Memorandum

Recipient	Arrow Energy Pty Ltd
Memo date	02/11/2018
Author	Coffey Services Australia Pty Ltd
Project number	ENAUABTF20484AA
Memo Subject	SGP Stage 1 WMMP Limits, indicators and triggers memorandum

1. Introduction

This memorandum has been prepared to document the development of an Early Warning Monitoring System (EWMS) for the Surat Gas Project (SGP) Stage 1 Coal Seam Gas (CSG) Water Monitoring and Management Plan (Stage 1 CSG WMMP). It addresses Approval Conditions 13j (i, ii, iii), 13k and closes out Condition 13(j)iv.

Approval Condition 13(j)i: *A groundwater early warning monitoring system, including groundwater drawdown limits for all consolidated aquifers potentially impacted by the action, excluding the Walloon Coal Measures.*

Approval Condition 13(j)ii: *A groundwater early warning monitoring system, including for the Condamine Alluvium, appropriate triggers and groundwater limits and a rationale for their selection*.

Approval Condition 13(j)iii: *A groundwater early warning monitoring system, Early warning indicators and trigger thresholds, including for Lake Broadwater, Long Swamp and other groundwater dependent ecosystems that may potentially be impacted by the action, including those that may occur outside the project area and may be impacted by the action*.

Approval Condition 13(k): *Early warning indicators and trigger thresholds, including corrective actions for both early warning indicators and trigger thresholds, for aquatic ecology and aquatic ecosystems*.

Approval Condition 13(j)iv: *A groundwater early warning monitoring system, including investigation, management and mitigation actions, including substitution and/or groundwater re-pressurisation, for both early warning indicators and trigger thresholds to address flux impacts on the Condamine Alluvium*.

This memorandum addresses the following aspects of Condition 13(j)iv only:

- Early warning indicators and trigger thresholds to address flux impacts on the Condamine Alluvium, and
- Investigations required as part of the EWMS.

Remaining aspects of Condition 13(j)iv (i.e. aspects relating to mitigation actions) are addressed separately in the 'Assessment of Impacts and Development of Management Measures' Memorandum (ENAUABTF20484AA-M04). Therefore condition 13(j)iv is wholly addressed by these two memoranda.

1.1. Approval Conditions and related documents

In addition to the Environmental Impact Statement (EIS) and Supplementary Report to the EIS (SREIS), further supporting information for Approval Conditions is presented in separate memoranda, as summarised in Table 1.1.

Table 1.1: Summary of Stage 1 CSG WMMP supporting assessments

Memoranda	Conditions addressed	Document ID
Groundwater Modelling Technical Memorandum (and referenced documents)	13a, 13b and 13d	ENAUABTF20484AA-M01
GDE and Aquatic Ecosystem Impact Assessment Technical Memorandum	13c and 13p	ENAUABTF20484AA-M03
Flood Risk Technical Memorandum	13o	ENAUABTF20484AA-M02
Subsidence Technical Memorandum	13g	ENAUABTF20484AA-M05
Groundwater Monitoring Network and Program Technical Memorandum	13e, 13f	ENAUABTF20484AA-M07
Early Warning, Limits and Triggers Memorandum	13j, 13k, 15	ENAUABTF20484AA-M08 (this document)
Assessment of Impacts and Development of Management Measures Memorandum	13j(iv)	ENAUABTF20484AA-M04
Surat Gas Project CSG Water Management Strategy	13l, 13m and 13n	ENAUABTF20484AA-WMS-R05

1.2. EWMS requirements

The approval conditions variably require early warning indicators, trigger thresholds and limits. In addition to these requirements, periodic data review and analysis is a commitment under Arrow Energy Pty Ltd's (Arrow's) EIS/SREIS and an ongoing requirement under the Queensland *Water Act 2000* obligations. Table 1.2 summarises the condition requirements that form the basis of the EWMS.

Table 1.2 EWMS requirements

System	Early warning indicator	Trigger threshold	Groundwater or drawdown limit
Consolidated aquifers	-	-	✓
Condamine Alluvium	✓	✓	✓
GDEs	✓	✓	-
Aquatic ecosystems	✓	✓	-

1.3. Definitions

Definitions relevant to this document and approval conditions are presented in Table 1.3.

Table 1.3: Definitions

Term	Definition
Background level	Non-Arrow CSG influenced existing conditions (levels or quality).
Consolidated aquifer	Aquifer in a consolidated sedimentary formation.
Drawdown factor	Derived from the Queensland Water Act1 for similar systems, being 5 m for consolidated aquifers and 2 m for unconsolidated aquifers. Note no drawdown factor is added for non-spring GDEs.
EPBC Spring	EPBC springs within the Surat CMA are locations where a community of native species is dependent on natural discharge of groundwater from the Great Artesian Basin, or listed threatened species are reliant on springs
Groundwater drawdown due to the Action	Change in head relative to the background level arising from the Action.
The Action	The Arrow SGP.
Early warning indicator	A first-tier drawdown level that provides early indication of potential for an impact.
Trigger threshold	A second-tier drawdown level that triggers response actions.
Groundwater limit or drawdown limit	A groundwater level based limit for an aquifer or non-spring GDE not to be exceeded.

[1] Taken from the bore trigger thresholds under the Queensland Water Act 2000

2. Early Warning Monitoring System

An Early Warning Monitoring System (EWMS) is presented for the SGP Stage 1 CSG WMMP. Arrow will update the EWMS in the Stage 2 CSG WMMP, taking into account revised modelling predictions using the most recent OGIA model version and updated field development plans.

Section 2.1 provides an overview and rationale for the EWMS, and Section 2.2 presents the EWMS.

2.1. Early warning monitoring system - overview

Factors influencing groundwater drawdown predicted in affected formations include impacts due to the Action (i.e. Arrow drawdown), other CSG developers, and non-CSG users. Because of the relative magnitude of these influences, it is difficult to differentiate impact due to the SGP based on simple analysis of field data. To account for this, an EWMS approach based on cumulative impacts is necessary.

Figure 2.1 provides a conceptual representation of Arrow and non-Arrow drawdown impacts.

EWMS operation is underpinned by an early warning monitoring network (described and presented in the Groundwater Monitoring Network and Program Technical Memorandum). A summary of groundwater monitoring locations for the Stage 1 CSG WMMP monitoring network is provided in Attachment 1.

