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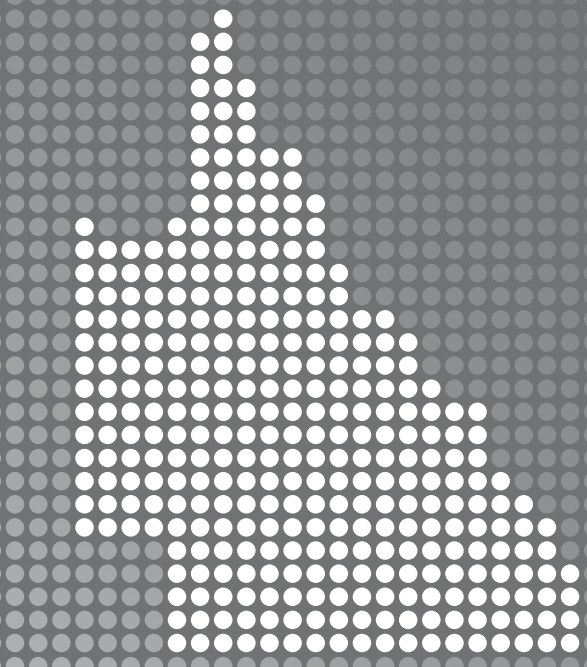
13.0
Groundwater management – response plans and actions



13.0 Groundwater management – response plans and actions

#	Department Condition		Description	Completion date	Status
	Pre-Dec 2012	Post-Dec 2012			
31	49c and d, 52di I and II; 52d ii	53B d, 53B E	Finalisation of groundwater draw down response plan	April 2013	●
32			Confirmation of early warning and threshold monitoring bore construction	October 2014	●
33			Finalisation of groundwater quality response plan	April 2014	●
34	52c viii, 52d i III	53B e	Development of environmental risk management and response plan and an upgrade of exceedance response plans	April 2013	●
35	52d iv		Completion of upgraded emergency response plans to cover all regulated water and waste storage facilities	April 2014	●
36	49h, 52d i IV	53B c	Develop Emergency Discharge Management Plan	July 2013	●

● Commitments completed
○ Commitments work in progress
△ Evergreen Commitments
● Firm deliverables for that month

13.1 INTRODUCTION

Ultimately, the strength of a water management program lies with application of exceedance limits, standards and robust response plans. QGC is undertaking a range of actions to protect the water environment and MNES in the event that threshold values (see Chapter 4) are exceeded.

In this way, the company is equipped to manage those risks and to develop plans and processes to avoid or mitigate unwanted impacts. The early warning and trigger monitoring and the response strategies as described below, are designed to protect EPBC listed springs.

Condition 53B e states the response plan requirements as:

e. An exceedance response plan that includes:

- i. Mechanisms to avoid, minimise and manage risk of adverse impacts and response plans and timeframes that can be taken by the proponent if;
  - I. Threshold values in the CSG WMMP for aquifer drawdown or groundwater contamination are exceeded;
  - II. Subsidence or surface deformation occurs that impacts on surface or groundwater hydrology;
  - III. There are any unforeseen emergency discharges;
- ii. A program and timetable for repressurisation using reinjection of CSG water from hydraulically connected aquifers back into appropriate permeable aquifers and for other groundwater repressurisation options to re-establish pressure levels and water qualities to the satisfaction of the Minister on the advice of an expert panel, in conjunction with appropriate measures to forecast and proactively manage any short-term impacts.

Note: The design of these groundwater repressurisation activities must be informed by a regional-scale groundwater model and a hydrochemical model approved by the Minister.

13.2 EXCEEDANCE RESPONSE PLANS

The following exceedance response plans have been addressed in the Stage 3 WMMP:

- **Response Plan iia:** If Investigation or Mitigation Trigger Values or Drawdown Limits for aquifer drawdown in relation to EPBC listed springs are exceeded;
- **Response Plan iib:** If Threshold Values for aquifer drawdown in relation to groundwater-producing bores are exceeded;
- **Response Plan iic:** If Threshold Values for groundwater contamination are exceeded;
- **Response Plan iii:** If Subsidence or surface deformation occurs which impacts on surface or groundwater hydrology; and
- **Response Plan iv:** If there are 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 and Stage 2 WMMPs.

Appendix O contains exceedance response plans which have been summarised and updated in this document.

Draft Exceedance Response Plans were submitted with the Stage 2 CSG WMMP and included:

- **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; and
- **Response Plan iii:** Subsidence or surface deformation occurs which impacts on surface or groundwater hydrology.

Response Plan i was accepted by the Department in the Stage 2 Plan however the need for the plan has subsequently been superseded by the 'Variation to Conditions Attached to Approval' on 2 November 2012 as Condition 60A which states:

"...60A. the proponent must treat all coal seam gas water as required under this approval before the coal seam gas water associated with the approved action enters the following pipelines:

- *The Kenya to Chinchilla Pipeline referred to the Department (EPBC 2011/6000)*
- *The Woleebee Creek to Glebe Weir pipeline (EPBC 2011/6181)*

Once the coal seam gas water has been treated as required under this approval and has entered the pipelines specified above, conditions 43-60 will no longer apply to that water..."

A copy of the variation and associated correspondence is included at Appendix A. Revised Response Plans iia, iib, iic and iii were submitted to the Department in May 2013 and are presented in Appendix O.

QGC's Unforeseen Emergency Discharge Management Plan has been developed and is presented in Chapter 16.

13.3 APPROACH TO DEVELOPING EXCEEDANCE RESPONSE PLANS

Each Response Plan contains investigation and management/mitigation stages depending on which particular thresholds have been exceeded and is based on the following principles:

- The investigation stage will include the targeted data collection for and evaluation of potential mitigation measures to lead to the selection of a preferred mitigation measure; and
- Exceedance of the management/mitigation threshold will trigger the implementation of that preferred mitigation measure as long as conditions have not significantly changed to negate the preferred option.

This approach recognises that there could be several years between threshold values being reached. 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 the Department at key times. Where necessary, a Mitigation Plan would be identified and implemented.

In each case under Phase 1 (the Monitoring Phase), a desktop review and written report would be prepared and submitted to the Department 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;
- 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; and
- Statement about potential effects on the receiving environment and the need for further investigation and assessment.

Phase 2 (the Response Plan) 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 the Department 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 2 may also involve the implementation of mitigation measures. Specific mitigation measures will depend on the type of exceedance. Indicative mitigation measures for each exceedance type are outlined below.

13.4 RESPONSE PLAN IIA IF INVESTIGATION OR MITIGATION TRIGGER VALUES OR DRAWDOWN LIMITS FOR AQUIFER DRAWDOWN IN RELATION TO EPBC LISTED SPRINGS ARE EXCEEDED

Response Plan iia is the plan presented in the Joint Industry Plan (JIP) for springs monitoring and management (Appendix J).

13.4.1 EXCEEDANCE CRITERIA

The Proponents individual approval conditions require the definition of three levels of exceedances: an Early Warning Trigger Value, an Exceedance Threshold; and a Drawdown Limit. A more intuitive terminology is proposed below (see Table 13-1) and is used throughout the JIP. The criteria apply to either groundwater pressure alone or groundwater pressure and groundwater quality:

- Investigation trigger – applying to groundwater pressure and water quality;
- Management / mitigation trigger– applying to groundwater pressure; and
- Drawdown Limit – applying to groundwater pressure.

