Department of Natural Resources and Mines
Office of Groundwater Impact Assessment

Annual Report 2014

for the

Surat Underground Water Impact Report

December 2014

Queensland Government

Version history

Version	Date	Description
1.0	23/12/14	Approved by Randall Cox for submission to DEHP

This publication has been compiled by the Office of Groundwater Impact Assessment, of the Department of Natural Resources and Mines.

Table of contents

List of figures

Abbreviations

CDA	Central Development Area
CMA	Cumulative Management Area
CSG	Coal seam gas
DNRM	Department of Natural Resources and Mines
EHP	Department of Environment and Heritage Protection
EIS	Environmental Impact Statement
IAA	Immediately Affected Area
LAA	Long-term Affected Area
NDA	Northern Development Area
OGIA	Office of Groundwater Impact Assessment
SDA	Southern Development Area
SIMS	Spring Impact Management Strategy
UWIR	Underground Water Impact Report
WCM	Walloon Coal Measures
WMS	Water Monitoring Strategy

Executive Summary

The production of coal seam gas (CSG) involves the pumping of water from coal formations to reduce water pressure and release the gas. This can affect water pressures in overlying and underlying aquifers because of connectivity between the formations. Petroleum tenure holders are required to make good impairment of bore water supplies, to assess future impacts and monitor water resources. In areas of concentrated development the impacts on water pressures from multiple operations can overlap and a cumulative approach is needed. In those situations the Office of Groundwater Impact Assessment (OGIA) carries out a cumulative assessment, specifies integrated monitoring and other management requirements and assigns responsibility for implementation of separate parts of those management requirements to individual petroleum tenure holders. These assessments are set out in an Underground Water Impact Report.

The Surat Underground Water Impact Report (UWIR) was approved in December 2012. The 2014 Annual Report is the second annual report in the life of the current Surat UWIR. It describes changes that have occurred since the UWIR was prepared.

To prepare the UWIR a regional groundwater flow model was constructed to predict the impact of current and planned CSG development on water pressures in aquifers. The model is the tool currently used to assess regional impacts and has been used in the preparation of the annual report.

Production on individual petroleum leases will commence and cease at different times over the life of the industry. The collective set of commencement and cessation times is the cumulative industry development profile. The cumulative industry development profile is used as input to the UWIR groundwater flow model to predict impacts on water pressures. Industry planning for development will change over time for many reasons. Therefore it is updated every year and predicted impacts are reassessed.

The industry development profile has been updated for 2014. As for 2013 there has been little change to the long-term footprint of planned development, with some expansion in fringe areas and some contraction in others. However, there have been significant changes with regard to timing. In 2013 it became clear that CSG development was not beginning as early as planned at the time the UWIR was prepared. In 2014 there has been some further rescheduling to later development.

The changes to the industry development profile do not change the extent of long-term predicted impacts. However because of the changes to the scheduling of commencement there have been changes to the short-term predicted impacts. In 2013 it was reported that the short-term impacts would be smaller for the most part than previously predicted. In 2014 that trend has continued.

The UWIR specifies a regional monitoring network and assigns to individual tenure holders responsibility to implement separate parts of the network. Installation continues to be behind schedule, due primarily to land access issues, although 90% of the first phase of monitoring installations is expected to be in place by March 2015. A range of technologies has been employed by tenure holders to address the technical challenges of monitoring in deep gaseous environments. A review of the monitoring installations that have been constructed is in progress. Reassessment of the requirements for the second phase of monitoring point installation will be carried out as part of the updating of the UWIR in December 2015. It is too early in the development of the industry to detect any clear water pressure impacts in aquifers resulting from CSG water extraction.

The UWIR identifies where there is a predicted long-term pressure impact in any aquifer underlying a spring. It specifies monitoring requirements at 10 spring complexes and five watercourse springs. The monitoring seeks to provide information about the background variability in the hydraulic function of the springs. Monitoring is in progress with results showing significant variability in flow which is likely to be related to seasonality in rainfall, evapotranspiration and local groundwater contributions.

The UWIR also identifies five spring complexes where water pressure impacts are predicted in the source aquifer for the springs in the long term. Although the predicted pressure impacts are relatively small (up to 1.5 m), tenure holders have been required to investigate options to prevent or mitigate impacts. Those assessments show that at two sites effective mitigation options are available for activation when and if necessary. At two other sites new geological information is likely to result in revised water pressure impacts which are smaller and later than currently predicted when the groundwater flow model is revised. At the fifth site, where impacts are the smallest, new monitoring data will continue to be evaluated before mitigation options are considered further.

A major current focus for OGIA is to undertake a range of technical research projects to build new knowledge about the groundwater flow system. Outcomes from the projects will be incorporated into the construction of a revised groundwater flow model which will be used in updating the UWIR in 2015. The projects are being carried out by OGIA in collaboration with commonwealth research agencies, universities and petroleum tenure holders. Project summaries are as follows.

Geological model: A revised geological model for the Surat and southern Bowen basins is nearing completion. The model incorporates detailed geological and geophysical information from some 3000 CSG wells and other improvements. It will form the basis for construction of a revised groundwater flow model.

Hydraulic parameters: Hydraulic parameters relate to the ease with which water can move through and between geological formations. Knowledge has improved through detailed analysis of wireline log data and water bore data.

Condamine Connectivity: Connectivity between geological formations is important for the whole system, but it is a particular interest in the Condamine area because of the economic value of the groundwater resource in the Condamine Alluvium. Bores have been surveyed to collect new water pressure data. The water pressure and hydro-chemical data suggests that there has been little past movement of water between the Condamine Alluvium and the underlying coal formations. Aquifer pump tests have been carried out at two sites with preliminary results suggesting that vertical permeabilities are consistent with those used in the current groundwater flow model.