The EWMS includes tiered investigation levels with escalating responses:

1. Early warning indicators, for early identification of potential issues.
2. Trigger thresholds, for identifying the potential to exceed limits, and enable measures to be selected and implemented to reduce the likelihood of limit-exceedance.
3. Limits, that define levels of impact not to be exceeded.

Data from this monitoring network will be analysed and compared to the assigned early warning indicators, triggers and limits. The data will also be used to generate new impact forecasts and help consolidate the understanding of groundwater systems across the SGP, and for updating groundwater models supporting the WMMP.

Processes for investigation and actions are also incorporated in the EWMS. Key elements include investigation processes for trigger and limit exceedances, and actions to manage, address and correct exceedances.

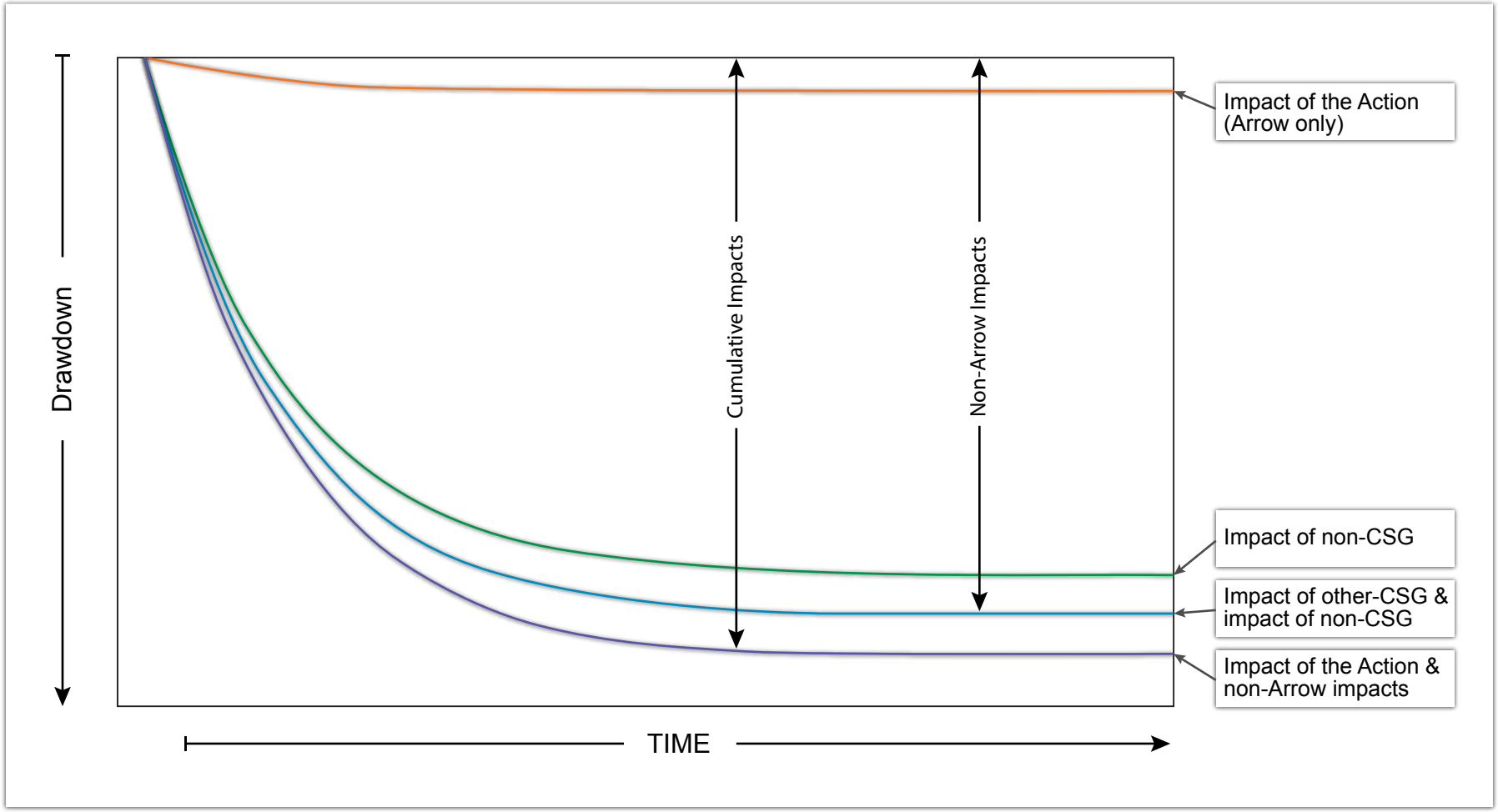


Figure 2.1 Conceptual Representation of SGP Impacts

Source:
Coffey.

Date: 21/09/2018
Issued To: Arrow Energy
Author: Helen.Unkovich/Richard.Heath

2.1.1. EWMS elements

The EWMS relies on periodic collection, review and assessment of data. The following primary elements are incorporated:

- **Early warning indicator** – the greatest drawdown from any location within that aquifer for a 3-yearly period taken from the predicted P95 (cumulative) case plus half the applicable drawdown factor.
- **Trigger threshold** – a drawdown that is half-way between the early warning indicator and the limit.
- **Limit -** a level of change due to the action that is considered unacceptable. The limit is:
    - Derived from the greatest predicted P95 drawdown (cumulative case) across Arrow tenure within an aquifer, plus the applicable drawdown factor;
    - Taken from the drawdown predicted to have occurred in 100 years; and
    - Recognises that the model will not perfectly predict where or when impact will occur.
- **Drawdown Factor -** Taken from the Queensland Water Act for similar systems, being 5 m for consolidated aquifers and 2 m for unconsolidated aquifers. No drawdown factor is applied for non-spring GDEs.

Figure 2.2 illustrates the EWMS conceptualisation.

2.1.2. Basis for EWMS levels

EWMS levels are derived from numerical groundwater modelling of cumulative drawdown. The levels will be established based on the latest OGIA model version (or its equivalent) and will incorporate (where available) updated production data for other CSG producers and non-CSG extractors. The early warning indicator, trigger threshold or limit may be updated with each new OGIA model if an explanation for the change to the limit is provided in an updated WMMP/annual review.

Consolidated aquifers and Condamine Alluvium

Consolidated aquifers may be depressurised by CSG water extraction from the Walloon Coal Measures (WCM). Indirectly-affected aquifers include the Springbok Sandstone, Hutton Sandstone and Precipice Sandstone.

