Appendix K

Agricultural impact assessment

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Narrabri Gas Project - Environmental Impact Statement

Agricultural Impact Statement

August 2016

Executive summary

The Proponent is proposing to develop gas wells, gas and water gathering systems, and supporting infrastructure in State Forest and on agricultural land within the Narrabri local government area (LGA). This Agricultural Impact Statement (AIS) has been completed to consider the issues that could arise as a result of the proposed development on agricultural land in response to the Secretary's Environmental Assessment Requirements dated 25 July 2014. In summary, the AIS provides the following:

- detailed assessment of the agricultural resources and agricultural production of the project area
- identification of the agricultural resources and current enterprises within the surrounding locality of the project area
- identification and assessment of the impacts of the project on agricultural resources or industries
- mitigation measures
- consultation.

This report should also be read in conjunction with a range of other technical reports that directly or indirectly address the impacts on agriculture. The reports of major relevance to the AIS include: Site Verification of Biophysical Strategic Agricultural Land report (GHD 2015a), Soils report (GHD 2016a), Groundwater Impact Assessment (CDM Smith 2016), Concept Irrigation Design (BeneTerra Pty Ltd 2015) and the Hydrology and Geomorphology Report (GHD 2016b).

The project area is approximately 95,000 ha, of which some 27,000 ha (around 28%) is agricultural land. The remaining land is comprised of State Forest and part of the Brigalow and Nandewar Community Conservation Area Agreement. The agricultural land is used predominantly for livestock grazing with occasional dryland cropping depending on seasonal conditions. There is no irrigated agriculture in the project area.

Development of the Narrabri Gas Project will have both direct and indirect impacts on agricultural production during both the construction and operation phases. The direct impacts will be the removal of land required for the construction of well pads and various storage and treatment facilities. Indirect impacts relate to the temporary interruption of farming activities during construction and operation which could reduce agricultural production and therefore landholder profitability.

The above loss of land could be compensated by the proposal to treat the produced water from gas wells at the Leewood centralised water treatment facility and make this available for irrigated agriculture. It is estimated there is potential to irrigate approximately 500 hectares of land for crop or pasture production for the two three to four years and 150 hectares for the remaining 21 or so years using treated water.

The annual value of the loss of agricultural land during the operation phase has been estimated as approximately $230,000 per year in the absence of irrigated crop or pasture production. Assuming treated and amended water was used to irrigate crops or pasture, the total net benefits from 500 hectares (two to four years) and 150 hectares (21 or so years) is estimated to be $250,000 and $75,000 per year respectively which would partially offset the value of the losses.

The direct and indirect impacts can be mitigated via a number of different actions to be adopted by the proponents that will minimise potential outcomes. The maintenance of land and soil capability as well as groundwater and surface water integrity during and after the project will be a critical requirement. Other mitigation activities are outlined in the report. In the first instance, Land Access Agreements with landholders will need to be concluded. In addition to land access agreements, farm management plans would be developed in consultation with landholders that would document activities and indicative timing of both the landholder and Santos to ensure that coexistence of activities is managed effectively.

There will be compensation for loss of production and/or increased costs caused by development activities which will further compensate for loss of productive agricultural land. In addition, a Farm Management Plan will be prepared in liaison with landholders.

The calculations completed in the AIS show that the compensation framework developed by Santos clearly recompenses landholders for expected loss in agricultural production.

The assessment included consultation with selected landholders and representatives to ensure that a comprehensive assessment has been completed. Additional consultation has also been completed by other technical specialists who have contributed reports for the EIS process.

The project area does not contain biophysical strategic agricultural land under the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* as confirmed through a detailed assessment and soil survey (refer to Chapter 14).

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1. Introduction

1.1 Overview

The Proponent is proposing to develop natural gas in the Gunnedah Basin in New South Wales (NSW), southwest of Narrabri (refer Figure 1-1).

The Narrabri Gas Project (the project) seeks to develop and operate a gas production field, requiring the installation of gas wells, gas and water gathering systems, and supporting infrastructure. The natural gas produced would be treated at a central gas processing facility on a local rural property (Leewood), approximately 25 kilometres south-west of Narrabri. The gas would then be piped via a high-pressure gas transmission pipeline to market. This pipeline would be part of a separate approvals process and is therefore not part of this development proposal.

The primary objective of the project is to commercialise natural gas to be made available to the NSW gas market and to support the energy security needs of NSW. Production of natural gas under the project would deliver economic, environmental and social benefits to the Narrabri region and the broader NSW community. The key benefits of the project can be summarised as follows:

- Development of a new source of gas supply into NSW would lead to an improvement in energy security and independence to the State. This would give NSW gas markets greater choice when entering into gas purchase arrangements. Potential would also exist for improved competition on price. Improved competition on price would have flow on benefits for NSW's economic efficiency, productivity and prosperity.
- The provision of a reduced greenhouse gas emission fuel source for power generation in NSW as compared to traditional coal-fired power generation.
- Increased local production and regional economic development through employment and provision of services and infrastructure to the project.
- A Gas Community Benefit Fund would be established which would receive an estimated $120 million through the life of the project. The fund would be contributed by industry and the Government up to a cap of 10 per cent of the royalty payments, where Government would match industry payments dollar for dollar by redirecting the royalty payments it receives.

1.2 Description of the project

The project would involve the construction and operation of a range of exploration and production activities and infrastructure including the continued use of some existing infrastructure. The key components of the project are presented in Table 1-1, and are shown on Figure 1-1.

Table 1-1 Key project components

Component	Infrastructure or activity
Major facilities	
Leewood	• a central gas processing facility for the compression, dehydration and treatment of gas • a central water management facility including storage and treatment of produced water and brine • optional power generation for the project • a safety flare • treated water management infrastructure to facilitate the transfer of treated water for irrigation, dust suppression, construction and drilling activities • other supporting infrastructure including storage and utility buildings, staff amenities, equipment shelters, car parking, and diesel and chemical storage • continued use of existing facilities such as the brine and produced water ponds • operation of the facility
Bibblewindi	• in-field compression facility • a safety flare • supporting infrastructure including storage and utility areas, treated water holding tank, and a communications tower • upgrades and expansion to the staff amenities and car parking • produced water, brine and construction water storage, including recommissioning of two existing ponds • continued use of existing facilities such as the 5ML water balance tank • operation of the expanded facility
Bibblewindi to Leewood infrastructure corridor	• widening of the existing corridor to allow for construction and operation of an additional buried medium pressure gas pipeline, a water pipeline, underground (up to 132 kV) power, and buried communications transmission lines
Leewood to Wilga Park underground power line	• installation and operation of an underground power line (up to 132 kV) within the existing gas pipeline corridor
Gas field	
Gas exploration, appraisal and production infrastructure	• seismic geophysical survey • installation of up to 850 new wells on a maximum of 425 well pads – new well types would include exploration, appraisal and production wells – includes well pad surface infrastructure • installation of water and gas gathering lines and supporting infrastructure • construction of new access tracks where required • water balance tanks • communications towers • conversion of existing exploration and appraisal wells to production
Ancillary	• upgrades to intersections on the Newell Highway • expansion of worker accommodation at Westport • a treated water pipeline and diffuser from Leewood to Bohena Creek • treated water irrigation infrastructure including: – pipeline(s) from Leewood to the irrigation area(s) – treated water storage dam(s) offsite from Leewood • operation of the irrigation scheme

The project is expected to generate approximately 1,300 jobs during the construction phase and sustain around 200 jobs during the operational phase; the latter excluding an ongoing drilling workforce comprising approximately 100 jobs.

Subject to obtaining the required regulatory approvals, and a financial investment decision, construction of the project is expected to commence in early 2018, with first gas scheduled for 2019/2020. Progressive construction of the gas processing and water management facilities would take around three years and would be undertaken between approximately early/mid-2018 and early/mid-2021. The gas wells would be progressively drilled during the first 20 or so years of the project. For the purpose of impact assessment, a 25-year construction and operational period has been adopted.

1.3 Project location

The project would be located in north-western NSW, approximately 20 kilometres south-west of Narrabri, within the Narrabri local government area (LGA) (see Figure 1-1).

The project area covers about 950 square kilometres (95,000 hectares), and the project footprint would directly impact about one per cent of that area.

