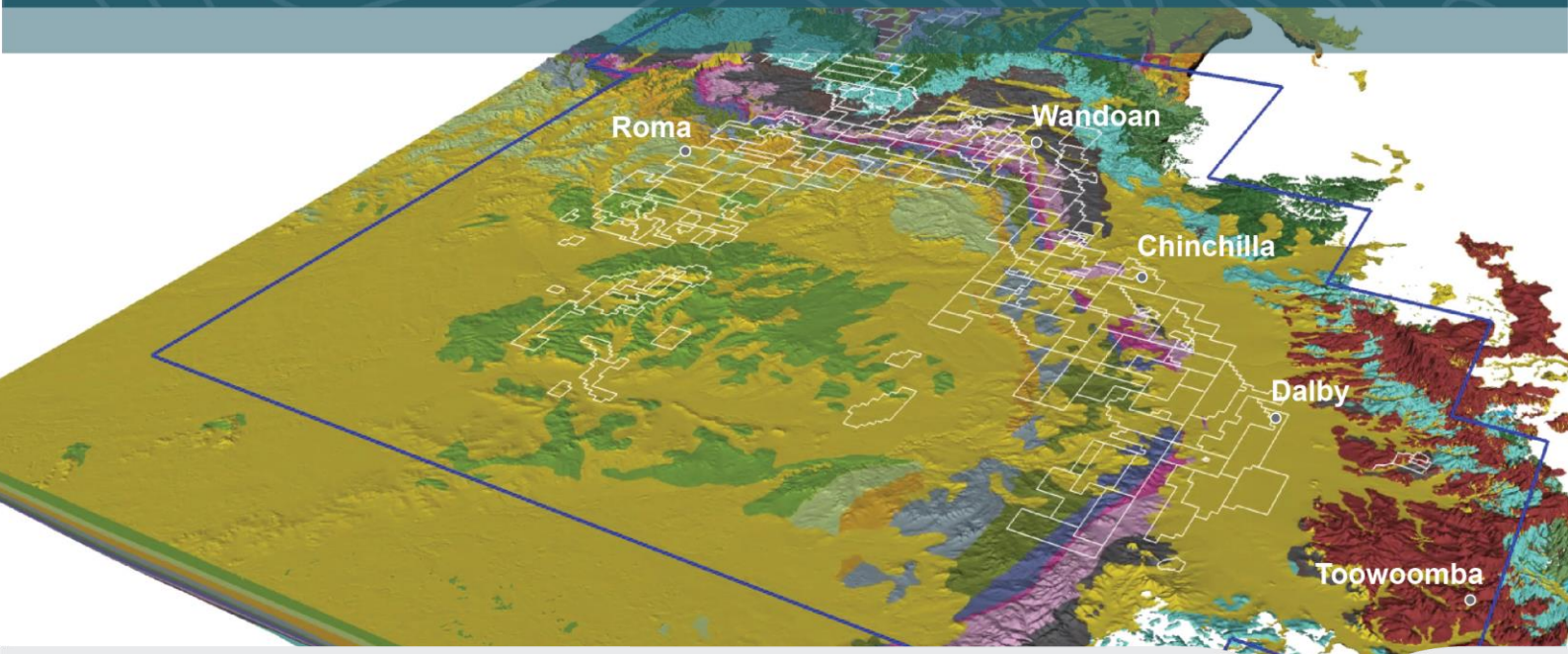
Queensland Government

Office of Groundwater Impact Assessment

Department of Regional Development, Manufacturing and Water



Annual Report 2022

for the Surat Underground Water Impact Report

January 2023

rdmw.qld.gov.au

Original version, authorised release on 13 January 2023 by Sanjeev Pandey, Executive Director, Office of Groundwater Impact Assessment.

This publication has been compiled by the Office of Groundwater Impact Assessment, Department of Regional Development, Manufacturing and Water.

Bibliographic reference:

OGIA, 2023. *Annual Report 2022 for the Surat Underground Water Impact Report*. OGIA, Brisbane.

Summary

An Annual Report is prepared by the Office of Groundwater Impact Assessment (OGIA) to provide an update on changes to circumstances that would materially affect the predictions reported by OGIA in the Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR) 2021 that was approved in March 2022, and to provide updates on the implementation of management strategies specified in the UWIR 2021. This is the first Annual Report for the current UWIR reporting cycle and should be read in conjunction with the UWIR 2021.

In order to provide an update in this Annual Report on the circumstances which may influence predictions made in the UWIR, OGIA compiled an updated development profile based on information received from each tenure holder in November 2022. This was then used in determining changes to predictions resulting from changes in the development profile.

Key changes, and updates on implementations, are as below:

- Despite localised changes in existing and proposed production areas there is no net change to the overall footprint or number of projected coal seam gas (CSG) wells.
- Development of planned CSG production areas has generally been delayed, due to the ongoing impact of the global pandemic and higher-than-average rainfall that has caused access and logistical issues, with some gas fields planned to be online sooner.
- The decline in associated water extraction has continued over the past 12 months to 52,000 ML/year.
- Due to slight delays in planned production in some areas, 48 of the 108 Immediately Affected Area (IAA) bores identified in the UWIR 2021 are now predicted to be impacted by more than five metres by the end of 2025 instead of three-year threshold to the end of 2024.
- Make good agreements of the IAA bores identified so far, including those from the previous UWIRs, are progressing further and there are now 147 IAA bores with make good agreements in place, compared to 135 at the time of the UWIR 2021.
- There have been general delays in rolling out the installation, repairs and replacement of monitoring points required under the UWIR – primarily due to a combination of logistical issues from higher-than-average rainfall and continued supply chain disruptions from the pandemic.
- Inferred CSG impacts from additional monitoring data are progressing as expected. In the Walloon Coal Measures impacts are still largely restricted to the gas fields themselves and the immediately surrounding areas, but declining groundwater pressure trends continue to be observed across the Hutton Sandstone due to non-CSG factors.
- In relation to subsidence, capturing of monitoring data is continuing broadly as planned. Additional ground motion data collected since the UWIR 2021 indicates that the subsidence trend in and around the Condamine Alluvium has also continued as anticipated, with an increase to about 120 mm.
- OGIA's research program for ongoing improvements to monitoring, modelling and conceptualisation has evolved to accommodate the significantly higher level of effort required in supporting subsidence related matters.

Table of contents

Table of figures

Table of tables

This page is interntionally blank

1 Introduction

1.1 What is the Annual Report for?

An Annual Report is prepared to provide an update on changes to circumstances that would materially impact on the predictions reported in the Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR) 2021, and to provide updates on the implementation of management strategies specified in the UWIR 2021.

This is the first Annual Report for the current UWIR reporting cycle and should be read in conjunction with the UWIR 2021.

1.2 Background

A UWIR for a CMA is a report prepared by the independent Office of Groundwater Impact Assessment (OGIA), every three years, on cumulative assessment and management of groundwater impacts from extraction of associated water. There is currently one CMA in Queensland – the Surat CMA, declared in 2010 in response to rapid coal seam gas (CSG) development in the Surat Basin. In January 2020, the Surat CMA was amended to include coal mines in the Surat Basin.