Numerical modelling shows that a reduction in groundwater flux from the WCM to the Condamine Alluvium may occur, that will lead to a minor impact on groundwater levels in the Condamine Alluvium. Because groundwater inter-formation flux between the WCM and the Condamine Alluvium cannot be directly measured, groundwater levels can be used instead as an indicator of flux-induced drawdown in the formation due to the Action.

The early warning indicator, trigger thresholds and groundwater limits adopted for the Condamine Alluvium are level based. However, groundwater levels in the formation (as for the consolidated formations) are subject to significant fluctuation which is dependent on non-Action factors such as abstraction by irrigators, other users, and other CSG producers, and natural processes including groundwater recharge and surface water interaction.

Adopting groundwater levels as a basis for triggers and limits requires careful interpretation. This includes comparison of observed level changes with predictions and using groundwater modelling to evaluate the component of drawdown actually resulting from the Action.

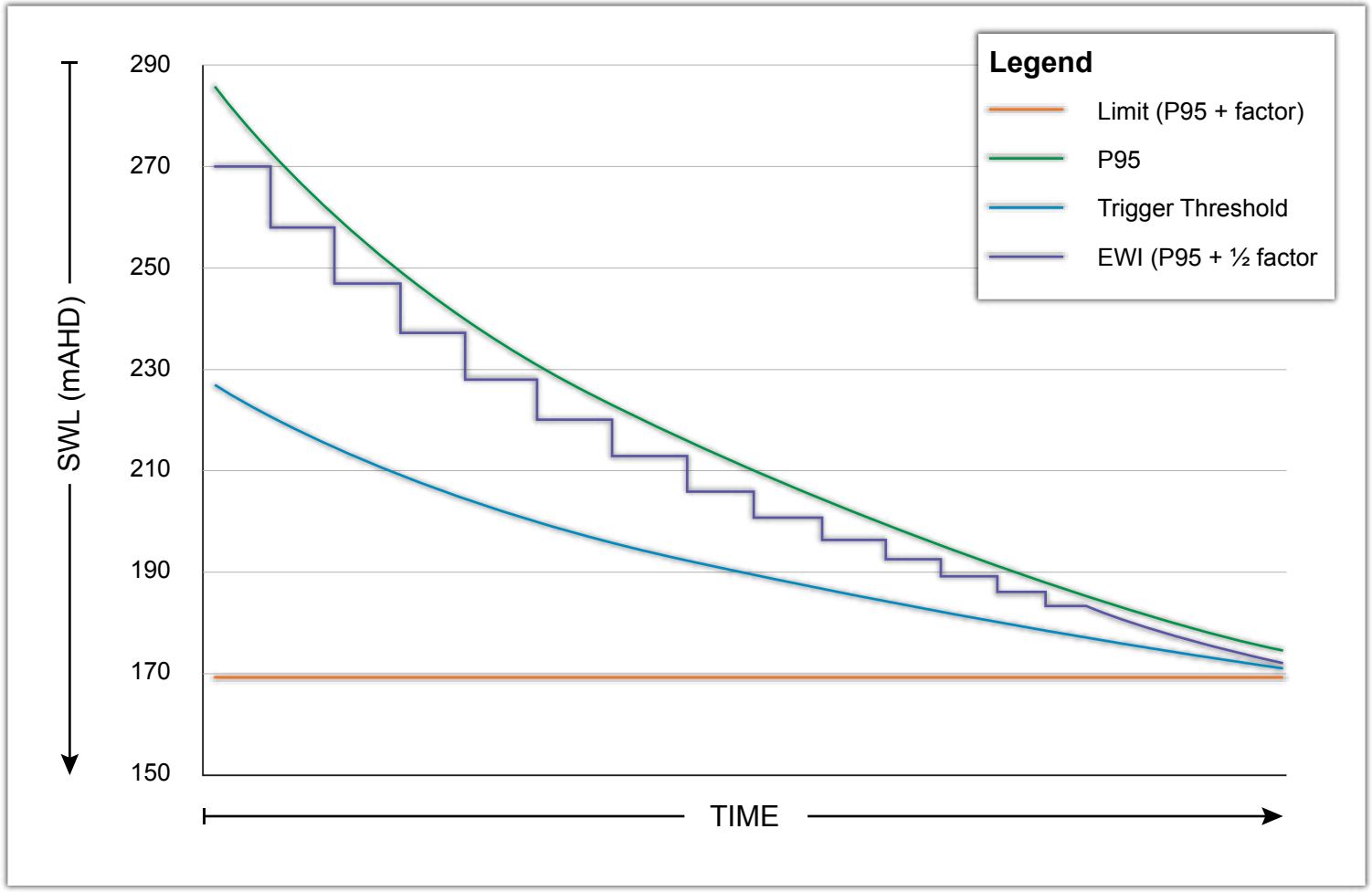


Figure 2.2 **EWMS Conceptualisation**

Source:
Coffey.

Date: 10/09/2018
Issued To: Arrow Energy
Author: Helen.Unkovich

GDEs included in the EWMS

The basis for identifying GDEs that may be impacted by the Action is set out in the GDE and Aquatic Ecosystem technical memorandum, and in the SGP EIS/SREIS.

The EWMS focuses on GDEs that may be impacted by the Action including spring GDEs which are managed through the JIP (Section 2.4).

EPBC springs within the Surat CMA are locations where a community of native species is dependent on natural discharge of groundwater from the Great Artesian Basin, or listed threatened species are reliant on springs (Section 8.2.3 of the Supplementary Report to the Surat Gas Project EIS [Arrow Energy, 2013]). There are currently no EPBC springs located within Arrow tenure and there are currently no off-tenure EPBC springs allocated to Arrow for monitoring and management in accordance with the JIP. Further information is provided in Section 2.4.

The JIP provides reference to OGIA's Spring Impact Management Strategy (SIMS) in the Surat CMA UWIR which provides an assessment of potential impacts to springs. Arrow has no assigned responsibilities regarding potentially affected springs under the SIMS. The SIMS is considered to adequately address the potential impact to springs and no further assessment has been undertaken in this plan. In addition, no springs within Arrow tenure other than those identified and considered in the Surat CMA UWIR are known to be present.

