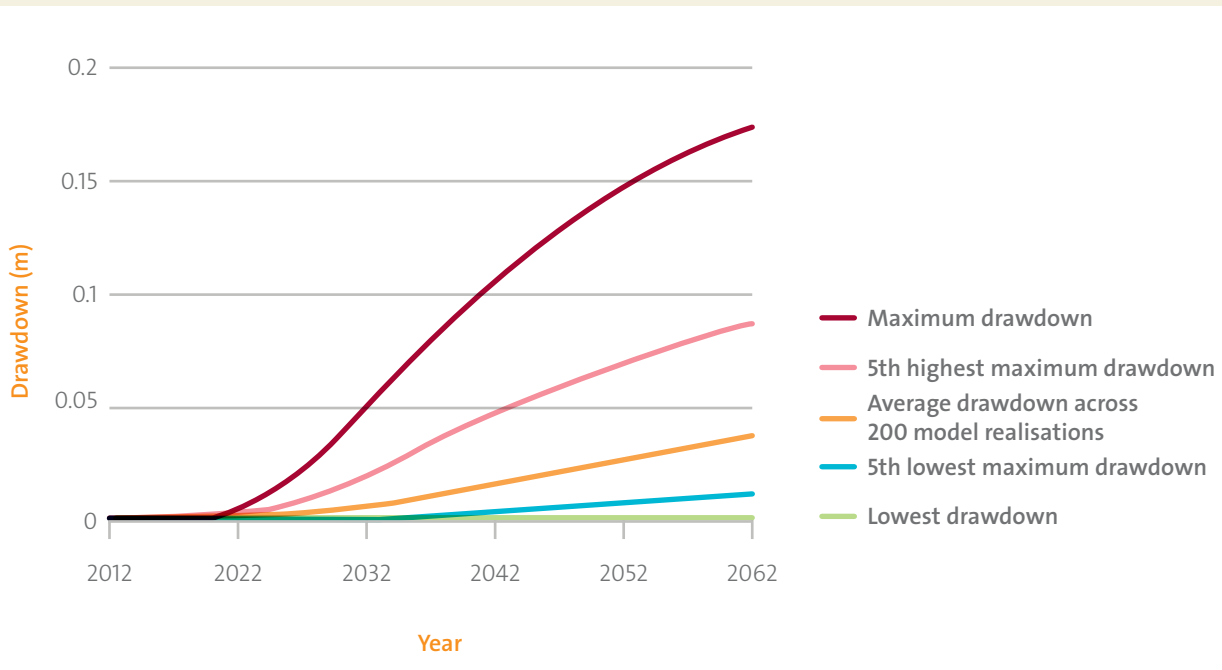


Figure 44 – Predicted range of drawdowns in Precipice Sandstone 20 km northeast from QCLNG tenements towards Scott's Creek Spring

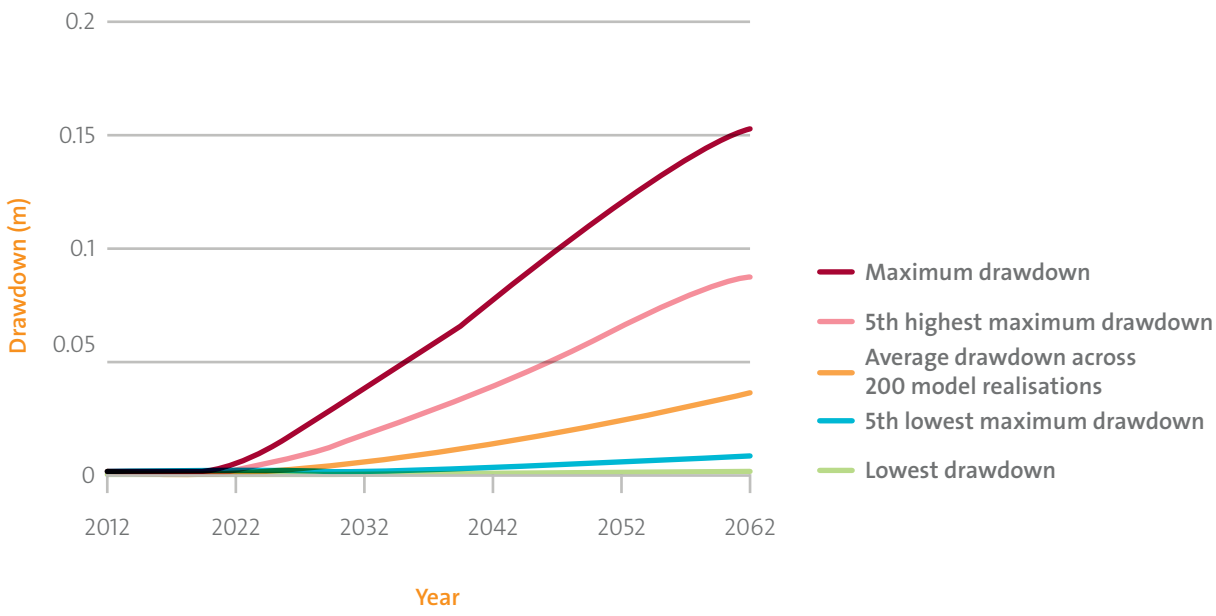


Figure 45 – Predicted range of drawdowns in Hutton Sandstone 20 km northeast from QCLNG tenements towards Scott's Creek Spring

It is known that natural oscillations alone can commonly be in the order of 0.1 m/day and sometimes larger. Superimposed on these non trending variations are longer term trends. These are before any CSG development and can be both rising and falling trends of up to 2 m/yr, but more commonly are 0.1 m/yr. Hence QGC recommends exclusion of these natural variations and oscillations from the drawdown limit definition and to normalise the monitoring results.

Clearly, there can be very significant variations in groundwater levels over time due to a range of causes. Consequently, it is likely observed fluctuations in target aquifers may exceed CSG water extraction modelled drawdown estimates – hence the recommendation for 'representative periods' excluding existing trends.

QGC recommends that these factors be considered and evaluated when determining the cause of an observed drawdown before reaching conclusions about the application of drawdown limits at specific locations.

12.6.3 QWC REQUIREMENTS ON DRAWDOWN THRESHOLDS

The Queensland Government recently introduced new requirements for UWIRs under the Water Act 2000, including the definition of 'trigger thresholds'. These are expected to include maps of the immediate and longer-term affected aquifer areas.

An 'immediately affected area' is where groundwater levels are expected to fall because a petroleum tenure holder has exercised its underground water rights by more than prescribed trigger thresholds (5 m in consolidated aquifers such as the GAB sandstones and 2 m in unconsolidated aquifers such as the Condamine Alluvium) within a three-year period following the QWC's UWIR report release.