Spring Function: The nature of how a spring has formed and how it is connected to a source aquifer will affect the susceptibility of the spring to a change in water pressure. Field data has been collected at representative springs to better define spring function, and new investigation bores have been established at key sites. This will enable an improved assessment of risk when the UWIR is updated.

Groundwater flow modelling: Improved methodologies for regional groundwater flow modelling, to better simulate CSG water extraction and represent the complex geology of the coal formations, have been developed. The construction of a revised regional groundwater flow model will commence in early 2015.

Chapter 1: Introduction

1.1 Regulatory framework

Under the Queensland regulatory framework, petroleum and gas tenure holders have rights and responsibilities in relation to the extraction of groundwater in the process of producing petroleum and gas. These responsibilities include to 'make good' impairment of private groundwater supplies caused by the water extraction activities and to carry out monitoring and other management activities.

In areas of concentrated development, the impacts of groundwater extraction activities by multiple petroleum and gas operations on groundwater resources can overlap and an integrated management approach is needed. Such an area of overlapping impact can be declared to be a 'cumulative management area' (CMA). When a CMA is established, the Office of Groundwater Impact Assessment (OGIA) becomes responsible for carrying out a cumulative impact assessment and preparing an Underground Water Impact Report (UWIR) which contains:

- predictions of cumulative short and long-term impacts on water pressures in aquifers
- a regional water monitoring strategy
- a regional spring impact management strategy
- assignments of management responsibilities to individual tenure holders
- a research program to build knowledge to improve predictions of impacts.

The significance of the component parts of a UWIR are as follows.

Prediction of impacts: Multiple aquifers can be affected because of interconnectivity between aquifers. Impacts are identified using a regional groundwater flow model. For each affected aquifer an Immediately Affected Area (IAA) is identified. The IAA for an aquifer is the area where water pressure reductions of more than statutory triggers (five metres for consolidated aquifers such as sandstone and two metres for unconsolidated aquifers such as alluvium) are predicted within three years. For bores sourcing water from the aquifer in its IAA, responsible tenure holders must, on approval of the UWIR, carry out a bore assessment and enter into a make good agreement with the bore owner. This proactive arrangement ensures make good actions are timely. A Long-term Affected Area (LAA)—where modelling indicates that the statutory triggers may be exceeded at any time in the future—is also identified to show the predicted whole-of-life regional impacts.

Regional Water Monitoring Strategy (WMS): Specifies a regional network of monitoring bores for water pressure and water quality data collection, to improve the accuracy of future regional groundwater flow modelling.

Regional Spring Impact Management Strategy (SIMS): The flow of water to springs can potentially be affected by groundwater extraction. The SIMS specifies spring monitoring and other spring management arrangements that are needed to understand and manage risks to springs.

Assignment of management responsibilities to individual tenure holders: Rules in the UWIR assign responsibilities for implementation of component parts of the WMS and SIMS to individual tenure holders. Rules also provide for the identification of a single petroleum tenure holder as being responsible for make good responsibilities in relation to any particular water bore.

Research: A UWIR is revised every three years to take into account new knowledge from research and monitoring data. The UWIR describes the research program.

1.2 The Surat Underground Water Impact Report

The Surat CMA was established in April 2010. As a result the Surat UWIR was prepared. It was approved by the Department of Environment and Heritage Protection (EHP) in December 2012.

The Surat UWIR is currently being implemented. It will be revised to incorporate new knowledge in December 2015.

1.3 Purpose of the Annual Report

Annual reports are prepared to provide updates about changes to circumstances that would impact on the predictions in the 2012 Surat UWIR, and to provide updates on the implementation of management strategies specified in the UWIR. The first annual report was prepared in December 2013. The annual report for 2014 is the final annual report in the current reporting cycle. In December 2015 the UWIR will be updated based on the current industry development profile and on a revised groundwater flow model.

Chapter 2: Update on industry development profile

2.1 Planned development

In order to prepare the Surat UWIR, a whole-of-life cumulative industry development profile was prepared and used as the input scenario for the regional groundwater flow model. Output from the model provided short-term and long-term predicted cumulative impacts on water pressures in aquifers for the given cumulative development profile.

Information about the cumulative development profile used for the UWIR was provided in Figures A-1 and A-2 of the UWIR. Those figures showed the then planned time of commencement and cessation of production on tenures across the CMA. The cumulative development profile was prepared by obtaining planned development information from individual tenure holders.

Many factors can change development planning over time. Changes can relate to the timing of development of individual petroleum lease areas, or to changes to the long-term footprint of development through the relinquishment of leases altogether or expansion into new areas.

Since changes to the cumulative development profile can alter the predicted impacts, changes are reviewed annually.

2.2 Changes to planned development

The current cumulative development profile is provided in Figures 1 and 2. Significant changes since the UWIR was prepared are described in the following sections.

2.2.1 Changes in 2013

Changes to planned development during 2013 were described in the 2013 annual report. Generally there was at that time little change to the long-term footprint of planned development, but there were significant shifts in the timing of development. The long-term footprint had contracted slightly to exclude some lands in Arrow Energy's southern development area and also along the easterly extent of Arrow's holdings to the north of Dalby. All of the tenure holders reported significant changes in timing of commencement. For the most part commencement had been set back further in time although in some small areas it had been brought forward.

2.2.2 Changes in 2014

The changes during 2014 have continued trends established in 2013. Overall the planned long-term footprint has contracted slightly although there are areas of expansion as well as areas of contraction. The timing of development has also been set back further in many areas although it been brought forward slightly in some areas. Further detail is provided in the following sections.