Adopted terminology	Approval condition terminology
Investigation Trigger	A nominated value at an EWMI and TMP that triggers some action such as data review, model review, increased monitoring frequency, increased monitoring parameters. For groundwater pressure, this is equivalent to 'early warning indicator' referred to in Condition 49cd.
Management / Mitigation Trigger	A nominated value at a TMP that triggers some action to be taken to prevent an impact occurring at an EPBC spring (i.e. a mitigation activity). For groundwater pressure, this is equivalent to 'drawdown threshold' referred to in Condition 49cd.
Drawdown Limit	A nominated value at a TMP that, if exceeded, would result in a breach of the Commonwealth Approval Conditions should drawdown exceed this value (see Condition 49 a). This value corresponds to greater than 0.2 m modelled impact at an EPBC Spring.

Table 13-1 – Definition of Exceedance Criteria

The regional groundwater flow model or Cumulative Impact Model (CIM) developed for the Surat UWIR to examine the cumulative impact of CSG water extraction represents the most really extensive regional groundwater impact model. Accordingly, the groundwater level drawdown predicted by the CIM has been used to determine a prediction of the drawdown at each of the EWS regional monitoring bores. Section 4 presents the relevant triggers for QGC responsible bores.

A differentiation in approach is necessary between EPBC springs located off-tenements and on-tenements, as the approach for the off-tenements springs and initially agreed to by the Proponents relied on a percentile of the 95th percentile drawdown. This resulted in predicted drawdowns for the on-tenement EPBC springs and associated EWS network being in the order of millimetres which is within measurement error for all monitoring instrumentation. Accordingly, in the JIP separate groundwater pressure exceedance levels have been defined for both on and off tenement springs. As QGC does not have any on tenements springs only the off tenement approach is discussed here.

The time-drawdown data used has been the 95th percentile predictions from the current CIM outputs, however this may be modified based on the revised predictions of future iterations of the Surat Basin model. The JIP currently uses the outputs of model version 1.2.

To assess the potential impact of CSG activities, estimated natural and anthropogenic (non-CSG) effects will be removed from the measured monitoring data (see Section 4). If a trigger or threshold is exceeded for a period exceeding three months, a response will be initiated. The Proponent's approach is as follows:

Case 1: General case

- The drawdown limit is set as the 95th percentile drawdown in an EWS monitoring bore corresponding to the last time period in the model corresponding to zero metres drawdown at the spring. It is defined for TMPs only;
- The investigation trigger value is set at 50% of the drawdown limit for that EWS bore; and
- The management/mitigation trigger is set at 80% of the drawdown limit for that EWS bore.

Case 2: No drawdown predicted at spring

Where no drawdown is predicted at the spring by the CIM, the maximum 95th percentile drawdown value at an EWS monitoring bore is used:

- The investigation trigger value is set at 50% of the maximum 95th percentile drawdown value;
- The management/mitigation trigger value is set at 80% of the maximum 95th percentile drawdown value; and
- The drawdown limit is set at the maximum 95th percentile drawdown value.

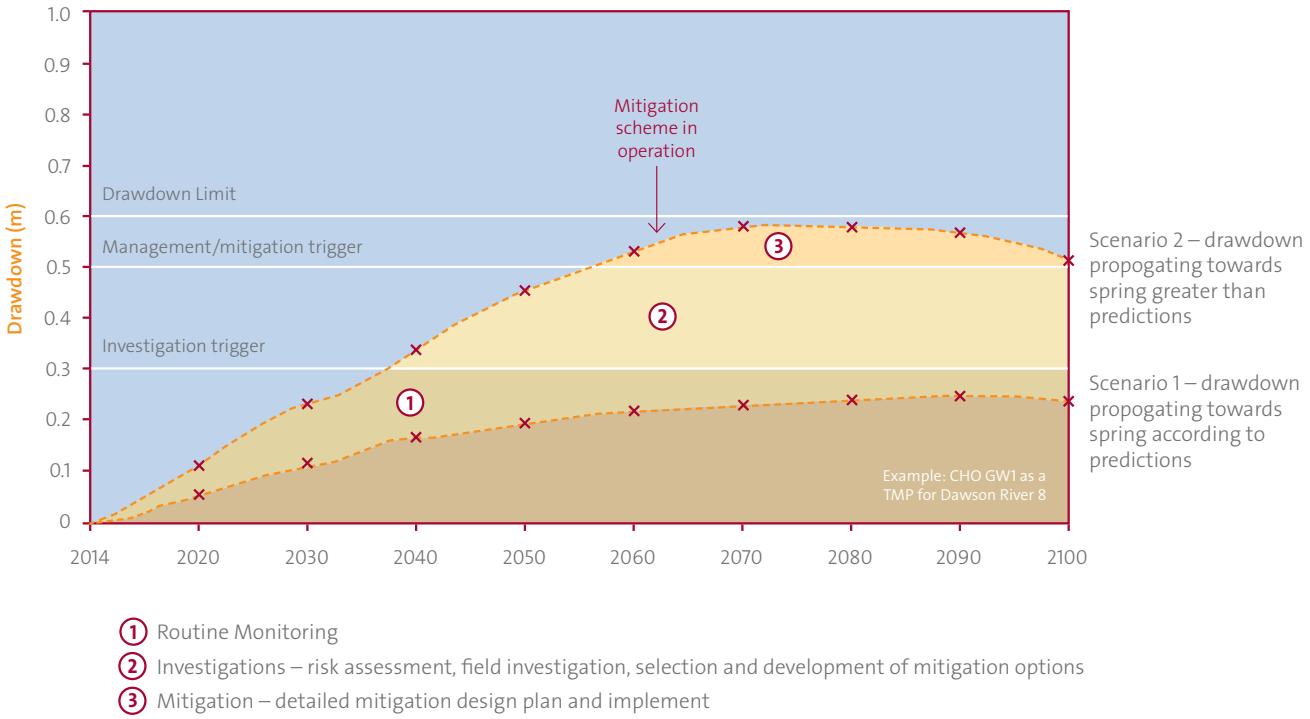


Figure 13-1 – Schematic of Groundwater Pressure Exceedance Response for off-Tenement Springs

Case 3: No drawdown predicted at spring and at the TMP

Where no drawdown is predicted at the spring by the CIM and no measurable drawdown is predicted at a TMP, the drawdown limit is set at 0.2 m, investigation triggers and management /mitigation triggers are set as the percentile of the drawdown limit:

- The investigation trigger value is set at 50% of the drawdown limit (i.e. at 0.1 m);
- The management/mitigation trigger is set at 80% of drawdown limit (i.e. at 0.16 m); and
- The drawdown limit is set at 0.2 m.

The investigation trigger, management/mitigation trigger and drawdown limit are developed using the current CIM predictions. Those values may require updates to account for:

- The outcome of the update of the CIM as part of UWIR updates;
- The outcome of the interconnectivity studies; and
- Update to the Proponents' projects development plans and controls.

Reviews of the Surat CIM will possibly result in a review of the triggers and drawdown values. As a minimum, updates are expected to be required every three years to reflect the update of the CIM and Surat UWIR.

Investigation trigger values for groundwater quality will be established after baseline is defined. No management/mitigation and drawdown limits will be defined. A groundwater quality baseline will be established over a minimum of seven sampling events on a six monthly basis (i.e. over a 3.5-year period).

An exceedance of a groundwater quality trigger value will trigger review and further evaluation to enable risk management such as confirmation of the exceedance and analysis of collected results jointly with groundwater pressure data. However, as any impact at the monitoring bore would be first observed in the pressure data, no management/mitigation triggers based on water quality is considered appropriate.

13.4.2 EXCEEDANCE RESPONSE MEASURES

The EWS is designed to provide sufficient warning time to enable response before impact on EPBC springs occurs. It is important to remind the reader that the EWS and associated timing of response relies on The CIM in its current state: the time between the exceedance of the Mitigation/management trigger and potential impacts at a spring is considered to be the minimum time over which such propagation could occur. Regardless, estimates based on the Surat CIM outputs (version 1.2) have been made of the time available between the investigation trigger, mitigation/management trigger and drawdown limit being reached. These are presented on Table 13-2.