A 'long-term affected area' is where groundwater levels are predicted to decline by more than the trigger thresholds because of the gas field operations at any time in the future. QWC's groundwater monitoring strategy and the regional groundwater model support a three-yearly determination of immediately affected and long-term affected areas to allow for negotiation of 'make good' agreements with the owner of each bore in an immediately affected area.

There is an opportunity for Queensland Government and Australian Government requirements to align on early warning and threshold drawdown levels, subject to known groundwater level fluctuations. It is QGC's view that DEHP's target drawdown trigger level thresholds of 5 m for consolidated aquifers and 2 m for unconsolidated aquifers be adopted by SEWPAC for aquifers which are not directly connected to EPBC listed springs. This will present a constructive calibration point.

12.6.4 COMMON INDUSTRY APPROACH TO SPRING MONITORING AND RESPONSE

The three major CSG operators in the southern Bowen and Surat Basins (Santos, APLNG and QGC) have developed a joint approach for a collaborative monitoring scheme to address the risk of groundwater drawdown propagating from CSG production areas and affecting springs that have been listed by SEWPAC as hosting ecological values of national environmental significance. The joint Industry strategy for springs will propose the clear allocation of monitoring bores between proponents and the allocation of springs to proponents to ensure consistency across the industry, minimise disturbance by elimination of duplicate monitoring points and an optimised spatial coverage.

For each spring cluster, it is proposed that groundwater level monitoring be undertaken at two locations:

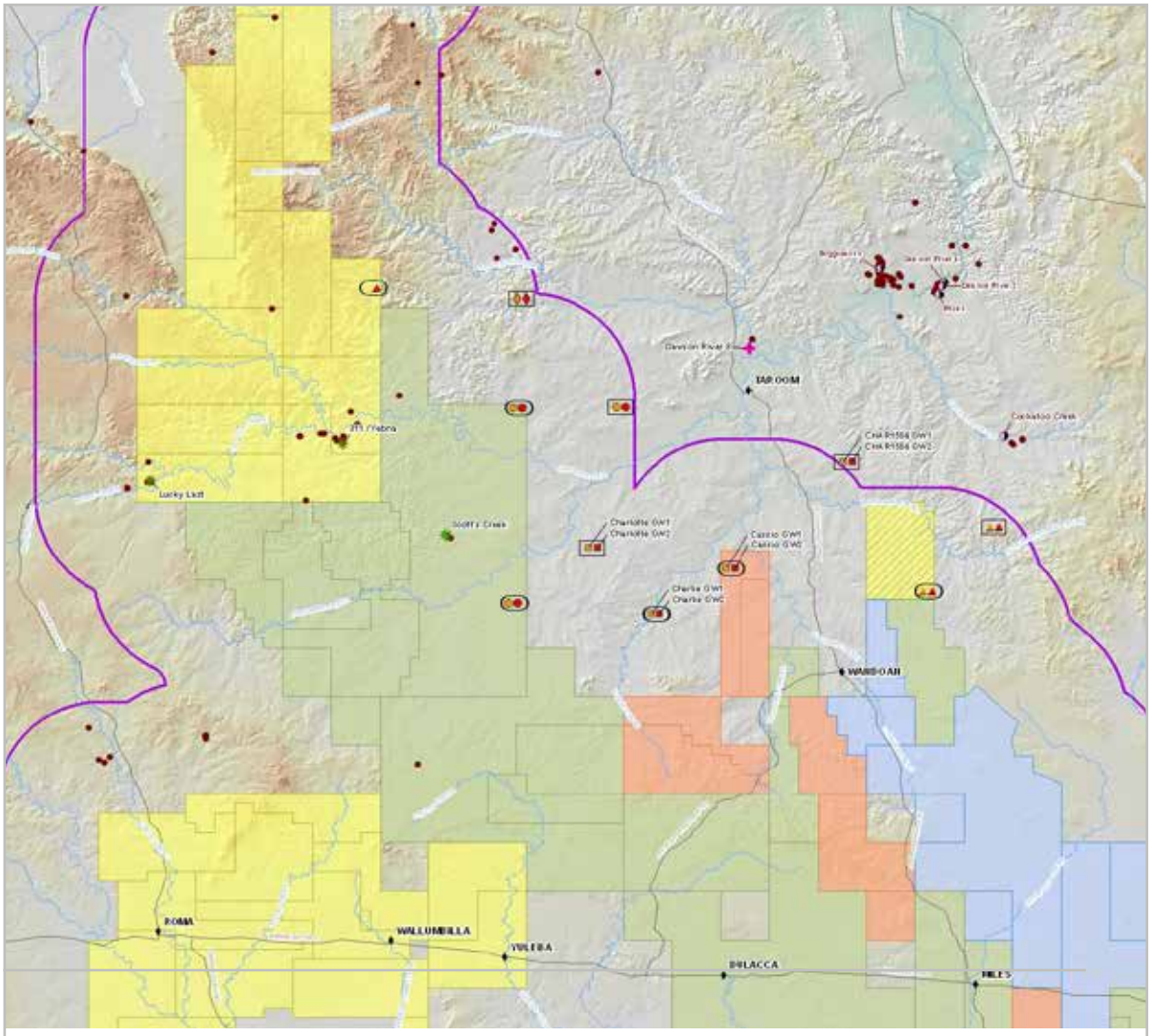
- Early Warning Monitoring Installations (EWMI) in the vicinity of tenure boundaries
- Trigger Monitoring Points (TMP) between tenement boundaries and the spring locations.

The relative locations of the monitoring bores to springs and CSG company tenure are shown in Figure 46. Two lines of monitoring bore nests are shown in relation to CSG company tenure, spring locations and outcrop of Hutton and Precipice Sandstone. The Phase 1 bores are Early Warning Monitoring Installation bores at or close to tenement boundaries and the Phase 2 bores are Trigger Monitoring Points nominally 20 km from tenement boundaries. The relationship of the bores to CSG wells and spring complexes is shown at Figure 46.

The fundamental concept of the Trigger Monitoring Points is that if any groundwater drawdown impacts were observed there would be sufficient time available to investigate the observations and to develop and implement a mitigation plan so that no adverse effects on the EPBC listed springs actually occur. For the purposes of this plan QGC assume that it will have responsibilities (sole and shared) for the following spring monitoring bores. This might be updated following finalisation of the joint industry spring monitoring approach and the Monitoring Bore Implementation submission to QWC in February 2013. QGC is proposing to constructed bores into Hutton and Precipice Sandstones at each location.

