28. CUMULATIVE IMPACTS

The Surat Gas Project Terms of Reference requires that the EIS *"describe any cumulative impacts on environmental values caused by the project, either in isolation or by combination with other known existing or planned development or sources of contamination*". This cumulative impacts chapter fulfils that requirement.

There is no standard methodology in Queensland for the assessment of cumulative impacts as part of an EIS and there are no specific requirements in the legislation as to how cumulative impacts should be addressed. For the purposes of this chapter, cumulative impacts are defined as changes to the environment that are caused by an action in combination with other past, present and future human actions (Hegmann et al., 1999). In this cumulative impacts chapter the combined effects of different developments within a similar spatial and temporal scope are considered. Cumulative impacts occur when impacts from individual developments combine to result in an impact which is greater than the individual residual impact of each development when considered in isolation. This impact may be positive or negative. The severity and duration of the cumulative impact will depend on the timing and duration of principally construction activities, as operational activities will over time establish a new equilibrium in supply and demand.

Past and present developments are considered part of the existing environment in chapters 9 to 26 of this EIS, hence the cumulative impacts of these developments in combination with the Surat Gas Project has been assessed in the residual impacts of each chapter. This chapter provides an assessment of the environmental impact of the Surat Gas Project in synergy with the environmental impacts from future developments planned within the region.

The delineation between past and present developments and future developments for the purposes of the Surat Gas Project EIS is as follows:

Past and Present Developments: Physical development is observable (in the form of operational infrastructure but excluding projects where a financial investment decision has been made, but no physical works have been undertaken).

Future Developments: Documented evidence of a serious intent to develop and sufficient data to conduct a cumulative impact assessment exists (e.g., including an approved EIS, and detailed Initial Advice Statement (IAS) etc., but excluding early studies that do not indicate commitment such as feasibility studies).

The geographic separation of known and proposed developments in the region will reduce the severity of some impacts, particularly where the impacts are concentrated at or near the project site. However, in some instances this also serves to increase the severity of cumulative impacts, as activities are concentrated in the larger towns that provide the necessary infrastructure and services.

28.1 Legislative Context

The following legislation and policy are relevant to assessing and managing cumulative impacts:

Water Act 2000 **(Qld)**. This act provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. Under the act, a Cumulative Management Area can be declared if an area contains two or more petroleum tenures, including tenures on which coal seam gas activities operate and where there

may be cumulative impacts on groundwater resulting from water extraction by the tenure holders. The project development area falls within the Surat Cumulative Management Area.

The declaration of the Surat Cumulative Management Area means that the Queensland Water Commission (QWC) will be preparing a groundwater impact report for this area, which will identify likely future impacts on groundwater from the water extraction associated with the petroleum tenures, and provide appropriate strategies for managing these impacts.

Sustainable Resources Community Policy. This policy focuses on communities being impacted by rapid development driven by the resource industry and works to foster equitable and sustainable resource communities. One of the four key themes under the policy is 'Fostering partnerships with local government, industry and community'. These partnerships will aim to establish local leadership groups to focus on regional planning issues and key projects that will address cumulative or regional issues arising from resource development.

28.2 Assessment Method

Impacts have been assessed throughout the EIS and are described in chapters 9 to 26 and in greater detail in the technical studies within appendices C to S. Mitigation measures have been proposed to reduce the significance or risk of impacts resulting from the project. In some cases the impact may become negligible after implementation of mitigation measures and need not be considered further.

The remaining impacts are termed residual impacts. It is only these residual impacts, which could result in cumulative impacts when considered alongside impacts from other developments. Therefore only residual impacts are discussed in this chapter and are considered to be the starting point of the cumulative impact assessment.

For the purposes of this chapter, environmental and social values that are considered important for inclusion in cumulative impacts are defined within the individual discipline chapters that make up the EIS (i.e., chapters 9 to 26). Those values impacted by the Surat Gas Project, but not impacted by future developments within the same spatial and temporal scope were excluded from the cumulative impact assessment (e.g., climate adaptation and contaminated lands).

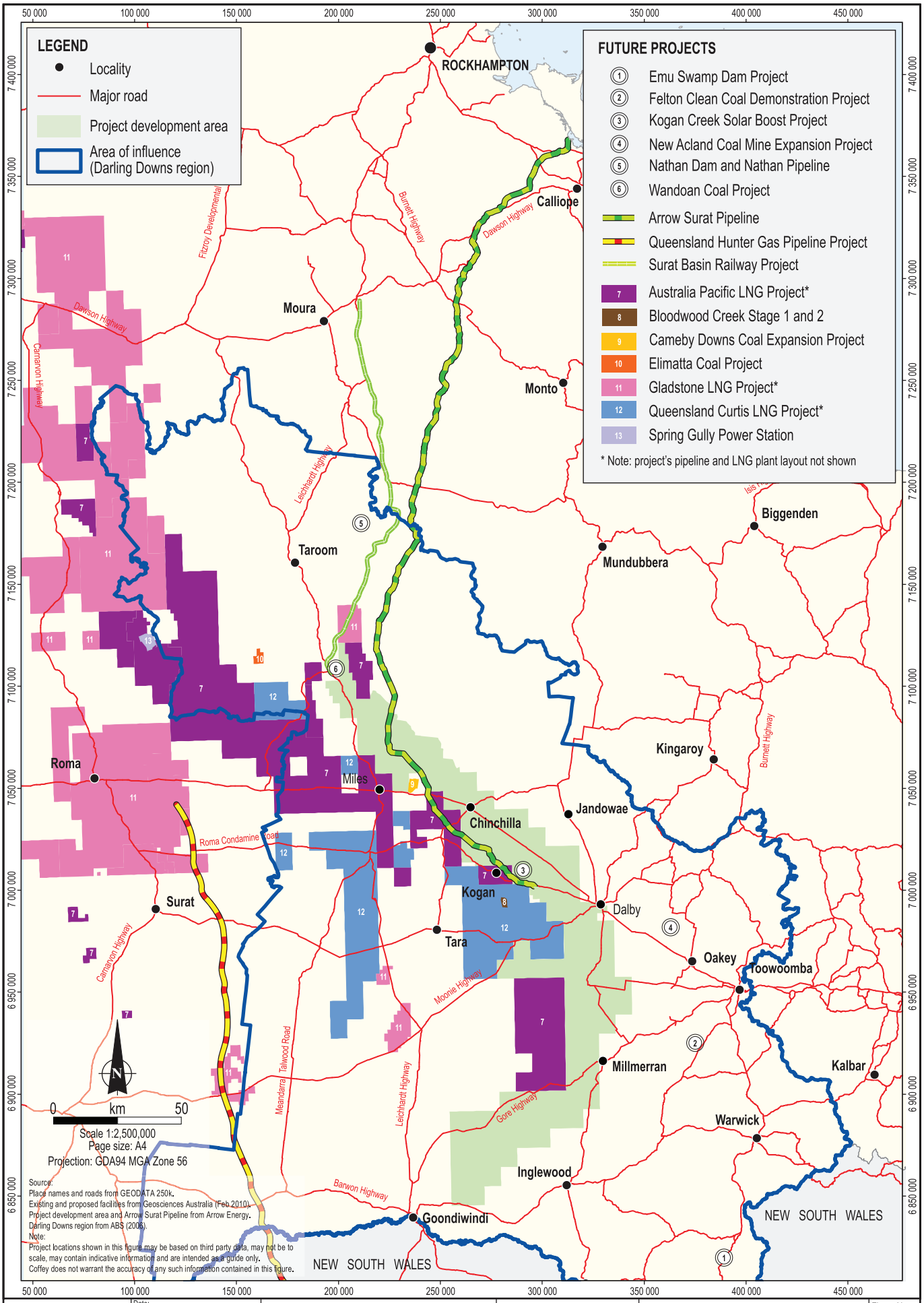
The method used to undertake the cumulative impact assessment varied with each technical study but generally consisted of a similar approach using either qualitative, quantitative, compliance assessment or descriptive methods.

All technical studies have included future developments that were within the same spatial and temporal scope as the Surat Gas Project and:

- Are being assessed under Part 1 of the Chapter 3 of the *Environmental Protection Act 1994* (Qld) with the Queensland Department of Environment and Resource Management (DERM) being the EIS Coordinator. As a minimum an IAS is available on the DERM website.
- Have been declared a 'state significant project' by the Coordinator-General under the *State Development Public Works Organisation Act 1971* (Qld) and an EIS for the project is currently being completed or is complete. As a minimum an Initial Advice Statement is available on the website of the Department of Local Government and Planning.
- Are directly associated with the development of coal seam gas projects within the Surat Basin or Clarence-Morton Basin (i.e., gas fields, gas pipelines etc).

- Will, or may, utilise resources located within the region (including materials, groundwater, road networks, workforces) that are the same as the Surat Gas Project.
- Could potentially compound residual impacts that the Surat Gas Project will potentially have on environmental or social values.

Developments that satisfied the above criteria and could reasonably and practically be assessed for impacts were included in the cumulative impact assessment. Table 28.1 outlines the developments assessed and Figure 28.1 depicts their approximate locations. The developments were categorized as coal seam gas resource projects, coal resource projects, other energy resource projects, energy infrastructure projects, transport infrastructure projects and water infrastructure projects.