The project area contains a portion of the region known as 'the Pilliga', which is an agglomeration of forested area covering more than 500,000 hectares in north-western NSW around Coonabarabran, Baradine and Narrabri. Nearly half of the Pilliga is allocated to conservation, managed under the NSW *National Parks and Wildlife Act 1974*. The Pilliga has spiritual meaning and cultural significance for the Aboriginal people of the region.

Other parts of the Pilliga were dedicated as State forest, and set aside for the purpose of 'forestry, recreation and mineral extraction, with a strategic aim to "provide for exploration, mining, petroleum production and extractive industry" under the *Brigalow and Nandewar Community Conservation Area Act 2005*. The parts of the project area on state land are located within this section of the Pilliga.

The semi-arid climate of the region and general unsuitability of the soils for agriculture have combined to protect the Pilliga from widespread clearing. Commercial timber harvesting activities in the Pilliga were preceded by unsuccessful attempts in the mid-1800s to establish a wool production industry. Resource exploration has been occurring in the area since the 1960s; initially for oil, but more recently for coal and gas.

The ecology of the Pilliga has been fragmented and otherwise impacted by commercial timber harvesting and related activities over the last century through:

- the establishment of more than 5,000 kilometres of roads, tracks and trails
- the introduction of pest species
- the occurrence of drought and wildfire.

The project area avoids the Pilliga National Park, Pilliga State Conservation Area, Pilliga Nature Reserve and Brigalow Park Nature Reserve. Brigalow State Conservation Area is within the project area but would be protected by a 50 metre surface exclusion zone.

Agriculture is a major land use within the Narrabri LGA; about half of the LGA is used for agriculture, split between cropping and grazing. Although the majority of the project area would be within State forests, much of the remaining area is situated on agricultural land that supports dry-land cropping and livestock. No agricultural land in the project area is mapped by the NSW Government to be biophysical strategic agricultural land (BSAL) and detailed soil analysis has established the absence of BSAL. This has been confirmed by the issuance of a BSAL Certificate for the project area by the NSW Government.

1.4 Planning framework and structure of this report

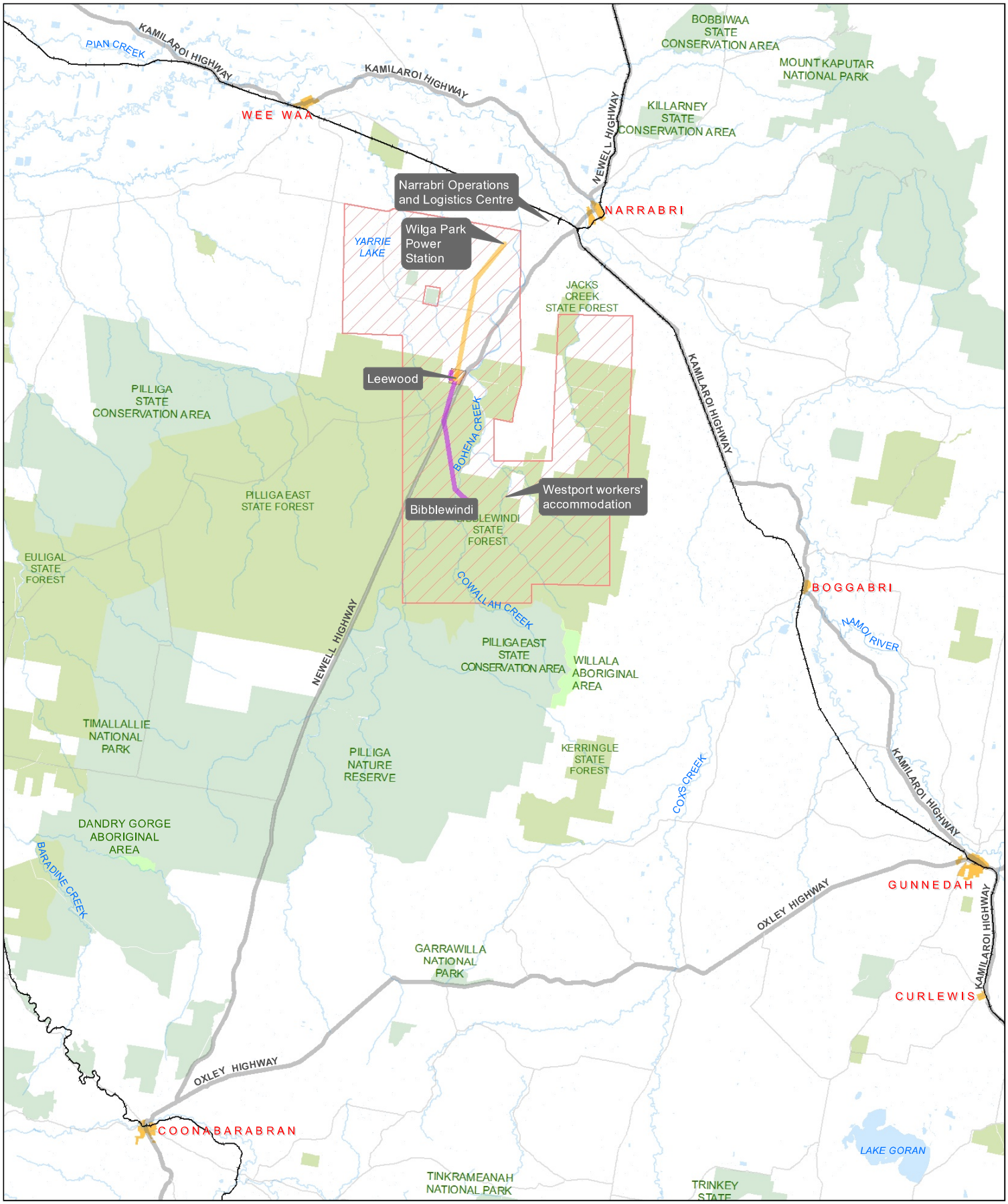
1.4.1 Planning Framework

The project is permissible with development consent under the *State Environmental Planning Policy (Mining, Petroleum and Extractive Industries) 2007*, and is identified as 'State significant development' under section 89C(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *State Environmental Planning Policy (State and Regional Development) 2011*.

The project is subject to the assessment and approval provisions of Division 4.1 of Part 4 of the EP&A Act. The Minister for Planning is the consent authority, who is able to delegate the consent authority function to the Planning Assessment Commission, the Secretary of the Department of Planning and Environment or to any other public authority.

The project is also a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The project was declared to be a controlled action on 5 December 2014, to be assessed under the bilateral agreement between the Commonwealth and NSW Governments, and triggering the following controlling provisions:

- listed threatened species and ecological communities
- a water resource, in relation to coal seam gas development and large coal mining development
- Commonwealth land.



LEGEND

- Project area
- Leewood
- Urban Areas
- State forest
- Parks and reserves
- Aboriginal areas
- Lakes and dams
- Watercourses
- Highways
- Major Roads
- Train line
- Leewood to Wilga Park infrastructure corridor
- Bibblewindi to Leewood infrastructure corridor

0 5 10 20
Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Narrabri Gas Project
EIS Technical Appendix Agricultural Impact Statement

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Revision A
Date 06 Apr 2016

Regional context and location of key infrastructure

Figure 1-1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: NSW Department of Lands: DTDB and DCDB - 2012-13. Santos: Operational and Base Data - 2013. Created by: afoddy

This Agricultural Impact Assessment identifies the potential environmental issues associated with construction and operation of the project and addresses the Secretary's environmental assessment requirements for the project. The assessment will be used to support the EIS for the project. The requirements addressed in this report include:

- an assessment of the likely impacts of the development on the soils and land capability of the site and surrounds, including likely erosion and salinity impacts
- an assessment of the compatibility of the development with other land uses in the vicinity of the development
- an assessment of the likely economic impacts of the development
- a description of consultation with affected landowners, identifying the issues raised and how these issues have been addressed.

1.4.2 Structure of report

The report is structured as follows:

- **Chapter 1 – Introduction** – This chapter introduces the proposed development and the proponent and describes the project area.
- **Chapter 2 – Methodology** –This chapter defines the study area assessed in this report and describes the steps undertaken in the assessment.
- **Chapter 3 – Legislative context –** This chapter outlines the relevant Commonwealth and State legislation relating to the assessment. Guidelines and assessment criteria (where applicable) relevant to the gas field construction, operation and decommissioning are also identified.
- **Chapter 4 – Existing environment** – This chapter describes the existing environmental values of the study area relevant to Agriculture, including results of desktop assessments and field investigations (where applicable).
- **Chapter 5 – Impact assessment** – This chapter examines the potential environmental impacts associated with the construction and operation of the project.
- **Chapter 6 – Mitigation measures.** This chapter outlines the proposed mitigation strategies to be implemented during the life of the project to manage the potential environmental impacts.
- **Chapter 7 – Conclusion.** This chapter presents a conclusion to the report and presents the next steps in the advancement of the project.