The GDE and Aquatic Ecosystem Technical Memorandum provides the basis for the assessment of impact to non-spring GDEs.

Future iterations of the UWIR are expected to also cover non-spring GDEs and Arrow will comply with all obligations set out in the UWIR regarding GDEs.

Lake Broadwater and Long Swamp are the subject of ongoing investigations to assess the connectivity of these systems to underlying aquifers that may be affected by the Action (in accordance with approval condition 13(f)). Where connectivity is demonstrated, the EWMS set out for GDEs will be applied to these features as part of the Stage 2 CSG WMMP. This is an appropriate approach as no gas extraction is permitted prior to Ministerial approval of the Stage 2 CSG WMMP therefore no impact to these features can occur in the interim.

2.2. Groundwater EWMS: consolidated aquifers, Condamine Alluvium, and non-spring GDEs

Events triggering an EWMS level initiate prescribed investigation and actions. The EWMS operation is described in this section and illustrated in Figure 2.3.

2.2.1. Limits, trigger thresholds and early warning indicators - consolidated aquifers, Condamine Alluvium and non-spring GDEs

Limits

Groundwater limits are minimum potentiometric groundwater levels specified for consolidated aquifers (i.e. the Springbok, Hutton and Precipice sandstone aquifers), the Condamine Alluvium, and non-spring GDEs. The approach adopted recognises that numerical model predictions have uncertainty and may not perfectly predict exactly where or when impact will occur.

The limit assigned for the consolidated aquifers and the Condamine Alluvium aquifer is:

- The maximum model-predicted P95 cumulative (CSG + non-CSG) drawdown level to have occurred in 100 years[2], at any point in the aquifer on Arrow tenure, plus a drawdown factor[3] (5 m for consolidated aquifers and 2 m for the Condamine Alluvium); or

[2] From commencement of CSG extraction

- For consolidated aquifers where dewatering of the aquifer itself is not predicted to occur, the top of the aquifer formation.

The limit assigned for non-spring GDEs is:

- The maximum model-predicted P95 cumulative (CSG + non-CSG) drawdown level to have occurred in 100 years[4], at any point in the aquifer on Arrow tenure.

[3] Taken from the bore trigger threshold set for aquifers under the Queensland *Water Act 2000*.

[4] From commencement of CSG extraction

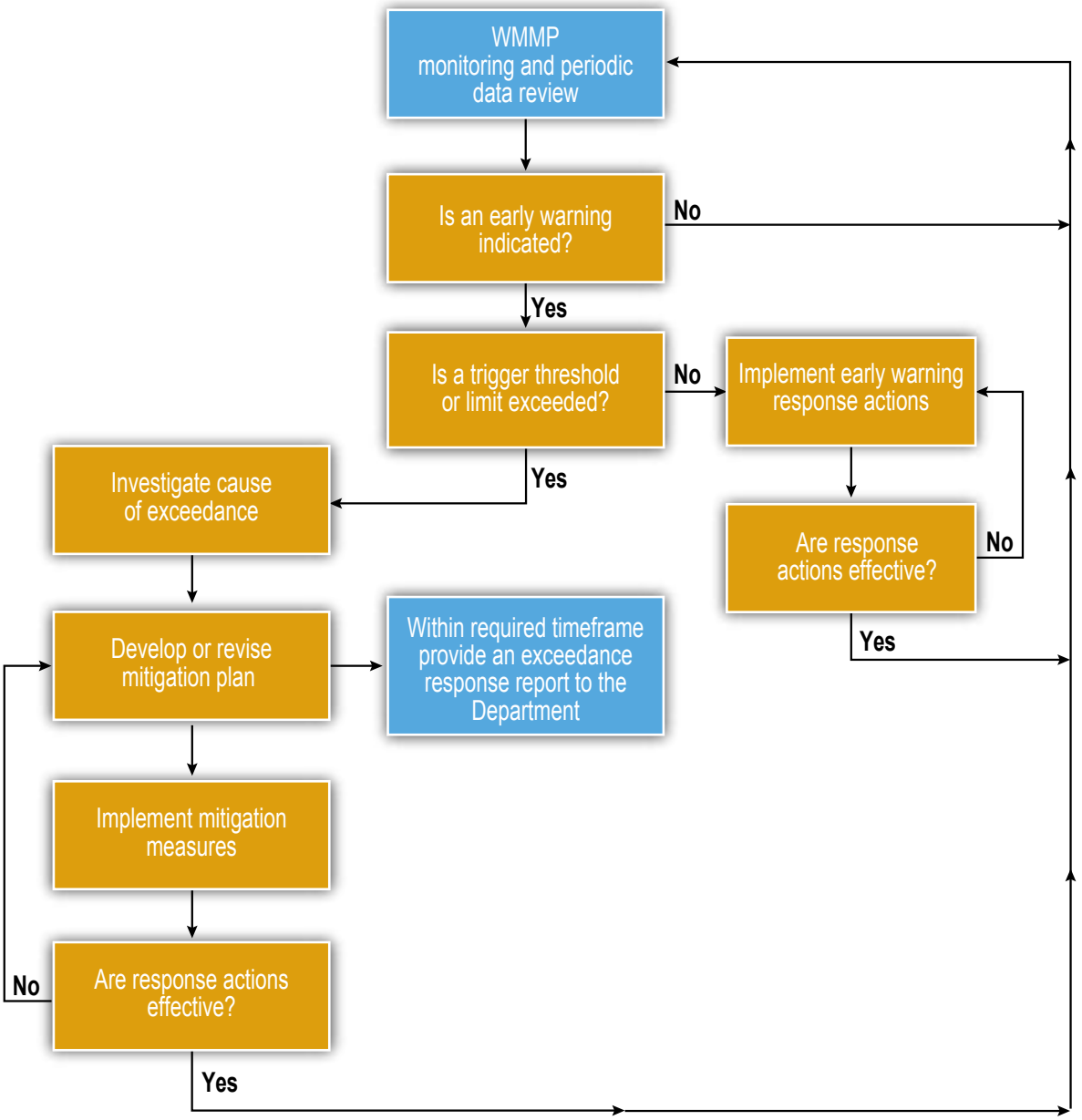


Figure 2.3 **EWMS process and actions**

Source:
Coffey

Date: 19/09/2018
Issued To: Arrow Energy
Author: Helen.Unkovich/Richard.Heath

arrow energy
go further

Early warning indicators

An early warning indicator, has been assigned by taking the maximum model-predicted P95 cumulative (CSG + non-CSG) drawdown on Arrow tenure (within each three year period) and adding half the drawdown factor (i.e. 2.5 m for consolidated aquifers, and 1 m for the Condamine Alluvium).