Bores	Function	Indicative location	QCLNG Tenure	Aquifer monitored	Spring complex monitored	UWIR Bore management responsibility
Cassio GW1, GW2	EWMI	30 km south of Taroom	Cassio Block	Hutton, Precipice	Dawson River 2/ Dawson River 6/ Boggomoss/ Prices	QGC
CHAR1584 GW1, GW2	TMP	10 km south-east of Taroom	Coochiemudlo Block	Hutton, Precipice	Dawson River 2/ Dawson River 6/ Boggomoss/ Prices	QGC
Charlie GW1, GW2	EWMI	40 km north-west of Wandoan	Charlie Block	Hutton, Precipice	Dawson River 8/ Scott's Creek	QGC
Charlotte GW1, GW2	TMP	60 km north-west of Wandoan	Charlotte Block	Hutton, Precipice	Dawson River 8/ Scott's Creek	QGC

Table 20 – Early Warning and Trigger Monitoring bores



Proposed early warning and trigger monitoring bores

- Town / City
- Major Roads
- Major Watercourses
- EIS Tenement Boundary 20 km Buffer

Springs Impact Management Strategy
Source: Draft Underground Water Impact Report

- Springs Impact Mitigation – APLNG
- Springs Impact Mitigation – Santos
- Spring Monitoring Programme – QGC
- EPBC Listed Spring – Monitoring not required under UWIR

Tenement Holder

- ARROW
- APLNG
- Santos
- QGC
- Santos Conventional Gas

Monitoring Wells

- Trigger Monitoring Bores
- Early Warning Monitoring Bores
- QGC – Hutton
- QGC – Precipice
- QPLNG/Santos – Hutton
- APLNG/Santos – Precipice
- APLNG – Hutton
- APLNG – Precipice
- Santos – Hutton
- Santos – Precipice

0 10 20 30 40 50
Kilometres

Scale 1:680,000 (A3)

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Figure 46 – Tenement buffer, early warning bores, source aquifers and EPBC springs

It is important to note that in the Northern Gas Fields the monitoring of the Hutton and Precipice Sandstones is already in place at Woleebee Creek. As a possible response in the Hutton (in this case it is vertical leakage) is predicted to be several years away, these observation bores in effect act as very early warning bores.

The trend analysis approach (as described in Section 3.22) directly feeds into the response action process as defined below.

12.6.5 AQUIFER DRAWDOWN EXCEEDANCE RESPONSE PLAN OUTLINE

QGC's aquifer drawdown exceedance response plan incorporates the rationale outlined in Geoscience Australia's strategy of enabling action commensurate with escalating risk with the use of an exceedance envelope, an example of which is outlined in Figure 47.

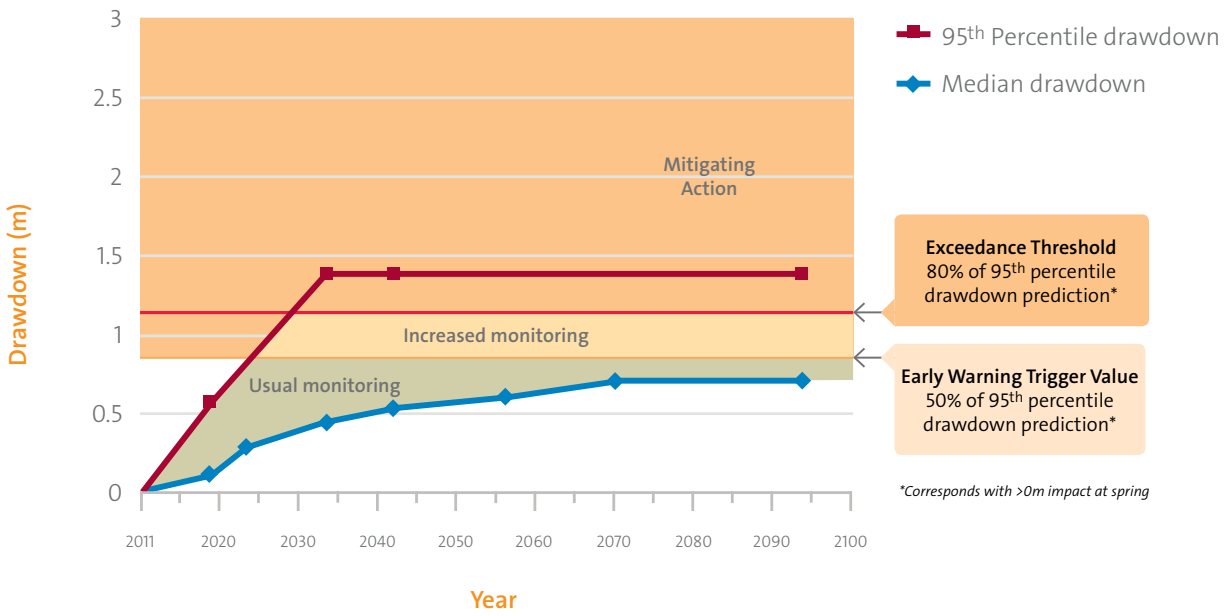

Figure 47 – Example of envelope to groundwater risk management

QGC defines an exceedance as: 'Groundwater levels measured in a monitoring bore that are greater than a trigger value for a continuous period of three months'. This methodology requires the estimation of three response action drawdown levels:

- Early warning drawdown values
- Exceedance Threshold Values and
- Drawdown limits.

Drawdown predictions for the EWMI and TMP locations have been developed based on QWC modelled drawdown values. These drawdown predictions and the GA methodology are presented in Appendix V.