2. Methodology

2.1 Project area

The project area for the Agricultural Impact Statement (AIS) consists of the project area as shown in Figure 1-1. The project area is contained within the Narrabri Local Government Area (LGA) in which land use planning is subject to provisions within the *Narrabri Local Environmental Plan 2012*. The project area includes a portion of the Pilliga East, Bibblewindi and Jacks Creek State Forests in the south, and agricultural land in the north. The area of land within the project area is approximately 95,000 hectares (refer to Table 2-1) of which about 27,000 hectares is land that can be potentially used for agricultural purposes. A more detailed breakdown of land use in the project area is provided in section 4, Table 4-4.

Table 2-1 Gas field land area (hectares) – approximate

Land type	Area (hectares)[1]
Agricultural land	27,000
State Forest, Reserve land and other uses	68,000
Total project area	95,000

Source: NSW Office of Environment and Heritage (2013)

The project area is located within the North West Local Land Services (LLS) region which includes land previously included in the former Namoi Catchment Management Authority (CMA). Local Land Services regions were established in 2014 by the NSW Department of Primary Industries.

2.2 Data sources

This AIS relies on data sourced from public sources, an inspection of the project area in January 2014, and a range of targeted interviews with existing agricultural landholders and other representatives (refer to Table 2-2 for list of interviewees). Landholder interviewees were chosen by Santos and were selected to be representative of the main agricultural industries within the project area (cattle, sheep, dryland cereal cropping). Additional consultation with relevant stakeholders was also conducted as part of various technical studies comprising the EIS (refer to the Social Impact Assessment (GHD 2016c) and the Stakeholder and Community Consultation Technical Appendix (Santos 2016).

The AIS also relies on other specialist technical studies completed by the consultants for the EIS. Accordingly, reference to the source document is provided where information from other specialist studies is used in this report. A list of the references is included in Section 8.

Table 2-2 Interviews for data collection

Interviewees	Description
Five agricultural landholders	A range of livestock and cropping landholders considered representative of the range of agricultural land use within the project area.
Organisations	NSW Farmers Association North West Local Land Services

[1] Numbers in this and other tables in the AIS have been rounded and as such may not reflect actual numbers in source documents.

In addition, a report by FPC Water Solutions (2014) provided information on Santos' current operations – particularly their operations with regard to water management. The FPC Water Solutions (2014) report identified and / or clarified key concerns of the local agriculture/irrigation industry/community, and identified opportunities to address those concerns.

Santos has an ongoing consultation and engagement framework in place to understand and address affected landholders' concerns in relation to the Narrabri Gas Project. A range of communication strategies were used to ensure landholders in the project area and in the broader regional context were informed of the project and their input was incorporated into project planning.

Santos has also undertaken consultation activities with the NSW Apiarist's Association. At the 2014 NSW Apiarist's Conference held in Narrabri, Santos presented a paper discussing the impact of Santos coal seam gas operations in the Pilliga Forest and the impact on bees in the forest.

3. Legislative context

As stated in Section 1.4.1, the project is permissible with development consent under the *State Environmental Planning Policy (Mining, Petroleum and Extractive Industries) 2007*, and is identified as 'State significant development' under *State Environmental Planning Policy (State and Regional Development) 2011*. The requirement for an AIS applies to all state significant development applications for mining and petroleum development (including coal seam gas) and will form part of the EIS prepared for the proposal.

The content of this AIS is based on the "Guideline for agricultural impact statements" (NSW Department of Planning & Infrastructure 2012) and technical notes prepared by the NSW Department of Primary Industries (2013). The major requirements for inclusion in an AIS are:

- detailed assessment of the agricultural resources and agricultural production of the project area
- identification of the agricultural resources and current enterprises within the surrounding locality of the project area
- identification and assessment of the impacts of the project on agricultural resources or industries
- mitigation measures
- consultation.

Included in an AIS is the need to determine the presence or otherwise of land that meets criteria for determining the presence of biophysical strategic agricultural land. This requirement is considered separately in the Site Verification of Biophysical Strategic Agricultural Land (BSAL) report (GHD 2015a). No BSAL is within the project area as acknowledged by the issuance of a Site Verification Certificate by the NSW Office of Environment and Heritage for the project.

4. Existing environment

4.1 Climate

Narrabri is located in the North West Slopes and Plains region of NSW. The average annual rainfall at Narrabri is 659 mm per year with a pattern of higher rainfall in summer compared to winter months (refer to Table 4-1 and Figure 4-1). Temperatures are characterised by hot maximum temperatures in summer (with high evaporation rates) and low minimum temperatures in winter (including frost risk) (refer to Table 4-1 and Figure 4-2). The complex interaction of rainfall and temperature impacts on the choice of agricultural enterprise within the project area (refer to Section 4.4).

Note that the climatic data is from the Bureau of Meteorology (BOM) Narrabri West Post Office (Station Number 53030) based on records dating from 1891 through to 2014. Such long-term records provide information on rainfall and temperature patterns throughout the year that assist in understanding agricultural enterprise selection and production in the area. It should be noted that the BOM climatic statistics used in the Air Quality Impact Assessment (Air Environment Consulting 2015) are based on shorter term records (since 2001) collected from Narrabri Airport (Station Number 54038). While the average annual rainfall differs between the sources, this difference is not material when assessing the impact of the gas field development on agricultural production within this AIS.

While average rainfall and temperature are important indicators of potential rain fed agricultural production, actual annual production is greatly influenced by monthly variability compared to the monthly average. Variability of rainfall is exemplified in Table 4-1 with the comparison of rainfall per month in 2013 and the long term mean monthly rainfall. For example, while average rainfall for April is 38 mm the amount recorded for April 2013 was nil. By contrast, the average rainfall for January is 83 mm while the amount recorded for January 2013 was 154 mm.

While rainfall impacts on all forms of agricultural production, both surface water and groundwater resources also have an impact depending on their availability. These resources provide opportunities for irrigation and livestock drinking water and are discussed further in Section 4.3 below.

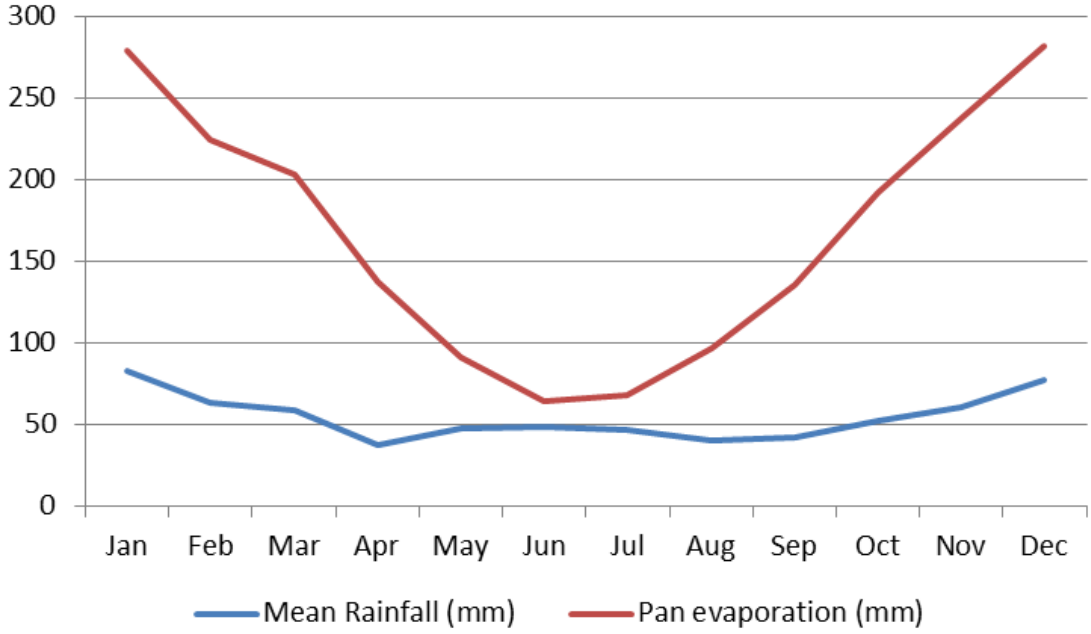
Table 4-1 Climate statistics for Narrabri