The current Surat UWIR (UWIR 2021) was finalised and approved in March 2022, and took effect on 1 May 2022. It is the fourth UWIR since the establishment of the Surat CMA and was finalised following the release of a consultation draft in October 2021.

1.3 A summary of the Surat UWIR 2021

At the time of the UWIR 2021, the resource industry's existing and planned development plan consisted of approximately 22,000 projected CSG wells – of which about 8,600 were already in place. The coal mines located in the Surat Basin had a combined footprint less than two per cent of the CSG footprint.

Associated water extraction by the CSG operators was around 54,000 megalitres per year, with associated groundwater extraction by the coal mines a fraction of that, at less than 1,000 megalitres per year. At the same time, 59,000 megalitres of groundwater per year was extracted for consumptive use.

Monitoring data available at the time of the UWIR was showing declines of up to about 400 metres in the Surat Basin CSG target formations and to a lesser extent in the Springbok Sandstone. The data also showed no impacts were occurring at that time in the Hutton Sandstone, Precipice Sandstone or Condamine Alluvium.

The predicted impacts in the UWIR 2021 were broadly similar to the previous UWIR of 2019, with only minor impacts predicted to reach the Hutton Sandstone and Precipice Sandstone. Similarly, predictions of impact to the Condamine Alluvium groundwater levels remained less than a metre.

A total of 702 water bores were predicted to be impacted in the long term, spanning across the Springbok Sandstone, Walloon Coal Measures, Hutton Sandstone and Bandanna Formation. Of the 702 water bores, 108 were newly identified as Immediately Affected Area (IAA) bores – i.e. water bores that would be impacted by more than five metres within the next three years, which is the end of 2024 in this instance. This was in addition to 233 IAA bores similarly identified in the previous UWIRs for three-year rolling periods.

The UWIR 2021 also identified seven groups of springs predicted to be impacted by a decline of groundwater level by more than 0.2 m in their source aquifers. Mitigation strategies were in place for three of these groups.

To strengthen the Water Monitoring Strategy (WMS) monitoring network, OGIA increased the monitoring network from 707 to 824 monitoring points.

Modelling of subsidence was enhanced for the UWIR 2021. The predictions showed that most of the cropping area around the Condamine Alluvium is likely to experience less than 100 mm of subsidence, with a maximum change in slope for most areas of less than 0.001% (10 mm per km). Satellite data available to OGIA at the time of the UWIR suggested that about 100 mm of CSG-induced subsidence had occurred around the CSG fields near Condamine Alluvium.

2 Update on industry development profile

2.1 Planned development at the time of the UWIR

For the UWIR 2021, OGIA integrated the footprint and timing of the petroleum and gas (P&G) and coal mine industry development plans, to establish a resource industry ***development profile***. A whole-of-life resource industry development profile was prepared and used as the input scenario for the regional groundwater flow model for impact predictions. Output from the model provided, for the given resource industry development profile, short-term (within three years) and long-term (any time in the future) predicted cumulative impacts on groundwater pressures in aquifers.

The resource industry development profile for the UWIR 2021 was prepared based on information available in late 2020. This includes historical production data and planned development from individual tenure holders as presented in Chapter 2 of the UWIR 2021.

Many factors can cause changes to the development profile over time. Changes can relate to the timing of development of individual tenure areas, or to the long-term footprint of development. Any such change directly affects the extent and timing of predicted impacts on groundwater pressure.

OGIA requires, and receives annually, information directly from tenure holders about updates to their development plans to compile a development profile across the whole CMA. The latest update is from November 2022. This chapter presents a summary of changes since late 2020, which then provide context to implications on predictions and management strategies in the UWIR, as detailed in the following chapters.

2.2 Description of changes to planned development

A revised P&G industry development profile as at November 2022 is presented in Figure 1, along with the equivalent presented in the UWIR 2021, to allow for comparison in terms of the development footprint ('production area') and timing. ***Production area*** is the part of a petroleum lease or petroleum lease under application where production is either occurring (existing production area) or proposed (planned production area). Production area can increase or decrease within the leases without necessarily affecting authorisations associated with the leases – this is often the case within the CMA.

With regard to the coal mines, other than New Wilkie Energy, there are no changes to the development plans already provided to OGIA for the UWIR 2021. New Wilkie Energy is the current tenure holder for Wilke Creek mine.

2.2.1 Overview of the cumulative changes

As anticipated, the existing CSG production area has increased by 4% as some of the planned production areas have progressively come online since 2020. However, despite localised changes to planned production whereby some areas are likely to retract and others expand, the net existing and proposed P&G production area has remained much the same, at approximately 15,000 km, with the number of projected CSG wells remaining at 22,000 – the same as reported in the UWIR 2021. Most of the expansion in planned production area is along the fringes of previously planned production areas located in Santos's tenure that are east of Roma and northeast of Injune along the Fairview and Arcadia fields. There is also some expansion in an area between Dalby and Cecil Plains, within Arrow's tenures. Similarly, most of the retraction in planned production area is also along the fringes – between Chinchilla and Dalby within Arrow's tenure, as well as southeast of Roma and north of Injune within Santos's tenures, and west of Wandoan within QGC's tenures.