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Projects considered relevant for regional cumulative impact assessment

Figure No: 28.1

Table 28.1 Future developments considered relevant for regional cumulative impact assessment

Future Developments	Description	Location	Status
Coal Seam Gas Resource Projects			
Australia Pacific LNG Project	• An Origin Energy and Conoco Phillips project to develop: - Coal seam gas fields. - A 450 km gas transmission pipeline. - An LNG facility (18 Mtpa) on Curtis Island (4 x 4.5 Mtpa trains). • Project to commence 2014. • Estimated capital of AU $35,000 million (through to 2020). • Estimated peak workforce of 2,100 for construction and 690 for operation (Gas field component only).	LNG facility in Gladstone, with gas supplied from the Bowen and Surat (near Chinchilla) Basins. *7	EIS approved with conditions in November 2010 (State Government) and February 2011 (Australian Government).
Gladstone Liquefied Natural Gas (GLNG)	• A Santos Ltd project to develop: - Coal seam gas fields. - A 435 km gas pipeline. - An LNG facility (10 Mtpa). • Project to commence 2014. • Estimated capital of US $16,000 million. • Estimated peak workforce of 775 to 975 for construction and 2,000 for operation (Gas field component only).	LNG facility in Gladstone, with gas supplied from the Bowen and Surat (near Roma) Basins. *11	EIS approved with conditions in May 2010 (State Government) and October 2010 (Australian Government).
Queensland Curtis LNG Project (QCLNG)	• A QGC Pty Ltd (BG Group Business) project to develop: - Coal seam gas fields. - A 380 km gas pipeline. - An LNG facility (12 Mtpa). • Project to commence 2014. • Estimated capital of AU $8,000 million. • Estimated peak workforce of 4,900 for construction and 530 for operation (Gas field component only).	LNG facility in Gladstone, with gas supplied from the Surat Basin (Western Downs). *12	EIS approved with conditions in June 2010 (State Government) and October 2010 (Australian Government).

Table 28.1 Future developments considered relevant for regional cumulative impact assessment (cont'd)

Future Developments	Description	Location	Status
Coal Resource Projects			
Cameby Downs Coal Expansion Project	• A Syntech Resources Pty Ltd project to expand an open cut coal mine to produce approximately 15Mtpa to 20Mtpa of product coal for export. • Water demand for project is estimated to be 8,000 - 10,000 ML a year for washing of coal, dust suppression and production of potable water. • Stage 1 to commence in 2011 and stage 2 in 2014. • Estimated capital of AU $100 million. • Estimated peak workforce of 100 for construction and 600 for operation.	~16km northeast of Miles. *9	EIS in progress.
Elimatta Coal Project	• A Taroom Coal Pty Ltd project to develop: - An open cut mine over approximately 2,500 ha. - Approximately 42 km of rail line to connect the project to the Surat Basin Rail. • Project to commence 2013. • Estimated capital of AU $615 million. • Estimated peak workforce of 300 for operation.	~35 km west of Wandoan. *10	EIS in progress.
Felton Clean Coal Demonstration Project	• An Ambre Energy (Felton) Pty Ltd project to operate an open cut coal mine and a di-methyl ether pilot plant to produce syngas for the production of 455 tonnes per day of di-methyl ether and the co-generation of electricity. • Mine Stage 1: coal production 0.8 Mtpa. • Mine Stage 2: coal production 3.8 Mtpa. • Project to commence 2014. • Estimated capital of AU $3,500+ million. • Estimated peak workforce of 1,880 for construction and 530 for operation.	30 km southwest from Toowoomba. *2	EIS in progress.
New Acland Coal Mine Stage 3 Expansion Project	• New Hope Coal Australia project to expand an open cut coal mine. • Project to commence 2013. • Estimated capital of AU $500 million. • Estimated peak workforce of 225 for construction and 450 (170 new) for operation.	14 km north-northwest of Oakey. *4	EIS approved with conditions in November 2009 (State Government). Supplementary EIS in progress.

Table 28.1 Future developments considered relevant for regional cumulative impact assessment (cont'd)

Future Developments	Description	Location	Status
Coal Resource Projects (cont'd)			
Wandoan Coal Project	• An Xstrata Coal Queensland Pty Ltd project to develop a 30 Mtpa open cut coal mine and rail spur from proposed Surat Basin Rail Project. • Project to commence 2012. • Estimated capital of AU $1,800 million. • Estimated peak workforce of 1,375 for construction and 884 for operation.	West of Wandoan. *6	EIS approved with conditions in November 2010 (State Government) and March 2011 (Australian Government).
Other Energy Resource Projects			
Bloodwood Creek Queensland – Stage 2 (Commercial Gas Production) (Both Stage 1 and 2 are shown on Figure 38.1)	• A Carbon Energy (Operations) Pty Ltd project to develop: - Approximately 40 operational panels. - A 30MW electrical power generation plant fuelled by syngas. - Carbon dioxide (CO_2) separation. - Assessment of the alternatives for CO_2 sequestration. • Project to commence 2011. • Estimated peak workforce of 200 for operation.	40 km west of Dalby. *8	EIS in progress.
Kogan Creek Solar Boost Project	• CS Energy Qld AREVA Solar project to use AREVA Solar's Compact Linear Fresnel Reflector technology planned to supply additional steam to the turbine, supplementing the conventional coal-fired steam generation process. • The use of energy from the sun will avoid the use of 35,600 tonnes of greenhouse gas emissions annually. • Project to commence 2013. • Estimated capital of AU $104.7 million. • Estimated peak workforce of 120 for construction.	Kogan Creek Power Station. *3	Project approved in April 2011 (State and Australian Government).
Energy Infrastructure Projects			
Arrow Surat Pipeline (formerly Surat-Gladstone Pipeline) Pty Ltd	• An Arrow Energy project to develop a 467 km long buried gas pipeline from Queensland's Surat Basin gas fields to Gladstone. • Project to commence 2012. • Estimated capital of AU $548 million. • Estimated peak workforce of 450 for construction.	Kogan to Gladstone	EIS approved with conditions in January 2010 (State Government).

Table 28.1 Future developments considered relevant for regional cumulative impact assessment (cont'd)

Future Developments	Description	Location	Status
Energy Infrastructure Projects (cont'd)			
Queensland Hunter Gas Pipeline Project	• A Hunter Gas Pipeline Pty Ltd project to develop an 831 km gas pipeline. • Project to commence 2012. • Estimated capital of AU $850 million. • Estimated peak workforce of 600 for construction and 25 for operation.	Wallumbilla to Newcastle.	Pipeline license issued by QLD Government in April 2007. Approved with conditions in February 2009 (NSW state Government).
Spring Gully Power Station	• An Origin Energy Power Ltd project to develop: - 30 coal seam gas wells. - 500 MW base load power station. - 1000 MW combined gas fired power station constructed in two 500 MW stages. • Estimated capital of AU $870 million. • Estimated peak workforce of 400 for construction and 30 for operation.	~80 km northeast of Roma. *13	EIS completed in 2006.
Transport Infrastructure Projects			
Surat Basin Railway Project	• A Surat Basin Rail Pty Ltd project to develop an open access, multi-user, 210 km single railway track with up to eight passing loops. • Rail infrastructure corridor will be approximately 60 m wide and will be located wholly within the proposed Surat Basin Infrastructure Corridor State Development Area. • Project to commence 2015. • Estimated capital of AU $1,200 million. • Estimated peak workforce of 1,000 for construction and 44 for operation.	Wandoan to Moura.	EIS completed in November 2009.

Table 28.1 Future developments considered relevant for regional cumulative impact assessment (cont'd)

Future Developments	Description	Location	Status
Water Infrastructure Projects			
Emu Swamp Dam Project	• Southern Downs Regional Council previously Stanthorpe Shire Council project to develop: - A 5000 ML urban water supply dam or a 10,500 ML urban and irrigation water supply dam. - Urban Pipeline linking the dam to the Mt Marlay Water Treatment Plant. - A Combined Urban and Irrigation Dam connected to a number of irrigators in Stanthorpe Shire. • Estimated capital of AU $76 million. • Estimated peak workforce of 145 for construction.	15 km southwest of Stanthorpe. *1	Supplementary EIS in progress.
Nathan Dam and Nathan Pipeline	• A Sunwater project to develop: - An 888,000 ML dam. - 260 km pipeline, primarily servicing future coal and power station projects. • Project to commence 2015. • Estimated capital of AU $120 million. • Estimated peak workforce of 425 for construction.	~75 km downstream of Taroom. *5	EIS in progress.

* Number denotes the project ID as shown in Figure 28.1.

The aggregation of information across multiple developments is challenging and in some cases, not possible due to:

- Inadequacy of available data.
- Variability in impacts assessments, assumptions, reporting and management measures.
- Unclear definitions of the spatial extent of potential residual impacts.
- Variability in the classification of the residual impact significance or risk.

These challenges preclude a meaningful qualitative assessment of cumulative impact significance or risk, but do allow for a subjective assessment of whether the cumulative impact may be worse (or better, in the case of positive impacts) than the expected residual impacts of the Surat Gas Project. As such, the below assessment of cumulative impacts has been described in terms of a worsening or improvement of the project's residual impacts.

28.3 Cumulative Impact Assessment

The outcomes of the cumulative impact assessments conducted for the project are summarized below.

28.3.1 Air Quality

In addition to the Surat Gas Project, a number of emission sources have been identified throughout the region. Sources likely to contribute to cumulative impacts in the region are industrial activities such as coal seam gas resource projects, coal resource projects and energy infrastructure projects.

One cumulative impact that arises from all developments is a potential health impact from the emissions of NO_2. Regional modeling (Chapter 9, Air Quality) predicted that the Surat Gas Project, in consideration of past, present and future projects, would increase NO_2 and O_3 concentrations (commonly used as indicators of photochemical smog). The highest concentrations were predicted west of the project development area in a valley subjected to low mixing heights. Although concentrations are predicted to increase, these would be below relevant guidelines in the Environmental Protection Policy 2008 (Air) (EPP (Air)). While this impact is worse than the residual impact of the project when considered in isolation, the ambient air limits remain within the prescribed health objectives.

Maximum predicted concentrations of NO_2 and O_3 for each emission scenario are shown in Table 28.2, along with existing air quality concentrations and health-based EPP (Air) objectives.