For non-spring GDE locations, early warning indicators are assigned based on a drawdown level equivalent to the maximum model-predicted P95 cumulative (CSG + non-CSG) drawdown level for a 3-year period.

Early warning levels will be assigned in 3 year time steps, and taken from the end of each 3 year period. This period is consistent with the review cycle of the WMMP.

Trigger thresholds

Trigger thresholds are assigned as a drawdown level half-way between the early warning indicator and the drawdown limit.

Assignment and update of EWMS levels

Limits, early warning indicators and trigger thresholds will be established as part of the Stage 2 CSG WMMP in accordance with approval condition 17(h)(iv) by analysing the groundwater model predicted drawdown, and specifying the levels for limits, early warning indicators and trigger thresholds.

The limits, early warning indicators and trigger thresholds will be updated on an ongoing basis every three years if a new or revised OGIA model simulation has been developed (in accordance with Approval Condition 13).

Where EWMS levels are revised, Arrow will provide an explanation of the revision based on the latest groundwater modelling that has led to the revised levels. This would be supported by a review of actual performance vs predicted, based on evaluation of actual and predicted Arrow water production.

2.2.2. Groundwater data assessment

For each early warning monitoring location, groundwater monitoring data will be reviewed and assessed against the EWMS levels assigned for the location. Data assessment procedures are described below. Where an early warning indicator, trigger threshold, or limit is exceeded, the response actions in Section 2.2.3 will be implemented.

Data collection and interpretation

The WMMP requires the collection and interpretation of data to understand groundwater-related impacts resulting from the Action. Many factors can influence data trends, including CSG and non-CSG factors, and therefore to properly understand impacts associated with Arrow's CSG operations, data must be analysed in a rigorous manner.

A detailed approach for groundwater level and water quality trend analysis will be established and set out in the Stage 2 CSG WMMP, as required under Condition 17(h).

Data QA/QC

To ensure a robust EWMS, monitoring results will be checked to verify the data by:

- Reviewing and checking data and field documents to identify transcription errors.
- Reviewing and checking the calibration of measurement equipment (for example data loggers and piezometers).
- Barometric compensation of uncompensated logger data.
- Obtaining further field data if necessary to confirm or clarify the results.

Data review

The data review process will:

1. Compare the observed data with the assigned early warning indicator, trigger threshold, and limit for each monitoring location.

2. If the results indicate an exceedance, undertake the following to evaluate whether the results are due to the Action or other factors:

    a) Review aquifer baseline data to assess whether the exceedance is due to natural system variability or due to groundwater abstraction by third-party groundwater users[5].

    b) Review monitoring data from relevant monitoring locations in the region to identify whether an apparent exceedance is a result of regional hydrological change (for example, groundwater decline caused by reduced recharge, drought, or climate variation).

2.2.3. Exceedance response actions

EWMS response actions are escalating actions that apply to exceedances due to the Action of an early warning indicator, trigger threshold, or limit. The actions are identified in Table 2.1.

Table 2.1 Exceedance response action

Exceedance level	Response action
Early warning indicator	Within 90 days, prepare and submit to the Department an Early Warning Exceedance Report which includes: a) The results of an evaluation of the reasons for the EWI exceedance, and the likelihood of a future exceedance of a trigger threshold or limit, b) The scope and schedule for implementing a groundwater investigation, to be undertaken if the evaluation indicated a likely future trigger threshold or limit exceedance. Within 90 days of the release of a new UWIR, comparison will be made between the Arrow only drawdown impact predictions
Trigger threshold	Within 120 days, prepare and submit to the Department a Trigger Threshold Exceedance Report which includes: a) The results of an evaluation of the reasons for the trigger threshold exceedance, and the likelihood of a future exceedance of a limit, b) If the evaluation indicates a likely future limit exceedance: • Prepare a scope and schedule for a management plan that includes procedures to reduce the likelihood of a future limit exceedance.
Limit	Within 120 days, prepare and submit to the Department a limit exceedance report that includes: a) The results of an evaluation of the reasons for the limit exceedance, and an evaluation of any impacts that may arise due to the exceedance. b) An evaluation of the risk to groundwater environmental values. c) Corrective actions to mitigate against any impacts.

[5] Due to the dynamic nature of groundwater systems, adverse trends may in certain cases be indicated due to a combination of natural fluctuation and measurement tolerance.

A detailed mitigation strategy will be designed and a mitigation plan developed and implemented as required in the Stage 2 CSG WMMP (approval condition 17(i)).

2.3. EWMS: aquatic ecology and ecosystems

Approval Condition 13(k) requires an EWMS for aquatic ecology and ecosystems. The EWMS is to include early warning indicators and trigger thresholds, including corrective actions.

Impact to aquatic ecology and ecosystems as a result of the Action may occur as a result of the discharge of produced water to surface water systems or due to groundwater drawdown.

Discharge of produced water to surface water systems is not part of the SGP. Therefore discharge-related impacts are not considered further in this CSG WMMP. Should discharge be proposed in the future, the WMMP relevant to the stage of work will require update and approval for discharge will be sought from the Minister, and a minimum of 12 months of baseline data will be collected prior to the discharge.

The potential for groundwater drawdown related impacts on aquatic ecology and ecosystems will be assessed and managed as for non-spring GDEs, under the Groundwater EWMS (refer Section 2.2).

Based on this approach, a stand-alone EWMS for aquatic ecology and ecosystems is not considered necessary. Should discharge to surface water systems be proposed in the future, this will necessitate an update of this plan and associated Ministerial approval. An aquatic ecology and ecosystems EWMS will be included in the revised plan if this eventuates.

2.4. EWMS: Springs

Monitoring and management of springs located within the Surat CMA is undertaken through the implementation of the JIP. The JIP was developed by key CSG proponents including Santos, APLNG and QGC to provide an early warning system (EWS) for the monitoring and management of groundwater-fed springs identified as being potentially impacted by CSG production activities including springs that contain EPBC listed communities or species dependent on the natural discharge of groundwater from the GAB.