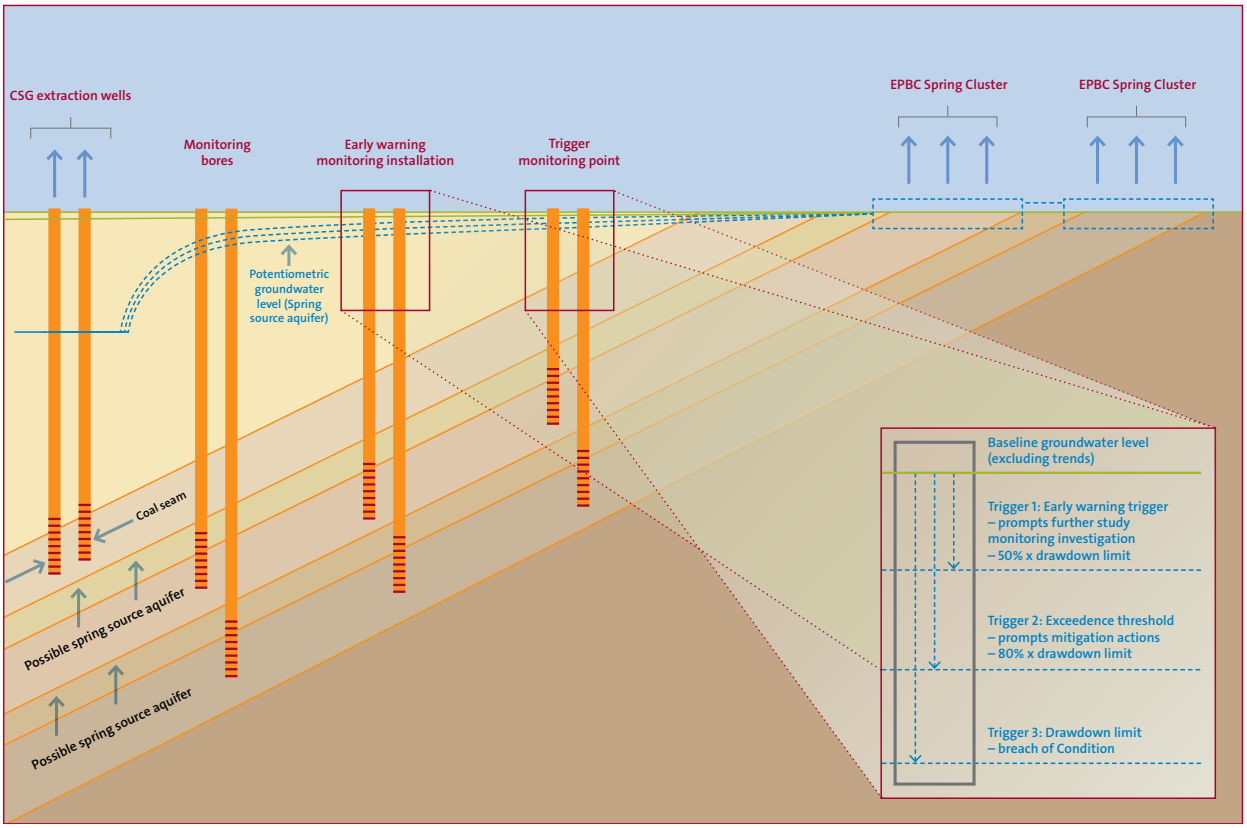

Figure 48 – Proposed early warning monitoring bores scheme

As indicated in Figure 48, the response plan can be triggered by three events:

- When the Early Warning Trigger Value is exceeded. This has been set at 50% of the 95th percentile maximum drawdown prediction at the monitoring bore that corresponds with ≥0m impact at the EPBC listed spring
- When the Exceedance Threshold Value is exceeded. This will be set at 80% of the 95th percentile maximum drawdown prediction at the monitoring bore that corresponds with ≥0m impact at the EPBC listed spring
- When the Drawdown Limit is exceeded. This is set at 100% of the 95th percentile maximum drawdown prediction at the monitoring bore that corresponds with ≥0m impact at the EPBC listed spring
- Where drawdown levels using the above approaches cannot yet be defined (e.g. because the model does not estimate a drawdown at a particular monitoring point), default maximum predicted drawdowns are 1 m for Early Warning Drawdown Values and Exceedance Threshold Values at EWMI and 0.2 m for Exceedance Threshold Values at TMP.

Table 21 provides an overview of the Early Warning Drawdown, Exceedance Threshold Values and Drawdown Limits that will apply for the duration of the Stage 2 CSG WMMP at the Cassio, CHAR 1584 and Charlotte sites. Values and limits will be updated based upon the joint industry spring monitoring approach and detailed model runs with QWC's regional model by April 2013 (see Commitment 19). Values and limits for the Charlie site will be developed accordingly.

Bore location	Bore name	Bore type	Aquifer	Spring	Early Warning Drawdown Value (year)	Exceedance Threshold Value (year)	Drawdown limit	Comment
Cassio	GW001	EWMI	Hutton	Dawson River 2/ Dawson River 3/ Boggomoss Prices	0.5 m (2030)	0.8 m (2040)	N/A	No drawdown at springs predicted with the 1 m 95th percentile maximum drawdown – this is expected to be a conservative value
	GW002	EWMI	Precipice	Dawson River 2/ Dawson River 6/ Boggomoss Prices	0.5 m (2030)	0.8 m (2040)	N/A	No drawdown at springs as predicted – this is expected to be a conservative value
Char	GW001	TMP	Hutton	Dawson River 2/ Dawson River 6/ Dawson River 8/ Boggomoss Prices	0.3 m (2030)	0.5 m (2035)	0.6 m (2040)	No drawdown at springs predicted with the 0.6 m 95th percentile maximum drawdown – this is expected to be a conservative value
	GW002	TMP	Precipice	Dawson River 2/ Dawson River 6/ Dawson River 8/ Boggomoss Prices	0.1 m (2030)	0.16 m (2030)	0.2 m (2030)	No drawdown predicted at bore – the 0.2 m limit – this is expected to be a conservative value
Charlotte	GW001	TMP	Hutton	Dawson River 8/ Scott's Creek	1.0 m (2025)	1.6 m (2030)	2.0 m (2035)	The predicted 95th percentile 2.0 m (2035) would result in a 0.06 m drawdown at the Spring in 2040
	GW001	TMP	Precipice	Dawson River 8/ Scott's Creek	0.1 m (2025)	0.16 m (2025)	0.2 m (2025)	Minimal drawdown predicted at bore (0.1 m in 2096) – the 0.2 m limit is expected to be a conservative value

Note: if drawdowns reached before years shown early mitigation measures may be required
(EWMI) Early Warning Monitoring Installation
(TMP) Trigger Monitoring Point

Table 21 – QGC's early warning drawdown, exceedance threshold values and drawdown limits

12.6.6 EARLY WARNING AND THRESHOLD VALUE RESPONSE EXCEEDANCE APPROACH

QGC's Response action process is outlined in Figure 43. This section provides an overview of the response actions which will be triggered by the various exceedances.