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall (mm)*	83	63	59	38	48	49	47	40	42	52	61	77
Rainfall in 2013* (mm)	154	37	128	0	33	66	17	3	19	6	90	19
Mean maximum temperature (°C)	34	33	31	27	23	19	18	20	23	27	30	33
Mean minimum temperature (°C)	19	19	16	12	8	5	4	5	8	12	15	18
Pan evaporation (mm)	279	224	203	137	91	64	68	97	136	192	237	282

Source: *Bureau of Meteorology Narrabri West Post Office Station Number 53030*

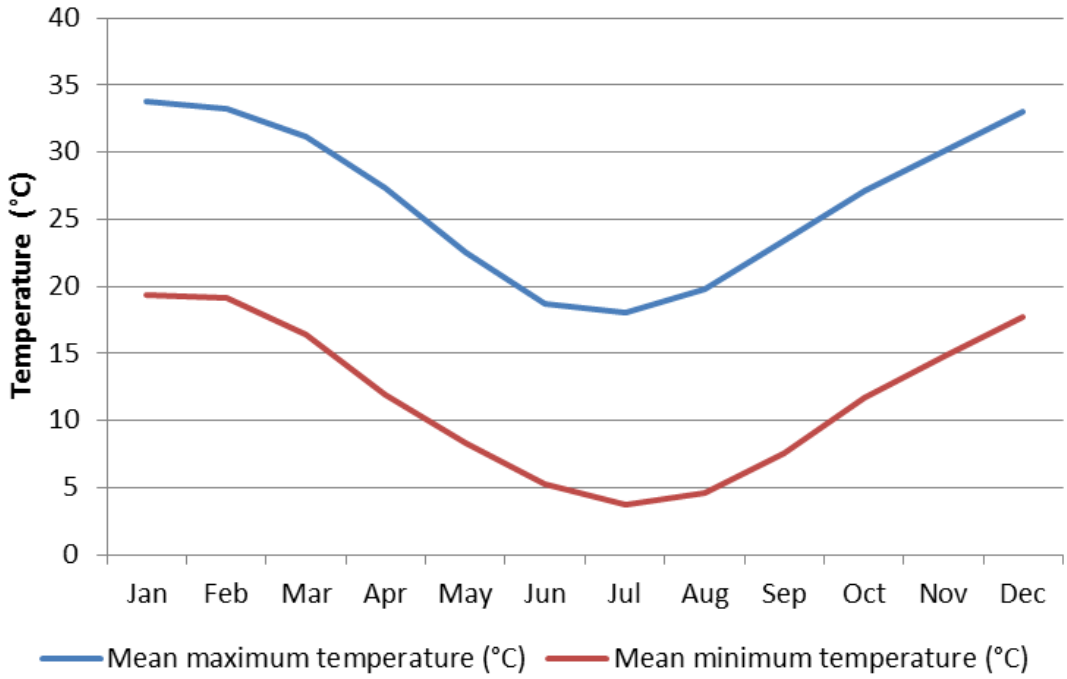
Pan Evaporation data sourced from RPS Australia East Pty Ltd (2013) *Tintsfield CSG Pilot & Flare Agricultural Impact Statement*. Data from SILO Climate Data (2013)

* Mean rainfall is based on averages to 2013 as the 2014 rainfall data was incomplete at time of publication



Source: Bureau of Meteorology Narrabri West Post Office Station Number 53030

Figure 4-1 Monthly distribution of rainfall, evaporation



Source: Bureau of Meteorology Narrabri West Post Office Station Number 53030

Figure 4-2 Monthly maximum and minimum temperatures

4.2 Land capability, including soils

Land capability for agricultural production in the project area is a function of a range of natural resource conditions including geomorphology, topography, vegetation and soils. Each of these natural resource types has been investigated in separate technical reports (refer to the Site Verification of Biophysical Strategic Agricultural Land (BSAL) report (GHD 2015a) and the Interpretive Soils Report (GHD 2016a). The following is a summary of publicly available data on land capability and soil fertility that has been adapted for use in the project area.

It should be noted that the site verification of BSAL report identified that there was no evidence of BSAL in the project area. This was verified through the issuance of a Site Verification Certificate by the NSW Office of Environment and Heritage for the project.

Land and soil capability for agricultural purposes is often described using an 8-Class classification system in NSW with regional classifications available from the NSW Office of Environment and Heritage website. Table 4-2 and Figure 4-3 show the land and soil capability for the land within the project area. The majority of the land (approximately 82 per cent of the project area) is classified as Class 4 and Class 5 and as such has moderate to severe limitations such that land generally is not capable of sustaining high impact agricultural land uses unless using specialised management practices and resources. This is consistent with the findings of the BSAL report (GHD 2015a).

About 18 per cent of the project area is identified as Class 3 with moderate limitations such that this land is capable of sustaining high impact land uses such as cropping. The Class 3 land occurs in the north-west of the project area.

Table 4-2 Land and soil capability (LSC) classes

LSC Class	Description	Area (ha)	% of project area
3	Moderate limitations. Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.	17,000	18%
4	Moderate to severe limitations. Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology.	32,500	34%
5	Severe limitations. Land not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.	45,500	48%
7	Extremely severe limitations. Land incapable of sustaining most land uses. Limitations cannot be overcome.	21	0.02%
Total		**95,000**	**100%**

Source: NSW Office of Environment and Heritage (2013)

NSW Office of Environment and Heritage also holds information on soil fertility. Table 4-3 indicates that 24 per cent of the land within the project area is classified as having moderate soil fertility with 75 per cent of the land within the project area classified as low or moderately low soil fertility.

The moderately low soil fertility status was confirmed by comprehensive soils testing and assessment survey undertaken for the Interpretive Soils Report (GHD 2016a). From this survey, six broad soil types, were identified and characterised namely Red brown earths, Brigalow grey clays, Red brown clays, Sandy sodic duplex, Recent alluvium and Acidic sands. The report concludes that all the soils in the project area are potentially susceptible to engineering works, although all potential impacts can be mitigated if regulatory procedures for erosion and sediment control and rehabilitation guidelines are followed.

Figure 4-4 indicates that the moderate soil fertility land occurs mainly in the northerly regions of the project area and that the lower fertility land is mainly associated with those areas in the south of the project area that are non-agricultural land uses (refer to Figure 4-7).

Table 4-3 Soil fertility

Fertility	Area (ha)	% of project area
Low	14,000	14%
Moderately Low	58,000	61%
Moderate	23,000	24%
Total	**95,000**	**100%**

Source: NSW Office of Environment and Heritage (2013)