Spring Complex	Main GAB aquifer interpreted to be source aquifer	Type of bore	EWS nominated monitoring bores – Target Aquifer	Investigation Trigger	Mitigation / Management Trigger	Drawdown Limit
Dawson River 8	Hutton Sandstone	EWMI	Charlotte GW1 – Hutton	2027	2030	NA
		TMP	Kinnoul-MB2-H – Hutton	2033	2039	
		EWMI	Charlie GW1 – Hutton	2047	2087	NA
Dawson River 6, Dawson River 2, Boggomoss, Prices	Precipice Sandstone	EWMI	Cassio GW1 –– Hutton	2037	2082	NA
		EWMI	Coochiemudlo GW1 (CHAR)- Hutton	2032	2041	NA
		EWMI	Charlotte GW1 (CHR)– Hutton	2027	2031	NA
		EWMI	Charlie GW2 –– Precipice	2078	2093	NA
		EWMI	Cassio GW2 (CAS)- Precipice	Not predicted	Not predicted	NA
		EWMI	Charlotte GW2 (CHR)- Precipice	2105	2195	NA
		TMP	Coochiemudlo GW2 (CHAR)- Precipice	Not predicted	Not predicted	Not predicted
Scotts Creek	Hutton Sandstone	TMP	RN38333 –– Hutton	Not predicted (EPMOR studies)	NA	Not predicted
		TMP	RN14881 –– Hutton	Not predicted	NA	2025
		EWMI	Charlie GW1 – Hutton	2047	2087	NA

Table 13-2 – Response time available for springs management and mitigation

The zero drawdown of groundwater pressure in the source aquifer is a proxy for zero impact at the springs. However, a drop of groundwater pressure at a spring may not necessarily result in any impact or any immediate impact to the spring ecosystem (included to EPBC listed species). The vulnerability of the spring to a decreased groundwater pressure will need to be assessed on a case by case basis (National Water Commission, 2013). This has the potential, on the basis of a site specific vulnerability assessment and in view of the collected monitoring data, to enable update to the "zero drawdown proxy" used. The risk assessment will identify potential updated triggers for management/mitigation. The flow chart diagram on Figure 13-2 provides a summary of the early warning system monitoring and response process.

Before an exceedance is considered to have been reached, monitoring will continue for up to three months beyond the initial exceedance measurements, to check that the exceedance is repeated and ongoing. The following explanatory details are presented to support Figure 13-2:

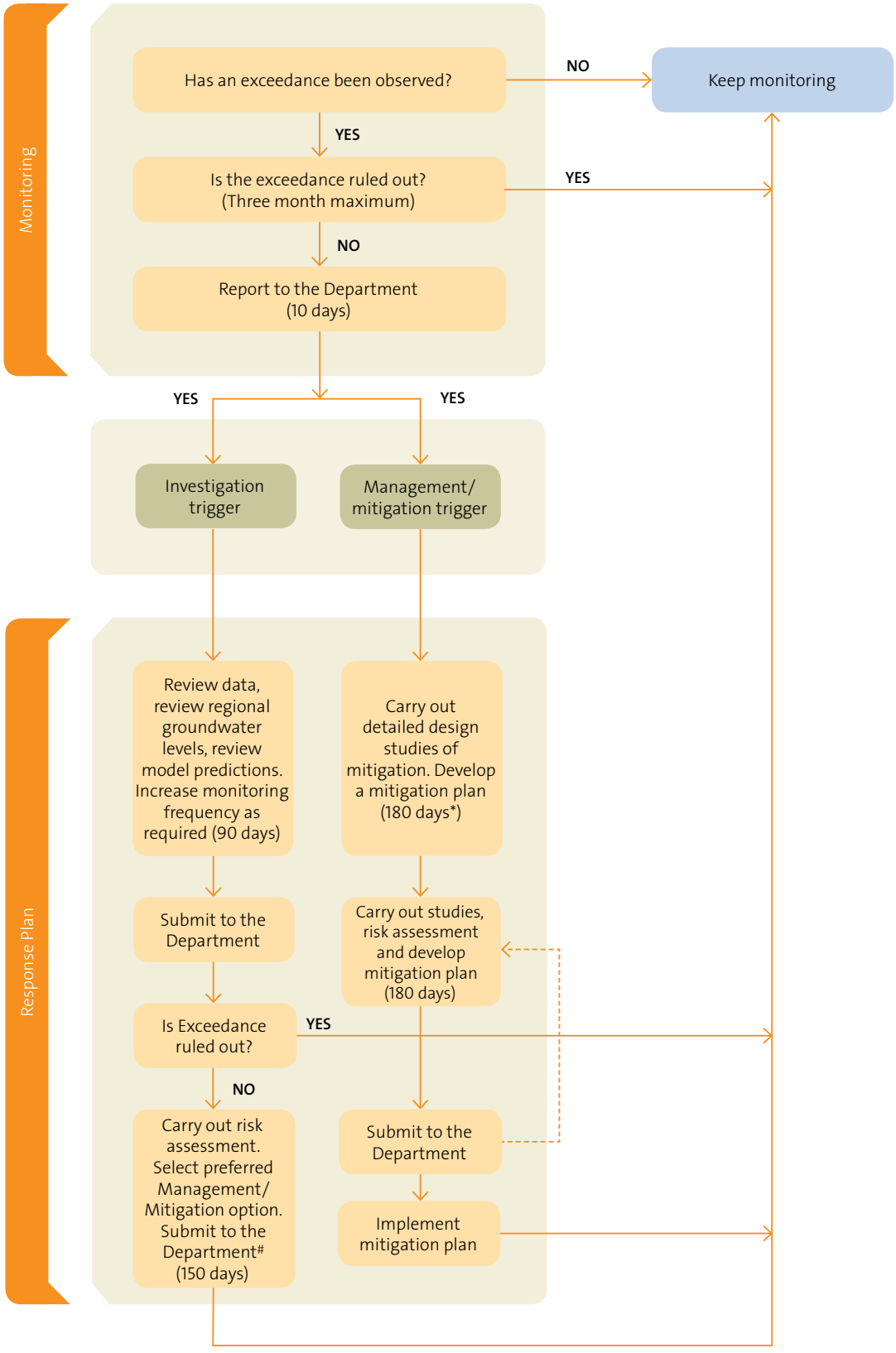
When an Investigation Trigger value is exceeded (at an EWMI or TMP), the responsible Proponent will:

- Verify the exceedance by:
  - Assessing exceedance with historical data for the bore, this may include the use of a statistical trend procedure to remove natural variations;
  - Assessing water level data in neighbouring bores monitoring the same aquifer;
  - Reviewing the model predictions and comparison with observed water levels;
  - Identifying the potential causes that may have contributed to the exceedance; and
  - Increasing monitoring if necessary; then,
  - Notify The Department of the Environment within 10 days of confirmation of the exceedance.
- Where an observed exceedance cannot be ruled out, the responsible Proponent will:
  - Undertake a risk assessment and other studies resulting in nomination of a concept mitigation approach. This will include field investigations to assess site specific features, an assessment of the vulnerability of the spring to the level of predicted drawdown and a review of the hydrogeological conceptual model to understand the actual level of risk of impact to the EPBC springs (note: the hydrogeological conceptual models would have been developed earlier and provided to the Department at the end of spring baseline at the latest). A methodology is proposed in Table 13-3 for the selection of potential impact management/mitigation solutions. One key element is the multi-criteria analysis which ensures that a range of criteria are taken into consideration in the selection process and in particular:
    - The timing available for implementation of the management/mitigation option;
    - The timing of the Proponent CSG activities; and
    - Other criteria such as technical success rate of the solution, environmental footprint, stakeholder and regulatory acceptability.