Modelling of Scenario 1 and Scenario 2 demonstrates that, while there is variation in ground-level NO_2 and O_3 concentrations within the study area, there is effectively no difference in the overall maximum experienced within the study area. This indicates that the separation distance between conceptual locations of production facilities ensures that the dispersion of plumes does not result in a cumulative air quality impact. Activities undertaken as part of the project are not predicted to cause exceedences of the ground-level EPP (Air) objectives for NO_2 and O_3 in the region.

Table 28.2 NO2 and O3 maximum concentrations and health-based objectives

	EPP (Air) (µg/m³)	Averaging Time	Existing Value (µg/m³)	Scenario 1 - All Facilities (µg/m³)	Scenario 2 - Year 2020 (µg/m³)
NO_2	250[a]	1 hr	22[b]	85[b]	86[b]
	62	Annual	2.2	9	9
O_3	210[a]	1 hr	136[b]	160[b]	160[b]
	160[a]	4 hr	123[b]	154[b]	154[b]

[a] Value considers one-day exceedence allowable per annum as per EPP (Air).
[b] Second highest day modelled value.

Dust (or particulate matter) from the various projects in the region could also result in additional cumulative nuisance, amenity and health impacts. Potential dust generation will be greatest during construction, and will be managed by implementing dust suppression measures and minimising the footprint of disturbance.

Worst-case greenhouse gas CO_2 equivalent emissions from the project indicate that project emissions are equivalent to 0.012% of global emissions and the potential residual impact associated with climate change directly attributable to the Surat Gas Project on a global scale is negligible. Although the cumulative impact of additional emissions from all projects is expected to be worse than the residual impact of the project, the significance or risk will likely remain negligible.

Maintaining air pollution control technologies, ensuring engines operate efficiently and implementation of energy efficiency programs will reduce NO_2 and greenhouse gas emissions.

28.3.2 Land Use

The existing land use in the region is predominantly agricultural. Agriculture is diverse with both summer and winter crops that concentrate on higher value crops such as grain, legumes and cotton. Cotton and wheat are grown across the region, as are speciality grains used in high-value niche exports. There are also some certified organic farms operating in the region. Livestock (cattle, pigs and sheep), cereal crops and non-cereal broad acre crops are the major agricultural enterprises in the region. Most farms are about 500 ha in size, with the majority of broad acre farms in the region being family-owned.

A cumulative impact that could result from developments in the region is the change of land use, specifically agricultural land use. GQAL and strategic cropping land uses will be temporarily and permanently changed during construction and operation of most developments. The primary cause of this cumulative impact is ground disturbance. For the Surat Gas Project and other coal seam gas developments, ground disturbance will be greatest during construction, but will decrease substantially during operations. Ground disturbance for mining developments will not decrease between construction and operations.

The most relevant projects in the area include those with a larger proposed footprint (especially within agricultural areas) and those projects adjacent to the Surat Gas Project that disturb contiguous tracts of land. Land use disruption is expected to be less significant for pipeline projects (e.g., pipelines associated with coal seam gas fields) where disturbance will be temporary during the construction of pipeline. Pipeline right of ways will be rehabilitated to existing land use following construction.

The specific location of coal seam gas infrastructure has yet to be determined. Arrow, based on its experience, has estimated that the typical disturbance during the construction of production

wells and associated gas and water gathering infrastructure is 2 to 3% of land associated with a typical 65 ha (160 acre) production spacing. Arrow expects this will reduce to approximately 1% during operations following rehabilitation of construction worksites. Production facilities will require larger footprints which range from 0.5 ha to over 220 ha for a single facility.

The change of land use from agriculture to petroleum activities will persist until decommissioning and rehabilitation of the well and production facility sites to their former land use. The primary factors that will determine the success of rehabilitation and any residual impacts are reinstatement of the drainage patterns, soil profiles and their chemical and biological function, and land use capability and productivity.

Other projects have proposed avoidance, mitigation and management measures, similar to those proposed for the Surat Gas Project. Successful implementation of these measures will:

- Avoid GQAL and strategic cropping land where possible, resulting in only relatively minor areas experiencing temporary or permanent changed land use.
- Ensure consultation with landowners is undertaken regarding the timing and location of activities and proposed rehabilitation.

28.3.3 Groundwater

Cumulative impacts to groundwater are considered most likely where multiple projects are intersecting or using the same groundwater aquifers as the Surat Gas Project, namely adjacent coal seam gas developments. Minor impacts to regional groundwater systems are expected from mining developments and are not expected to significantly contribute to the cumulative impacts.

Prior to considering mitigation, three potential cumulative impacts were identified during the construction and operation phases of coal seam gas developments:

- Groundwater drawdown.
- Land subsidence.
- Groundwater contamination.

Causes for the cumulative impacts include the extraction of groundwater and surface and subsurface activities (e.g., drilling of production wells) that could potentially contaminate groundwater.

The residual impacts from groundwater drawdown were quantitatively assessed by modelling in Appendix G, Groundwater Impact Assessment Report. The cumulative impact was also modelled from the Surat Gas Project in conjunction with other coal seam developments in the area of influence. Non-coal seam gas related developments were not considered in the modelling due to the lower volumes of expected groundwater extraction. Figure 14.2 in Chapter 14 (Groundwater) shows the predicted coal seam gas water extraction between the years 2011 and 2051. This data was used in the cumulative impact assessment modelling scenario (modelling scenario 3).

The modelling results show that the groundwater drawdown cumulative impact would be notably worse than the residual impact of the Surat Gas Project when considered in isolation. Figures 28.2, 28.3, 28.4, 28.5 and 28.6 show the results of the cumulative impact modelling within key aquifer units of the four groundwater systems present across the region. The figures represent peak groundwater drawdown contours for each aquifer within the four groundwater systems, together with predicted drawdown in 2061, which includes a ten year timeframe after the

cessation of coal seam gas extraction across the region. Groundwater systems are inclusive of the:

- Shallow underground system: Condamine Alluvium.
- Intermediate groundwater system: Springbok Sandstone.
- Coal seam groundwater system: Juandah Coal Measures (a unit within the Walloon Coal Measures).
- Deep groundwater system: Hutton Sandstone and the Precipice Sandstone.

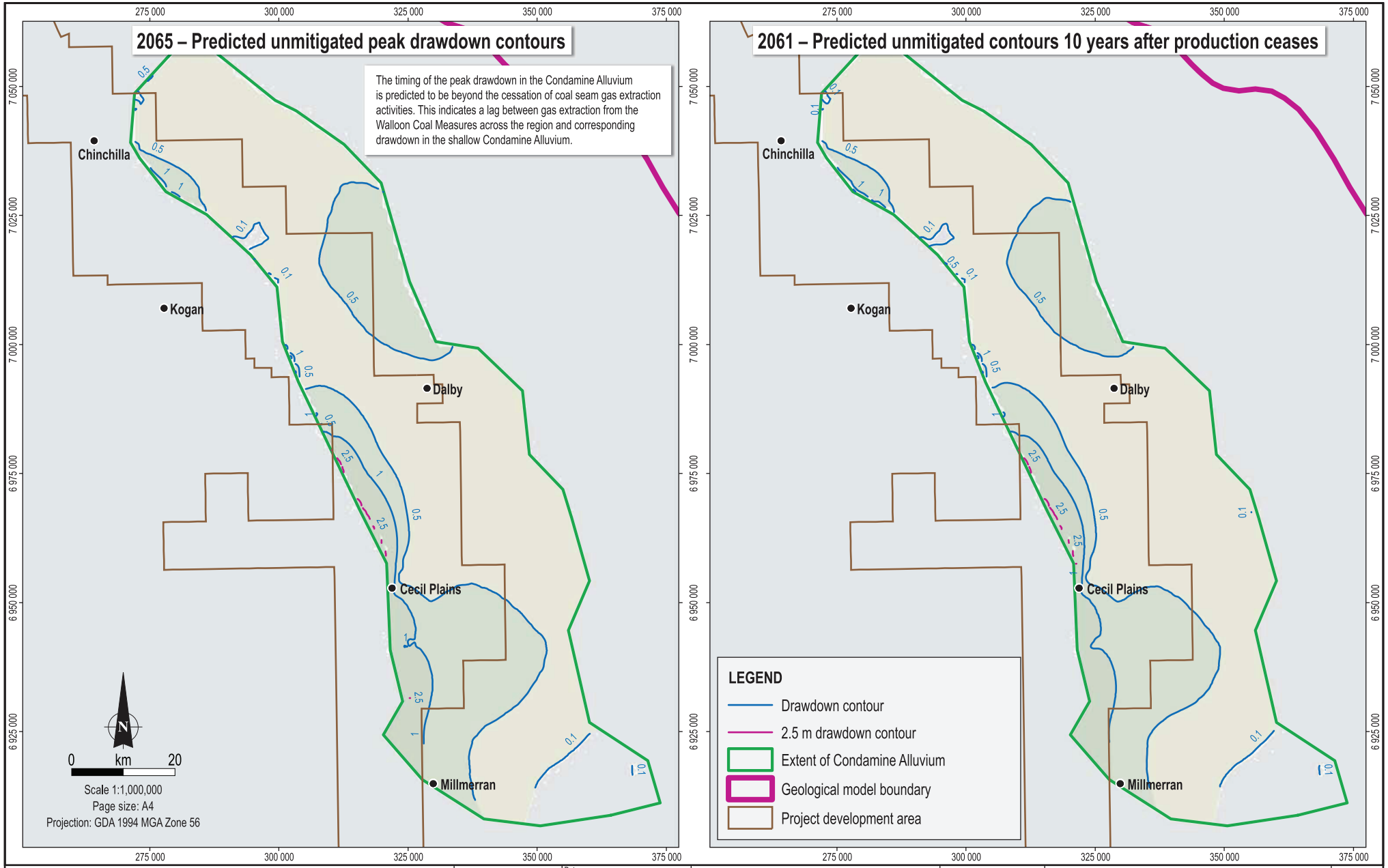
Results of the predicted groundwater modelling for the Surat Gas project (in isolation) and the cumulative scenario are summarised in Table 28.3.