4.3 Surface and groundwater resources

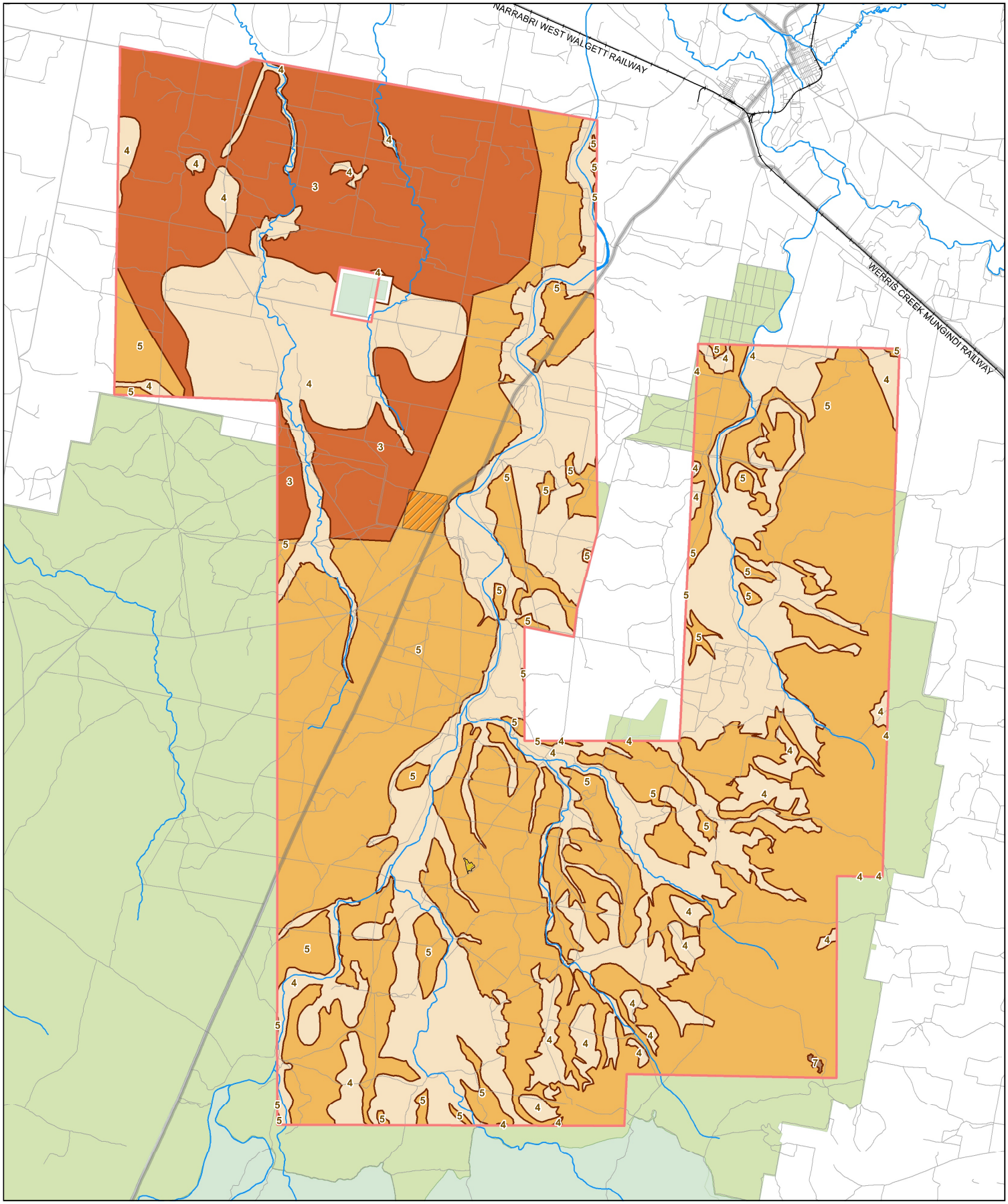
In addition to land capability considerations, agricultural production is also influenced by surface and groundwater resources. Surface and groundwater resources have been investigated in separate technical reports (refer to the Groundwater Impact Assessment (CDM Smith 2016) and the Hydrology and Geomorphology technical appendix (GHD 2016b).

In general, the groundwater and surface water resources extracted within the project area are used for stock and domestic purposes and not for irrigation purposes. The stock and domestic bores are generally less than 100 metres deep. Surface water dams for livestock drinking water are an important resource for the livestock industries.

4.4 Land use

Table 4-4 denotes the distribution of land use in the project area based on data obtained from the NSW Office of Environment and Heritage. The majority of the land (approximately 57 per cent) is classified as State Forest. Grazing comprises 22 per cent and dryland cropping 6 per cent of the project area. A map of land use is provided at Figure 4-7.

State forests and conservation areas in the region are administered under the *Brigalow and Nandewar Community Conservation Area Act 2005*, which designates the area into Community Conservation Areas. The purpose of Community Conservation Areas is to reserve land for conservation, protect areas of natural and cultural heritage significance to Aboriginal people, sustainable forestry and mining and other appropriate uses. Pilliga East State Forest, Bibblewindi State Forest and Jacks Creek State Forest are also used for recreational activities such as bird watching, bushwalking and hunting.



LEGEND

- Project area
- Leewood
- Bibblewindi
- Parks and reserves
- State forest
- Lakes and dams
- Watercourses
- Roads
- Train line

Land and soil capability (LSC) classes

- 3
- 4
- 5
- 7

0 1.75 3.5 7

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Land and soil capability

Figure 4-3

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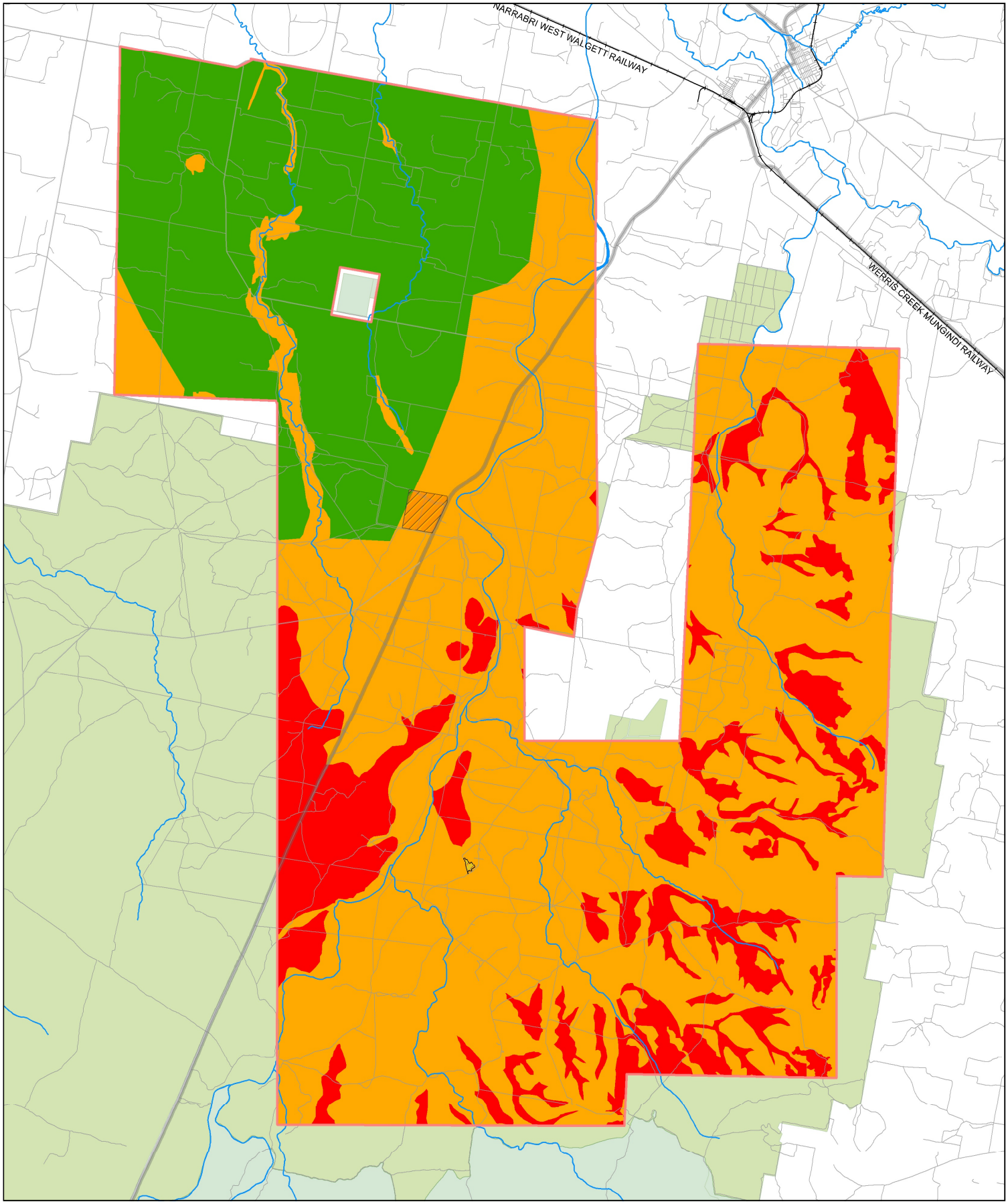
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: NSW Department of Lands: DTDB and DCDB - 2012-13. Santos: Operational and Base Data - 2013. Created by: afoddy



LEGEND

- Project area
- Leewood
- Bibblewindi
- Parks and reserves
- State forest
- Lakes and dams
- Watercourses
- Roads
- Train line

Surface Fertility (OEH 2012)

- Low
- Moderately low
- Moderate

0 1.75 3.5 7

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Narrabri Gas Project
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Soil fertility

Figure 4-4

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: NSW Department of Lands: DTDB and DCDB - 2012-13. Santos: Operational and Base Data - 2013. Created by: afoddy

Table 4-4 Current land use within the project area

Land Use	Area (ha)	%
State Forest	54,000	57%
Native forest / Crown reserve	9,000	9%
Lakes Rivers Swamps and Drainage	800	1%
Farm dams	80	0.1%
Quarry	52	0.05%
Research facility	14	0.02%
Grazing	21,000	22%
Cropping	6,000	6%
Travelling Stock Routes	600	1%
Windbreak or tree corridor	100	0.1%
Farm Infrastructure	150	0.2%
Urban / Rural Residential	2,580	3%
Infrastructure (Roads)	624	1%
Total	**95,000**	**100%**

Source: NSW Office of Environment and Heritage (2014)

Land use in the project area can be compared to land use in the Narrabri Local Government Area (LGA) (refer to Table 4-5) and the broader Namoi Catchment Management Authority (CMA) land use (refer to Figure 4-6).