12.6.6.1 EARLY WARNING MONITORING BORE EXCEEDANCE

In the case of the first event scenario, exceedance at the Early Warning Monitoring Bore, initial advice to QGC management and SEWPAC of an exceedance within 10 days of QGC becoming aware of the exceedance as outlined in Figure 48 (where exceedance is defined as 'groundwater levels measured in a monitoring bore that are greater than a trigger value for a continuous period of three months'). QGC will prepare a Desktop Review and written report which will be submitted to SEWPAC within 60 days of the initial advice and address the following:

- Verification of the exceedance from the results of a manual standing water level measurement at the monitoring bore
- Assessment and verification of groundwater level trend type using the approved trend assessment procedure
- Identification of potential causes that may have contributed to the exceedance
- Likelihood of continued exceedances without further action
- Management options to avoid future trigger actions and exceedances
- Any additional monitoring required to confirm the significance and duration of the exceedance
- Any changes recorded by the Groundwater Monitoring Plan
- Statement about potential effects on MNES and/or non-CSG groundwater users and the need for further assessment at springs
- Recommendations for any Phase 2 work would be identified in the Phase 1 report. No mitigation works would be expected to be proposed.

12.6.6.2 THRESHOLD MONITORING BORE EXCEEDANCE WITHOUT EARLY WARNING MONITORING BORE EXCEEDANCE

In this case initial advice to QGC management and SEWPAC of an exceedance within 10 days of QGC becoming aware of the exceedance. A Desktop Review and written report must be prepared and submitted to SEWPAC within 60 days of the first such exceedance and address the following:

- Verification of the exceedance from the results of a manual standing water level measurement at the monitoring bore
- Assessment and verification of groundwater level trend type using the approved trend assessment procedure
- Identification of potential causes that may have contributed to the exceedance
- Likelihood of continued exceedances
- Assessment of spring condition
- Recommended actions.

Note that reaching or exceeding the trigger value for the threshold value would initiate a series of management actions including verification that the trigger was likely caused by CSG production. The management actions are:

- Calibrate the monitoring bore
- Review the regional model and calibrate the findings
- Establishing a permanent monitoring regime at relevant spring
- Assess the potential for water supply substitution in the area
- Establishing permanent injection infrastructure at the Woleebee Creek area
- Assess the potential for (locally) reduced water production.

These actions will be evaluated individually or as a combined action as a function of the identified trigger exceedance. Recommendations for any Phase 2 work would be identified in the Phase 1 report.

For any subsequent exceedance where there has been no Early Warning Monitoring Bore exceedance SEWPAC will be advised within 28 days of QGC becoming aware of the exceedance.

QGC commits to upgrading its Exceedance Response Plans to ensure compatible monitoring frequencies by April 2013.

Threshold monitoring bore exceedance with previous Early Warning Monitoring Bore exceedance

In this case initial advice to QGC management and SEWPAC of an exceedance within 10 days of QGC becoming aware of the exceedance. The Desktop Review and written report must be prepared and submitted to SEWPAC within 60 days of the exceedance and address the following:

- Verification of the exceedance from the results of a manual standing water level measurement at the monitoring bore
- Assessment and verification of groundwater level trend type using the approved trend assessment procedure
- Identification of potential causes that may have contributed to the exceedance
- Assessment of likelihood of continued exceedances (by additional groundwater modelling to better predict impacts) without further action
- Outline management options to avoid future exceedances
- Any additional monitoring required to confirm the significance and duration of the exceedance
- Any changes recorded by the Groundwater Monitoring Plan
- Statement about potential effects on MNES and/or non-CSG groundwater users and the need for further assessment at springs.

Recommendations for any Phase 2 work would be identified in the Phase 1 report. The possible management actions are listed below:

- Calibrate the monitoring bore
- Review the regional model and calibrate the findings
- Establishing a permanent monitoring regime at relevant spring
- Assess the potential for water supply substitution in the area
- Establishing permanent injection infrastructure at the Woleebee Creek area
- Assess the potential for (locally) reduced water production.

These actions will be evaluated individually or as a combined action as a function of the identified trigger exceedance.

12.7 THRESHOLD VALUES FOR DRAWDOWN IN WALLOON COAL MEASURES

QGC has Petroleum Licenses in place and pending for all tenements within the approved QCLNG project area. These licenses and associated state approvals allow QGC to extract gas and groundwater for domestic gas production while additional state and federal approvals also allow the production and exporting of liquefied natural gas derived from coal seam gas from the Walloon Coal Measures.

The WCM constitutes the hydrocarbon reservoir for coal seam gas production. In order to extract the coal seam gas, the pressure in the coal seams needs to be reduced to release the gas. QGC has indicated the drawdown prediction for the WCM in its Environmental Impact Statement as a head reduction to approximately 70 m above the top of the lowest producing layer in the WCM strata (refer Appendix 3.2 Groundwater Assessment).

In line with Condition 47, QGC submitted modelled groundwater contour data for the various Surat Basin aquifers (Stage 1 WMMP, Appendix B) which showed the expected drawdowns in the WCM to produce Coal Seam Gas (CSG).

QGC has defined groundwater drawdown limits for specific TMP locations for the primary source aquifers (as defined in the QWC UWIR) for EPBC listed springs (Hutton and Precipice Sandstones). In line with Condition 48 and the fact that the WCM is not a primary source aquifer, QGC believes it is contrary to the EPBC 2008/4398 approval to set a drawdown limit for the WCM to trigger response action for the protection of the EPBC listed springs.

The Walloon Coal Measures has not been identified by the QWC as a primary connected source aquifer for MNES springs which lie outside the approved QCLNG project area (draft Surat Underground Water Impact Report, Table H-2). Accordingly QGC does not propose to have a default drawdown limit or threshold for the Walloon Coal Measures aimed at the protection of MNES springs.

It is important to note that the regional scale horizontal hydraulic conductivity of the WCM is low because the coals seams are lenticular and not laterally extensive. Hence broad scale lateral transmission of pressure reduction via the WCM is not a credible scientific mechanism. The monitoring network in the overlying and underlying primary source aquifers is designed to identify any regional pressure declines. Hence setting a drawdown limit for the WCM for spring protection is not appropriate nor necessary.

However, in line with Geoscience Australia's recommendation, QGC will define Early Warning Trigger Values for dedicated VWP in the Walloon Coal Measures in the Northern Gas Fields for model validation (see Figure 23). Upon exceedance of this trigger value in the Walloons, the early warning monitoring bore protocol will be followed (see Section 12.6.5). These VWPs combined with the on tenement nested monitoring bores will provide accurate data to monitor the actual drawdown propagation and to calibrate (regional) modelling.

Also, QGC will apply the Queensland Water Act groundwater drawdown threshold of 5 m for consolidated aquifers to the WCM. Predicted exceedances of this threshold value in consolidated aquifers by the Regional Groundwater Model triggers 'make good' obligations between CSG proponents and potentially affected landholders.