Santos/GLNG:

In late 2014 Santos GLNG published for public comment a draft EIS for the Santos GLNG Gas Development Project (GDP). The Santos GDP provides for the ongoing development of the gas fields of the Santos GLNG project, broadly covering the originally planned area. The EIS states that it provides for the maximum possible development with actual development expected to be more limited. This is reflected in the planned development information provided by Santos GLNG for the current annual report which shows a smaller development footprint than that outlined in the draft EIS.

Since 2013 the overall long-term footprint of planned development has contracted slightly with expansion in some areas and contraction in others. Expansion areas include Arcadia and western parts of the Fairview field. Contraction areas include the eastern flank of Fairview and the south western part of the Roma field.

Since 2013 the timing of development has been further set back in some areas. In general terms, production across Santos GLNG's Roma tenements, and expansion of production areas across the Scotia and Fairview tenements have been set back to commence in 2015 or later. Planned commencement in peripheral areas of the Roma and Arcadia tenements have been set back to 2020–25.

Origin APLNG:

Since 2013 the planned Origin APLNG long-term footprint of development has expanded slightly to include areas on the east and west margin of the Spring Gully tenures, and north of the Ironbark tenures.

Since 2013 the timing of development has been set back in some areas. In particular, planned commencement in parts of the Combabula/Ramyard area has been set back from 2019 to 2026. Commencement has been brought forward on the eastern edge of the Talinga field.

QGC:

There have been no significant changes to the long-term footprint of planned development and timing of development in the QGC Central Development Area (CDA) since 2013.

In the Southern Development Area (SDA), since 2013 the long-term footprint has contracted significantly to exclude the majority of the western half of this area. There have also been minor changes to timing.

In the Northern Development Area (NDA), since 2013 the long-term footprint has contracted to exclude an area south of Wandoan. The timing of development over the area has also been set back by 2–4 years.

Arrow Energy:

Since 2013 there have been no significant changes to the Arrow Energy planned long-term development footprint or timing of development.

2.3 Summary of changes to planned development

Since the UWIR was prepared there has been a trend to the rescheduling of development to commence at later dates. It can be expected that the commencement dates will continue to be adjusted as tenure holders adjust the rate of tenure development in response to increasing knowledge about the relative productiveness of parts of tenures, as well as market conditions.

The long-term footprint of planned development has also changed. All tenure holders have made adjustments involving expansions or contractions of their planned development areas. The cumulative effect is a slight contraction in the long-term footprint of planned development.

Although the number of constructed wells has increased from around 4100 to 6400, most of these are appraisal wells or wells that will not be brought into production until a later stage.