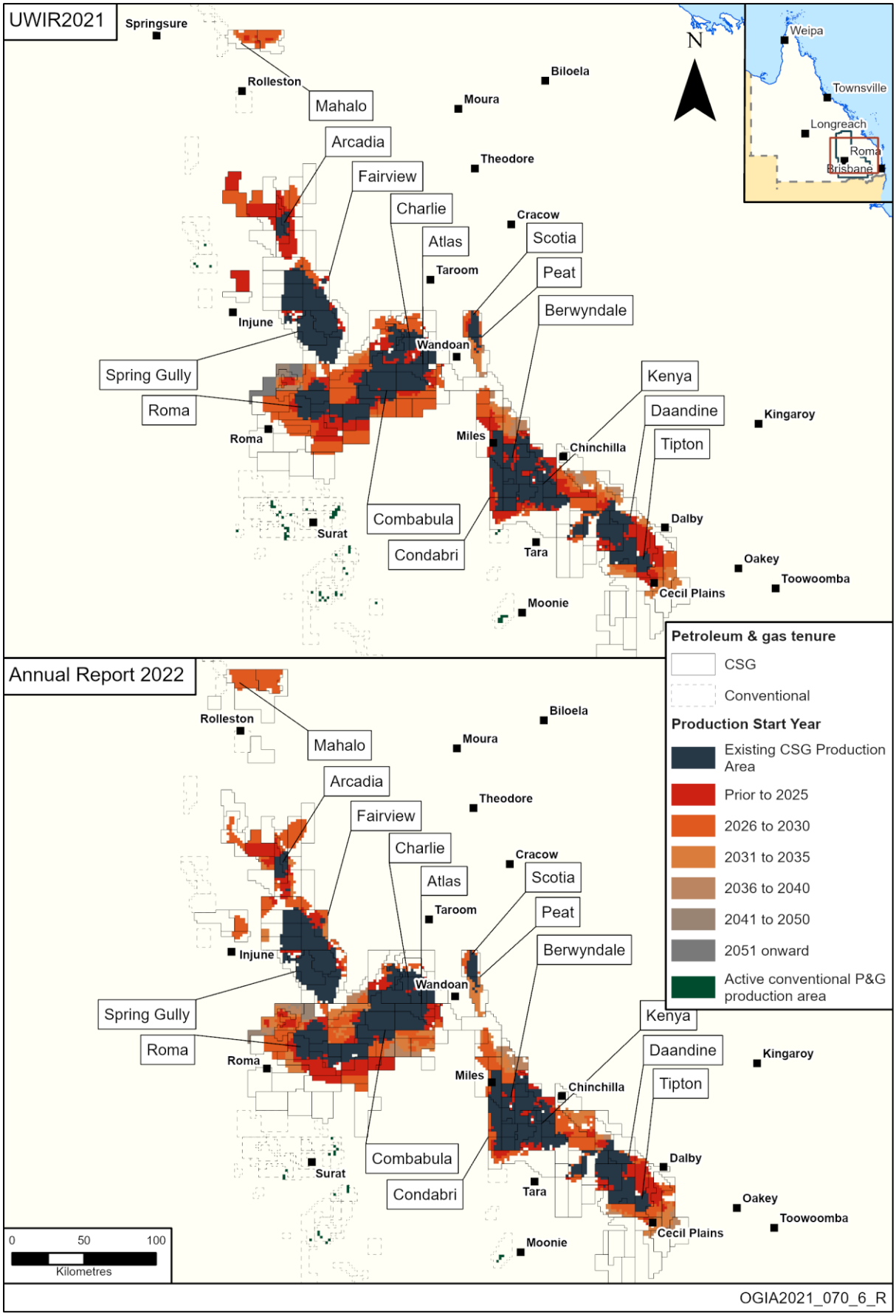


Figure 1 – P&G development profiles for the UWIR 2021 and for the Annual Report 2022

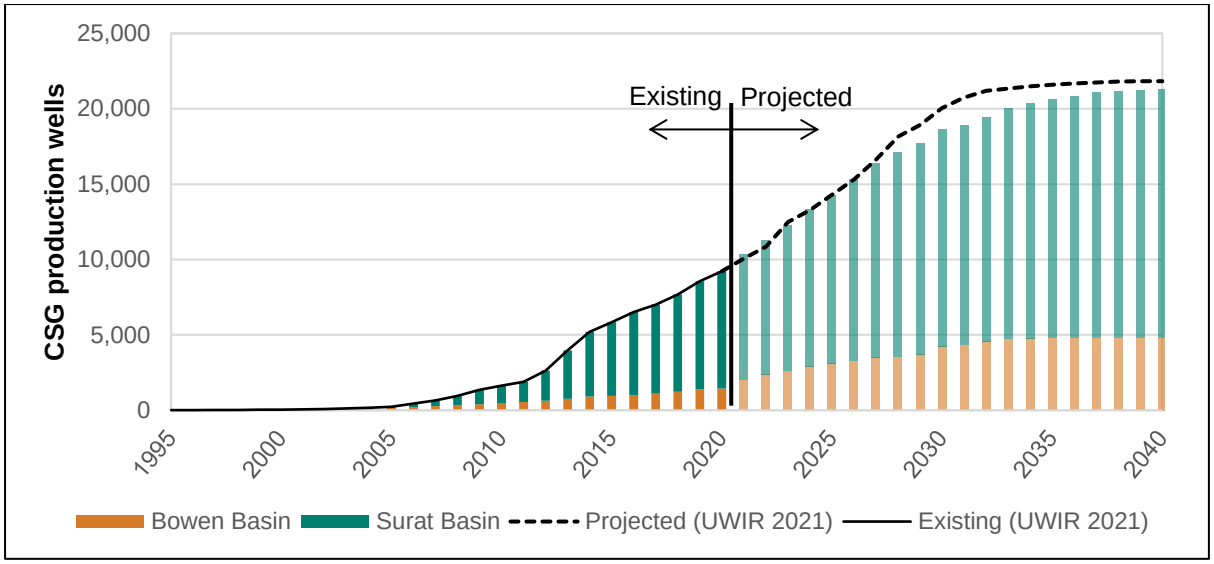


Figure 2 – Existing and projected CSG wells in the Surat CMA in current and planned production areas

In terms of changes to the commencement timing, there are delays to the earlier proposed timing. This is possibly due to the ongoing impact of the global pandemic on supplies, as well as the continuing higher-than-average rainfall that has caused land access and logistical issues. It is reported by tenure holders that, to offset those impacts, some gas fields have been optimised to be online sooner in and around the existing production areas, while planned development in fringe areas has generally been pushed back by a few years.

Consideration of changes to timing within the next three years of the UWIR – to the end of 2024 – is important because they can potentially affect IAAs, which may then affect make good obligations. In that context, there is some bringing forward of planned commencement with respect to the end of 2024, notably in an area immediately east of Roma within Santos's tenures, however this has not affected the short-term affected bores, as detailed in the next chapter. Similar to previous years, the planned development has been pushed back to later years in most cases, particularly in areas adjacent to existing production areas between Chinchilla and Cecil Plains.

Cessation dates have also been brought forward by an average of five years for the CMA, with the average cessation year now being 2050.

Associated water extraction by P&G tenure holders in the Surat CMA is presented in Figure 3. The trending decline noted in the UWIR 2021 has continued over the past 12 months, with extraction rates dropping below the average production from the previous three years to about 52,000 ML/year. This is primarily due to a combination of slower growth rate, reduction in extracted water over time from existing wells and infilling of new wells in areas where partial depressurisation has already occurred.