If in the future the Walloon Coal Measures or its equivalents are identified as potential connected primary source aquifers to EPBC listed springs, QGC commits to review the approach to WCM drawdown limits and will review how a locally applicable drawdown limit can be defined for the relevant EPBC spring(s). This local approach will be duly modelled and monitored.

12.8 THRESHOLD VALUES FOR AQUIFER DRAWDOWN AT GROUNDWATER-PRODUCING BORES ARE EXCEEDED

For the case of predicted aquifer drawdown that potentially affects groundwater supplies, QGC must comply with the requirements of the Queensland Water Act (2000) as amended which include 'make good' provisions with landholders. Potentially affected landholders over three year periods through the definition of Immediately Affected Areas (IAA) are identified by the QWC in its UWIR over three year periods. The inaugural UWIR identifies land parcels that are allocated to CSG proponents from which 'make good' requirements could potentially be required as well as identification of specific land parcels for which 'make good' arrangements will need to be entered into with landowners. The UWIR became effective on 1 December 2012 and QGC will have 60 business days to complete the bore assessments and another 40 business days to enter into the 'make good' agreements.

12.9 THRESHOLD VALUES FOR GROUNDWATER CONTAMINATION ARE EXCEEDED

QGC interprets this requirement to address potential changes in groundwater quality due to inter-aquifer leakage. QGC recognises that there are several different mechanisms which can cause groundwater quality degradation and depending upon the mechanism, different risks and possible management responses are required. QGC commits to evaluate the risks of different mechanisms and the accuracy of possible predictions by April 2013.

Accordingly, the response plan is designed to address threshold value exceedances by indicator parameters for the following locations/activities:

- Monitored water quality at springs
- Regional groundwater monitoring bores.

The determination of the appropriate indicator parameters will be undertaken when the baseline sampling program is completed. Groundwater Threshold Values will be highly dependent on the location within the formation where groundwater is monitored. Groundwater Threshold Values will be developed in three stages:

- Stage 1 – Regional default groundwater quality Threshold Values will be developed based on existing groundwater quality information. Timing: April 2013.
- Stage 2 – Initial monitoring bore specific groundwater Threshold Values will be developed based on a minimum of three baseline analyses for bores constructed in 2011/2013, where the resultant Threshold Values are consistent with the regional default groundwater Threshold Values or judged appropriate based on hydrochemical model development. Timing: October 2013.
- Stage 3 – Final monitoring bore specific groundwater Threshold Values will be developed based on a minimum of three baseline analyses for bores constructed in 2013, where the resultant Threshold Values are consistent with the regional default groundwater Threshold Values or judged appropriate based on hydrochemical model development. Timing: October 2014.

QGC's nominated Threshold Values for water quality changes in indicator parameters are a 20% change in the average annual value of the water quality parameter. (The water quality exceedance trigger is defined by confirming the 20% change in the average annual value through (i) sampling and (ii) observing the change for at least the continuous three months through EC readings). A threshold value for each nominated parameter will be defined once there is sufficient water quality data obtained from the monitoring bores. QGC commits to provide the methodology for the water quality trend analysis and exceedance criteria by April 2013. Indicator parameters could include pH, TDS, bicarbonate and chloride.

Where trigger thresholds have been exceeded, an incident report will be submitted to QGC management and SEWPAC within 10 days of QGC becoming aware of the exceedance. Subsequently a Phase 1 Desktop Review and written report must be prepared and submitted to SEWPAC within 90 days of the exceedance being identified and address the following:

- Verification of the change in concentration causing an exceedance. This would at least involve sampling and re-analysis.
- Processes that may have contributed to the change
- Likelihood of continued threshold exceedances without further action
- Identification and qualification of potential risks to EPBC listed springs due to the identified exceedance in line with national drinking water guidelines
- Management options to avoid future exceedances
- Any additional monitoring required to confirm the significance and duration of the exceedance
- Any other changes recorded by the relevant monitoring program
- Statement about potential effects on the receiving environment and the need for further investigation/ assessment
- Statement about potential effects on MNES and/or non-CSG groundwater users and the need for further assessment at springs.

Recommendations for any Phase 2 work would be identified in the Phase 1 report. Mitigation works could be proposed.

12.10 SUBSIDENCE OR SURFACE DEFORMATION OCCURS WHICH IMPACTS ON SURFACE OR GROUNDWATER HYDROLOGY

Currently QGC is in a data collection phase with regard to ground motion, as detailed in Section 10.0. The derivation of area specific triggers in relation to ground motion will be completed once the baseline program is complete and the adjoining programs have also been advanced in support of this process. However the absence of trigger values does not preclude the development of a response plan should the trigger values being derived be exceeded in the future.

Ground motion over time

Should ground motion occur this motion is predicted to advance at a very slow rate over long time periods. This is due to the depths at which the CSG water extraction process and competency of the rock is occurring as well as the competency of the overlying material. As detailed earlier predicted settlement rates are in the order of 0.08 to 0.18 m for the WCMs for the lifetime of the project, with movement in the Springbok unit that overlays the WCMs estimated at less than 5 mm (Golder Associates, 2010). These longer timeframes have been considered in the development of this response plan.

Types of deformation event

While ground motion is expected to be very limited and occur over long timeframes QGC has tentatively identified the following deformation events that may require a risk management and a response plan:

- Movement in and around MNES or areas identified as a sensitive receptor
- Flooding extent and flood heights
- Movement in and around existing surface infrastructure
- Defined cracking (cracks in roads etc.)
- General ground motion.

Ground Motion Monitoring and Management Plan

In order to monitor and assess potential deformation relating to ground motion QGC is developing a Ground Motion Monitoring and Management Plan. A summary of this plan is presented in Section 10.10.

12.10.1 SUBSIDENCE RESPONSE PLAN

Data review process

As detailed, in the Ground Motion Monitoring and Management Plan, ground motion data will be reviewed every three years with a formal report generated every six years. Reviews outside this period will not be possible as satellite data compilation is in bi-yearly periods. The satellite program is detailed further in Section 10.10.

Notification

QGC will notify SEWPAC of any ground motion event, attributable to events outside of natural and anthropogenic influences as part of the assessment, risk profiling, review and reporting process every three years for approval prior to any amendments to the sampling frequency being implemented.