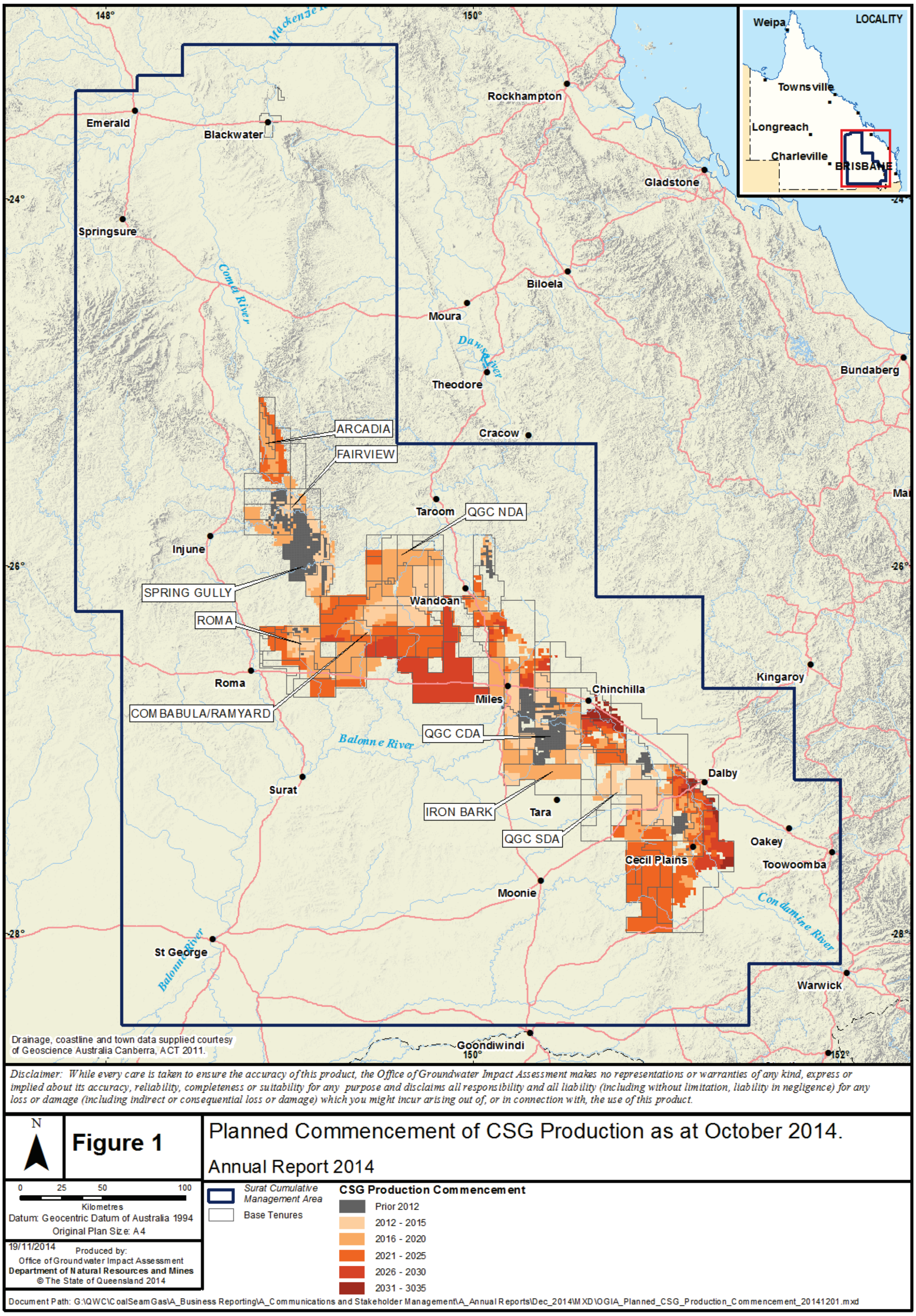

Figure 1: Planned Commencement of CSG Production as at October 2014

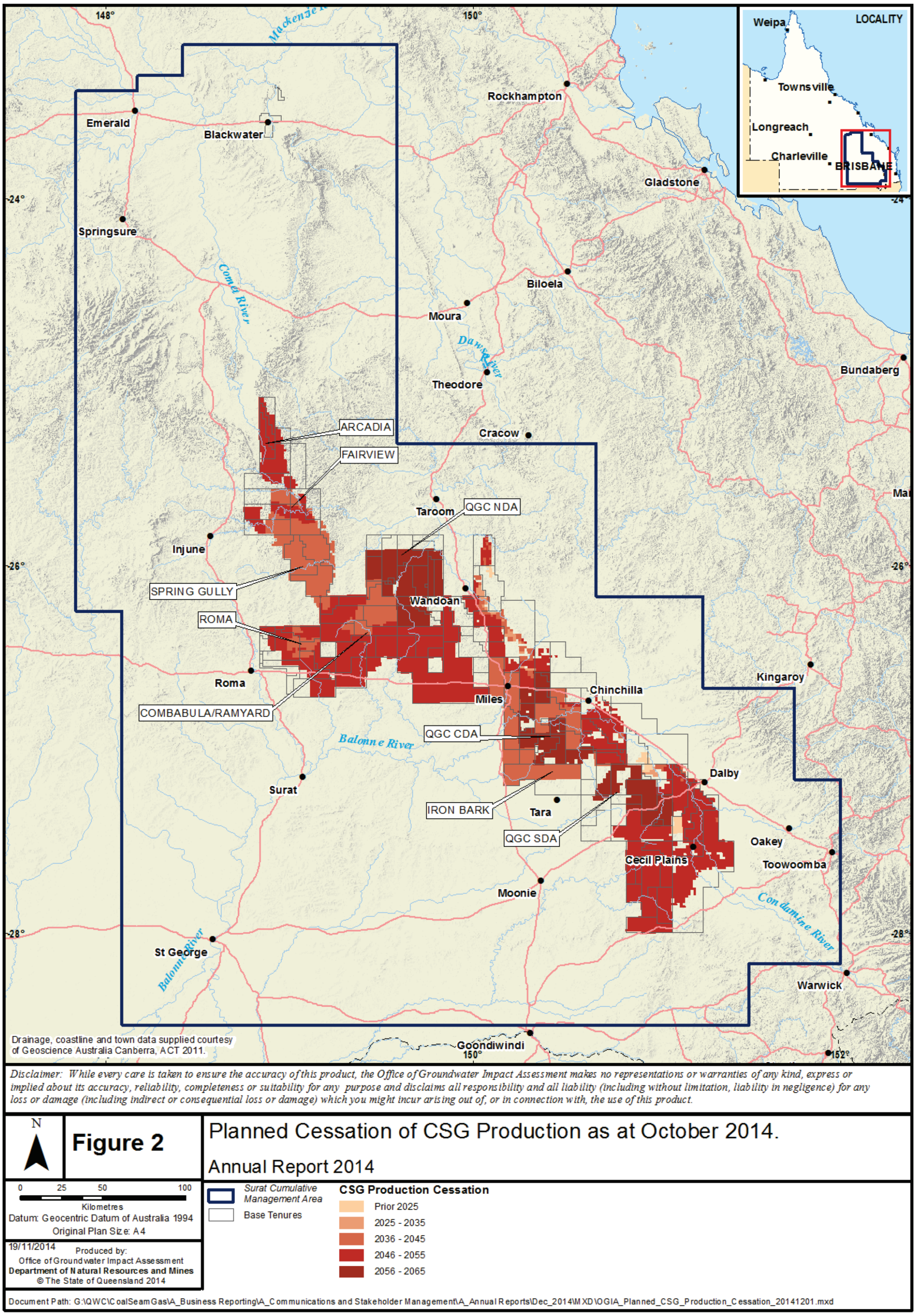

Figure 2: Planned Cessation of CSG Production as at October 2014

Chapter 3: Update on predicted impacts on water pressures

3.1 The UWIR groundwater model

A regional groundwater flow model was constructed to support the preparation of the Surat UWIR. It was used for predicting the impact of the cumulative industry development profile on water pressures in aquifers. Since then, minor amendments have been made to the model arising from local issues and to improve the operational efficiency of the model, as described in the 2013 annual report.

The UWIR groundwater flow model is recognised as the most up to date and comprehensive model for cumulative groundwater impact predictions for the Surat CMA. It is used by OGIA for annual reporting purposes, and by the tenure holders to meet various regulatory requirements.

A revised regional groundwater flow model will be developed to support the updating of the UWIR in December 2015. OGIA has carried out a range of research projects to build new knowledge about the groundwater flow system. That new knowledge will be incorporated into the revised model.