The JIP's EWS was developed to allow adequate time for assessment and implementation of management measures prior to adverse impacts taking effect. Arrow was consulted in the development of the JIP. The JIP is also intended to align with spring monitoring and mitigation requirements obligated by the Surat CMA UWIR.

The fundamental concepts and primary principles of the JIP are:

- To ensure consistency in the approach to springs monitoring and management between the proponents;
- To measure groundwater drawdown at locations and times such that meaningful responses can be undertaken before there is any impact on MNES springs;
- An early warning approach based on modelling and monitoring to manage increasing levels of risk;
- The use of the Surat CMA cumulative impact model (CIM) to assess risks to the springs;
- A clearly defined network of monitoring bores allocated to each of the proponents;
- Single proponent responsibility for each EPBC spring aligning with Surat CMA UWIR Springs Strategy;
- Differences in approaches to limit/trigger setting at monitoring bores for on-tenements and off-tenements springs; and
- Alignment on exceedence response process and timing.

The JIP's EWS network takes into account the mechanisms by which drawdown propagates from the source (CSG production area) to the receptor (spring). It utilises early warning monitoring installations (EWMI) and trigger monitoring points (TMP) as the basis for the monitoring network. The function of these monitoring points is:

- an EWMI will typically be on-tenure and close to the area of CSG water extraction or, between the extraction areas and the spring. These early warning bores are located to provide initial drawdown data, and secondary data in support of interpretation of observations made closer to springs. At these locations groundwater drawdowns are expected to be more pronounced due to their proximity to the source of drawdown; and

- A TMP located closer to the spring i.e. further away from the CSG production area. For on-tenure springs, the TMPs have been selected within close proximity of the springs.

The early warning monitoring network utilises three levels of exceedance criteria, including:

- Investigation Trigger: a nominated value at an EWMI and TMP that triggers some action such as data review, model review, increased monitoring frequency, or increased monitoring parameters;

- 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); and

- 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.

The JIP identifies the EPBC springs located within the Surat CMA and allocates each of these springs to their respective responsible proponent for monitoring and management through implementation of the JIP to ensure consistency across the industry.

The JIP provides reference to OGIA's SIMS in the Surat CMA UWIR which provides an assessment of potential impacts to all springs (EPBC springs and other spring GDEs). The UWIR identifies 387 spring vents amongst 87 spring complexes and 40 watercourse springs that may be potentially affected by petroleum and gas related water extraction (OGIA, 2016). The Queensland Water Act (2000) defines a potentially affected spring as a spring overlying a GAB aquifer in which the modelled long-term predicted reduction in water pressure in any underlying aquifer resulting from petroleum and gas related water extraction exceeds 0.2 metres. Four of these potentially affected springs are classified as EPBC springs.

There are currently no EPBC springs located within Arrow tenure and all off tenure EPBC springs are either currently allocated to other CSG proponents or, where not yet explicitly allocated, are located closer to other CSG proponents who would then be the responsible tenure holders under the JIP. In accordance with the JIP, Arrow does not currently have any monitoring obligations under the JIP. Should Arrow be assigned as the responsible proponent for any EPBC Springs under the JIP, Arrow will, if applicable, adopt the JIP for the monitoring and management of the EPBC spring/s.

In addition, Arrow has no assigned responsibilities regarding potentially affected springs under OGIA's SIMS within the UWIR. No springs within Arrow tenure other than those identified and considered in the Surat CMA UWIR are known to be present and accordingly Arrow has no UWIR assigned monitoring responsibilities. Arrow will comply with the UWIR obligations for water course springs along the Condamine River.

3. Trend analysis

This section provides a general overview of the basis for trend analysis that will assist in the assessment of data, and identification of exceedances under the EWMS.

Many factors will influence the observed trends in data collected under the SGP WMMP. To properly understand and identify impacts associated with Arrow's CSG operations, data must be analysed in a consistent and appropriate manner.

The detailed approach Arrow will take to analyse data, including methods to determine trends, will be established and set out in the Stage 2 CSG WMMP, as required under Condition 17 (h). The following provides preliminary guidance for the Stage 1 CSG WMMP.

3.1. Guidelines and reference documents

Guidance documents relating to methods for groundwater level trend analysis specifically relating to coal seam gas impacts have been developed. This includes DEHP (2016) Underground water impact reports and final reports. ESR/2016/2000 Version 3.00 Effective 06 December 2016.

In addition, detailed methods for groundwater level trend analysis have been developed as part of the Joint Industry Plan (JIP) to address the monitoring and management requirements of springs containing EPBC listed communities or species. These and other relevant guidance will be used in the development of Arrow's approach to trend analysis.

3.2. Groundwater level trend analysis

3.2.1. External factors influencing groundwater levels

Consideration for the following factors that have the potential to influence groundwater level and pressure readings will be made during trend analysis:

- Rainfall, and seasonal trends influencing recharge. This will include consideration for cumulative departure from mean rainfall, in particular for the assessment of groundwater levels in unconfined aquifers.
- Non-CSG extractive groundwater users including irrigators, and local stock and domestic users (local and regional scale influences).
- Barometric pressure variation.
- Earth tides (i.e. aquifer deformation as a result of the gravitation effects of the moon and sun).
- Aquifer loading from major flooding events and surface infrastructure (e.g. produced water dams).
- Land use practices (i.e. changes in land use leading to changed recharge conditions).
- Groundwater extraction associated with Arrow SGP operations.
- Groundwater extraction associated with other CSG operations.
- Nearby mining operations or other extractive industry.
- Other factors, such as well integrity and unregistered groundwater extraction.

3.2.2. Statistical trend analysis

Methods for trend analysis will include standard statistical measures, such as (for example) Man-Kendell test, regression analysis, and serial correlation.

3.3. Groundwater quality trend analysis

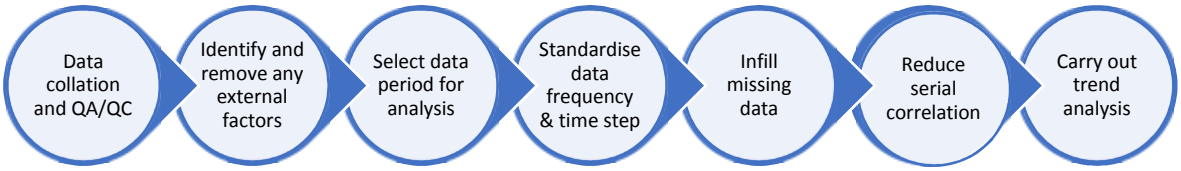
Time series groundwater quality data can be used to support an assessment of recharge and regional flow processes. Groundwater quality trend analysis is not expected to form a primary assessment tool

for the identification and assessment of drawdown related impacts, however may be useful in supporting conceptual site model development and verification, if needed.