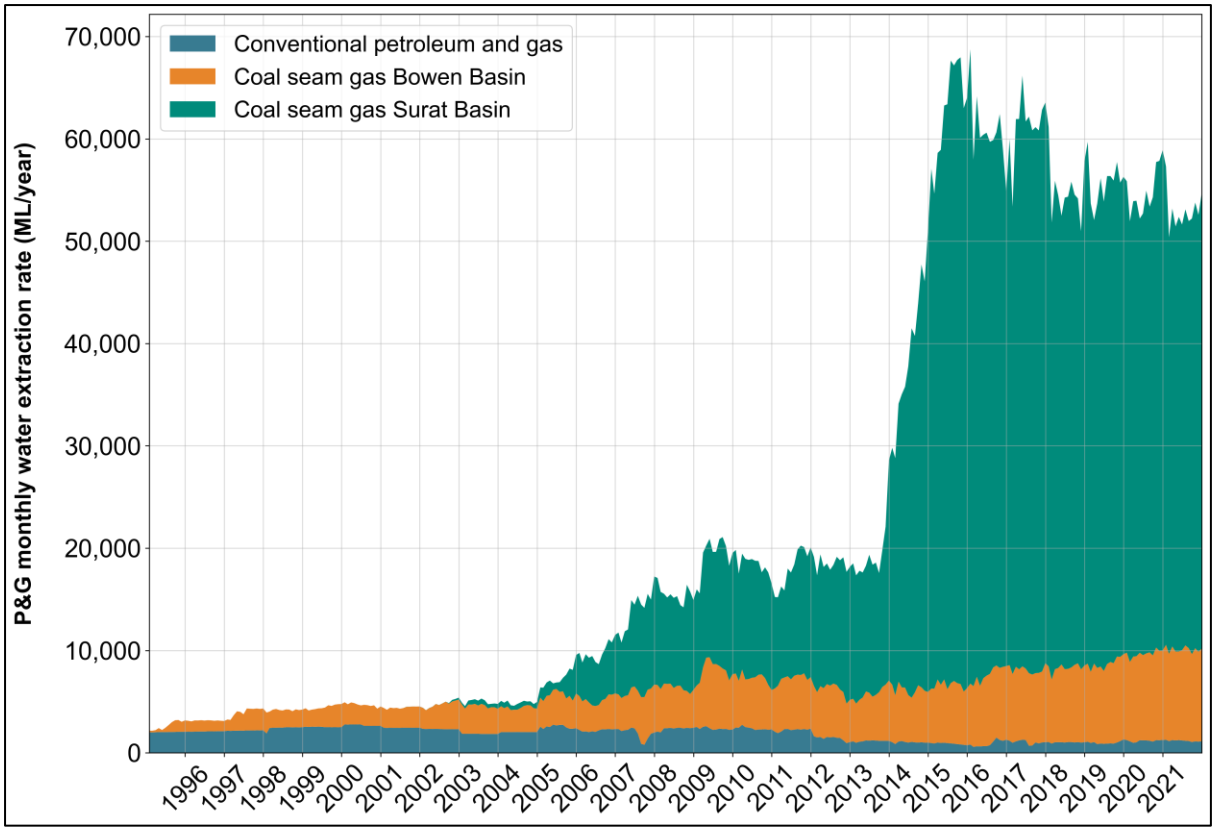


Figure 3 – P&G water extraction

2.2.2 Santos

Santos's total planned CSG production area has increased overall, mainly due to taking over the Mahalo project, previously operated by Origin.

Santos has revised its development plans for several gas fields, including Roma, Fairview, Scotia, and Arcadia, resulting in a retraction of parts of the gas fields. Santos has also included new areas of planned CSG production. These areas add planned CSG production area to the Roma, Fairview, Arcadia and Mahalo footprint. There is a total 10% increase to Santos's production footprint compared to the UWIR 2021.

Some areas of planned development have also been brought forward by a few years. A portion of the western flank of the Roma field has been brought forward, now to be developed prior to the end of 2024. Santos has informed OGIA that large CSG fields, such as Roma, are developed as a series of smaller sub-projects. The sequencing of sub-projects is reviewed typically every year and is subject to change in future. This is dependent on a range of factors such as reservoir characteristics, land access constraints and the overarching economics of drilling and connecting CSG wells.

2.2.3 Origin

As stated in the previous section, the Mahalo project is now operated by Santos and its removal from Origin's tenure contributes to Origin's approximate 10% reduction in overall planned CSG production area. Origin's planned development has generally been delayed across the CMA, which Origin has advised is due to better performance than expected from its in-production gas fields.

2.2.4 QGC

QGC has a notable retraction in planned CSG production area for its northern development area and only minor changes to the scheduling. The retraction in planned production area contributes to a 20% reduction in projected wells for QGC from what was projected in the UWIR 2021.

2.2.5 Arrow Energy

Arrow's overall planned production area footprint has reduced by approximately 8% compared to that presented in the UWIR 2021. This is mainly due to retractions in the northern gas fields – due to reservoir assessment and facility and infrastructure rationalisation – and in areas around the western margins of the Condamine Alluvium, such as PL 1039. There is also increased footprint to the south of Dalby in PL 238. Arrow has experienced scheduling delays over the past 12 months due to weather and other logistical reasons, which have also resulted in a general delay in commencement of production across its tenures.

2.2.6 Senex

The western portion of Senex's Roma North project area (previously named Western Surat Gas Project) has been brought forward, and the eastern fields of the project have been delayed. Eos and Glenora remain the primary existing production areas to date, with sequencing stretching to the west to 2040. The project area to the northeast and southwest are scheduled to come online around 2045.

In the past 12 months, Senex has also acquired tenure area from Origin. This area is adjacent to, and now forms part of, the Atlas project area near Wandoan. The additional tenure area added to Senex's Atlas project is now planned to commence in 2023 – as much as seven years earlier than the plans formerly held by Origin.

The acquisition of tenure increases Senex's overall planned production area by approximately 10% and its total projected wells by about 200 wells.

2.2.7 New Wilkie Energy (Wilkie Creek coal mine)

New Wilkie Energy recently acquired the Wilkie Creek coal mine from Peabody, which had provided development plans to OGIA indicating the mine was in a rehabilitation phase. Upon acquisition of the mine, the tenure holder has been working toward designing and building its mine development models and plans, which are not yet made available to OGIA.

3 Update on predicted impacts on groundwater pressures and bores

3.1 Overview of predicted impacts in the UWIR 2021

The UWIR 2021 determines the IAA for each aquifer based on predictions. For a consolidated aquifer, such as sandstone, the *Water Act 2000* stipulates the IAA is the area where groundwater pressure is predicted to decline by more than five metres within three years as a result of water extraction by the resource industry. Water supply bores accessing water in the affected area of an aquifer become IAA bores. For these bores, various make good arrangements are then triggered as described in s8.4 of the UWIR 2021.

The UWIR 2021 also determined the Long-term Affected Area (LAA) for each aquifer. The LAA for a consolidated aquifer is the area where groundwater pressure is predicted to decline by more than five metres at any time in the future as a result of water extraction from by the resource industry. A total of 702 existing bores were predicted to be impacted in the long term – including the IAA bores.

The UWIR 2021 identified 108 additional water supply bores as IAA bores, a further increase from the 233 IAA bores that were identified in the previous UWIRs. This is because of the rolling three-year basis for IAA – which was the end of 2024 for the UWIR 2021, compared to the end of 2021 for the previous UWIR 2019.

3.2 Assessing changes to predicted impacts

For the purpose of this Annual Report, the model and the predictive set-up used is the same as that of the UWIR 2021 to simulate the impacts from the current resource industry development profile as described in the previous chapter. Results from the simulations were then compared with UWIR 2021 predictions to assess the implications of changes in the development profile.

3.3 Changes to long-term impacts

There are some minor reductions in predicted impacts in the northern and south-eastern areas of the CMA. The most significant influence on the shrinking in predicted long-term impact areas is the shortening of the period during which the gas fields are planned to be in production. As a result, the number of LAA bores may decrease by about 43 – mainly to the southwest of Cecil Plains. Because of very high bore density in that area, a slight change in LAA boundary results in relatively much larger change in LAA bores.

3.4 Changes to short-term impacts

Revised predictions based on the current resource industry development profile suggest that 48 of the 108 IAA bores listed in the UWIR 2021 are now predicted to be impacted by more than five metres by the end of 2025, rather than by the end of 2024 which was the IAA threshold period for the UWIR 2021. This is because of slight delays in commencement of production in some areas, as described in the previous chapter. Most of these bores are within 7 km (north and south) of the Warrego Highway and within 40 km (to the southwest) of Chinchilla.

It is to be noted that while the predicted impacts on some IAA bores are now less than the trigger threshold of five metres by the end of 2024, those bores still remain IAA bores. The status of a bore as an IAA bore is based on the IAA that is established through a current UWIR, based on the development profile at the time. The IAA for an aquifer does not change between UWIRs, but a bore's

status as an IAA bore can change based on the new information available about the bore – such as changes in location, authorisation, physical status or aquifer attribution. Changes to IAA bores are detailed further in the next chapter.