Table 28.3 Summary of cumulative groundwater drawdown impacts

Groundwater System and Aquifer	Predicted Maximum Groundwater Drawdown – Surat Gas Project Only	Predicted Maximum Groundwater Drawdown – Cumulative
Shallow groundwater system	>0.1 m to <1 m	2.5 m
Intermediate groundwater system	30 m	60 m
Coal seam groundwater system (Walloon Coal Measures)	>75 m	150 m
Deep groundwater system	10 m to 30 m	75 m

The results of the numerical modelling conducted for the cumulative extraction scenario are summarised below:

- **Shallow groundwater system (Condamine Alluvium):** Maximum drawdowns are predicted to exceed the trigger threshold drawdown value of 2 m in the very western extent of the Condamine Alluvium. The area predicted to exceed the trigger threshold drawdown values is very limited in lateral extent.
- **Intermediate groundwater system (Springbok Sandstone):** The Springbok Sandstone is more widespread across the groundwater model extent, and more representative of the intermediate groundwater system in the cumulative modelling scenario than the more laterally restricted Kumbarilla Beds. Maximum drawdowns in the Springbok Sandstone are predicted to exceed the trigger threshold drawdown value of 5 m across the majority of the project development area, and also up to 100 km to the west in the northern area of the groundwater model extent.
- **Coal seam gas groundwater system (Walloon Coal Measures):** Maximum drawdowns within the Juandah Coal Measures (a formation within the Walloon Coal Measures) are predicted to exceed the trigger threshold drawdown value of 5 m across the majority of the project development area, and extending up to approximately 100 km to the west
- **Deep groundwater system (Hutton Sandstone and Precipice Sandstone):** Maximum drawdowns in the Hutton Sandstone and Precipice Sandstone are predicted to exceed the trigger threshold drawdown value of 5 m across the majority of the project development area. In both aquifers, drawdowns are predicted exceed the trigger threshold value approximately 20 km beyond the eastern extent of the project development area, and up to approximately 100 km beyond the western extent of the project development area.



Source:
Place names from DERM.
Project development area from Arrow Energy.
Extent of Condamine Alluvium, geological model boundary and drawdown contours from Schlumberger.

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File Name: 7008_04_F28.02_GIS_FT

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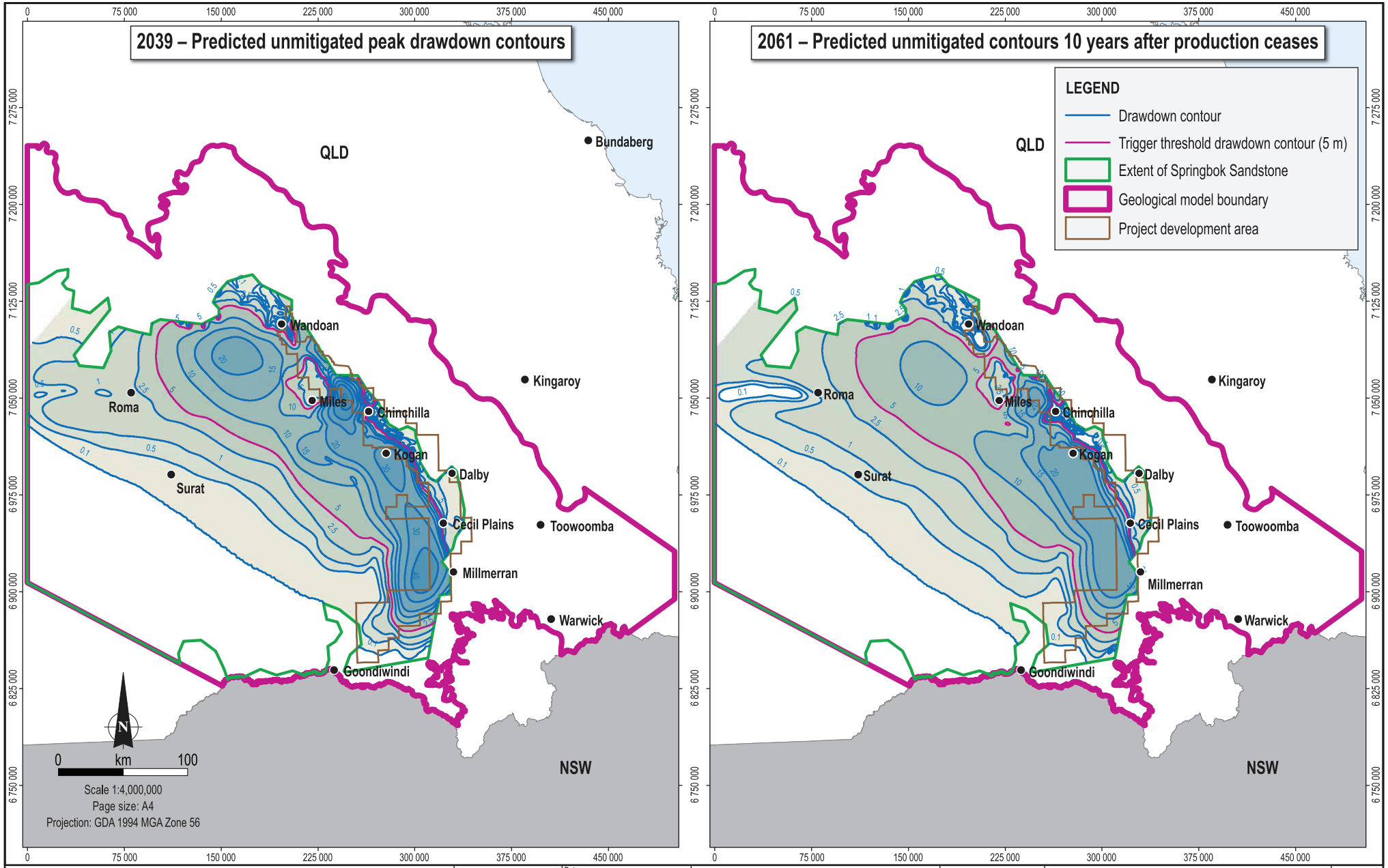
Predicted unmitigated groundwater drawdown contours in the Condamine Alluvium (modelling scenario 3: cumulative case)

Figure No: 28.2



Source:
Place names from DERM.
Project development area from Arrow Energy.
Extent of Springbok Sandstone, geological model boundary and drawdown contours from Schlumberger.

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File Name: 7008_04_F28.03_GIS_FT

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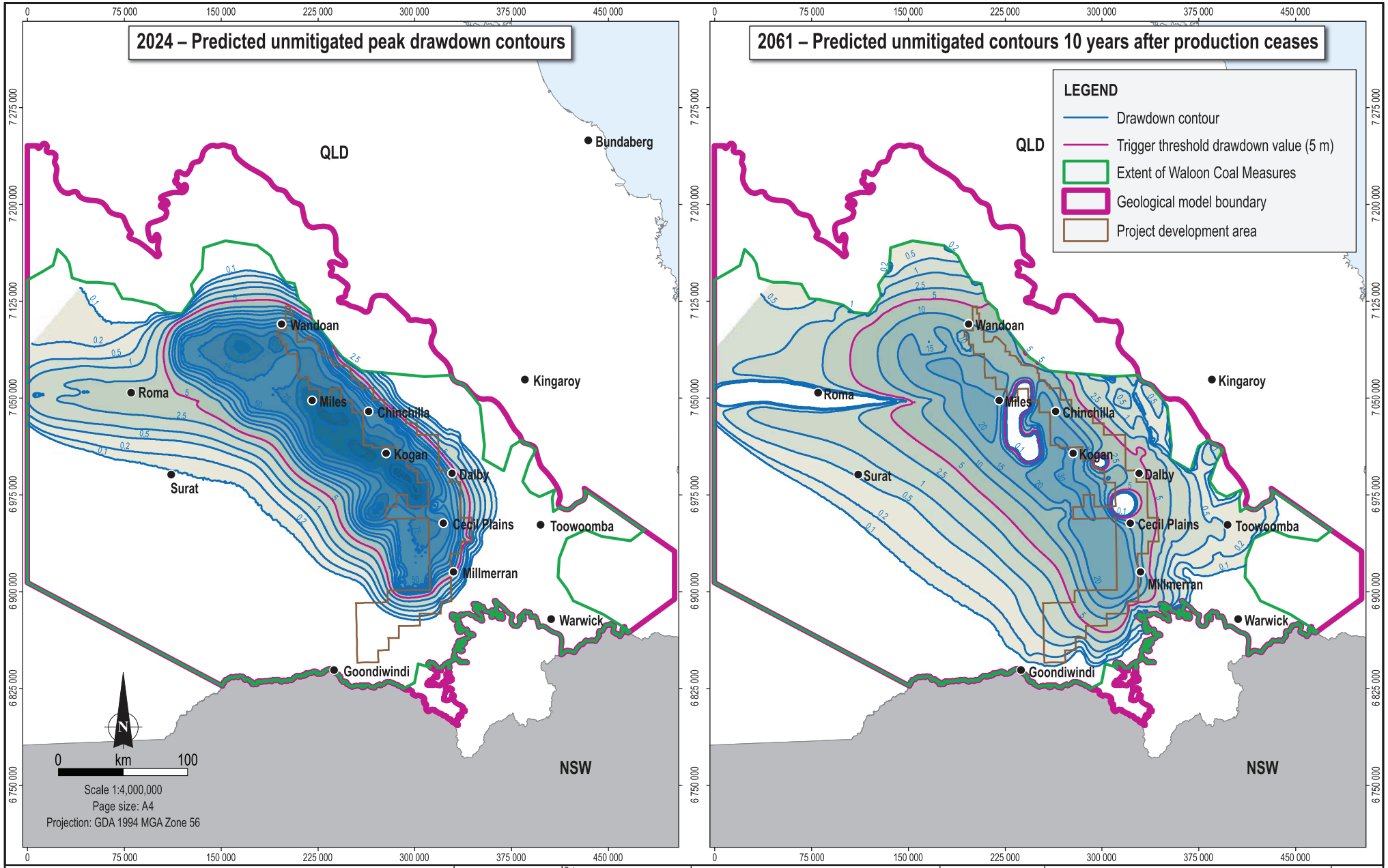
Predicted unmitigated groundwater drawdown contours in the Springbok Sandstone (modelling scenario 3: cumulative case)

Figure No: **28.3**



Source:
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Project development area from Arrow Energy.
Extent of Waloon Coal Measures, geological model boundary and drawdown contours from Schlumberger.