The approach to groundwater quality trend analysis is dependent on the record of available data. Where sufficient time series data exists, trend analysis methods similar to those outlined for groundwater level assessment will be adopted. Where limited time series data exists (precluding reliable statistical methods), relevant data will be assessed qualitatively, such as through graphical representation.

3.4. General trend analysis process

The general trend analysis process is illustrated below. It is underpinned by a hydrogeological conceptualisation of each monitoring location to identify factors that will influence groundwater level and quality and therefore need to be considered in the trend analysis process.



4. Compliance reporting and notification

Approval Conditions 27, 28 and 29 require record keeping, reporting and non-compliance notification. Arrow will meet the requirements of these conditions, with respect to the Stage 1 CSG WMMP, as set out in this Chapter, and in conjunction with Arrow's EIS/SREIS reporting, updating and review commitments. In particular:

Approval Condition 27 requires that the annual report (condition 28) must state all confirmed cases of non-compliance along with details of any remedial actions.

Approval Condition 28 requires that the approval holder must publish an annual report on its website outlining how they have been compliant with the conditions of the approval over the previous 12 months, and documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of the approval must be provided to the Department[6] at the same time as the compliance report is published.

Approval Condition 29 requires that the approval holder must notify the Department in writing of potential non-compliance with any condition of this approval as soon as practical and within no later than ten business days of becoming aware of the potential non-compliance. Under Approval Condition 29, the notice provided to the Department must specify:

a) The condition which the approval holder has potentially breached;

b) The nature of the potential non-compliance;

c) When and how the approval holder became aware of the non-compliance;

d) How the non-compliance will affect the approved action;

e) How the non-compliance will affect the anticipated impacts of the approved action, in particular how the non-compliance will affect the impacts on the matters of national environmental significance (MNES);

f) The measures the approval holder will take to address the impacts of the non-compliance on the MNES and rectify the non-compliance; and

g) The time by when the approval holder will rectify the non-compliance.

Arrow's reporting compliance relating to the EWMS is provided in the following sections.

4.1. Departmental notification

Arrow will comply with the reporting and notification requirements of the Approval Conditions, including non-compliance reports. Reporting provided to the Department will be in compliance with the conditions.

4.2. Potential non-compliance reports

The Department will be notified in writing no later than ten business days after becoming aware of any potential non-compliance with any Approval Condition.

Potential non-compliance notification will occur if:

1. A groundwater or drawdown limit has potentially been exceeded.

2. Arrow fail to meet any of the requirements of approval condition 13 (i.e. Arrow do not develop or carry out any of the activities required under approval conditions 13(a) to 13(r).

[6] Department is defined in the conditions to mean the Australian Government Department administering the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth.)

The notification will include:

- The Approval Condition that has been potentially breached;
- The nature of the potential non-compliance;
- When and how the approval holder became aware of the potential non-compliance;
- How the potential non-compliance may affect the approved action;
- How the potential non-compliance may affect the anticipated impacts of the approved action, in particular any impacts on MNES, and the measures the to be taken to address the impacts of the potential non-compliance on MNES and to rectify the potential non-compliance; and
- The time by when the approval holder will rectify the potential non-compliance.

5. References

Department of Natural Resource and Mines (DNRM) (2016). Underground water impact report for the Surat Cumulative Management Area. September 2016.

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Attachment 1: Stage 1 CSG WMMP monitoring network summary

Stage 1 CSG WMMP monitoring network

Location ID	RN	OGIA UWIR Site ID	OGIA monitoring Point ID	Surface elevation (m AHD)	Latitude	Longitude	Target Aquifer	Status
Bora Creek-10	160837	124	579	419.2	-27.9245	151.1249	WCM	Installed
Burunga Lane-174	160686	91	625	272.93	-26.2427	150.0502	Evergreen	Installed
Burunga Lane-174	160686	91	478, 479	272.93	-26.2427	150.0502	Precipice	Installed
Burunga Lane-176	160677	91	476, 477	273.13	-26.2429	150.05	Hutton	Installed
Burunga Lane-176	160677	91	473, 474, 475	273.13	-26.2429	150.05	WCM	Installed
Carn Brea-17	160657	8	38, 39	362.91	-27.533	151.3664	Condamine Alluvium	Installed
Carn Brea-18	160688	8	40, 41, 42, 43	362.67	-27.533	151.3663	WCM	Installed
Carn Brea-19	160689	8	46	362.59	-27.533	151.3662	Evergreen	Installed
Carn Brea-19	160689	8	44, 45	362.59	-27.533	151.3662	Hutton	Installed
Carn Brea-20	160632	8	47, 48	362.54	-27.533	151.366	Precipice	Installed
Carn Brea-21	160997	19	94	355	-27.4376	151.3575	WCM	Installed
Carn Brea-23	160998	19	92	355.23	-27.438	151.3576	Condamine Alluvium	Installed
Carn Brea-24	160999	19	93	355.23	-27.438	151.3574	CA / WCM transition layer	Installed
Castledean-18	160687	73	375	315.58	-26.5529	150.222	Springbok	Installed
Castledean-18	160687	73	376, 377, 378	315.58	-26.5529	150.222	WCM	Installed
Daandine-121	160350	37	182, 183	331.9	-27.1004	150.9557	Hutton	Installed
Daandine-123	160347	32	159	337.25	-27.1441	150.9481	WCM	Installed
Daandine-124	160349	32	157, 158	337.28	-27.1441	150.948	Westbourne	Installed
Daandine-134	160553	32	162, 163	336.97	-27.144	150.9486	WCM	Installed
Daandine-134	160553	32	164	336.97	-27.144	150.9486	Eurombah	Installed
Daandine-161	160643	34	166	327.9	-27.1185	151.0756	Condamine Alluvium	Installed
Daandine-163	160676	34	167	327.85	-27.12	151.0759	CA / WCM transition layer	Installed
Daandine-164	160678	34	168	327.86	-27.12	151.076	WCM	Installed
Daandine-254	160802	32	160, 161	337.18	-27.1442	150.9483	WCM	Installed
Daandine-263	160838	37	181	329.19	-27.1024	150.9613	WCM	Installed
Daandine-264	160847	29	148	330.2	-27.1533	151.0445	WCM	Installed
Dundee-20	160803	55	283, 284, 285	311.45	-26.7435	150.6784	WCM	Installed
Glenburnie-19	160836	4	23	370	-27.6392	151.1677	WCM	Installed
Hopeland-17	160699	142	615	314.88	-26.9732	150.6118	Springbok	Installed
Hopeland-17	160699	142	616, 617, 618	314.88	-26.9732	150.6118	WCM	Installed
Kedron-570	160348	143	628	353.45	-26.4134	150.1537	Eurombah	Installed
Kedron-570	160348	143	629	353.45	-26.4134	150.1537	Hutton	Installed
Kedron-570	160348	143	630	353.45	-26.4134	150.1537	Springbok	Installed
Kedron-570	160348	143	626, 627	353.45	-26.4134	150.1537	WCM	Installed