The LGA has an area of 1,303,060 hectares of which 737,000 hectares (57 per cent) is utilised for agriculture. Agricultural land use is predominantly cropping (48% of agricultural land) and grazing (44% of agricultural land) with additional areas of remnant vegetation and forestry.

Table 4-5 Agricultural land use Narrabri Shire 2011

Land use	Approximate area (ha)	%
Land under crop	357,500	48%
Grazing land (including pastures and rangelands) - Improved pastures 112,300 ha - Grazing on other land 211,200 ha	323,500	44%
Remnant vegetation and woodland not suitable for grazing	54,000	7%
Land under commercial forestry plantations	300	0.04%
Other agricultural purposes (incl. not reported)	2,300	0.3%
Total	**737,600**	100%

Source: ABS (2012) Agricultural Commodities Small Area Data, Australia, 2010-11, Cat. No. 7121.0 (Table 10)

Within the Narrabri LGA, major crops are wheat, cotton and chickpeas (refer to Table 4-6) and the majority of cotton is grown using irrigation. Irrigation is not available in the project area and as such, cropping decisions are dependent on rainfall which is highly variable, as described in Section 4.1.

Based on landholder interviews and site inspections the major agricultural land uses in the project area are dryland crop production and grazing livestock (mainly beef cattle and sheep). There is limited land used for timber production and also honey production.

Table 4-6 Major Crops for Narrabri LGA

Commodity	Approximate area (ha)
Wheat	145,000
Barley	10,000
Sorghum	12,000
Cotton	67,000
Canola	3,000
Chickpeas	41,500
Faba Beans	5,500

Source: ABS (2012) Agricultural Commodities Small Area Data, Australia, 2010-11, Cat. No. 7121.0 (Table 10)

The relatively low level of cropping activity in the project area was demonstrated by a NSW Office of Environment and Heritage analysis of the frequency of cropping events in the project area for summer 2000 to summer 2009 (OEH 2009). Table 4-7 indicates that out of a total of 1,807 paddocks, the majority (1,686 or 93 per cent) did not record a single cropping event. The remaining 121 paddocks recorded at least one crop event (winter or summer crop). Two paddocks each recorded seven cropping events during the period consisting of 10 winter crops and four summer crops. This demonstrates the relatively low level of cropping in the project area, as compared to pasture grazing by livestock. The pattern is shown in Figure 4-5

Table 4-7 Cropping history in the project area 2000-2009

Cropping events	Paddocks	Winter Crop	Summer Crop
0	1,686		
1	34	31	3
2	31	31	31
3	23	49	20
4	20	42	38
5	9	22	23
6	2	8	4
7	2	10	4
Total	**1,807**	**193**	**123**

Source: NSW Office of Environment and Heritage (2009)

The Apiary industry

Honey production is significant in the Narrabri region especially in the Pilliga Scrub where beekeeping dates back to the 1930s (Stace 1996). The Pilliga forest is a preferred site for beekeepers as production responds positively to increases in rainfall. In addition, the forest offers protection from pesticide use and locust control measures that occur elsewhere in the region. Stace (1966) also noted the important role that bees play in pollinating agricultural crops and supporting the economies of regional towns.

A study by Hassall and Associates (2004) for the Nandewar Bioregion (which incorporates the eastern edge of Narrabri LGA) examined the characteristics and extent of the apiary industry. The report noted the importance of native and state forests to the apiary industry. In particular, it noted that native forests and pine plantations are used for nectar resources, locations for overwintering and additional sources of pollen useful for bee breeding due to regrowth following timber harvesting.

NSW accounts for about 40 per cent of national honey production from approximately 230,000 hives. The NSW apiary industry currently employs over 3,100 bee keepers (RIRDC 2012) and the total gross value of honey production is $36 million per year (NSW Apiarists Association 2013), excluding the value of pollination services provided indirectly to other agricultural industries.

Apiarists generally rely on the use of public land for their hives with the majority of NSW production being derived from eucalypt species. Eucalyptus species tend to flower on a two to five-year cycle. Therefore, it is important for apiarists to have a variety of forests available in different locations throughout the year.

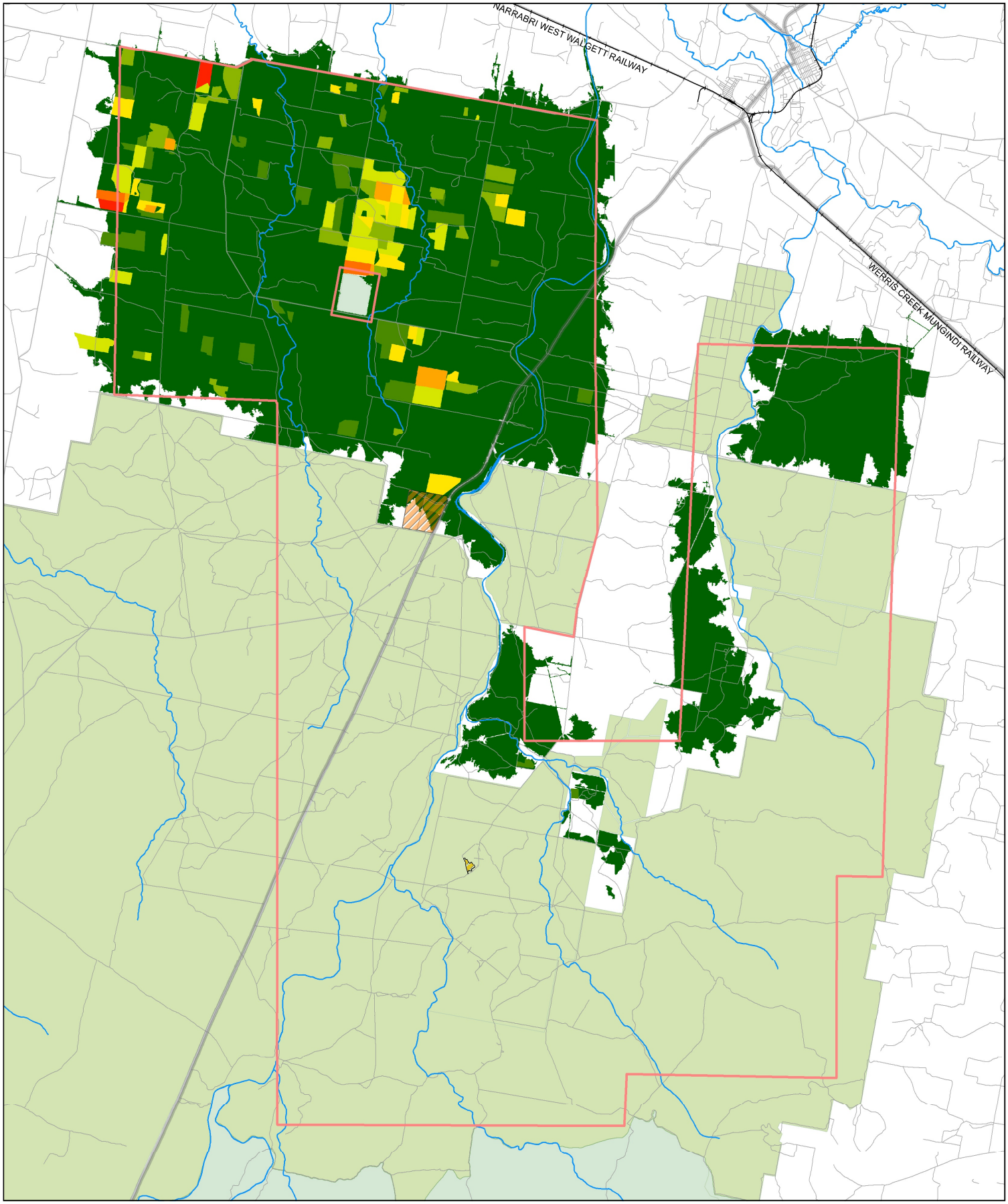
Santos has completed a number of consultation activities with the NSW Apiarist's Association including a field trip to the proposed project area in 2012 (Australia's Honeybee News 2012). In addition, Santos addressed the NSW Apiarists' Association 2014 annual conference, which was held in Narrabri. Santos presented an overview of the project, including a discussion on the potential impact on the bee industry with reference to access. Santos will continue to undertake ongoing stakeholder communication with the apiary industry.