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File Name: 7008_04_F28.04_GIS_FT

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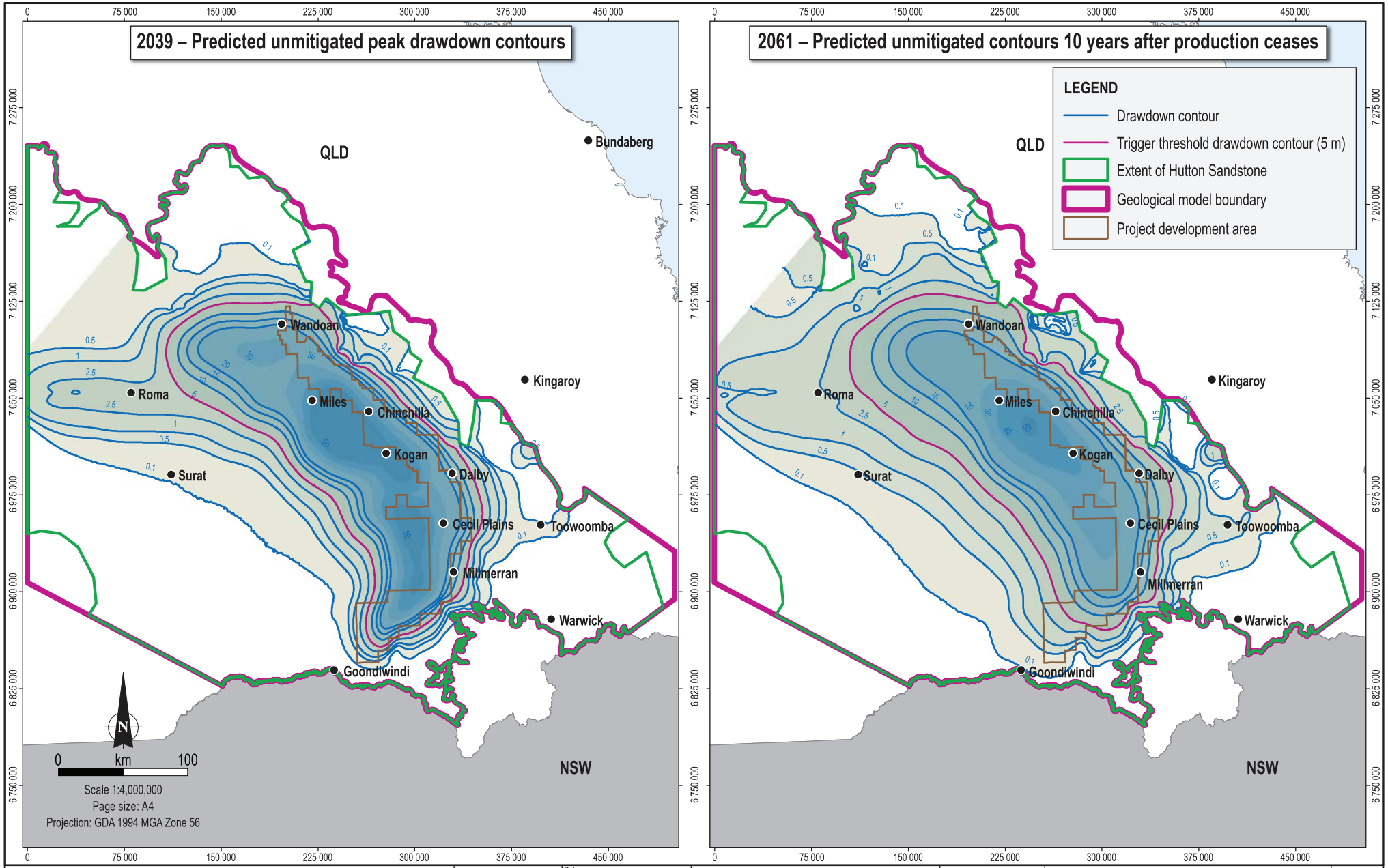
Predicted unmitigated groundwater drawdown contours in the Juandah Coal Measures (modelling scenario 3: cumulative case)

Figure No: 28.4



Source:
Place names from DERM.
Project development area from Arrow Energy.
Extent of Hutton Sandstone, geological model boundary and drawdown contours from Schlumberger.

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Date: 12.12.2011
MXT: 7040AC_04_GIS173_v1_3
File Name: 7008_04_F28.05_GIS_FT

Arrow Energy

Surat Gas Project

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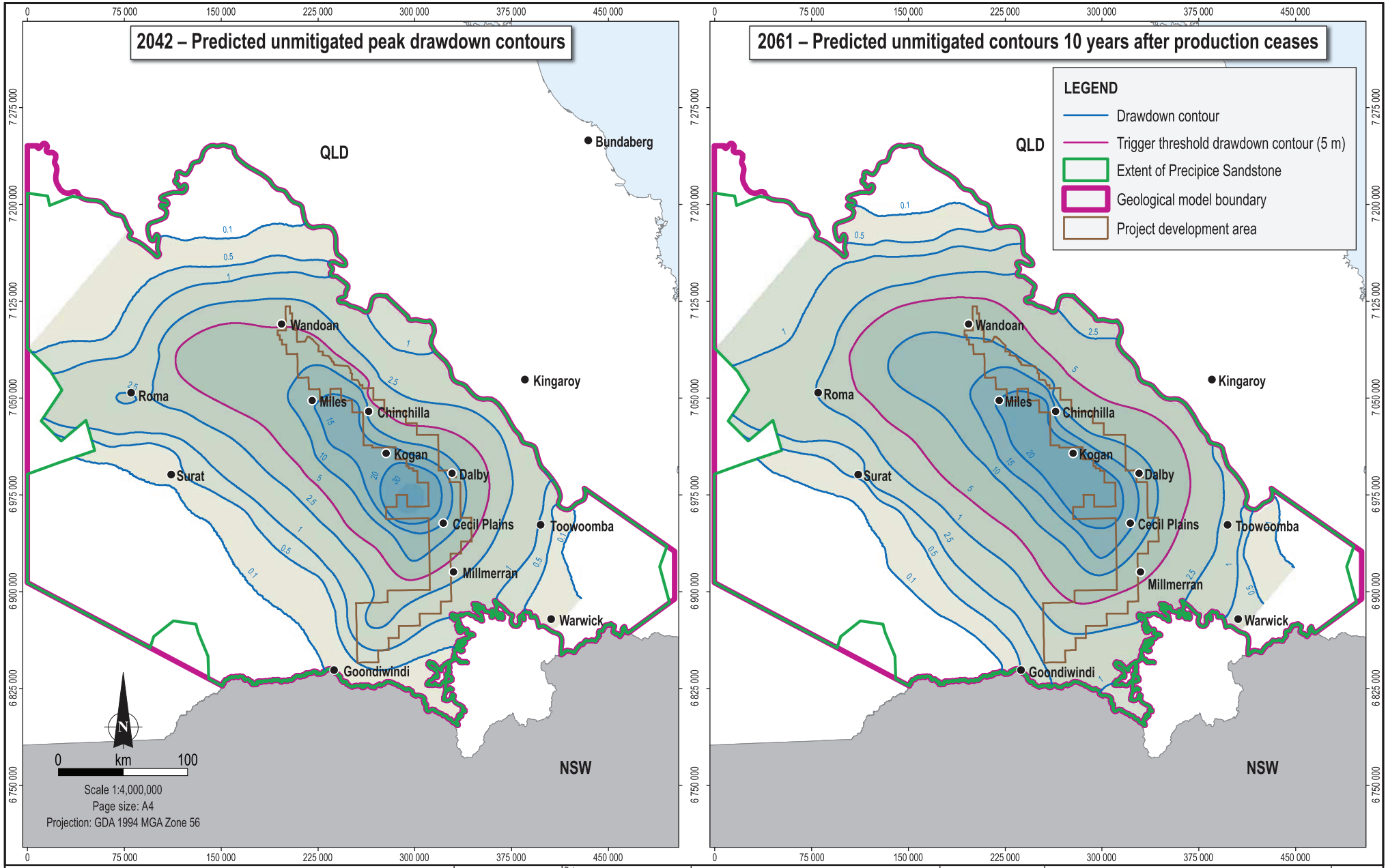
Predicted unmitigated groundwater drawdown contours in the Hutton Sandstone (modelling scenario 3: cumulative case)

Figure No: 28.5



Source:
Place names from DERM.
Project development area from Arrow Energy.
Extent of Precipice Sandstone, geological model boundary and drawdown contours from Schlumberger.

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Date: 12.12.2011
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File Name: 7008_04_F28.06_GIS_FT

Arrow Energy

Surat Gas Project

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Predicted unmitigated groundwater drawdown contours in the Precipice Sandstone (modelling scenario 3: cumulative case)

Figure No: **28.6**

Another potential cumulative impact is land subsidence which is generally associated with the depressurisation of unconsolidated formations. In the case of the Walloon Coal Measures and most other groundwater systems within the project development area, the aquifers are consolidated (i.e., lithified) and surface subsidence is considered unlikely. Consequently, the cumulative impact is no worse than the residual impact of the Surat Gas Project in isolation.