When a Management/Mitigation trigger is exceeded, the responsible Proponent will:

- Move to carry out detailed mitigation design and develop a mitigation plan. To this end, the previously selected impact management/mitigation concept(s) will be developed in detail. This will involve:
  - Confirmation of the concept options;
  - Additional field investigations;
  - Hydrogeological modelling; and
  - Detailed engineering design studies.
- Develop a mitigation plan. The mitigation plan will identify the potential of time before impact, the timing of mitigation and will potentially be redefining the value used as a 'zero impact proxy';
- Submit the mitigation plan to The Department of the Environment; then,
- Implement the mitigation plan.

When a drawdown limit is exceeded and the exceedance cannot be ruled out, the responsible Proponent will report to The Department of the Environment within 10 days of confirmation of exceedance.



** Available time before impact taken into consideration in concept design choice. Time frames are consistent with impact propagation timing.*
 # Risk assessment and selection preferred management/mitigation option is already done for Lucky Last, Yebra 2 and Scotts Creek.

Figure 13-2 – Early Warning System Monitoring Exceedance and Response Process for EPBC Springs

The response process diagram provides the length of time between elements of the response process. Time-lengths are set to allow only for assessment and communications from the Proponents to the Department and site access where necessary.

13.4.3 POTENTIAL MITIGATION MEASURES

If the monitoring data exhibits exceedance of an investigation trigger, the responsible Proponent will select possible mitigation solution(s). The list of mitigation options to be considered is extensive depending on the methodology used for implementation, however these options can be classified by the mitigation concept they are developed from. A list of possible mitigation options is presented in Table 13-3.

	Aspect	Scope of work and target
Mitigation Design	Mitigation options identifications	Identify all potential options for mitigation at the springs
	Mitigation options early assessment	Initial screening of mitigation options through a multicriteria analysis. Will also allow focusing work efforts in data which is effectively required.
Studies	Survey / topography	Survey spring vents elevation, topography at spring site, river bed elevation (if any), groundwater monitoring bore and private bore elevation nearby
		Prepare cross sections for hydrogeological conceptual models
	Surface water	Identify gauging stations near spring sites
		Assess baseflow, identify source of baseflow, if same as spring source aquifer potential seasonal pattern, identify influence of dry/wet periods
		Identify relationship between groundwater level variations and river baseflow. What is the level of confidence in this assessment?
		Define if baseflow at a gauging station can be used as a trigger to impact to aquifer pressure?
	Hydrochemistry	Compare chemistry signatures for surface water, spring vents, and groundwater. Confirm/ update previous results on aquifer source and GW/SW interactions on the basis of water quality.
	Ecology	Ecological survey, quarterly for one year to determine spring ecological values and seasonal variability. Select representative spring vents for ongoing monitoring
		How stable is the spring ecosystem, how can we identify an impact to the ecosystem (resulting from decreased water supply) on the flora?
		Assess the vulnerability of the spring ecology to a predicted drawdown in the source aquifer. Comment on resilience to dry periods, root zone extend, resilience to a lowered water level.
		Define the point where impact to spring may be non-reversible for ecological species
	Spring History	Obtain all historical aerial photography and old remote sensing data for the spring area to document spring variability. Interview landholders/stakeholders for anecdotal knowledge.
	Groundwater	Gather available groundwater data for the area (incl. water levels, groundwater usage, groundwater chemistry). Assess reliability of the data. Discard low confidence data. Create maps.
		Carry out groundwater monitoring and spring monitoring events, possibly at the same time as the ecological monitoring.
		Define existing groundwater structures which could be used for monitoring
		Assess water level data, assess historical and seasonal variations
		Assess pressure heads in the source aquifer vs spring elevation
		Assess from the CIM the predicted level of impact at the spring and the timing of this impact and recovery.

	Geology	Assess geology at the site using published geological maps, and other sources such as seismic data or in-house geology to identify the presence of faults or geological features which can inform on spring behaviour. It may be necessary to carry out shallow seismic or resistivity imaging.
	CSG Production Areas	Establish impact propagation
	Hydrogeological conceptual model	Develop / refine hydrogeological conceptual models
		Assess the vulnerability of the spring flow to a decrease of water level in source aquifer. Refer to similar work by National Water Commission.
		develop the hydrogeological model and associated illustrations
Mitigation assessment and selection	Mitigation	Using the initial high level MCA outcome and current understanding of vulnerability of EPBC spring , refine the MCA and select mitigation option(s)
		Define an early schedule for preparation of a mitigation plan
		Identify data/studies requirements for the option(s) selected
	Review of spring drawdown limit	Review adequacy of the drawdown limit set in the JIP for the specific site
		If trigger is not adequate, propose to The Department of the Environment a new drawdown limit using either ecology, baseflow or aquifer pressure as an indicator. Define time available for implementation.
Mitigation assessment and selection	Mitigation	Using the initial high level MCA outcome and current understanding of vulnerability of EPBC spring , refine the MCA and select mitigation option(s)
		Define an early schedule for preparation of a mitigation plan
		Identify data/studies requirements for the option(s) selected
	Review of spring drawdown limit	Review adequacy of the drawdown limit set in the JIP for the specific site
		If trigger is not adequate, propose to The Department of the Environment a new drawdown limit using either ecology, baseflow or aquifer pressure as an indicator. Define time available for implementation.

Table 13-3 – Work program for spring mitigation option selection

It should be noted that depending on the length of time for which mitigation is required, the selected mitigation may consist of several options which will be implemented successively.

The selection of the suitable spring mitigation option(s) will follow a work program similar to the one presented in Table 13 3. Initially, all mitigation options will be considered. Through a high level multi-criteria analysis, unsuitable mitigation options will be set aside. The exercise will also be used to focus the studies on potentially viable mitigation options, it will ensure that sufficient time available for studies and implementation of the mitigation solution is taken into consideration and will also allow to identify any additional data requirements early in the mitigation selection process. When the vulnerability of the spring ecosystem to a decrease in water level in the source aquifer is understood, the mitigation selection process will be refined and the mitigation option or combination of mitigation options will be selected.

13.5 RESPONSE PLAN IIB THRESHOLD VALUES FOR AQUIFER DRAWDOWN IN RELATION TO GROUNDWATER-PRODUCING BORES ARE EXCEEDED

This specific plan have been developed to address compliance requirements under the Queensland Government's Water Act 2000 for underground water management. Note this Act is administered at state level and not under the QCLNG federal approval. The Response Plan outlined can be triggered by three types of events:

- Where bores at risk are identified through the UWIR reporting process;
- In response to specific complaints of aquifer drawdown or impairment in bores from landholders; and
- Spring management.

The bore trigger threshold value for aquifer water level drawdown exceedance is set by the Queensland Water Act 2000 (Section 362) at 5 m for bores in consolidated rock formations.

The OGIA UWIR predicts cumulative impact of CSG activities in the Surat Basin Cumulative Management Area for bores that could be impacted:

- In the next three years (2013 to 2015) in the Immediately Affected Area (IAA); and
- In the Long-term Affected Area (LAA) over the life of the projects.

The UWIR has identified 32 bores in the IAA on QGC tenements and potentially 94 long-term affected bores in total on QGC tenements. QGC will have responsibility to enter into make good arrangements with affected landholders. All IAA bores draw groundwater from the Walloon Coal Measures except one Hutton Sandstone bore.

QGC has been negotiating with 28 bore owners for the 34 IAA bores. Of those 28 Make Good Agreements being negotiated, three have been executed, another nine are with landholders or their legal representative, and the remainder are in the process of being prepared based on negotiations to date.

In addition to those 'make good' bores identified in the UWIR, QGC has been negotiating with some bore owners to monitor their bores so as to better predict if there will be an impairment within QGC's operations phase.