Timber production

Timber production has been a significant industry in the project area in the past. However, current activity is limited (Pers. Comm. Landholder interviewees, January 2014).

Despite this, in June 2014 the Natural Resources Commission (NRC) recommended actively managing timber within Community Conservation Areas (CCA), including within the Narrabri region, via interventions such as ecological thinning and targeted grazing. The aforementioned NRC report notes that 'if commercial use of thinning by-products is permitted, ecological thinning will provide an economic benefit to local timber businesses, households and families, particularly in the communities of Baradine and Gwabegar' (NRC 2014).

Ecological thinning is likely to benefit the timber harvesting, transport and processing sector with the benefits likely to be largely opportunistic due to the variability of supply. NRC modelling indicates the production volume could range from 1,000 cubic metres per year to 14,000 cubic metres per year. Sawmills located in the towns of Baradine and Gunnedah currently process cypress sawlogs from the Brigalow and Nandewar region and sell a range of solid wood products into the NSW and Victorian domestic markets. Both sawmills employ between 14-20 employees.



LEGEND

- Project area
- Leewood
- Bibblewindi
- Parks and reserves
- State forest
- Lakes and dams
- Watercourses
- Roads
- Train line

Total Crops 1999-2009

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

0 1.75 3.5 7

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Narrabri Gas Project
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Revision A
Date 06 Apr 2016

Cropping history 2000-2009

Figure 4-5

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: NSW Department of Lands: DTDB and DCDB - 2012-13. Santos: Operational and Base Data - 2013. Created by: afoddy

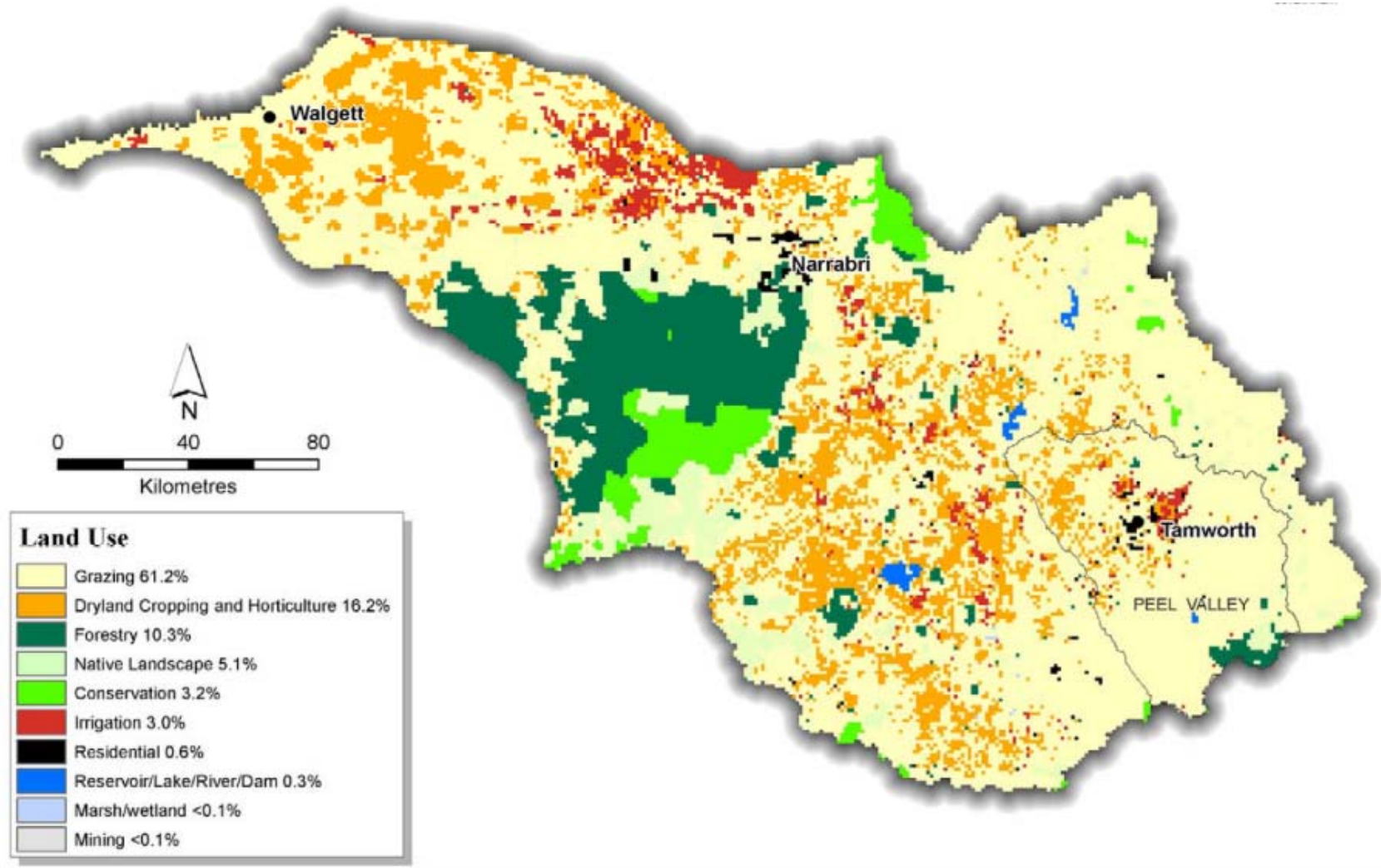
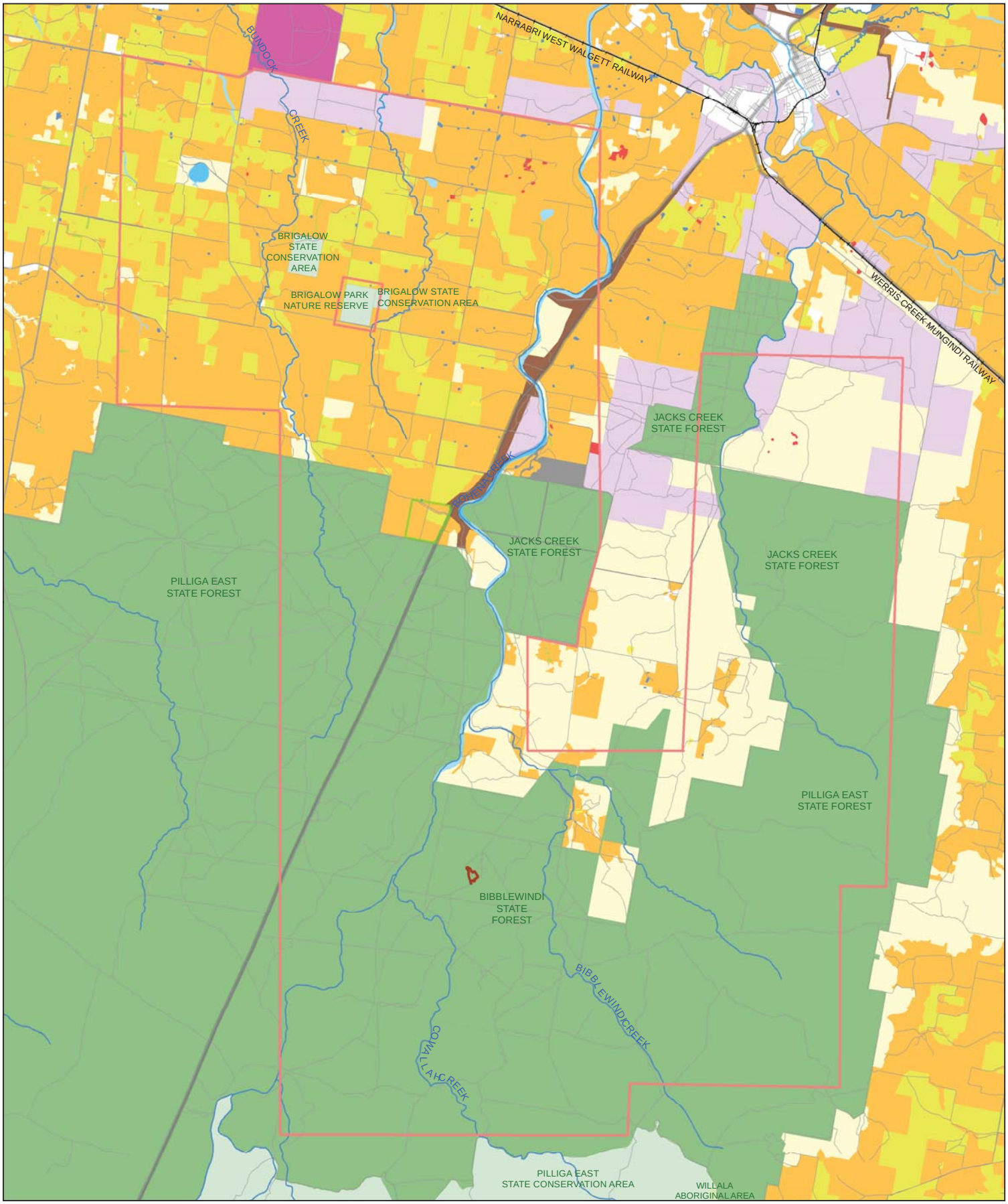