Response process

Should a ground motion event be recorded during the data review process, either via the radar satellite program or the physical program defined in Section 10.0, the following response process is proposed:

- QGC will advise SEWPAC within 10 days of unexpected ground motion being detected
- In parallel, QGC will undertake a Phase 1 investigation which will include:
  - A review of ground motion data, including all historic records
  - Assessment of any changes to natural surface environments occurring independently of CSG activities (increased erosion due to vegetation loss, changes in drainage or rainfall patterns etc.) or changes in anthropogenic factors in the area of interest
  - Reporting to SEWPAC within 60 days
- If required, a Phase 2 program of detailed investigations would subsequently be undertaken to:
  - Notify ecological and environmental teams of the motion. Commission ecological/hydrologic studies to assess the impact of this motion
  - Review current field survey plan and commission new field survey plans to include the area of interest as required
  - Once ecological/hydrological impact studies are available submit to SEWPAC with a update
  - Examine the potential use of corner reflectors or an increase in radar satellite coverage
  - Report to SEWPAC within one to six months of an agreed commencement date

- The studies referred to above are proposed to consist of:
  - Surface water/hydrologic/ecologic assessment of all surface waterways within the suspected deformation area. Through this process sensitive surface water bodies and waterways will be identified and quantified. Once these have been identified these features will be surveyed in detail by survey field teams.
  - Assessment of all road bridges and major intersections within the suspected deformation area and ensure accurate surveys for these features are completed. Any significant surface cracks or deformation of the road surface will also be recorded.
  - Assessment of any major man-made structures that exist within the suspected deformation area (such as large barns, grain silos etc.) These structures will also be surveyed in detail and any defects or surface deformations noted.
- Once these assessments are completed QGC will catalogue those features according to environmental and community risk and then implement an ongoing detailed satellite and ground truthing monitoring program for these locations (six months and beyond) which will include:
  - Modify radar and field survey programs to enable annual reporting for the area of interest
  - Submit interim reports for the area of interest to SEWPAC on an annual basis
  - Reporting and detailed analysis, including the field survey, ecological, hydrological and hydrogeological assessment programs are to continue until the ground motion in the area of interest stabilises.

12.11 GROUNDWATER REPRESSURISATION

Condition 52d (ii) Response Action

Aquifer Repressurisation

Condition 52d (ii) requires a program and timetable for repressurisation using re-injection of CSG water to be presented in the Stage 2 WMMP. The primary objective of this requirement is to guard against impacts on MNES which are mainly located in the Dawson/Fitzroy River catchments due to CSG depressurisation of primary source aquifers, principally the Hutton and Precipice Sandstones. It is noted that any groundwater repressurisation plan can only be designed once the QWC Regional Groundwater Model has become available and an approved hydrochemical model has been developed.

QGC's GEN2 Groundwater Model results in the vicinity of EPBC listed springs are presented in Appendix C.3. These show that in the cases of the Hutton (see Figure 49) and the Precipice Sandstones that the GEN2 modelled 0.2 m drawdown contours wrap around the northern boundary of the QGC tenements. That is, the significant effects of CSG water extraction are mainly restricted to QGC's tenements.

In the UWIR, QGC has been allocated the monitoring of the Dawson River 8 spring complex. Under the collaborative industry approach to early warning springs monitoring, QGC are proposing two springs trigger monitoring bores 20 km from QGC tenement boundaries (refer Figure 46). Bores CHAR1584 GW1, GW2 will act as threshold monitors for Dawson River 8 and Cockatoo Creek whilst Bores Charlotte GW1, GW2 will be used for Scott's Creek. Given the distribution of approved CSG extraction by the various proponents, the Scott's Creek spring complex is the most critical.

Note that QGC's Stage 1 WMMP model results (non-cumulative for all proponents) predict that 0.1 m of maximum modelled drawdown could occur in the Hutton Sandstone at 2050 at approximately 20 km from the boundary of the Kathleen Block in the direction of the Scott's Creek Springs. The minimum modelled drawdown contour is close to zero during the operational life of the project.

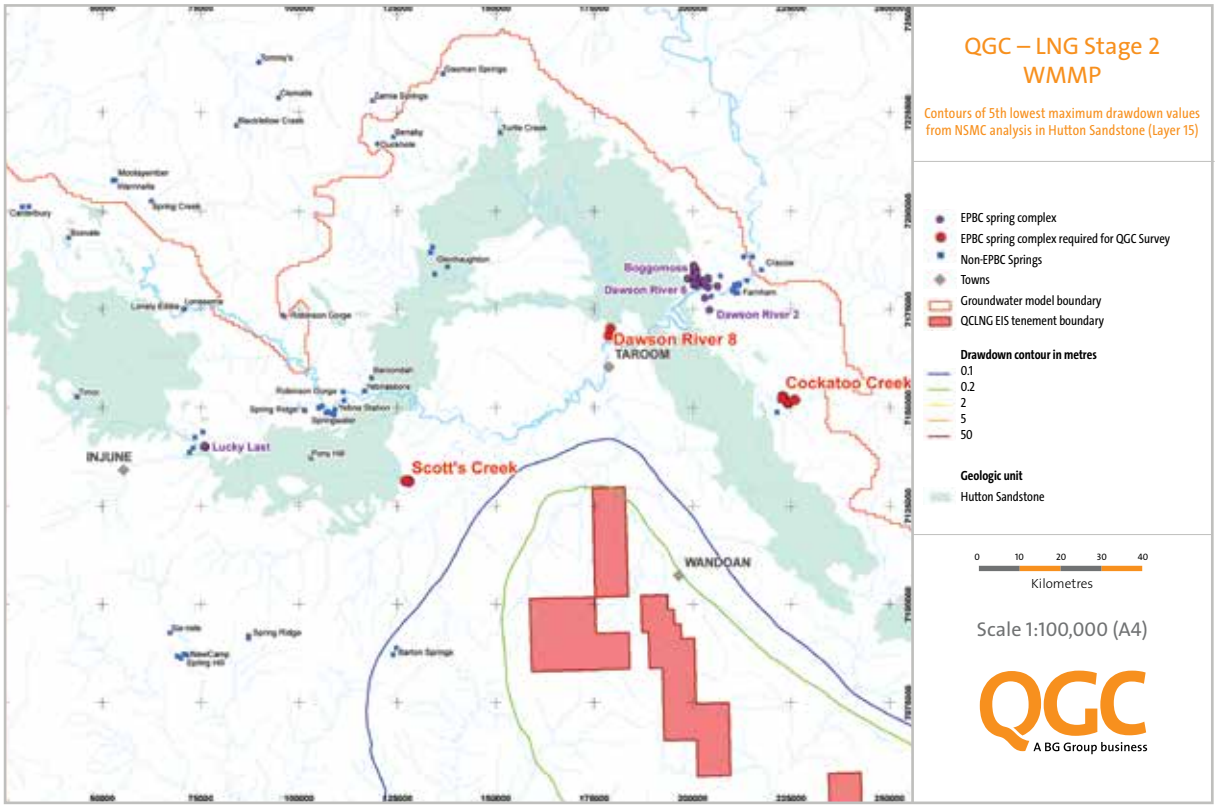

Figure 49 – Hutton Sandstone drawdown contours in vicinity of EPBC listed springs