The make good bore response plan for bores in the Immediately Affected Area is shown at Figure 13-3. The Queensland Water Act 2000 requires that make good arrangements are entered into with affected landholders within 60 business days of release of an UWIR report or an amended report or at a later date as agreed with the regulatory agency. For the present IAA identified by the first Surat Cumulative Area UWIR (OGIA 2012), negotiations are ongoing with landholders regarding make good measures and make good agreements. Landholder complaints of potential bore impairment or aquifer drawdown are overseen by the CSG Compliance Unit (CSGCU) of the Queensland Department of Natural Resources and Mines.

A landholder complaint can either be received directly by QGC or referred to QGC from the CSGCU. This response plan incorporates the following steps:

- Incident report to QGC management and the Queensland Government CSG Compliance Unit (CSGCU) as required within seven days;
- Initiation of Response Plan;
- Investigation of complaint, and/or likely drawdown causes. This will include a review of data; ascertain the sources or causes of the exceedance;
- Undertake field measurements, sampling and testing as necessary and reporting; and
- Negotiations to rectify the drawdown and 'make good' with the bore owner, if required. The complaint response plan is illustrated in Figure 13-3.

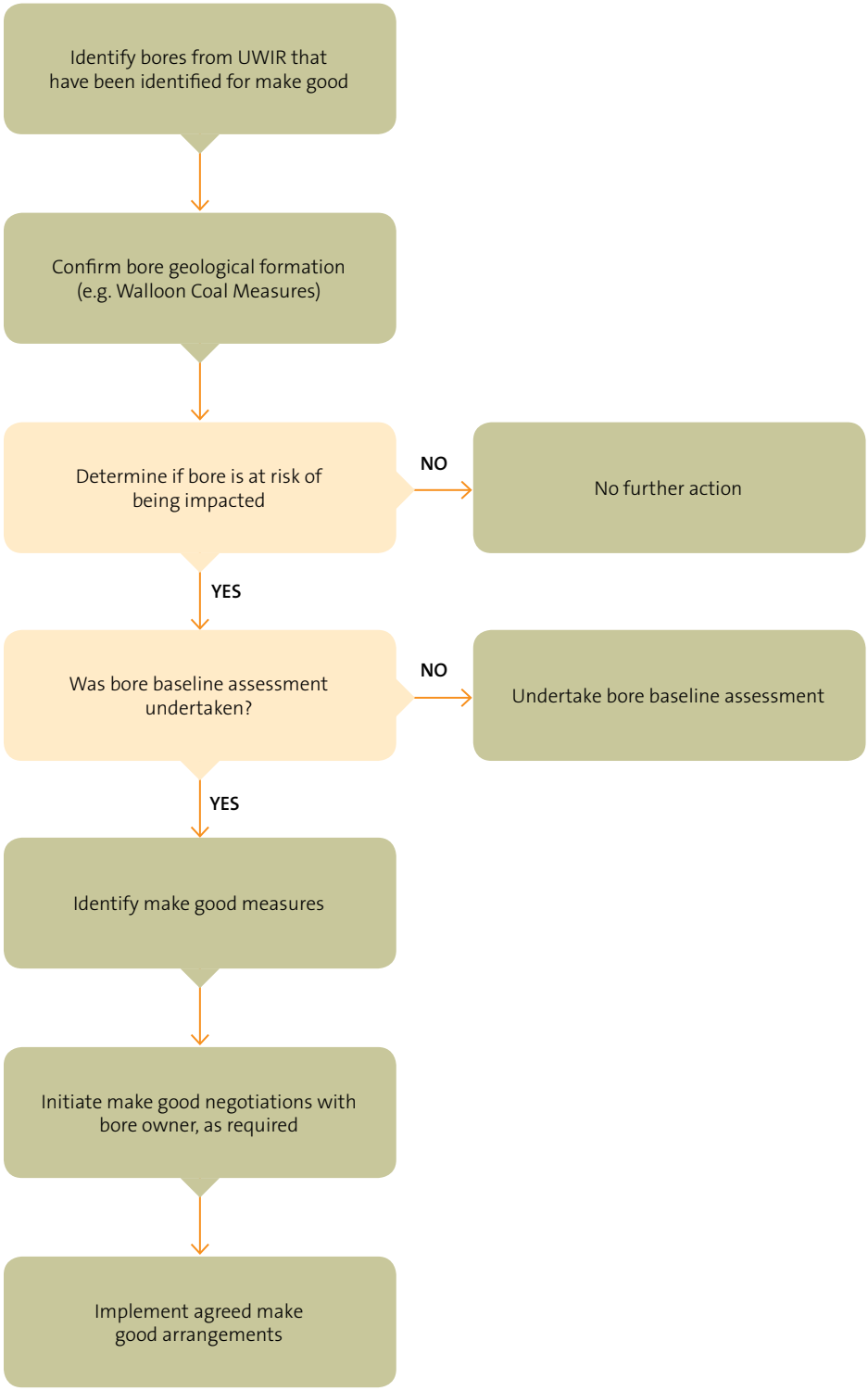


Figure 13-3 – Bore owner complaint response plan

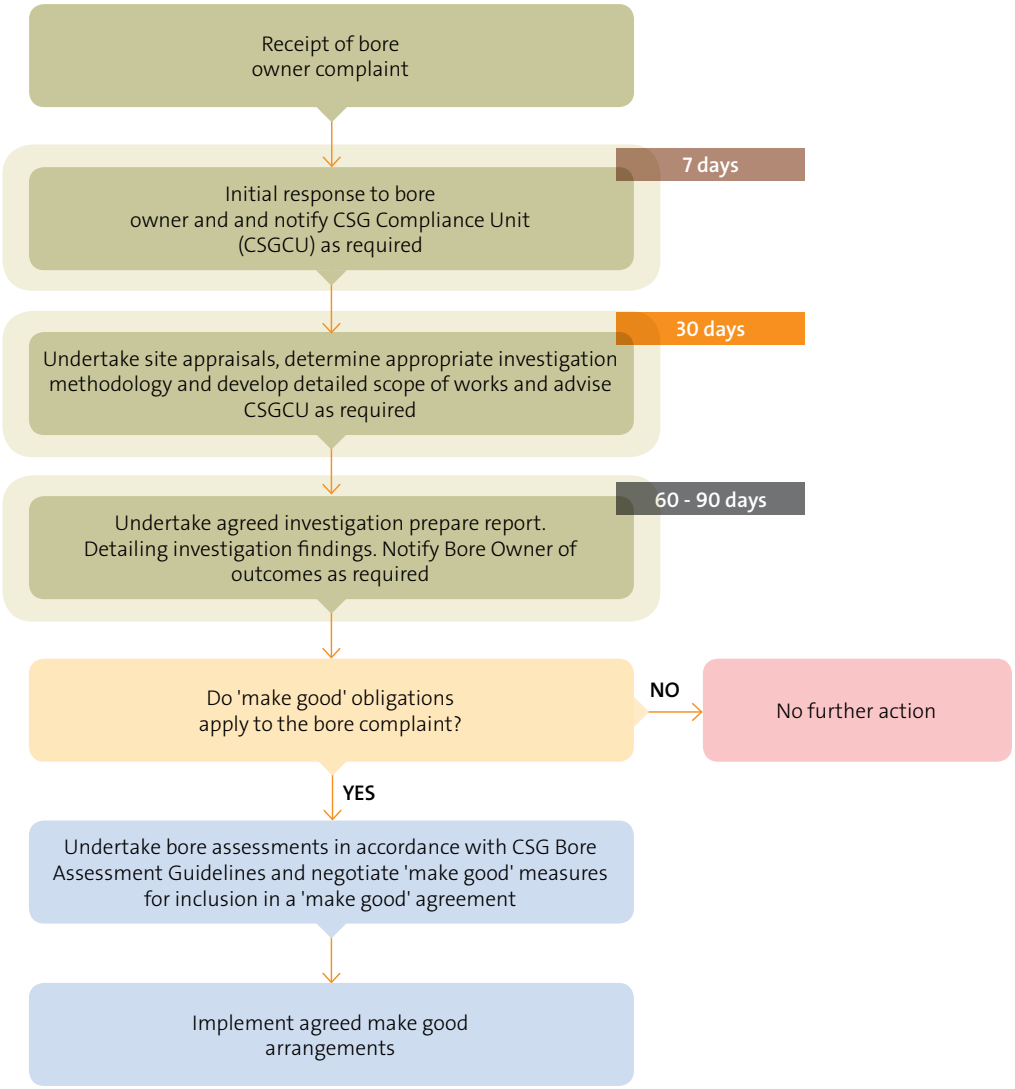


Figure 13-4 – Bore owner UWIR 'make good' response plan

13.6 RESPONSE PLAN IIC THRESHOLD VALUES FOR GROUNDWATER CONTAMINATION ARE EXCEEDED

13.6.1 GROUNDWATER CONTAMINATION THRESHOLD DEVELOPMENT

QGC's groundwater quality monitoring program comprises a baseline exercise of six monthly sampling of all groundwater monitoring bores for physico-chemical parameters, major ions, trace elements, carbon parameters, nutrients, gas parameters and organics. One round of stable isotope analyses for each bore is planned. Ongoing sampling will continue at a six-monthly frequency with a reduced analysis suite as per the Joint Industry Springs Plan.

Groundwater threshold values will be developed in two stages:

- Regional specific default groundwater quality threshold values or ranges for the Hutton and Precipice Sandstones for the northern Surat Basin will be developed based on existing groundwater quality information. (QGC farm bore baselining and historical DEHP data); and
- Initial site specific monitoring bore groundwater threshold ranges will be developed for the northern Surat Basin based on up to three baseline analyses for the eight early warning and trigger monitoring bores (of which six have already been completed), where the resultant threshold ranges are consistent with the regional default groundwater threshold ranges or judged appropriate based on hydrochemical model development. Timing October 2014.

QGC has developed regional default groundwater quality threshold ranges for the Hutton Sandstone and Precipice Sandstone in the northern Surat Basin. Threshold ranges have been developed for key indicator parameters (electrical conductivity and chloride) based on water quality data derived from QGC's baseline survey and historical DEHP (formally DNRM) data.

The limited data available for the Hutton Sandstone and Precipice Sandstone groundwater in the northern Surat Basin indicate a water type trend from Na-Cl in the shallower regions to the north-east to Na-HCO3 in the deeper regions to the south-west.

In the Hutton Sandstone, Cl and TDS also reach a peak along the eastern Surat Basin boundary and decrease to much lower concentrations north of QCLNG blocks in the vicinity of the Mimosa Syncline to below 700 mg/L Cl and 2,500 mg/L TDS. A similar pattern occurs in the Precipice Sandstone with concentrations of below 200 mg/L Cl and 600 mg/L TDS.

Formation	Parameter	Concentration ranges
Hutton Sandstone	Chloride (mg/L)	100 – 700
	Electrical conductivity (µS/cm)	300 – 1,800
Precipice Sandstone	Chloride (mg/L)	5 – 200
	Electrical conductivity (µS/cm)	200 – 900

Table 13-4 – Regional default groundwater quality threshold values

The current proposed investigation threshold is a 20% change in average values from the default or average or median value (whichever is most representative) for EC and chloride and a change of 1 pH unit from the default or upper baseline value for a six-to-twelve month period.

These thresholds are initial estimates and will be reviewed on a triennial basis as more data becomes available. Data will be analysed for trends of those parameters that are of prime significance to the hydrogeochemistry of the Hutton and Precipice Sandstone aquifers being assessed but will consist of:

- Major ion ratios (e.g. Na/Cl,);
- Major ion concentrations (e.g. Na, Cl, HCO3);
- Isotope ratios (e.g. 86Sr/87Sr, δ18O/ δD); and
- Key trace elements, if appropriate.