4 Changes to bore information

This Chapter provides an overview of the status of bores identified as IAA bores in the current and previous UWIRs, in relation to the completion of baseline assessments, bore assessments, their current status, and an update on progress with make-good agreements.

4.1 Baseline assessments

Prior to commencing production, resource tenure holders must complete baseline assessments for water bores located on tenure. The schedule for their completion is specified in baseline assessment plans (BAP), which the responsible tenure holders submit to DES for approval.

For water bores that are located off tenure but within an LAA, the UWIR WMS includes a program for the assessment of these bores – based on a prediction of groundwater pressure decline of more than one metre within the next three years (see Figure 9-7, UWIR 2021).

Baseline data is collected by tenure holders and reported to OGIA. The data is available to the interested parties to support the development of make-good agreements between bore owners and resource tenure holders.

OGIA currently holds information collected from 4,884 baseline assessments, 718 of which relate to bores located outside the Surat CMA. Information available to OGIA as at November 2022 shows baseline assessments have been conducted for 11 of the 38 bores identified for assessment in the UWIR 2021.

4.2 Bore assessment

Upon approval of a UWIR, responsible tenure holders are required to complete bore assessment of bores identified as accessing an aquifer within the aquifer's IAA –referred to as IAA bores. These water supply bores are listed in Table G-1 of the UWIR 2021. Separately, DES may also direct a tenure holder to undertake a bore assessment.

A bore assessment is undertaken to establish whether a bore has (or is likely to have) an impaired capacity and to assess which make-good arrangements may be appropriate. OGIA is not involved with undertaking bore assessments or the negotiations around make-good agreements. OGIA only receives and records the outcome of bore assessments. Currently, bore assessment outcomes are held for 239 bores, of which 195 relate to IAA bores.

4.3 Update on IAA bore information

Figure 6-4 of the UWIR 2021 shows the geographical extents of the IAA and LAA. Based on the information available at the time, the UWIR 2021 newly identified 108 IAA water bores (Table G-1, UWIR 2021). These IAA bores are in addition to the 233 IAA bores listed in previous UWIRs (Table G-2, UWIR 2021). The distribution of all the IAA bores and LAA bores identified in the UWIR 2021 is found in Figure 8-2 of the UWIR.

Bore assessments often provide new or updated information including location, depth, water chemistry and water level. This information can be used to reassess whether the bore is accessing water from aquifers other than those predicted to be affected. As a result, in the post-UWIR period, some IAA bores may be determined not to be IAA bores. Conversely, bores not previously identified as IAA bores may be found to be accessing water from affected aquifers. As a result, the number of IAA bores may change during a UWIR cycle without a change being made to the IAA footprint.

Since the UWIR 2021, bore assessments have resulted in changes to the aquifer assignment of one bore (RN192518) that is consequently no longer predicted to be affected by more than the trigger threshold in the short term; hence, it is no longer considered an IAA bore. Another bore, RN21786, is now also determined not to be an IAA bore.

At the time of preparing the UWIR 2021, 12 bores without registration numbers were identified as IAA bores. All those bores have now been assigned registration numbers in the Queensland Groundwater Database (GWDB), as listed in Appendix A.

As a result of post-UWIR 2021 changes to development profile and updated aquifer information, one additional bore (RN192246) is predicted to be impacted by at least five metres within an IAA. DES will now consider further action for this bore.

4.4 Current status of make-goods

Information available to OGIA as at November 2022 indicates that of the total 233 IAA bores so far, there are 147 bores with make good agreements in place and 60 bores with agreements currently in negotiations, compared to 135 and 45 bores respectively at the time of the UWIR 2021. Of the 108 IAA bores that were newly identified in the UWIR 2021, 89 still require bore assessment.

The regulatory framework under the *Water Act 2000* allows for the provision of make-good agreements where a bore is determined to be impaired, or likely to be impaired, as a result of resource industry water extraction. Generally, make-good negotiations will follow the completion of a bore assessment, which will determine if the bore is (or is likely to be) impaired. In some cases, however, make-good agreements are reached in advance of bore assessment.

An agreement about the make-good arrangement between a tenure holder and a bore owner may not necessarily involve decommissioning of the water bore. Such an agreement may provide some form of compensation while the bore continues to supply water; it may also provide for a period of ongoing monitoring and a future date for review of the agreement.

5 Implementation of the Water Monitoring Strategy

5.1 Overview of the UWIR 2021 Water Monitoring Strategy

The UWIR 2021 included a WMS which specified a regional monitoring network, comprising groundwater pressure and water chemistry points, as well as the monitoring of water production volumes. The WMS monitoring network is designed for the collection of data to meet multiple objectives related to regional groundwater assessment. The primary objectives are to:

- improve understanding of background trends
- identify pressure changes near resource development
- understand groundwater flow near connectivity features and high-value assets
- improve conceptual understanding and future groundwater modelling
- assess groundwater conditions around coal mining pits.

The UWIR 2021 identified each required monitoring point's location, target formation and responsible tenure holder, as well as a date by which the monitoring point must be installed. As with previous UWIRs, the UWIR 2021 recognises that the locations of the identified sites may need to be altered during implementation due to practical operational issues. To address operational constraints, tenure holders may propose, to OGIA, variations to obligation requirements, while not undermining the overall objectives of the monitoring network.

Any proposed changes to the installation or repair of monitoring points are reported to OGIA through the Network Implementation Report (NIR) every six months. A summary of progress with the implementation of the network since the UWIR 2021 is provided in the following sections.

5.2 Implementation summary

There are generally delays in implementation, reported to be due to a combination of logistical issues associated with higher-than-average rainfall and continued disruptions in supply chains due to the Covid-19 situation.

Also, since the UWIR 2021, Tri-Star advised OGIA of its intention to relinquish an authority to prospect, ATP 663. The monitoring requirements on and around this tenure were reviewed and, as a result, six monitoring points due for repair in 2022 were removed from the monitoring network. The rules for assigning UWIR obligations set out in chapter 13 of the UWIR 2021 mean that some of the monitoring obligations will transfer to the closest relevant P&G tenure holder, which in this case is Arrow Energy.

Based on updated information, one of QGC's monitoring points was also removed as a UWIR monitoring point because a nearby existing monitoring point (RN13030814A) was assessed to be monitoring the same formation.

5.3 Groundwater pressure network

The UWIR 2021 scheduled 73 monitoring points to be added to the groundwater monitoring network by the end of 2022. Of those, as of October 2022:

- one monitoring point is no longer required
- four new monitoring points have been completed

- 14 monitoring points have been constructed but are yet to go through final commissioning
- 26 monitoring points are either waiting on final components or are proposed to utilise existing bores with tenure holders to finalise access agreements or update the required infrastructure to enable these points to be completed
- some of the remaining 28 were scheduled for completion late in 2022, while others are delayed due to logistical issues, as detailed earlier.

There were 64 existing monitoring points scheduled to be repaired by the end of 2022. As of October 2022:

- six monitoring points have been removed from the network due to reduction in tenure area and optimisation of surrounding monitoring network points
- 13 monitoring points have been repaired
- 45 monitoring points were yet to be repaired.