3.2 Assessing changes to predicted impacts

Changes to the whole-of-life cumulative industry development profile that have occurred since the preparation of UWIR are described in Chapter 2. The UWIR groundwater flow model has been used to predict the impact of the current cumulative development profile on water pressures in aquifers.

This chapter describes the differences between the predictions in the UWIR and the predictions made using the current cumulative industry development profile.

3.3 Changes to short-term impacts

The UWIR identified the Immediately Affected Areas (IAAs) for each aquifer. The IAA for a consolidated aquifer such as sandstone is the area where water pressure is predicted to decline by more than five metres within three years as a result of water extraction for CSG development. An IAA of any significance was only identified for the Walloon Coal Measures (WCM). On approval of the UWIR, responsible tenure holders commenced bore assessments for the 85 bores recorded as tapping the WCM within its IAA (the ‘IAA bores’) and entering into agreements to make good the expected impairment of water supply.

3.3.1 Changes in 2013

Changes to the cumulative industry development profile between the preparation of the UWIR and 2013 were described in the 2013 annual report. The most significant change was the rescheduling of commencement to later times. As a result 28 of the IAA bores were then predicted to not experience impact of more than five metres until after 2015. However, because commencement was brought forward in some small areas, four bores were newly predicted to experience five metres of impacts before the end of 2015. Tenure holders were advised and bore assessments were completed.

3.3.2 Changes in 2014

The trends established in 2013 have continued into 2014 with timing of development being set back further in many areas. As a result an additional 12 of the IAA bores are now predicted to not experience impact of more than five metres until after 2015.

3.4 Changes to long-term impacts

The UWIR also identified the Long-term Affected Areas (LAAs) for each aquifer. The LAA for a consolidated aquifer such as sandstone is the area where water pressure is predicted to decline by more than five metres at any time in future.

Changes to the cumulative industry development profile have not resulted in significant changes to the LAAs of the aquifers.

Chapter 4: Corrections to bore records

4.1 Bores in Immediately Affected Areas

If the supply from a water bore is impaired as a result of CSG water extraction, the responsible tenure holder has an obligation under the *Water Act 2000* (the Act) to carry out a bore assessment and enter into an agreement with the bore owner about measures to make good the impairment.

The Act includes arrangements to trigger proactive action which seeks to ensure make good measures are in place before impairment occurs. It requires that, on approval of a UWIR, the responsible tenure holders carry out assessments of bores that tap an aquifer within the IAA for the aquifer and enter into a make good agreement with the bore owners about measures to make good impairment of bore supply. This is based on the premise that a water pressure decline of five metres in a bore in a consolidated aquifer would pose a significant risk of impairment to the water supply available from the bore.

Together with the maps showing the IAAs, the UWIR included a list of the water bores understood to tap an aquifer within its IAA. The list was provided to assist tenure holders in carrying out their responsibilities and also for community information purposes. The bores were identified using records in the DNRM groundwater database about the locations of bores and the aquifers tapped by the bores. The UWIR thereby identified 85 bores as accessing the WCM within the IAA for the formation.

The data in the DNRM groundwater database has been assembled from many sources over many years. In some cases the data held can be inaccurate or incomplete. Therefore, it was expected that information collected in the process of carrying out bore assessments, as well as from other sources, would result in corrections to the database.

4.2 Corrections to bore records

4.2.1 Corrections made in 2013

Bore assessments for each of the 85 identified bores commenced following approval of the UWIR in December 2012. In 23 cases the bore assessment concluded that the source aquifer for the bore is a shallower aquifer than the aquifer identified in the DNRM groundwater database. For most of these cases the recording of a coal band in the driller's log led to the WCM being recorded as the source aquifer rather than the Springbok Sandstone, which can contain some small coal bands. As a result, a water pressure reduction of more than five metres was not expected for those 23 bores in the short term. The CSG Compliance Unit and OGIA endorsed the results of the assessments and landholders were notified accordingly by EHP.

The CSG Compliance Unit also investigated situations where there was information to suggest that a bore had been incorrectly omitted from the list of bores predicted to experience a pressure reduction of more than five metres in the short-term. Three (3) such bores were identified. These bores were either not registered in the DNRM groundwater database or had the source aquifer incorrectly recorded. EHP notified the bore owners and tenure holders that bore assessment was required for these bores.

4.2.2 Corrections made in 2014

Most of the errors in records for bores in the IAA were identified in the immediate period following approval of the UWIR. During 2014 the CSG Compliance Unit identified only five additional errors. For all cases the records were corrected to show that the bores source water from the WCM. Because these bores are now known to source water from the WCM from within the IAA for the formation, a bore assessment and make good agreement with the bore owner is required. EHP has notified the bore owners and tenure holders accordingly.

4.3 Significance of the changes to bore records

As a result of corrections made in 2013 and 2014 the number of bores that source water from the WCM within the IAA specified in UWIR has changed from 85 to 70.

Bores that have been found to be sourcing water from an aquifer that is shallower than the WCM, will not be affected until a later time, and may not be affected at all. For bores that have been found to be tapping the WCM, a bore assessment and make good agreement is required.

4.4 Future corrections

The 2014 annual report is the last annual report for the current cycle of assessment. In late 2015 OGIA will publish an updated UWIR for consultation. That report will be based on a revised regional groundwater flow model and an updated industry development scenario, resulting in updated IAAs for aquifers.

In the process of preparing the UWIR, OGIA will work with the CSG Compliance Unit to ensure that records in the DNRM groundwater database for bores in key areas, including the predicted IAA and LAA areas, are as accurate as possible, minimising the need for future corrections.