Contamination of groundwater systems is a potential cumulative impact that could result from a variety of coal seam gas construction and operation surface activities (e.g., storage and handling of hazardous materials) and subsurface activities (e.g., drilling and installation of production and monitoring wells).

Potentially contaminating surface activities are more likely to impact on shallow groundwater systems. Aquifers of deeper systems are isolated by depth, and are less likely to be adversely impacted by leaks and spills of hazardous materials or coal seam gas water from surface storage infrastructure. Also, in the event of a leak or spill, the contaminants would more likely migrate laterally away from the source, and in the direction of local groundwater flow and at a rate comparable with the groundwater flow velocity. The shallow groundwater systems are often perched, localised systems, less likely to be accessed by multiple proponents, and mitigation measures developed to address this potential impact require that dams and surface storage infrastructure are installed to relevant standards together with leak detection systems (e.g. shallow groundwater monitoring bores) in the vicinity of the infrastructure. Therefore, the potential for cumulative contamination of shallow groundwater systems from surface activities is considered to be the same as the residual impact of the Surat Gas Project in isolation.

Potentially contaminating subsurface activities can impact on all groundwater systems intersected as part of that activity, that is, vertical drilling can potentially contaminate all the aquifers intersected by the well. In the event of a leak or spill during subsurface activities, the contaminants would have the capability to migrate both laterally and vertically through the geological profile and away from the source, in the direction of groundwater flow and at a rate comparable with the groundwater flow velocity. Although there is a higher chance of groundwater contamination with a greater number of developments intersecting multiple regional groundwater systems through subsurface drilling activities, mitigation measures developed to address this potential impact require that wells and gathering lines are installed to relevant standards together with integrity management programs to ensure installations comply with those requirements. Therefore, the potential for cumulative contamination of groundwater systems from subsurface activities is considered to be the same as the residual impact of the Surat Gas Project in isolation.

Mitigating cumulative impacts from coal seam gas developments will include:

- Support for the Queensland Water Commission (QWC), who are the central body responsible for cumulative groundwater impact monitoring, modelling and reporting. Within the Surat Cumulative Management Area, bore owners interface with the QWC rather than any individual coal seam gas producers. This central body will improve response times (for future planning) if the data suggests an overall decline in groundwater availability. The QWC will be supported by a technical advisory panel to review the monitoring data quarterly and an industry advisory panel, comprising members from the coal seam gas industry; and more importantly members from the agriculture, environment and community sectors.
- Compliance with all industry standards as they relate to the appropriate storage, handling and disposal of hazardous materials and the drilling and installation of wells.

- Monitoring programs conducted by Arrow and other proponents to ensure that water quality and groundwater level indicators are used to trigger the implementation of response actions in the event of leaks, spills or failed well integrity tests.
- Perform groundwater modelling simulations to predict impacts on groundwater resources in overlying and underlying aquifers. This information will subsequently be used to evaluate the suitability of these resources for use in make-good measures.

28.3.4 Surface Water

The regional surface water environment is represented by four drainage basins, all of which intersect the project development area: Condamine-Culgoa Drainage Basin; Fitzroy Basin; Border Rivers Basin; and Moonie Basin. The Condamine sub-basin within the Condamine-Culgoa Drainage Basin is the predominant sub-basin within the project development area accounting for over 50% of total area.

The region is characterised by an extensive network of watercourses that are largely ephemeral with varying geomorphic stream reach types that provide geomorphic diversity and contribute to habitat diversity. Rivers and creeks within the project development area are generally intermittent, with surface waters in many streams receding to disconnected pools and dry beds during the dry season.

The Surat Gas Project does not intend to discharge coal seam gas water under normal operating conditions; however controlled emergency releases may occur during high rainfall events. Chapter 15 (Surface Water) identified negligible to low residual impacts to the surface water environment as discharge from the project is limited and quality will be compliant with regulatory objectives. The surface water environment included geomorphology, stream flow, water use, water quality and flooding. The cumulative impact assessment resulted in an overall low risk to surface water from extreme weather and catastrophic events.

Cumulative impacts to surface water are considered likely where multiple planned developments discharge to the same drainage basins as the Surat Gas Project. A cumulative impact that could arise from the discharge of coal seam gas water is a change to watercourse hydrology. Numerous coal seam gas developments in the region have indicated that coal seam gas water could be released to watercourses during operations. The significance of the cumulative impact is variable depending on the location and nature of the stream (e.g., permanent or ephemeral) and the volume, frequency and quality of the water discharged.

With increased discharges and subsequent increased flows in watercourses, the cumulative impact from all developments would be greater than any one isolated development. The Surat Gas Project is not expected to significantly contribute to this cumulative impact as discharges are expected to be minimal.

28.3.5 Aquatic Ecology

Aquatic ecosystems within the region are relatively diverse with permanent, semi-permanent and highly seasonal changes to the flow of water. In general, the aquatic environment has been impacted upon over many decades by highly modified terrestrial environments and altered catchment processes, resulting in aquatic ecosystems that are moderately to highly modified.

Future developments were considered to contribute to cumulative impacts if they included clearing or disturbance in or near watercourses and were located within the same drainage basin as the Surat Gas Project. Discharge of effluents into watercourses was considered in Chapter 15

(Surface Water). The degree to which residual impacts are likely to occur will vary between developments, depending on the nature of construction activities, the location of infrastructure and their proximity to watercourses.

Diminished water quality in watercourses is the primary cumulative impact to aquatic ecology. Increased sediment loads caused by the clearing of riparian vegetation and construction activities in or near permanent watercourses can affect water quality. The Surat Gas Project and all other coal seam gas developments will be constructing numerous pipelines, which include the removal of riparian vegetation and in-stream disturbances. The result will be increased sediment loads in watercourses. The residual impact from the Surat Gas Project in isolation was assessed as being of low significance, but when considered in conjunction with other planned developments, the cumulative impact would be elevated sediment loads in watercourses, particularly where the developments are in close proximity. The severity of the impact would be less, and possibly negligible, where the activities are geographically remote.

Some developments are not within the same drainage basins as the Surat Gas Project, therefore will not contribute to the cumulative impact. The Spring Gully Power Station and Bloodwood Creek Queensland Project are also expected to negligibly contribute to the cumulative impact on aquatic ecosystems.

Mitigation of this cumulative impact includes the implementation of buffer zones, erosion controls, spill containment and response and restricted use of herbicides.

28.3.6 Terrestrial Ecology

The Surat Gas Project lies within the Brigalow Belt South Bioregion. This bioregion is a major pastoral and agricultural area with much of the natural vegetation heavily cleared as a result of land development. The resulting landscape is one of isolated patches of remnant, disturbed and regrowth vegetation, which vary in size, shape and isolation. This is evident in the network of linear vegetation (both remnant and regrowth) along road verges and fence lines; and by the few larger stands of vegetation containing unbroken habitat preserved in areas that are either unsuitable for agriculture, or that have been preserved through alternative use.

Developments with the potential to contribute to cumulative impacts are those within the same bioregion and have contiguous project boundaries with the Surat Gas Project. These include other coal seam gas developments, the Arrow Surat Pipeline, Cameby Downs Coal Expansion, Elimatta Coal and Wandoan Coal projects. Other less relevant developments are those with negligible predicted impacts to terrestrial ecology.

The cumulative impact assessment targeted ecological values that are at a greater residual risk of cumulative impact, namely sensitive vegetation communities/ regional ecosystems (REs) and significant flora and fauna species.

Two potential cumulative impacts to terrestrial ecology were identified:

- Habitat loss and fauna mortality.
- Fragmentation of habitat and isolation of populations.

These impacts are the result of vegetation clearance and ground disturbance works during construction.

Chapter 17, Terrestrial Ecology identified three ecological communities (including component REs), 14 flora species and 11 fauna species with high potential for cumulative impact. The ecological communities are:

- Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland ('critically endangered'). This comprises of REs 11.3.21 and 11.3.24.
- Brigalow (*Acacia harpophylla* dominant and co-dominant) ('endangered'). This is an EPBC Act–listed community and is located within REs 11.3.1, 11.4.3, 11.9.5 and 11.9.6.
- Semi-evergreen vine thickets of the Brigalow belt (north and south) and Nandewar bioregions ('endangered'). It comprises of REs 11.9.4a and 11.8.3.

The 14 flora species are curly-bark wattle (*Acacia curranii), Acacia wardellii, ooline (Cadellia pentastylis), Calytrix gurulmundensis, Cryptandra ciliate, Gonocarpus urceolatus,* Belson's panic (*Homopholis belsonii), Microcarpaea agonis, Micromyrtus carinata,* small-leaved wax flower (*Philotheca sporadic), Prostanthera sp. (Dunmore), Rutidosus lanata, Solanum papaverifolium, Solanum stenophorum* and *Xerothamnella herbacea.*

The 11 fauna species are pale imperial hairstreak *(Jalmenus eubulus),* collared delma (*Delma torquate),* brigalow scaly-foot *(Paradelma orientalis),* five-clawed worm-skink *(Anomalopus mackayi),* grassland earless dragon *(Tympanocryptis cf. tetraporophora),* common death adder *(Acanthophis antarcticus),* Dunmall's snake (*Furina dunmalli),* grey snake *(Hemiaspis damelii),* Australian painted snipe (*Rostratula australis),* painted honeyeater (*Grantiella picta)* and regent honeyeater *(Anthochaera Phrygia).*

The residual impacts resulting from habitat loss and fauna mortality are described Chapter 17, Terrestrial Ecology and are of moderate significance for the Surat Gas Project when considered in isolation. The cumulative risk is expected to be worse given that the above communities and species typically have a restricted distribution and are often endemic to the Brigalow Belt South bioregion.