The extent to which analysis will be carried out will be determined from the development of the QGC conceptual hydrochemical model of the Surat Basin that is being developed under Commitments 10 and 11 of the Stage 2 WMMP. The groundwater quality data will be plotted to visualise general behaviour characteristics. A line of best fit will be applied to identify the nature of any changes over time. However it must be interpreted with care in light of the data limitations. Observations will be qualitative and general in nature, until at least five years of record are available when a review of potential qualitative methods will be undertaken. Statistical analysis undertaken by Santos indicates that a minimum of seven samples from a data point taken over 3.5 years are necessary to meet a 95% confidence level and establish a baseline threshold value.

A number of processes may influence groundwater quality data and the magnitude of laboratory analysis, such as:

- Local and regional geological conditions and water movements;
- Local and regional land use and land use changes;
- Climate conditions and resulting recharge events;
- Local and regional groundwater pumping; and
- Water quality sampling and laboratory quality control procedures.

Given the depth of the confined aquifer systems of interest, it is unlikely that surface processes will impact on the quality of water in the groundwater system being analysed. Instead, it is likely that the characteristics of the adjacent groundwater systems will be more relevant if considering groundwater quality changes. However any interpretation will depend on the relative location of bores to inferred recharge areas. Note QGC is undertaking a detailed assessment of the hydrochemistry of groundwaters within the various formations in the Surat Basin.

13.6.2 EXCEEDANCE RESPONSE PLAN – INVESTIGATION PROCESS

Where trigger thresholds have been exceeded over three months of continuous EC readings or two consecutive groundwater quality analyses over a three month period, QGC management and the Department will be advised within 10 days of QGC becoming aware of the exceedance. Subsequently an Initial Review and report must be prepared and submitted to the Department 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 resampling and analysis of the location of interest;
- Review and assessment of the processes that may have contributed to the change;
- Likelihood of continued threshold 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/ assessment; and
- Statement about potential effects on MNES and/or non-CSG water users and the need for further assessment at springs.

Recommendations for any further work would be identified in the initial review.

13.6.3 EXCEEDANCE RESPONSE PLAN – RESPONSE PLAN PROCESS

The Response Plan is enacted where the conclusions of the Initial Review and the additional monitoring works defined above identify an unacceptable risk cause by CSG operations of an adverse or significant effect on the receiving environment and/or the Department concludes from the report that further investigation is required.

The current Response Plan process involves conducting a full risk assessment and the development of a conceptual model where sources, pathways and receptors are formally identified and assessed. In some instances the aquifers of interest are at some considerable depth with minimal connection to receptors. So while a threshold may have been exceeded the risk of the exceedance to receptors of concern could be minimal. A conceptual model and risk based approach defines the relationships between these three elements, which needs to be correctly defined before any mitigation or management plans are developed. This conceptual model and risk assessment process would typically involve:

- Spatial definition of the area where the groundwater thresholds have been exceeded;
- Assessment of the geological and hydrogeological conditions in that area and within the lithologies identified. Also review any pressure or water level data at this time to determine any changes in hydraulic conditions;
- A review of the geochemical conditions and an assessment of reactions that may be occurring that may be the cause of the change in water quality;
- Assessment of how and the rate at which inter aquifer leakage may be occurring (via mass balance/flux assessments);
- Definition of the groundwater users in and around the area, their location relative to the area where the threshold exceedance occurred. Consideration will also be given to what this water is used for (stock, irrigation etc);
- Development of a conceptual model for the area taking all above issues into consideration;
- Completion of a risk assessment based on these findings;
- Statement about potential effects on the receiving environment and the need for further investigation/ assessment; and
- Statement about potential effects on MNES and/or non-CSG water users and the need for further assessment at springs.