Chapter 5: Implementation of UWIR Water Monitoring Strategy

5.1 The UWIR Water Monitoring Network

The UWIR specified a regional monitoring network at 142 separate monitoring sites comprising 498 monitoring points for water pressure monitoring and 120 monitoring points for water quality monitoring. Of these, some were in existence at the time the UWIR was prepared, others were to be installed by the end of 2013, with the remainder to be installed by the end of 2016.

The regional monitoring network is designed for the collection of long-term data to meet multiple objectives related to regional assessment. There is additional monitoring carried out by tenure holders and DNRM to meet other objectives. OGIA also utilises that additional data, as appropriate, in carrying out assessments.

The UWIR assigns to individual tenure holders responsibility for implementing specified parts of the regional monitoring network. The UWIR recognises that the location of the identified sites may need to be altered during implementation due to practical operational issues. It provides for tenure holders to propose to OGIA variations to implementation requirements that overcome operational constraints while not undermining the overall objectives of the monitoring network.

5.2 Installation of the Water Monitoring Network

5.2.1 Changes to monitoring point locations

Tenure holders have proposed a number of variations to the location of monitoring sites because of operational issues. While most of the variations involve relocation over short distances, some involve more complex sets of changes. OGIA has ensured that these variations collectively retain value in terms of the monitoring objectives.

5.2.2 Progress with installation

The UWIR calls for monitoring points to be installed in two phases. The first phase was targeted for installation by the end of 2013. The second phase was targeted for 2016. This arrangement allows for new knowledge developed during the implementation of the UWIR to be used to review the requirements for the second phase as a part of the process of updating of the UWIR in 2015.

Significant progress has been made on the installation of the first phase. As at September 2014 some 60% of the required monitoring points were operational. Tenure holders have reported that most of the delays are associated with the time required to arrange land access to sites. By March 2015 some 90% of the required points are expected to be operational.

For more than half of the remaining first phase monitoring points, new geological or geophysical information has shown that it is not practicable to install the monitoring point. In those cases the target geological formation is not present or is not present at the expected depth, or has an unexpected hydrogeological character. The intention is to respecify the requirements for those points as part of the review of the UWIR in 2015.

5.2.3 Review of monitoring installations and instrumentation

There are a range technical issues that have to be overcome in implementing the monitoring network. The network requires the safe installation of monitoring points in gaseous environments in the coal formations as well as in underlying formations at depths of up to 1500 metres. Also, because connectivity between formations is a key consideration for ongoing assessment and management, monitoring points are being installed in low permeability environments where installations with short screen horizons can take long periods to equilibrate with background formation pressure.

These requirements pose technical challenges in terms of monitoring techniques and a variety of approaches have been taken by tenure holders to deal with those challenges. There is a need to evaluate the approaches that have been used and the success of outcomes.

Another issue concerns older monitoring points. At the time of preparation of the UWIR, there were a number of monitoring points already in existence. The monitoring network specified in the UWIR requires the installation of new points to complement those existing at the time. However, some of the older installations were not constructed as dedicated long-term monitoring points, and it has become clear that they are not all suitable for long-term monitoring purposes. Replacement of some installations is in progress.

Because of the above issues, OGIA is carrying out a review of monitoring points with regard to both construction and instrumentation to identify the most appropriate systems and identify any adjustments necessary. The review will assist with decisions about what weight to place on individual data elements when constructing the revised regional groundwater flow model and updating impact predictions. The review is being carried out in consultation with tenure holders.

5.3 Water pressure trends

The monitoring network is designed to provide data to meet a range of objectives relevant to improving knowledge about the groundwater flow system so that modelling of future impacts can continue to be improved. One of the objectives is to identify trends in water pressure caused by water extraction by CSG operations. Although monitoring data has been accumulated over time for shallow aquifers, data from coal formations and the aquifers above and below these formations have, for the most part, only become available over the last two years. A number of the recently installed monitoring points suggest a decrease in pressures over the period, which is not unexpected. However, data from other nearby installations suggest increases in pressures.

Overall, there are no discernible regional-scale trends evident at this time in the main CSG target units and other formations. Even where individual bores do indicate potentially significant water pressure changes, this is not necessarily indicative of CSG extraction impacts. Other factors can, and do, influence water pressures in the area. These include the impact of non-CSG related extractions and trends caused by issues with installation and instrumentation.

Subject to the findings of the previously mentioned review of monitoring installations and data, the following comments are made with regard to water pressure trends in response to CSG operations:

- The WCM is the CSG-bearing formation in the Surat Basin. Water pressure behaviour in the WCM is variable with no discernible regional-scale trends evident at this time. The formation is heterogeneous, with monitoring works being installed in a range of materials in gaseous environments using a variety of techniques. In general the recorded decrease in pressure in and around areas of CSG development has been less than anticipated. This could be related to issues with installation and instrumentation systems as previously discussed, or be related to complexities associated with permeability variations within the WCM.

- The Springbok Sandstone is the aquifer overlying the WCM. As for the WCM, water pressure behaviour in the Springbok is variable with no discernible regional trends evident at this time. Whilst some bores suggest a decrease in pressures over the monitoring period, others suggest an increase.

- The Hutton Sandstone is the aquifer underlying the WCM. As for the WCM and the Springbok, water pressure behaviour in the Hutton is variable with no discernible regional trends evident at this time. Whilst some bores suggest a decrease in pressures over the monitoring period others suggest an increase.

- The Precipice Sandstone is the basal formation of the Surat Basin. It comes into contact with the Bandanna Formation, the gas bearing formation of the Bowen Basin, in the northern part of the CMA. The data available from the area at this time is scattered and limited. It shows some decrease in pressure but no discernible trend.