Fragmentation of habitat and isolation of populations was also classified as a moderate residual risk for the Surat Gas Project in isolation. Given the limited extent of large stands of vegetation containing unbroken habitat and the thin, linear vegetation corridors (both remnant and regrowth) along road verges and fence lines, disturbance of these by multiple developments, especially those with a contiguous footprint to the Surat Gas Project, would likely result in a worse cumulative impact.

The successful management of cumulative impacts to terrestrial flora and fauna should occur at the individual project scale and be assisted by a collaborative approach between the proponents of interacting developments, particularly in regards to ongoing ecological studies and habitat offsets.

28.3.7 Landscape and Visual Amenity

The region contains a variety of landscapes including broad open arable plains, elevated native forest and wooded river valleys. The landscapes have been shaped by variations in geology, soils, landform, vegetation and the settlement and use by people.

The key cumulative impact identified from multiple developments was the potential loss of visual amenity (to the community and general public) due to widespread changes in the nature of the existing landscape.

Developments with the potential to contribute to this cumulative impact are those with:

- 'Combined' impacts that occur where a static receptor is able to view two or more developments from a viewpoint within the receptors' arc of vision (assumed to be 120 degrees for the purpose of this assessment) at the same time.
- 'Successive' impacts occur where a receptor is able to view two or more developments from a viewpoint, but need to turn their head to see them.
- 'Sequential' impacts occur where a receptor is moving from one area to another, for instance when a person is travelling along a road or track, and is able to see two or more developments at the same, or at different times as they pass along the route. Sequential effects can potentially affect views from routes over a wide area.

Assuming they are constructed, it is likely that 7 of the 16 future developments will contribute to cumulative landscape and visual impacts. These are described in detail in Appendix L (Landscape and Visual Impact Assessment) and summarised below:

- Arrow Surat Pipeline. Cumulative impacts are likely in the region near Miles, as a result of combined and successive visual impacts and sequential visual impacts along Warrego Highway and Dalby-Kogan Road.
- Australia Pacific LNG Project and Queensland Curtis LNG (QCLNG) Project. Significant impacts on the landscape character, views and visual amenity as a result of the installation of the coal seam gas field developments.
- Bloodwood Creek Queensland – Stage 2. Cumulative impacts in the region near Kogan, as a result of significant adverse, albeit short term, impacts on the landscape character, views and visual amenity as a result of the presence of construction crews and temporary mobile camp (including transportation of the crew between activity sites and nearby towns) and construction activities.
- Cameby Downs Coal Mine expansion Project. Combined and successive visual impacts for residents and visitors in the region of Miles and Columboola.
- Kogan Creek Solar Boost Project. Cumulative impacts are likely, particularly in the central-western part of the project development area near Kogan due to the construction and operation of the projects.
- Surat Basin Rail Project. Cumulative impacts are likely in the northern part of the project development area, as a result of combined and successive visual impacts for residents and visitors in the region of Wandoan. Sequential visual impacts, potentially along the Leichhardt Highway and other minor rural roads (e.g., Roche Creek Road).
- Wandoan Coal Project. Cumulative impacts are likely in the region near Wandoan, as a result of combined and successive visual impacts for residents and visitors. Sequential visual impacts, in particular, the Leichhardt Highway and Jackson-Wandoan Road.

For coal seam gas developments, the main activity that would modify the landscape and diminish visual amenity values is the construction of production wells, gathering lines, production facilities

and associated infrastructure (e.g., construction camps). Other visual amenity impacts are possible during operations and decommissioning from the presence of operating facilities, but are likely to be less significant than the construction phase. Other coal resource and energy developments will also have visual impact potential during construction and operation.

The impact of each development will vary depending on:

- The nature of the construction activity (e.g., construction of a production well versus construction of coal mine).
- The type of landscape and location of visual receptors.
- How these developments relate to each other in the design and relationship to their settings (e.g., massing, height, scale, form, style).
- Their frequency as one moves through the landscape (i.e., as seen sequentially from main transport and recreational routes).
- Their visual separation to allow experience of the character of the landscape in-between.

There is likely to be a multitude of activities experienced across the region from all coal seam gas developments. These activities will occur in different stages of development (e.g., construction/installation; operation and maintenance; decommissioning and rehabilitation) over a number of years. Consequently, the Surat Gas Project and other coal seam gas developments are likely to be experienced cumulatively, rather than in isolation. Sequential cumulative impacts of the coal seam gas developments are likely; most notably, the impact (combined and successive) of the production wells and as one moves through the landscape, due to their frequency and repetition.

Although the precise locations of infrastructure and activities for the Surat Gas Project and other developments have not been finalised, it is expected that the cumulative loss of visual amenity from changes in the nature of the existing landscape will be worse than the residual impact of the Surat Gas Project in isolation. Planning, mitigation and management measures proposed for the Surat Gas Project and other developments will assist in minimising cumulative visual impacts. Consultation with potentially impacted visual receptors in siting project infrastructure will allow for site specific mitigation measures.

28.3.8 Roads and Transport

Roads are anticipated to be the main mode of transport used for the Surat Gas Project. Presently Arrow does not anticipate use of the rail as a mode of transport and therefore potential cumulative impacts associated with rail is negligible.

Fly-in fly-out arrangements are not proposed for the project and Arrow aims to employ workers based on a hierarchy that prioritises a locally sourced workforce. Therefore, air transport has not been assessed.

Similarly, shipping has not been assessed as no imported materials are expected to require project-specific cargo ships.

Two potential cumulative impacts from all developments in the area are predicted, including:

- Reduced efficiency of higher order roads such as highways and regional connecting roads (e.g., disruptions to flow due to construction activity, poor road condition i.e., lack of sealing,

and lack of turning lanes during increased traffic conditions) due to increased traffic volumes and subsequent deterioration of the road network or congestion.

- Reduced safety of roads e.g., disruptions to flow and increased traffic turning onto access roads increasing the likelihood of traffic accidents, increased risk to pedestrians and increased vehicle exposure at rail crossings.

The developments that are likely to create a cumulative impact on roads and traffic within the area of influence are the coal seam gas projects and coal mining developments that are adjacent to the Surat Gas Project development area. Aside from planned infrastructure projects that consist of a construction phase over a short timeframe, the most significant planned developments in the area will have operations and construction which occur over 30 years or more with most commencing construction and production within the next decade.

The developments that are likely to use the road network in region have a large combined area. The other coal seam gas developments use similar construction and operations methods as the Surat Gas Project and will generally have similar traffic volumes and patterns.

With respect to the roads within the region, most of the traffic generation by other projects will contribute to increased traffic volumes on 'through routes' (i.e., highways and rural connecting roads). The following highways and regional connecting roads within the project development area may experience reduced efficiency and safety cumulative impacts:

- Warrego Highway from Toowoomba to Miles.
- Chinchilla-Tara Road south west of Chinchilla to Kogan-Condamine Road.
- Dalby Kogan Road from Dalby to Kogan.
- Kogan-Condamine Road to Chinchilla-Tara Road.
- Moonie Highway south-west of Dalby to Surat Developmental Road.

When considered in isolation the Surat Gas Project is predicted to increase traffic volumes on these roads between 1% and 4% above background traffic levels. This growth is expected to occur over an extended ramp-up period of a decade. Cumulative impacts are expected to be worse than the Surat Gas Project in isolation, assuming other developments in the region will generate similar traffic volumes. The total increase in traffic from all developments in the region is expected to be between 2% and 8%, equating to approximately 2 to 4 years of historical traffic growth. Cumulative impacts will result in reduced efficiency of highways and regional connecting roads and reduced safety of roads that will require mitigation and management measures to reduce the impact.

Measures specific to cumulative impacts include:

- Assistance with the management of impacts to the road network following the Guidelines for Assessment of Road Impacts on Development (DMR, 2006).

- Communication with relevant authorities on project activities so the government can ensure future planning documents are in place to accommodate development by designing and investing in the road network for expected growth. The Department of Traffic and Main Roads gives high priority to meeting road needs identified in formal planning documents.

Arrow will commit to informing road authorities of planned growth-generating activities, the provision of regular Road Use Management Plans and infrastructure agreements.

28.3.9 Noise and Vibration

The Surat Gas Project is located in a rural area of the Surat Basin that is dominated by natural sounds. These sounds, such as birds and wind in the trees, result in a low noise environment typical of a rural setting. Existing environmental vibration levels in the area are below the threshold of human detection.

Activities with the potential to cause noise and vibration impacts to the values of the existing environment relate primarily to the construction and operations of developments.

Modeling data from Chapter 20 (Noise and Vibration) demonstrated that noise impacts from the construction and operation of the Surat Gas Project activities is relatively localized and does not generally extend beyond Arrow's tenements. The result is a cumulative impact that remains similar to the residual impact of the Surat Gas Project when considered in isolation.

Similarly, vibration levels are predicted to be localised around the activity and will not have a cumulative impact.

28.3.10 Socio-Economic

While a separate social impact assessment and economic impact assessment were undertaken and employed different assessment methods, they are complementary and overlap. For example, both assessments examined demographic change; however the social assessment examined local culture while the economic assessment focused on the workforce. This section specifically summarises the cumulative social and economic impacts identified in Chapter 21 (Economics) and Chapter 22 (Social).

An assessment of the Surat Gas Project in conjunction with the planned developments in the area identified seven potential cumulative impacts, including impacts to:

- Regional, state and national gross product.
- Employment rates.
- Household incomes.
- Businesses.
- Housing prices and availability of affordable housing.
- Industrial / commercial land prices.
- Community services, infrastructure and amenities.

Regional, State and National Gross Product

The Surat Gas Project will generate significant economic benefits for the regional, Queensland and Australian economies. The Surat Gas Project's maximum contribution to the annual gross regional, state and domestic product is estimated to be approximately 5%, 0.3% and 0.1%, respectively. This equates to a maximum annual increase of about $1.4 billion per annum for the regional, state and national economies.