At the time of the UWIR 2021, there were 539 operational groundwater pressure monitoring points; this has now increased to 556.

5.4 Groundwater chemistry network

At the time of the UWIR 2021, there were 87 operational monitoring points for groundwater chemistry which has now increased to 88. By the end of 2022, eight monitoring points are scheduled to have been added to the groundwater chemistry network, of which one new monitoring point has been completed, two monitoring points have been constructed but are yet to go through final commissioning, and three existing bores are being considered for conversion to monitoring points.

The UWIR WMS also requires that water chemistry be sampled from production wells. Sampling water from CSG wells can be problematic as CSG wells may be turned off and operational factors may preclude water quality samples from being taken. Where water quality samples cannot be taken from a production well identified in the UWIR, the tenure holder may take a sample from another well within a three-kilometre radius. At the time of the UWIR 2021, this network included 135 existing production wells, one replacement well and 18 wells in planned development areas proposed for the future. Five of the 18 proposed wells were intended to be in place by the end of 2022, of which four are scheduled for sampling late in 2022 and one well requiring further investigation.

5.5 Associated water extraction

In addition to the monitoring of groundwater pressure and chemistry, tenure holders are required to report the volumes of associated water produced by CSG wells. For the UWIR 2021, water volumes were available for around 8,600 production wells in 2020. Since that time, OGIA has received data for an additional 800 wells. Note that some of the production wells may not report any volume because either they may not be in production at the time or they may be producing negligible amounts. A total volume of about 52,000 ML was produced from CSG wells in 2021.

5.6 Data availability

Responsible tenure holders provide monitoring data to OGIA every six months, in April and October each year. This includes a NIR, water monitoring report and monitoring point construction information. OGIA reviews each data submission for completeness and technical accuracy. Within about three months of each submission, data is publicly available on the GWDB and the Queensland Globe.

5.7 Update on trends in groundwater pressure

To support the preparation of the UWIR 2021, OGIA completed a detailed analysis of groundwater pressure trends in aquifers adjacent to the target coal formations – the Walloon Coal Measures and the Bandanna Formation – to identify impacts from associated extraction by P&G and coal mining on groundwater pressure (UWIR 2021, Chapter 5). The key findings presented were as follows:

- There was widespread CSG impact in the target formations where impacts of up to 400 m have been observed at some locations.
- In areas adjacent to operational coal mines, impacts in the Walloon Coal Measures drawdowns of up to 30 m were observed at some locations.
- In the overlying Springbok Sandstone, the trends were mixed, although there was evidence of CSG impact at some sites. There were substantial areas of rising trends around the north-eastern fringe of the development areas, likely to be caused by gas migration.
- In the underlying Hutton Sandstone, there was no evidence of CSG impact. Declining trends were attributed to groundwater use, although those trends appear to be somewhat stabilising in recent times.
- In the Precipice Sandstone, the basal unit of the Surat Basin, reinjection was the dominant influence on observed groundwater levels, particularly in the north. This increases the complexity of identifying any minor impacts that may have occurred around its contact with the Bandanna Formation in the Bowen Basin.
- No impacts were observed in the overlying Condamine Alluvium at this stage.

Since the UWIR 2021, additional monitoring data has been collected and a preliminary analysis of this information by OGIA suggests the following:

- Consistent with the UWIR 2021, CSG impacts in the Walloon Coal Measures are largely restricted to the gas fields and the immediately surrounding areas. The more significant declines are observed in the lower parts of the Walloon Coal Measures. There is little change around reported trends adjacent to operational coal mines.
- Groundwater pressures in the Springbok Sandstone continue to show variable trends – both rising and declining – across the formation. At most locations, the observed trends are consistent with those reported in the UWIR 2021.
- Declining groundwater pressure trends continue to be observed across the Hutton Sandstone. However, the magnitude and rate of decline varies spatially, with the more significant declines observed between Miles and Dalby. At two locations – Daandine-121 (RN160350A) and Glenburnie-18 (RN160941B) – an increased rate of decline is observed over the last 12 months. The declining rates do not correlate with associated water production volumes in that area and are most likely related to non-CSG factors. This is to be confirmed further with additional analysis during this UWIR cycle.
- In the Condamine Alluvium, groundwater pressures continue to show stable to minorly declining trends across the groundwater system. Consistent with the UWIR 2021, observed trends continue to correlate reasonably well with longer-term dry and wet periods and do not relate to CSG water extraction in the Walloon Coal Measures.

- In the Precipice Sandstone, observed groundwater pressure trends continue to show a consistent response to Origin's reinjection scheme, particular in areas north of Roma and Miles. Since late 2017, reinjection rates reduced from around 550 to 400 ML per month. Over the recent period, this change is expressed as a stabilisation of previously increasing trends and slight declines at monitoring locations further from the reinjection locations.

6 Implementation of the Spring Impact Management Strategy

6.1 Overview of the UWIR 2021 Spring Impact Management Strategy

The Spring Impact Management Strategy (SIMS) in the UWIR 2021 identified springs that may be at risk due to underlying aquifers being affected by associated water extraction for P&G or coal mining. The criteria for identifying potentially affected springs are conservative: springs overlying aquifers with predicted long-term pressure impacts of 0.2 metres, or more are identified as potentially affected.

Based on the predictions of impact and a follow-up risk assessment, three groups of springs were identified for mitigation actions. A significant inclusion in the UWIR 2021 is the Spring Impact Mitigation Plan (SIMP), which identifies specific triggers, actions and reporting responsibilities for Santos and OGIA. In addition, the SIMS also identified some of the watercourse reaches for field verification by a responsible tenure holder, as specified in Table H-1 of the UWIR 2021.

Changes to the development plans have resulted in alterations to the magnitude and timing of predicted impacts as described in Chapter 3; however, the changes have not resulted in any material change to predicted impacts at most of the spring locations.

6.2 Update on spring monitoring

The UWIR 2021 includes a risk assessment for springs and specifies a monitoring program for seven spring complexes and five watercourse springs. Responsibility for implementing the monitoring program is assigned to individual tenure holders.

Spring monitoring is necessary to understand the natural variability in spring discharge. Similar to understanding influences on observed groundwater levels, this information provides the basis for establishing the background conditions, for correlation with seasonal conditions, groundwater use and potential impacts from resource development. During the previous UWIR cycle, there were extended periods of lower-than-average rainfall and drought across many parts of the Surat CMA. At spring wetlands, this generally resulted in a smaller contribution of rainfall to the wetland water balance, increased grazing pressure on wetland vegetation that resulted in higher disturbance, and a contraction in spring wetland extent and overall condition. In contrast, during this cycle, higher-than-average rainfall has seen many sites stabilise or expand and regain condition in response to the increase in rainfall and reduction in grazing pressure.

The higher-than-average rainfall has also meant that access to some watercourse springs sites has not been possible, such as at Hutton Creek and the Dawson River.

6.3 Update on watercourse validation

In the UWIR 2021, the SIMS identifies some reaches for field verification and assigns responsible tenure holders (Table H-1, UWIR 2021). Field verification is expected to include a dry-season longitudinal survey of the reaches to determine if groundwater is discharging to surface and to identify source aquifers. The UWIR 2021 suggests field methods including surface water chemistry analysis, stream gauging, and measurement of water levels and chemistry in nearby water bores.