- For other aquifers there is no discernible trend in water pressures which could be related to CSG development.

5.4 Monitoring network review

OGIA will review the UWIR water monitoring strategy as a part of the updating of the UWIR in 2015. The review will take into account the then existing monitoring network, new understanding about the hydrogeology of the system established through research activities, and the outcomes of the current review of existing monitoring installations and instrumentation.

Chapter 6: Implementation of the UWIR Spring Impact Management Strategy

6.1 The UWIR Spring Impact Management Strategy

The Spring Impact Management Strategy in the UWIR identified springs that may be at risk due to an underlying aquifer(s) being affected by CSG water extraction. The criteria for identifying potentially affected springs was conservative being springs overlying an aquifer with predicted long-term pressure impacts of 0.2 metres.

As noted in Chapter 2 there have been some small changes to the cumulative industry development profile. This has resulted in slight alterations to the limits of long-term predicted impacts as described in Chapter 3. These alterations do not significantly change the situation with regard to predicted impacts at the location of springs.

The UWIR also included a risk assessment for springs and specified a monitoring program for 10 spring complexes and 5 watercourse springs that have higher risk of being affected. Responsibility for implementing the monitoring program was assigned to individual tenure holders.

Among the springs to be monitored is a group of five complexes which, on the basis of UWIR model predictions, are expected to experience some decrease in pressure in the spring's source aquifer. For those springs the UWIR requires tenure holders to assess options for prevention or mitigation of those impacts.

6.2 Spring monitoring

The UWIR identifies 10 spring complexes (33 spring vents) and five watercourse springs for quarterly monitoring. The monitoring approach and parameters to be measured at each site are specified in the UWIR.

The purpose of the monitoring is to build an understanding of the variability of the flow condition at the springs and existing impacts from current land use activities. It is necessary to understand these complex flow characteristics so that any later trends of change can be detected.

In addition to requirements under the UWIR, CSG companies have obligations under Commonwealth jurisdictions in relation to spring monitoring. As noted in the 2013 annual report, the responsible tenure holders collectively engaged a single contractor to undertake and meet their spring monitoring obligations. The approach has provided consistent and uniform implementation of the monitoring and uniform reporting of results to OGIA and the Commonwealth Government.

There have been minor adjustments to the sites and techniques as the spring monitoring program has progressed. These changes have occurred to accommodate site-specific conditions and have been agreed between OGIA, EHP and tenure holders. The changes are consistent with the overall objectives of the monitoring and represent a refinement to the monitoring program originally specified in the UWIR.

OGIA is currently collating and analysing the information gathered though the monitoring program and developing local-scale conceptualisations to guide assessments of risk which will form part of the update the UWIR in 2015. An early conclusion from the monitoring data is that many of the springs show significant variability in flow which is likely to be related to seasonality in rainfall, evapotranspiration and local groundwater contributions.

6.3 Prevention or mitigation of spring impacts

The UWIR identifies five spring complexes where long-term water pressure impacts in the spring's source aquifer from CSG water extraction are expected to exceed 0.2 metres at the location of the spring. The maximum long-term pressure reduction in the source aquifer at any of the sites is 1.5 metres. Although such pressure reduction may not cause significant change in actual flow to the spring and spring ecology, the UWIR required that tenure holders evaluate the options for avoiding or mitigating the predicted pressure impact in the source aquifer at the springs. Those evaluations have been carried out and the outcomes are as follows.

As noted in the 2013 annual report, at two of these sites (Barton and Scott's Creek), the potential predicted groundwater impacts are able to be fully offset by relocating existing stock water bores that currently impact on the water pressure in the source aquifer at the locations of the springs. Agreements are in place between the responsible tenure holders and the relevant bore owners to cooperate in the implementation of the measures when, and if, appropriate.

At the three other sites (Lucky Last, Spring Rock Creek and 311/Yebna 2), preliminary evaluations in 2013 found that the relocation of existing water bores to offset the predicted impacts was not viable. At these sites additional monitoring and research has been undertaken to improve the understanding of the local hydrogeological setting as follows.

At the Lucky Last and Spring Rock Creek sites, research has identified the need for significant revision of the previous understanding of the geology underlying the springs. Specifically, the previously defined location and extent of the contact between the Bandanna Formation and the Precipice Sandstone has been revised. This change will be incorporated into the revised groundwater flow model to be developed as part of updating of the UWIR in 2015. It is likely that the change will result in smaller predictions of impact and for those impacts to occur at a later time than previously predicted.

At the 311/Yebna site the predicted impacts are relatively small and are not expected to occur until 40 to 50 years from now. Spring monitoring data is now available for the site showing complex background variations. Detailed conceptualisation work is currently being carried out by OGIA. Outcomes of that work will be incorporated into the revised groundwater flow model that will be used to update the UWIR in 2015.

Given the improvement in knowledge and the timing of predicted impacts at these five sites, the need for development of options for mitigation actions will be reviewed as a part of updating the UWIR in 2015.

Chapter 7: Update on research projects

7.1 Overview

Extensive knowledge has been built over many years about the regional groundwater flow system and this was used as the basis for the development of the UWIR in 2012. However the groundwater system in the Surat Basin is complex and knowledge about the system is continuing to improve.

In preparing the UWIR the areas where knowledge would be most beneficially improved were identified. OGIA has subsequently implemented a research program to meet those needs.

OGIA undertakes research in collaboration with partners. OGIA maintains a core technical team and complements those skills with the purchase of expert services and collaborative relationships with research agencies, universities and CSG companies. This arrangement brings the best skills to bear on the research needs within a short time frame.