It can be assumed that other projects will also have a positive impact on the regional, state and national economies; therefore the cumulative impact is expected to be better than the residual impact of the Surat Gas Project in isolation.

Employment Rates

The Surat Gas Project is anticipated to result in a beneficial impact to employment with a net increase of just under 500 full-time equivalent employees in the Darling Downs during peak

labour demand in 2015/16 and 2016/17. On a percentage basis, this amounts to about a 0.4% beneficial impact on employment in the Darling Downs.

Along with other planned developments the cumulative impact is expected to be better than the residual impact of the Surat Gas Project when considered in isolation.

Household Incomes

A large proportion of the Surat Gas Project expenditure is expected to be associated with the supply of construction labour. Construction of the project in conjunction with the other planned developments will increase the demand for labour in the area thereby increasing competition and subsequent wages/ household income.

The Surat Gas Project is forecast to contribute to a marginal increase in household incomes of approximately 0.02% per annum on average in Australia, 0.05% per annum on average in Queensland and about 0.5% in the Darling Downs regional area.

The increase in household income will also reflect an increase in costs of production for business. Higher costs of production are likely to see prices for some goods and services increase to maintain business profitability. For households, the increase in prices for goods and services and for housing represents an increase in the cost of living, the impact of which will be felt mostly by lower income earning households. An increase in the cost of living will result in a reduction in disposable incomes, with the most obvious impact being on demand for discretionary expenditure items (e.g., luxury goods and other non-essentials).

However, modelling outcomes indicate that local residents of the Darling Downs are expected to be, on average, ‘better off’ as a result of an increase in the household income, which reflects an increase in wages and salaries above inflation. The cumulative impact of multiple projects is expected to accentuate positive effects on average household incomes.

Businesses

Short-term competition for construction labour can be expected with the development of multiple projects which will almost certainly result in additional demand and competition for labour and other services to supply these projects. Competition and shortage of labour can be expected to bid up wages in the region and can result in the migration of workers from local businesses to the higher paying industrial developments. Attraction and retention of staff will be more of an issue for lower income paying industries (in particular smaller manufacturing businesses and many service based industries such as retail, education and local government) that are unable to compete for labour on a price basis.

The cumulative impact on local businesses is expected to be worse than the residual impact of the Surat Gas Project in isolation. Arrow intends to collaborate with the existing job referral service set up by other proponents to make information available on positions vacant in local businesses with similar trade/skills requirements. This will allow applicants to choose between industry and non-industry jobs.

Housing Prices and Availability of Affordable Housing

The overlapping development of a number of major industrial projects is likely to increase the peak demand for housing in the region as the population increases during construction. This will place upward pressure on prices although it will be somewhat mitigated by individual project temporary workforce accommodation camps. Even with appropriate accommodation planning,

issues of housing affordability are likely to be of concern in the short to medium term in the Darling Downs if a significant number of major projects are constructed at the same time.

The cumulative impact arising from increased population and housing affordability is expected to be worse than the Surat Gas Project when considered in isolation.

Arrow will collaborate with other proponents in the region and identify opportunities to share temporary accommodation where possible for the construction and maintenance workforces. In addition, Arrow will continue participation in initiatives set out in the Major Resource Projects Housing Policy; Draft Resource Town Housing Affordability Strategy; and the proposed Western Downs Regional Council housing affordability strategy and implementation of the Surat Basin Future Directions Statement.

Industrial / Commercial Land Prices

The development of a number of major industrial and resource projects in the region will require significant supply services that will likely migrate to the region causing an increased demand for industrial / commercial property. Availability of appropriately zoned and developable industrial and commercial lands is an existing issue in the region, and the likely increase in demand is assessed as creating a worse cumulative impact on industrial / commercial property prices when consider to the residual impact of the Surat Gas Project in isolation.

Arrow will support the intent of the Surat Basin Regional Planning Framework and work with State government, Councils, ULDA, building industry, realtors and other project proponents to identify co-operative strategies that address cumulative housing impacts and to ensure that developable land is brought to market to meet demand.

Local Infrastructure and Service Capacity

Some infrastructure and services in the Darling Downs Region are currently experiencing capacity constraints – in particular road, rail, telecommunications infrastructure as well as health services and emergency services. This has been identified in regional planning as a key issue to be addressed. The concurrent development of multiple projects will almost certainly result in demand exceeding capacity for some infrastructure and services. The consequence of cumulative impacts on infrastructure and service capacity is assessed as being worse than the Surat Gas Project in isolation.

Arrow will mitigate the cumulative impacts through consultation and coordination with other development proponents, local and state governments, relevant economic and industry organisations, local businesses and the local community to facilitate longer term planning.

28.3.11 Indigenous and Non-Indigenous Cultural Heritage

Potential impacts to Indigenous and non-Indigenous cultural heritage in the region generally relate to ground disturbance during the construction phase of the projects.

Chapter 23 (Indigenous Cultural Heritage) and Chapter 24 (Non-Indigenous Cultural Heritage) identified a number of Indigenous and non-Indigenous cultural heritage sites within the project development area, however there is little risk of other projects impacting on these sites as their developments will be located within their own tenements.

Impacts to non-Indigenous heritage sites located within towns have been excluded from the assessment as there will be no direct impact on these sites from the Surat Gas Project and the sites are accessible to the general public.

The cumulative impact to Indigenous and non-Indigenous cultural heritage sites is considered no worse than the residual impact for the Surat Gas Project in isolation.

Avoidance, mitigation and management measures specific to cumulative impacts for cultural heritage include:

- Avoid known sites of significance. In most cases there is the potential for flexibility in the placement of project infrastructure (e.g., production wells and field infrastructure). Where this is not possible, other mitigation actions include archival recording, salvage excavation and relocation of historic items (where applicable for Indigenous and non-Indigenous heritage).
- Development of a Cultural Heritage Management Plan to further address mitigation measures and procedures.

All projects will be expected to develop a Cultural Heritage Management Plan.

28.3.12 Preliminary Hazard and Risk

The region is primarily composed of rural areas used for sheep, cattle grazing and cultivation, including isolated areas of bushland and state forests. Population is widely dispersed, except for townships such as Dalby, Chinchilla, Cecil Plains, Wandoan and Goondiwindi. This dispersed population, large amount of open land and the widely distributed extent of the coal seam gas resource allows the Surat Gas Project to develop facilities in locations that maintain distance from centres of population, residential locations and existing industrial developments.

The risks associated with the Surat Gas Project relate to human injury or fatality and/or propagation to adjacent facilities. These risks can be associated with the project's construction, operation and decommissioning phases; however operations of the production facilities poses the greatest risk.

Chapter 25 (Preliminary Hazard and Risk) indicated that major risks are limited to the immediate area surrounding the source of the hazard. Given that each development will be located within its own tenement the overall cumulative risk level would be similar to the residual risk level of the Surat Gas Project when considered in isolation.

28.3.13 Waste

The Surat Gas Project will generate waste through the construction, operation and decommissioning phases of the project. Similarly, all other developments will also contribute to the generation of waste in the region.

One cumulative impact that could result from developments in the area is a permanent reduction in available landfill and treatment capacity. All proposed developments are considered to have the potential to generate waste and this will occur regardless of when the other developments are constructed. However it is assumed that the waste management infrastructure within the region is able to cope with any new developments. If not, the Surat Gas Project will transport waste to another facility with adequate capacity.

The cumulative impact is considered worse than the residual effects of the Surat Gas Project when considered in isolation but will remain within the same classification of significance.

As described in Chapter 26 (Waste Management), Arrow will apply the following hierarchy of waste management options to mitigate the cumulative impact:

- Source reduction to avoid, eliminate, change or reduce practices which result in the generation of wastes.
- Reuse of waste materials that are in their original form.
- Recycling to convert waste into other useable materials.
- Treatment to render wastes safe by neutralisation or other treatment methods.
- Disposal of wastes which can no longer be reused or recycled.

A communications strategy will be developed between Arrow and the relevant offsite waste facilities to ensure there is open and transparent communication regarding the volume and type of waste predicted. With the communications strategy in place, waste facilities will be able to plan for the volume of waste expected from all developments.

28.4 Inspection and Monitoring

Inspection and monitoring programs are developed and incorporated into a project's environmental management plan and by conditions placed on approvals by state and federal governments. Monitoring cumulative impacts is difficult, therefore each project will be responsible for their individual inspection and monitoring requirements. Arrow intends to work with relevant stakeholders to mitigate potential cumulative impacts.

28.5 Summary of Cumulative Impacts

There are potential cumulative impacts to environmental and social values as a result of the multiple developments within the Darling Downs region. The cumulative impact assessment identified potential positive and adverse impacts to the following values:

- Land use, specifically the disturbance and/or loss of agricultural land use**.**
- Groundwater (aquifer depressurisation and loss of water availability) through extraction.
- Socio-economic through industrial growth and population increase:
  - Regional, state and national gross product.
  - Employment rates.
  - Household incomes.
  - Businesses.
  - Housing prices and availability of affordable housing.
  - Industrial / commercial land prices.
  - Community services, infrastructure and amenities.
- Aquatic ecology through diminished water quality.
- Visual amenity due to widespread changes in the nature of the existing landscape.
- Roads and traffic due to reduced road efficiency and safety.
- Waste facilities through the permanent reduction in available landfill and treatment capacity.

This cumulative impact assessment has considered the potential residual impacts to environmental and social values. The residual impacts of the Surat Gas Project by definition are those that remain after taking account of any mitigation and management measures. Therefore mitigation is beyond the control of Arrow. Mitigation can be achieved with implementation of effective management measures from each of the individual developments and from effective local, regional and national planning.

The majority of cumulative effects would occur only if construction of the Surat Gas Project and other developments coincided, which renders the findings of this assessment conservative. As the majority of the projects are progressing through the planning, construction and operation phases, potential cumulative impacts could change or be eliminated altogether.