Due to the higher-than-average rainfall during this cycle, there has been limited opportunity to undertake field verification of these locations. OGIA is liaising with responsible tenure holders and DES to identify the next opportunity for these to be implemented.

6.4 Update on spring impact mitigation

The UWIR is required to include a strategy for preventing or mitigating the predicted impacts on the springs, including the actions to be taken. Based on the predictions of impact and a follow-up risk assessment, three groups of springs were identified for inclusion in a SIMP – Springrock, 311/Yebna 2 and Lucky Last.

As described in the UWIR 2021 (section 10.7.2), the SIMP comprises three parallel streams:

1. **Mitigation actions** to bring the residual risk to low. These actions are described in the UWIR 2021 (section 10.7.3 and Table H-2) and are designed to be implemented within one to two years of being triggered (trigger sites).
2. **Trigger monitoring** and reporting by OGIA of groundwater level trends. This is a biannual assessment of the data to identify the likelihood of CSG impacts at early warning indicator sites (UWIR 2021, Table H-3, Appendix H). OGIA is required to notify Santos and DES of the outcome of this assessment and if actions are required.
3. **Ongoing investigations** at a number of spring groups to further improve knowledge about impact pathways and spring response to groundwater level impacts.

An update on further assessment and implementation at each mitigation group is provided as below.

Springrock

The Springrock mitigation group of springs is a section of watercourse incised into the Precipice Sandstone, approximately 20 km northeast of Injune. The wetlands are supported by discharge from the Precipice Sandstone, occurring as pools within depressions in exposed sandstone bedding plains and where stream sediment has accumulated. During wet periods, the wetlands are connected by surface water flow. During dry periods, the upper reaches of the tributary become disconnected wetlands.

The two specified early warning indicator sites (RN160653B and RN123531A) are completed in the Precipice Sandstone. No CSG impacts are currently detected at the trigger sites. The groundwater levels continue to show relatively stable trends with minor variability correlating with climate.

311/Yebna 2

The 311/Yebna 2 mitigation group is located along the Dawson River near the intersection of Hutton Creek, approximately 30 km east of the Springrock mitigation group. The group has characteristics similar to the Springrock group and is also fed by the Precipice Sandstone. These are permanent to semi-permanent wetlands which occur in the rocky channels of the watercourses within the outcropping Evergreen Formation and Precipice Sandstone.

The two specified early warning indicator sites (RN160661A and RN160650A) are completed in the Precipice Sandstone – one near the contact zone (see UWIR 2021, Figure 4-10) and the second adjacent to the springs. No CSG impacts are currently detected at the trigger sites. Similar to the Springrock mitigation group, the groundwater levels continue to show relatively stable trends with

minor variability correlating with climate – rising with higher-rainfall periods, reflecting lower groundwater extraction and recharge events.

Lucky Last

The Lucky Last mitigation group is located approximately 20 km northeast of Injune. This group of springs is adjacent to the Injune Creek and unlike the Springrock and 311/Yebna 2 mitigation groups, these are palustrine rather than riverine wetlands, fed by the Boxvale Sandstone.

The two specified early warning indicator sites (RN13030882A and RN123470A) are completed in the Precipice Sandstone. No CSG impacts are currently detected at the trigger sites. At these locations, the conceptual pathway for impact to the Boxvale Sandstone is via the Precipice Sandstone and early warning monitoring is therefore in this formation. Similar to the other mitigation groups, the groundwater levels continue to show relatively stable trends with minor variability correlating with climate – rising with higher-rainfall periods, reflecting lower groundwater extraction and recharge events.

7 Update on the subsidence monitoring strategy

7.1 Overview

The subsidence monitoring in the UWIR 2021 required: ***baseline monitoring*** to establish slopes using primarily an airborne Light Detection and Ranging (LiDAR) tool; and ***trend monitoring*** using the interferometric synthetic aperture radar (InSAR) technique. This would then enable identification of CSG-induced subsidence that may have already occurred, and continuous improvement of the model for making predictions of CSG-induced subsidence. This Chapter provides an update on the implementation of the monitoring strategy for subsidence in the UWIR 2021.

In parallel with implementation of the monitoring strategy, OGIA has been supporting the GasFields Commission Queensland (GFCQ) project to further understand the consequences of subsidence on farm-scale operations, and to inform development of a potential management framework. This has required significant refinement of modelling tools and extensive engagement with landholders to assess local-scale implications of CSG-induced subsidence.

7.2 Update on baseline monitoring

As part of the baseline monitoring, the UWIR requires Arrow Energy to acquire at least one airborne LiDAR survey annually, preferably during the dry season, across the cropping lands in and around the Condamine Alluvium.

Since the UWIR 2021, a LiDAR survey was acquired by Arrow Energy from two captures on 13 June and 7 August 2022. The data was provided to OGIA in November 2022 as it required significant processing and preparation by the survey provider.

OGIA will process and analyse the data on an as-needed basis. Prevailing higher-than-average rainfall conditions resulting in localised areas of ponded water during the period of survey may have reduced the ability to achieve representative ground strikes in affected areas from this particular single survey. However, multiple LiDAR captures at different time periods in the future will eliminate this effect and result in a more reliable baseline being established over time.

Arrow Energy is planning to undertake four LiDAR surveys in 2023. OGIA will progressively provide an update on the effectiveness of this approach. OGIA will also continue to facilitate engagement across stakeholders to seek views in relation to farming practices and how they may influence selection of appropriate timing for the survey, and evaluate options for making LiDAR data available to stakeholders in the first half of 2023.

7.3 Update on trend monitoring

Ground movement is interpreted from radar signals (InSAR) and therefore the application of different processing techniques and methods for this data means that the coverage and magnitude of interpreted ground motion is subject to change. Interpreted InSAR data was acquired and analysed further for the UWIR 2021 to understand background natural variability and historical impacts from CSG activities around the western Condamine Alluvium. The UWIR reported that since 2015, the available data indicated about 100 mm of CSG-induced subsidence at mature gas field areas near the Condamine Alluvium, and that natural or ‘background’ ground movement unaffected by CSG development had been in the order of ±25 mm/year.

OGIA committed to the acquisition of additional InSAR data (within the UWR cycle), reporting of observed trends in ground motion, making available of data to stakeholders, and ongoing evaluation of best-practice techniques for InSAR processing. Since the UWIR 2021, OGIA has acquired additional InSAR data for the same area presented in the UWIR 2021 from the same survey provider, TRE Altamira. The data now covers a period until August 2022.

To improve confidence and to get a better insight and coverage of the data, OGIA is also in the process of:

- acquiring data from other sources (commercial and research organisations) to facilitate comparison
- continuing discussions with TRE Altamira to seek more insight on the conversion method, better coverage and reliability of individual points – within the limits of the confidentiality of the provider's method.