Should this threshold exceedance be found to be a function of slowly evolving changes in aquifer water quality over time then QGC propose to adopt an adaptive management approach to the threshold. In such a case the derivation of the threshold would be revisited and a new threshold would be derived that more accurately allows for this naturally evolving system.

This approach could involve installation of monitoring bores close to springs and further groundwater modelling. This process is presented in the attached flow chart at Figure 13-5.

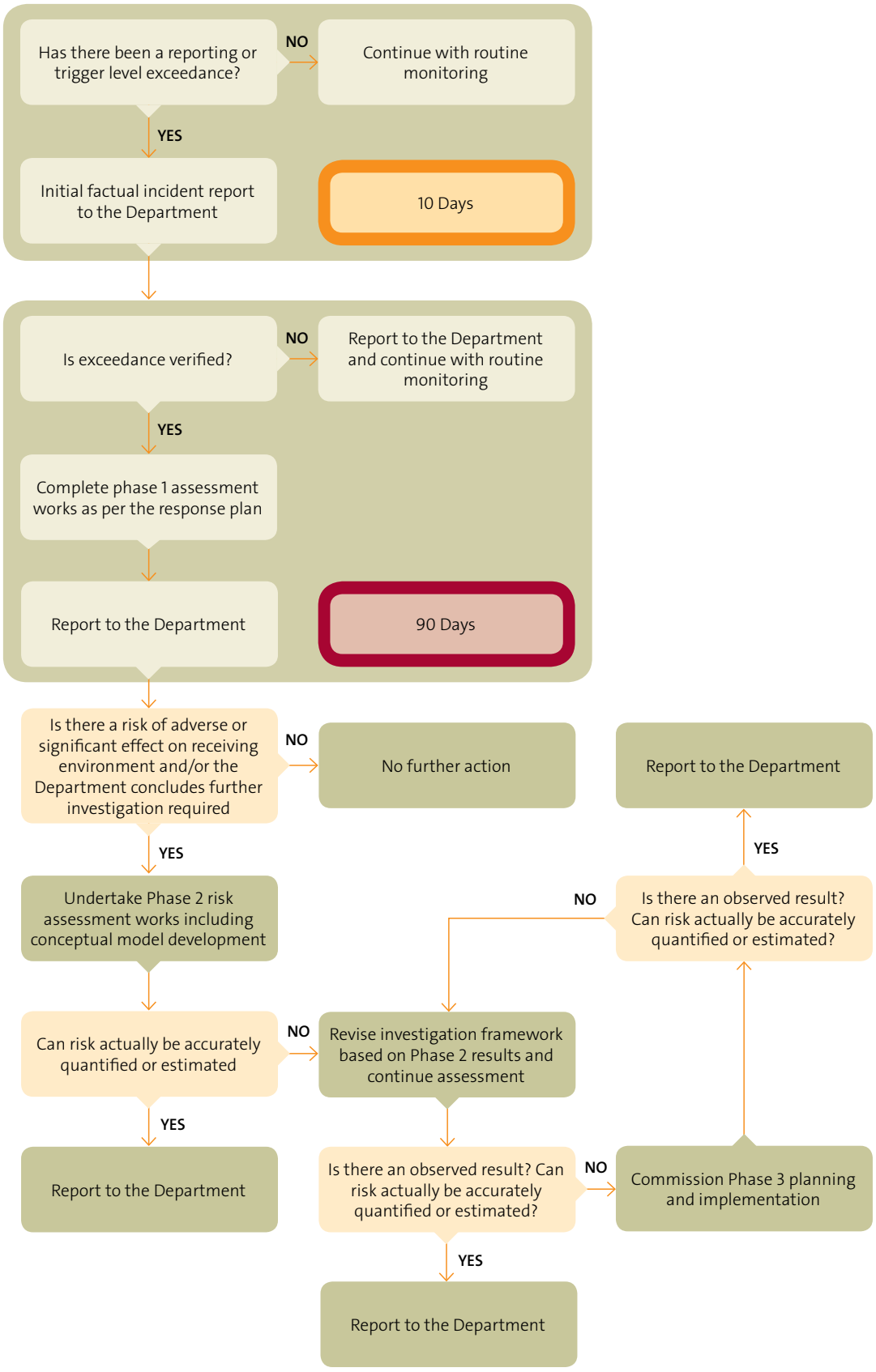


Figure 13-5 – Response plan: Groundwater contamination exceedance

13.7 RESPONSE PLAN III SUBSIDENCE OR SURFACE DEFORMATION OCCURS WHICH IMPACTS ON SURFACE OR GROUNDWATER HYDROLOGY;

13.7.1 GENERAL APPROACH

The monitoring and management of ground motion actions is presented in Chapter 10. A detailed exceedance response plan for the ground motion program has been developed as presented below, and graphically in Figure 13-6.

Definitions included in this Plan are defined as:

- Unexpected: motion which cannot be readily attributed to natural or anthropogenic activities or fall outside the calculated deformation criteria;
- Adverse impact: slight ground motion independent of natural or explained anthropogenic inputs), highly localised and which does not result in diversion of flow of any local water bodies or to damage of property or infrastructure;
- Significant impact: slight ground motion independent of natural or explained anthropogenic inputs), localised with a potential risk to sensitive receptors, including the public; and
- Unacceptable risk: increased ground motion, independent of natural or explained anthropogenic inputs, regional scale, potential risk to sensitive receptors, including MNES.

13.7.2 TYPES OF DEFORMATION EVENT

While ground motion is expected to be very limited, and to occur over long timeframes the following physical deformation events may express themselves visually, as well as through satellite monitoring (noted earlier), and require consideration in the risk management and response planning process:

- Unexpected movement in and around MNES or areas identified as sensitive;
- Unexpected movement that affects surface water drainage;
- Unexpected movement in and around existing surface infrastructure; and
- Unexpected defined cracking (cracks in roads etc.).

Should ground motion occur, it is predicted to manifest as a very slow rate over long time periods. This is due to the depths at which the CSG water extraction process is occurring, the competency of the reservoir rock (rock mass strength and geomechanical properties), as well as the competency of the overlying material.

As stated in Chapter 10, predicted settlement rates are in the order of 0.08 to 0.18 m for the WCM for the lifetime of the project, with movement in the Springbok unit that overlays the WCM estimated at less than 5 mm.

Given the settlement rates above, no subsurface mechanism that would promote a rapid ground motion event can be identified. Unlike underground mining activities or underground coal gasification activities CSG extraction does not open up voids in the order of metres to tens of metres high. With no credible rapid ground motion scenarios being identified, possible management planning and implementation options relating to rapid ground motion have not been considered further.

Note: triggers will be defined as outlined in Chapter 10

13.7.3 EXCEEDANCE RESPONSE PLAN – PHASE 1

Should a ground motion event be recorded during the data review process, either via the radar satellite program or physical observation, the following response process has been developed.

A Desktop Review and written report will be prepared and submitted to the Department within a nominated number of days of the exceedance and address the following:

- QGC will advise the Department within 10 days of unexpected ground motion being detected. An unexpected ground motion is defined as motion which cannot be readily attributed to natural or anthropogenic activities;
- A Phase 1 investigation will be undertaken which will include:
  - Ground motion data review including all historical records;
  - Assess 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 other changes in anthropogenic factors in the areas of interest;
  - Report to the Department in the area of interest;
  - Included in this report will be a statement about potential effects on the receiving environment and the need for further investigation/assessment; and
  - Statement about potential effects on MNES and/or non-CSG water users and the need for further assessment at springs.

Recommendations for any Phase 2 work would be identified in the Phase 1 report, in common with the response plans for aquifer drawdown. During Phase 1 a series of mitigation actions would be selected based on likely scenarios. These would be further developed to the appropriate level of confidence during succeeding phases for options selection at the required time.