Separately from those collaborative arrangements, OGIA seeks advice and peer review from external experts in relation to the design of projects and project outputs.

This chapter provides a summary of the research projects that are being implemented, progress made and future directions.

7.2 Project delivery and coordination

Several hydrogeological projects are being carried out concurrently and are currently being brought together to form a new conceptualisation of the regional groundwater flow system. In parallel to the implementation of the hydrogeological projects, new approaches to groundwater modelling have also been developed. In early 2015 construction of a revised regional groundwater flow model will commence based on the new conceptualisation of the regional groundwater flow system.

7.3 Project progress

7.3.1 The geological model

A revised geological model for the Surat and southern Bowen basins is nearing completion and will form the primary foundation for understanding the groundwater flow system. It represents the distribution of the various geological formations through which and between which water flows.

The previous geological model used by OGIA was based primarily on existing interpretations of geological relationships with limited analysis of primary data. Also it did not explicitly represent geological structures such as faults. In building the revised geological model, geological and wireline log data from more than 3000 CSG wells have been incorporated. Data from individual water bores has been used. Seismic data has been utilised. Major faults have been incorporated. A specific focus has been mapping as accurately as possible the contacts between the coal formations and underlying and overlying aquifers, as the thickness of separating material has an important effect on the hydraulic connectivity between the formations.

The geological model is now sufficiently well developed to be used in the construction of the revised regional groundwater flow model. However OGIA will continue its collaboration with the School of Earth Sciences at the University of Queensland with a view to further updating the geological model to support later revisions of the regional groundwater flow model.

7.3.2 Hydraulic parameters

Hydraulic parameters relate to the ease with which water can move through and between geological formations and the capacity of aquifers to store water. The vertical permeability is particularly important because together with the thickness of the separating materials it affects the degree of connectivity between adjacent formations.

Understanding of hydraulic parameters has been improved through a detailed review the wireline logs and lithological logs of CSG wells. Some of this work has been carried out in collaboration with CSIRO and other technical specialists. Aquifer test results have also been incorporated.

7.3.3 Water pressure and hydrochemistry

Several projects analysing water pressure and hydrochemistry data have been undertaken. A review of monitoring bores installed by tenure holders is also in progress. All recorded water pressure data available from private water bores has been checked against the revised geological model to confirm which aquifers are being tapped by each bore. This is an important activity to improve confidence in the pressure data to be used in the construction of the groundwater flow model. Water chemistry data has also been assessed to improve our current understanding of the flow paths of water.

7.3.4 Condamine connectivity

Although connectivity between formations is important for the whole groundwater flow system, it is a particular focus in the Condamine area because the Condamine Alluvium contains an economically important groundwater resource and is directly underlain in places by the WCM.

Some 130 targeted bores in the area were surveyed to identify points that could be used to measure the difference in water pressures between the alluvium and the underlying WCM. More than 3000 hydro-chemical analyses were assessed to improve understanding of past water mixing. Together the water pressure and hydro-chemical data have been analysed to understand how groundwater has moved in response to pressure gradients caused by agricultural water extraction over past decades. The data suggests there has been little movement between the alluvium and the WCM.

Arrow Energy has installed nests of monitoring points at two sites, and carried out aquifer pumping tests. At the sites, landholder bores were used to pump water from the Condamine Alluvium and pressure changes were monitored at several depths. OGIA and Arrow Energy analyse the data from the tests. Preliminary analysis suggests that the vertical permeabilities are consistent with the values used in the current groundwater flow model. Data collection and analysis is ongoing.

Geological modelling has been carried out at a detailed local scale. All available geological information has been reviewed to map as clearly as possible the material between the productive alluvium and the underlying coal formation.

7.3.5 Spring function and monitoring methodology

As discussed in Chapter 6 potentially affected springs were identified in the UWIR based on predicted impacts in underlying aquifers. However, it is not only changes to water pressure in a source aquifer that determines if a spring will be affected by changes in groundwater pressure. The nature of how a spring has been formed and how it is connected to the source aquifer will affect the susceptibility of a spring to a change in source aquifer water pressure. An aim of this project is therefore to improve our understanding of the local hydrogeology in order to better understand the level of risk at each of the spring sites.

A desktop assessment of available data was carried out, followed by a field program to fill critical data gaps. This included bore water pressure and elevation surveys, spring and water bore sampling for chemical analysis, local geological mapping and geophysical investigations. Investigation bores are also being constructed at key sites to collect geological and water pressure information. The results of this work, together with predictions of water pressure impacts made using the revised groundwater flow model, will be used to reassess the risk to springs when the UWIR is updated.

Improved techniques for spring monitoring will be trialled commencing in 2015, however, it will be several years before the results provide a basis for reviewing spring monitoring procedures.

7.3.6 Groundwater flow modelling

A number of improved methodologies for the construction of a revised regional groundwater flow model to support the updating of the UWIR in 2015 have been investigated. The work has focused on identifying better and more accurate ways of simulating the CSG water extraction environment and of representing the complexity of the geological system.

OGIA has a project team that includes collaboration with Flinders University researchers and tenure holders. Alternative modelling platforms including ECLIPSE and MODFLOW-USG have been evaluated. ECLIPSE is the petroleum industry standard platform for modelling reservoirs at a local scale. MODFLOW-USG is the most recent variation of one of the water industry standard platforms for modelling regional scale groundwater flow systems. Investigation included the construction of highly detailed sector models for several subregional areas within the CMA, using both ECLIPSE and MODFLOW-USG.

An approach based on the use of MODFLOW-USG using learnings from the subregional ECLIPSE models will be finalised in early 2015 and construction of the revised regional groundwater flow model will then commence.