Through this ongoing improvement process, OGIA is gradually improving understanding of the data and classifying each available data point as being of either high or low confidence, based on the attributes of the reflector – such as a CSG well, field or silo – and whether the reflector can provide a representative signal. Key observations so far from this updated data suggest that natural or 'background' ground movement unaffected by CSG development is still in the order of ±25 mm/year, overall trends are similar to those reported in the UWIR 2021, and existing CSG-induced subsidence has increased from 100 mm to about 120 mm in the last 18 months or so within mature gas fields near the Condamine Alluvium - broadly in line with model predictions in that area.

8 Update on OGIA's research, reporting and engagement activities

OGIA is continuing to update and build knowledge about the regional groundwater flow system through its ongoing research programs, industry initiatives and research by other organisations.

Since the release of the UWIR 2021, a range of additional datasets have also become available, particularly geological and formation property data from additional CSG wells and groundwater monitoring data, obtained through UWIR obligations as well industry's own monitoring initiatives. OGIA continues to assimilate these additional datasets to improve the hydrogeological conceptualisation, unpack historical impacts from monitoring data and constrain groundwater models used for impact predictions.

Current and ongoing research activities in each of OGIA's key focus areas are summarised below.

8.1 Conceptualisation

- Improved understanding of connectivity between the Condamine Alluvium and the Walloon Coal Measures through acquisition of additional data and additional focus on influence of the Horrane Fault.
- Integration of indigenous knowledge and furtherance of understanding of the cultural heritage values associated with high-risk springs.
- Characterisation of the Springbok Sandstone contact with the Walloon Coal Measures to better understand the permeability structures within the Springbok Sandstone and improve prediction of impacts in this formation.
- Improved understanding of heterogeneity within the Hutton Sandstone, its hydrogeological characteristics and those of any potential connectivity features, such as faulting – including further analysis of groundwater pressure trends and hydraulic gradients.
- Assessment of lateral and vertical connectivity of the Precipice Sandstone in target areas, to improve understanding of impact pathways for CSG and conventional oil and gas-induced impacts; focusing on areas in and around the Moonie wellfield and contact zones associated with the Peat field and the Hutton-Wallumbilla Fault, this will also incorporate more recent investigations by the University of Queensland and Origin.
- Further development of the trend analysis methods developed for the UWIR 2021 to unpack the contribution of different stresses reflected in monitoring data.
- Development of a range of tools for establishing and exploring baseline conditions in relation to CSG-induced subsidence.

8.2 Geological modelling

- Regional compilation, re-processing, normalisation and interpretation of wireline logs to compile a database of geophysical data to improve the understanding of hydrogeological and geomechanical properties in reservoirs, aquifers and aquitards within the Surat CMA.
- Stratigraphic interpretation from new airborne electromagnetic data to improve geological models in the near-surface.

- Development of several detailed sub-regional geological models to support conceptualisation and modelling projects.

8.3 Groundwater and subsidence modelling

- Exploring ways to maximise the use of ground motion data for integrated groundwater model calibration and continued development of the long-term modelling strategy.
- Refining modelling techniques and tools (including re-calibration with more up-to-date InSAR data) for sub-regional and local-scale subsidence modelling to inform understanding of the consequences of predicted subsidence (supporting the GFCQ).
- Exploring the contribution of specific factors, such as coal shrinkage, that could affect CSG-induced subsidence. Early analysis indicates that this may be of relevance particularly affecting subsidence in late stages of development. OGIA is also exploring ways to represent this in future modelling more explicitly, compared to its implicit representation through calibration in the current modelling.
- Developing numerical methods for separation of CSG-induced subsidence signals from overall ground movement derived from InSAR data.
- Development of a re-parameterised and fine-scale model to support future management of subsidence at a smaller scale.
- Exploring landscape-level and catchment-level impacts from predicted subsidence.

8.4 UWIR 2021 companion documents

As stated in s1.8 of the UWIR 2021, in order to maintain the readability of the UWIR, additional technical details are provided in a series of ‘companion documents’, which OGIA intends to update progressively. Several companion documents were prepared and released at the time of the UWIR or immediately thereafter, including:

- Surat CMA and its groundwater systems (OGIA21CD04)
- Status of coal seam gas and conventional petroleum and gas development in the Surat CMA (OGIA21CD01)
- Existing and proposed coal mining in the Surat Basin (OGIA21CD02)
- Modelling of cumulative groundwater impacts in the Surat CMA: approach and methods (OGIA21CD15)
- Details of the Water Monitoring Strategy for the UWIR 2021 (OGIA21CD20).

Preparation of additional companion documents were planned and referenced in the UWIR 2021. However, in the post-UWIR period, OGIA diverted significant resources to address emerging concerns from landholders on subsidence matters, supporting the GFCQ in assessing consequences of subsidence and developing potential options for its management. In particular, this included additional sub-regional and local-scale modelling, exploring new techniques for modelling to maximise use of available data, improving understanding of monitoring methods and data interpretation, very intensive engagement with landholders and other stakeholders, and information sessions. This reallocation of resources affected the preparation and finalisation of the remaining companion

documents. It is to be noted, however, that only the five companion documents listed earlier in this section formed part of the UWIR approval process. Other reports were effectively deemed optional.

9 Conclusions

There have been changes to the planned production footprint and timing of commencement of CSG development within the existing tenures since the UWIR 2021 was prepared. However, there is no net change to the overall footprint or number of projected CSG wells as a result. Associated water extraction from existing wells has also continued to decline to now 52,000 ML/year.

As a result of slight delays in planned production in some areas, 48 of the 108 bores identified in the UWIR 2021 as IAA bores are now predicted to be impacted by more than five metres by the end of 2025 instead of three-year threshold to the end of 2024 that was used in the UWIR. Make good agreements of 233 IAA bores identified so far from all previous UWIRs are progressing further. There are now 147 IAA bores with make good agreements in place, compared to 135 at the time of the UWIR 2021.

There are some delays in implementing the monitoring strategies of the UWIR 2021 – primarily due to a combination of logistical issues from higher-than-average rainfall and continued supply chain disruptions from the pandemic. This is unlikely to materially affect overall regional cumulative assessment and progression of research activities.

Implementation of the SIMS is progressing well and no further action is triggered based on the monitoring of groundwater trends at specified locations.

Inferred CSG impacts derived from additional monitoring data are progressing as expected. In the Walloon Coal Measures, impacts are still largely restricted to the gas fields themselves and the immediately surrounding areas. Declining groundwater pressure trends continue to be observed across the Hutton Sandstone due to non-CSG factors.

In relation to subsidence, capturing of monitoring data is continuing broadly as planned. Additional ground motion data collected since the UWIR 2021 indicates that the subsidence trend in and around the Condamine Alluvium has continued as anticipated, with an increase to about 120 mm.

Appendix A

Table A 1 – Update to IAA bore registration numbers

UWIR 2021 temporary RN	GWDB RN	Responsible tenure holder
1200001020	192514	Arrow
1200001083	192511	Arrow
1200001084	192512	Arrow
1200001203	192515	Arrow
1200001305	192416	Origin
1200001670	192519	New Hope Group
1200001704	192516	New Hope Group
1200001746	192541	QGC
1200001761	192518	QGC

Department of Regional Development,
Manufacturing and Water
GPO Box 2771, Brisbane, Queensland 4001
13 QGOV (13 74 68)
info@rdmw.qld.gov.au
rdmw.qld.gov.au

Queensland Government