13.7.4 EXCEEDANCE RESPONSE PLAN – PHASE 2

Phase 2 is enacted where the conclusions of the desktop review identify an unacceptable risk of an adverse or significant impact on the receiving environment, stakeholder and/or the Department concludes from the report that further investigation is required. The timeframe for Phase 2 depends on the specific exceedance but, considering the timeframes involved with the monitoring and measurement of ground motion, response in this phase is expected to be six months at a minimum.

Phase 2 is proposed to consist of the following in relation to ground motion:

- Commission ecological and hydrological studies to assess the potential impact of this motion as necessary;
- Review current field survey plan and commission new field survey plans to include the area of interest as required;
- Once ecological and hydrological impact studies are available submit to the Department with a update;
- Examine the potential use of other radar satellite coverage options, including increasing satellite data acquisition times;
- Statement about potential effects on the receiving environment and the need for further investigation/assessment; and
- Statement about potential effects on MNES and/or non-CSG water users and the need for further assessment at springs.

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. Once these assessments are completed features will be characterised according to environmental and community risk and then an ongoing detailed satellite and ground truthing monitoring program will be implement for these locations.

If Phase 2 yields inconclusive findings then it is intended to revisit the methodologies utilised for the investigation, review their suitability in light of the findings and potentially engage in a revised study schedule and/or aquifer assessment programs. QGC will inform the Minister via letter of the revision to the investigation process and a revised monitoring schedule as necessary. Should this threshold exceedance be found to be a function of slowly evolving changes in ground surface elevations over time then it is proposed to adopt an adaptive management approach to the threshold. In such a case, the derivation of the threshold would be reassessed and a new threshold derived.

13.7.5 EXCEEDANCE RESPONSE PLAN – PHASE 3 MANAGEMENT PROCESS

Phase 3 is enacted where the conclusions of the Phase 2 investigation and the additional monitoring works defined above continue to identify an unacceptable risk of an adverse or significant effect on the receiving environment, and/or the Department concludes from the report that further investigation/monitoring is required. Measures that may be considered during this phase could include:

- The development and implementation of a long-term incident management process;
- A modification of radar and field survey programs to enable more regular reporting for the area of interest;
- Numerical groundwater head modelling and ground motion estimation;
- The initial development of mitigation options including:
- Review potential modifications to water abstraction within aquifers and the area of interest to assess ground response;
- The continuation of field survey, ecological and hydrological assessment programs until the ground motion in the area of interest stabilises; and
- Investigation of ground stabilisation solutions.

During previous phases, a number of mitigation options would have been identified. The first phase of any Mitigation Response Plan (360 days) would be to develop those options further into a preferred solution.

As described in Section 10, a predictive deformation assessment will take place on receipt of the results of the updated UWIR ground water flow model (due December 2015). The results of that calculation will identify any potential impacts that might take place. To address those impacts a range of typical mitigation options will be identified and evaluated, see Commitment# 66. However, if satellite or ground surveys identify any significant impacts before those mitigation options are developed then location/impact specific mitigation options will be established as part of the management of that impact.

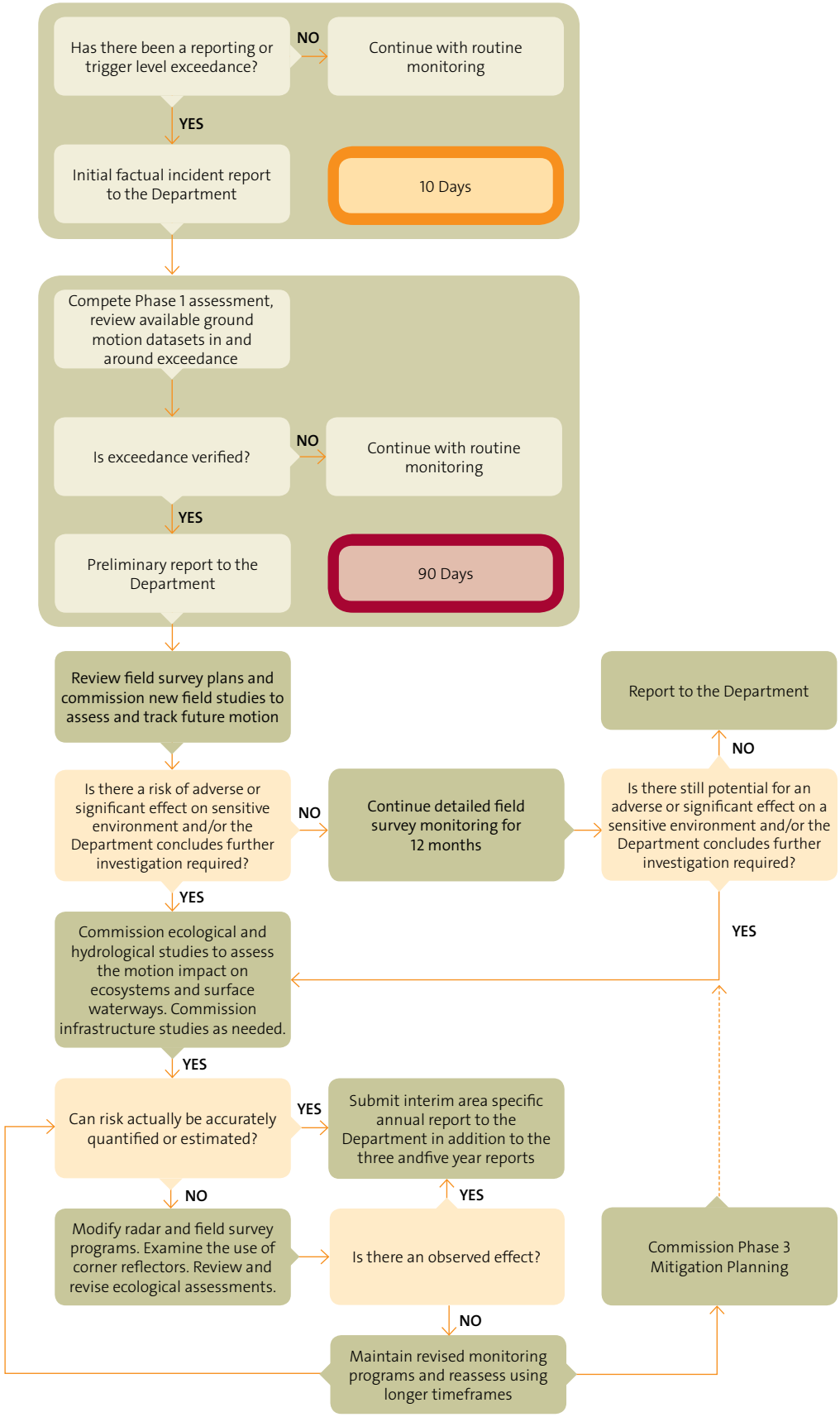


Figure 13-6 – Ground motion exceedance response process

The status of the Commitments relevant to response planning is as follows:

#	Department Condition		Description	Completion date	Status
	Pre-Dec 2012	Post-Dec 2012			
31	**49c and d, 52di I and II; 52d ii**	**53B d, 53B E**	Finalisation of groundwater draw down response plan	April 2013	●
32			Confirmation of early warning and threshold monitoring bore construction	October 2014	●
33			Finalisation of groundwater quality response plan	April 2014	●
34	**52c viii, 52d i III**	**53B e**	Development of environmental risk management and response plan and an upgrade of exceedance response plans	April 2013	●
35	**52d iv**		Completion of upgraded emergency response plans to cover all regulated water and waste storage facilities	April 2014	●
36	**49h, 52d i IV**	**53B c**	Develop Emergency Discharge Management Plan	July 2013	●

● Commitments completed
○ Commitments work in progress
△ Evergreen Commitments
● Firm deliverables for that month


CAT
11.85
11.96