In the Precipice Sandstone, a maximum modelled drawdown of 0.15 m was predicted to occur. In the vicinity of the various springs, the model predicts maximum drawdowns in the Precipice in the order of 0.02 to 0.1 m+. It is emphasised that the fundamental mathematical formulation of any groundwater model (the Theis solution) will result in a finite drawdown right up to any boundary. Hence the GEN2 model predicts very small, but finite, drawdowns in the vicinity of the springs. These are considered to be a function of the model and do not necessarily represent reality. When effects become so small, the normal variations due to barometric pressure, earth tides and many other processes overwhelm any theoretical modelling impacts. Hence it is considered that the effects at the three conditioned springs due to QGC activities are effectively nil.

QGC believes that the development of a long-term repressurisation program to protect MNES at this time is unnecessary. QGC understands that SEWPAC's intention for a possible future re-pressurisation program is solely to protect the EPBC listed springs. Within this context QGC is able to commit to ensuring that adequate pressure is maintained in those formations, close to the springs, which are source aquifers to the EPBC listed springs. If the early warning and threshold monitoring program indicates that the effects of CSG depressurisation occur earlier, or in the case of the Scott's Creek threshold monitoring bore as predicted, then a repressurisation program would be developed.

A repressurisation program would consider options such as:
- Establishing a permanent monitoring regime at critical springs (e.g. Dawson River 8)
- Establishing permanent injection infrastructure at Woleebee Creek
- Assess the potential for water supply substitution.

This process will be managed under the Response Plan outlined in Section 12.6.5.

QGC has however developed a short-term reinjection plan as outlined below. This involves:
- Trial injection and monitoring bore construction
- Modelling of groundwater repressurisation and impact assessment
- Injection trial
- Establishment of a permanent Precipice Sandstone injection bore subject to regulatory approval.

QGC is committed to the construction of a deep Precipice Sandstone trial injection bore and two monitoring bores on the Woleebee Creek Block. Construction of monitoring bore GW4 was completed in September 2012 and the extraction trial is programmed to commence by late 2012. Subject to satisfactory geological conditions being encountered and regulatory approvals, QGC plan to undertake an extended injection trial with treated CSG water in 2013. Following completion of the trial the injection bore will be maintained for future use as necessary.

12.12 SUMMARY – EXCEEDANCE THRESHOLDS AND RESPONSE PLANS

QGC has developed exceedance response plans for the potential situations of:
- Response Plan i — If Threshold Values for surface water quality and water environmental values are exceeded
- Response Plan ii — If Early Warning, Threshold Values or Trigger Limits for aquifer drawdown in relation to EPBC listed springs are exceeded
- Response Plan iib — Threshold Values for aquifer drawdown in relation to groundwater-producing bores are exceeded
- Response Plan iic — Threshold Values for groundwater contamination are exceeded
- Response Plan iii — Subsidence or surface deformation occurs which impacts on surface or groundwater hydrology.

Each plan is built around a three phased Response Action Process with identified management actions in each phase. Unforeseen emergency discharges are currently managed through Site Emergency Response Procedures and Dam Safety Emergency Response Plans. An overarching Emergency Discharge Management Plan will be developed.

QGC's approach to setting default drawdown limits for primary source aquifers for EPBC listed springs is:
- Define the groundwater level baseline for each primary source aquifer and to exclude long term trends, natural variations and oscillations from the baseline
- Develop specific drawdown limits for each individual threshold monitoring bore for the primary source aquifer (see Table 21)
- Define tailored early warning values and Threshold Values for early warning monitoring insulations and trigger monitoring bores to provide advanced warning
- Utilise VWP monitoring bores to monitor the drawdown propagation in the Walloon Coal Measures
- Use Queensland Water Act definitions for default drawdowns in consolidated rock strate to apply to the Mooga, Gubberamunda and Springbok formations and WCM for make good provisions.

The three major CSG operators in the southern Bowen and Surat Basins (Santos, APLNG and QGC) have developed a proposal for a collaborative, 'small footprint' monitoring scheme to address the risk of groundwater drawdown propagating from CSG production areas and potentially affecting springs that have been listed by SEWPAC as hosting ecological values of national environmental significance. This Stage 2 Plan will be updated in accordance with the agreed joint industry approach once available.

For each spring cluster, it is proposed that groundwater level monitoring be undertaken in at two locations:

- Early warning monitoring installations at tenure boundaries
- Threshold monitoring installations nominally 20 km from springs.

QGC has developed a short-term groundwater repressurisation plan that consists of:

- Trial injection and monitoring bore construction
- Modelling of groundwater repressurisation and impact assessment
- Injection trial
- Establishment of a permanent Precipice Sandstone injection bore subject to regulatory approval.

If the early warning and threshold monitoring program indicates that the effects of CSG depressurisation occur earlier than predicted, then a repressurisation program would be developed. A repressurisation program would consider options such as:

- Establishing a permanent monitoring regime at at-risk springs
- Establishing permanent injection infrastructure at Woleebee Creek
- Assess the potential for water supply substitution.

This process will be managed under the existing response plan.

Commitments	Target completion date
Re-injection	
Completion of first Injection Management Plan (Precipice Water)	February 2013
Construction/conversion of investigation, monitoring and trial injection production bore	April 2013
Completion of second Injection Management Plan (Treated CSG Water)	June 2013
Completion of Feasibility Study Report	April 2014
Response plans	
Finalisation of groundwater drawdown response plan	April 2013
Confirmation of early warning and threshold monitoring bore construction	October 2014
Development of Early Warning Trigger Values for groundwater pressure response in the Walloon Coal Measures in the Northern Gas Fields	July 2013
Finalisation of groundwater quality response plan	April 2014
Development of environmental risk management and response plan and an upgrade of exceedance response plans	April 2013
Develop Emergency Discharge Management Plan	July 2013
Completion of upgraded emergency response plans to cover all regulated water and waste storage facilities	October 2013
Completion of Northern Treatment Plant and Northern Gas Fields Emergency Response Procedure and Dam Safety Emergency Response Plan	October 2014

The above commitments are aimed at satisfying Conditions 49c and d, 52di I and II; 52 d ii