Location ID	RN	OGIA UWIR Site ID	OGIA monitoring Point ID	Surface elevation (m AHD)	Latitude	Longitude	Target Aquifer	Status
Kogan North-56	160730	42	209	322.13	-27.0093	150.9003	WCM	Installed
Kogan North-79	160702	42	208	317.75	-26.9989	150.9018	CA / WCM transition layer	Installed
Kogan North-79	160702	42	207	317.75	-26.9989	150.9018	Condamine Alluvium	Installed
Long Swamp-1	TBA	17	620	TBA	-27.3586	151.1531	Hutton	Proposed (UWIR)
Long Swamp-1	160731	17	83	342.67	-27.3431	151.1242	WCM	Installed
Longswamp-7	160869	28	145, 146, 147	332.06	-27.1843	151.1274	WCM	Installed
Macalister-5	160918	47	245	324.03	-26.8951	150.9543	Condamine Alluvium	Installed
Macalister-8	160919	47	244	323.97	-26.8951	150.9544	WCM	Installed
Meenawarra-21	160923	7	619	376.55	-27.5798	151.1335	Springbok	Installed
Meenawarra-21	160923	7	34, 35, 36	376.55	-27.5798	151.1335	WCM	Installed
Meenawarra-5	160732	7	33	376.73	-27.5779	151.1338	WCM	Installed
Pampas-18	160921	5	24	361.18	-27.6147	151.2267	Condamine Alluvium	Installed
Pampas-5	160788	5	25	361.27	-27.6146	151.2267	WCM	Installed
Plainview-1	160735	15	77	346.12	-27.3858	151.2165	WCM	Installed
Plainview-25	160800	23	120	342	-27.2521	151.2922	CA / WCM transition layer	Installed
Plainview-25	160800	23	119	342	-27.2521	151.2922	Condamine Alluvium	Installed
Plainview-25	160800	23	121	342	-27.2521	151.2922	WCM	Installed
RN 41620043	41620043	124	578	415.48	-27.9222	151.1214	Springbok	Installed
RN 42230088	42230088	5	24	359.12	-27.5898	151.2341	Condamine Alluvium	Installed
RN 42230209	42230209	55	281, 282	308.58	-26.7422	150.6799	Condamine Alluvium	Installed
RN 42231294	42231294	14	75	377.11	-27.3993	151.5484	Condamine Alluvium	Installed
RN 42231295	42231295	14	76	378.46	-27.3975	151.5619	WCM	Installed
RN 42231339	42231339	9	49	381.45	-27.5306	151.5037	Condamine Alluvium	Installed
RN 42231370	42231370	10	51, 52	359.07	-27.4915	151.3932	Condamine Alluvium	Installed
RN 42231463	42231463	8	37	359.9	-27.5488	151.313	Condamine Alluvium	Installed
Stratheden-63	160871	29	622, 623	330.32	-27.1989	151.0268	Springbok	Installed
Tipton-157	160799	13	72, 73, 74	358.28	-27.3981	151.0889	WCM	Installed
Tipton-195	160717	18	84, 85	339.86	-27.3205	151.2054	Condamine Alluvium	Installed
Tipton-196A	160750	18	86	339.69	-27.3202	151.205	CA / WCM transition layer	Installed
Tipton-197	160751	18	88, 89, 90, 91	339.62	-27.3202	151.2053	WCM	Installed
Tipton-204	160801	50	150	340.4	-27.1496	151.2094	CA / WCM transition layer	Installed
Tipton-204	160801	30	149	340.4	-27.1496	151.2094	Condamine Alluvium	Installed
Tipton-204	160801	50	151	340.4	-27.1496	151.2094	WCM	Installed
Tipton-206	160789	27	141	351.63	-27.2157	151.3489	Eurombah	Installed
Tipton-206	160789	27	142	351.63	-27.2157	151.3489	WCM	Installed

Location ID	RN	OGIA UWIR Site ID	OGIA monitoring Point ID	Surface elevation (m AHD)	Latitude	Longitude	Target Aquifer	Status
Tipton-221	160859	27	138	351.6	-27.2156	151.3489	Condamine Alluvium	Installed
Tipton-222	160877	27	139	351.6	-27.2156	151.3488	CA / WCM transition layer	Installed
Macalister 7	180020	41	203	337.64	-27.01	151.114	Condamine Alluvium	Installed
Macalister 6	160218	41	204	337.58	-27.01	151.114	WCM	Installed
Macalister 6	160218	41	205	337.58	-27.01	151.114	Eurombah	Installed
UWIR Site 48 (Wyalla 16, 17, 18)	TBA	48	624	TBA	26.84	150.7866	Hutton	Proposed (UWIR)
UWIR Site 94	TBA	94	497	TBA	-26.2301	149.9534	Hutton	Proposed (UWIR)
UWIR Site 94	TBA	94	494, 495, 496	TBA	-26.2301	149.9534	WCM	Proposed (UWIR)
Wyalla-16	160642	48	246, 248	307.9	-26.8662	150.755	Condamine Alluvium	Installed
Wyalla-17	160563	48	252, 253	307.86	-26.8663	150.755	Precipice	Installed
Wyalla-18	160658	48	249, 250, 251	307.92	-26.8661	150.7551	WCM	Installed

TBA: To be advised in the Stage 2 CSG WMMP