Figure 4-6 Current land use in Namoi CMA



LEGEND

- Project area
- Leewood
- Bibblewindi
- Parks and reserves
- State forest
- Aboriginal areas
- Lakes and dams
- Watercourses
- Roads
- Train line

NSW Land Use Mapping

- State Forest
- Native Forest / Crown reserve
- Lakes, rivers, swamps and drainage
- Farm dams
- Quarry
- Research facility
- Grazing
- Cropping
- Travelling stock routes
- Windbreak or tree corridor
- Farm infrastructure
- Urban / rural residential
- Infrastructure (roads and airstrip)

0 1.75 3.5 7

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Narrabri Gas Project
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Revision A
Date FEB 2015

Land use within the project area

Figure 4-7

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Data source: DTDB and DCDB -2012-13. Santos: Operational and Base Data - 2013. Created by:afoddy

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

4.5 Value of agricultural production

There is no publically available published information on the annual value of agricultural production in the project area. However, the importance of agriculture in the region can be demonstrated by considering data for the Narrabri LGA. The gross value of agricultural production in the Narrabri LGA was approximately $400 million in the 2012 financial year and $262 million in 2006, with 2006 considered to be a low rainfall year (refer to Table 4-8). The majority of the value of production is from crops with lesser contributions from livestock slaughterings (mainly cattle) and livestock products (mainly wool).

On a per hectare basis, the value of agricultural production for the Narrabri LGA in 2012 was $1,015 per hectare for crops (i.e. $362.7 million from 357,500 hectares – refer to Table 4-5) and $98 per hectare for livestock (i.e. $31.8 million from 323,500 hectares – refer to Table 4-5). The difference is due to the high value of irrigated cotton and other crops within the cropping total (refer to Table 4-9). Irrigated cropping is not present within the project area.

Table 4-8 Gross value of major agricultural products (Narrabri LGA)

Commodity	2010-11	2005-06
Total crops (including hay)	$362.7	$215.1
Horticulture – fruit (peaches, citrus and olives)	$0.8	$0.3
Horticulture – vegetables (potatoes)	$2.3	$1.4
Livestock slaughterings (Cattle $21.9, Sheep and Lambs $2.7, Pigs $3.5)	$28.1	$41.4
Livestock products (Wool $3.7)	$3.7	$4.0
Total ($ million)	**$398**	**$262**

Source: ABS (2012) Agricultural Commodities Small Area Data, Australia, 2010-11, Cat. No. 7503.0 (Table 10), ABS (2008) Agricultural Commodities Small Area Data, Australia, 2005-06 (Reissue), Cat. No. 7125.0 (Table 1)

Within the LGA, cotton is the most valuable crop produced followed by wheat (Table 4-9). Other crops contribute to a lesser extent.

Table 4-9 Gross value of major crops- Narrabri LGA (2010-11)

Commodity	Value ($m)
Wheat	$99.5
Barley	$4.5
Sorghum	$7.3
Cotton	$223.5
Canola	$3.0
Chickpeas	$11.5
Faba Beans	$3.0

Source: ABS (2012) Agricultural Commodities Small Area Data, Australia, 2010-11, Cat. No. 7503.0 (Table 10)

4.5.1 Value of agricultural production in the project area

As there is no publicly available statistics on the value of agriculture in the project area, an estimate of the value of production was derived using a combination of publically available data from the NSW Department of Primary Industries' (DPI) website and knowledge gained from farmer interviews in the region.

Table 4-10 denotes the gross income ($/ha/year) for major agricultural enterprises in the project area. This data has been sourced from the NSW DPI website (http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets).

Table 4-10 Assumed gross income per hectare for major enterprises within the project area

Enterprise	Gross income ($/ha/year)
Dryland cotton (summer)	$1,794
Dryland sorghum (summer)	$945
Wheat Long Fallow, No Till (winter)	$660
Dryland Canola (winter)	$598
Growing out steers 240kg – 460kg	$769
Young cattle 15-20 months	$151
Merino Ewes (20 micron)	$406
Prime lambs	$508

Source: NSW Department of Primary Industries, Gross Margin Budgets

It is necessary to determine the contribution of each enterprise to agricultural production in the project area. To determine this, land use data (refer to Table 4-4) and knowledge of agriculture gained during landholder interviews in the project area were used to derive the weighted estimates for gross income per hectare provided in Table 4-11.

Table 4-11 Gross income averages in the project area

Enterprise	Basis	Weighted gross income ($/ha/year)
Grazing	75% cattle (50% steers, 50% young) 25% sheep (50% Merino, 50% lambs)	$459
Cropping	70% winter (75% wheat, 25% canola) 30% summer (90% sorghum, 10% dry cotton)	$760
Average	76% Grazing, 24% cropping	$533

The average gross income per hectare per year from agricultural land in the project area is estimated at $533 per hectare. It is to be noted that the gross income averages in Table 4-11 differ from those calculated from Table 4-8 which were based on Narrabri LGA statistics with gross income from livestock being higher and gross income from crops lower. The lower crop average in the project area (refer to Table 4-11) is due to the absence of irrigated crops. The higher livestock average is likely to be the result of DPI gross margin information being based on higher stocking rates compared to actual stocking rates in the project area.

A value of $533 per hectare (average) was adopted to calculate the economic impact on agricultural production within the project area (refer above and Table 5-5). However, this is considered to be an overestimate of the potential agricultural production and therefore potential economic impact associated with project activities.

4.6 Agricultural employment

Agriculture, forestry and fishing are the largest employment industries in the Narrabri LGA employing 1,124 persons (22 per cent of the workforce) in 2011 (refer to Table 4-12). Retail trade (10 per cent), health care and social assistance (10 per cent), education and training (7 per cent) and mining (7 per cent) are the other main industries of employment. The aforementioned five industries account for approximately 55 per cent of employment in the LGA. Table 4-12 also demonstrates changes in employment between the 2006 and 2011 census years. Over this period, employment in the agriculture, forestry and fishing industry declined by 309 persons while employment in the mining industry increased by 295 persons.

Table 4-12 Industry by employment – Narrabri LGA

Industry of employment	2006		2011		Change 2011-2006
Agriculture, forestry & fishing	1,433	27%	1,124	22%	-309
Mining	44	1%	339	7%	295
Manufacturing	277	5%	238	5%	-39
Electricity, gas, water & waste services	58	1%	58	1%	0
Construction	254	5%	243	5%	-11
Wholesale trade	150	3%	178	3%	28
Retail trade	565	11%	524	10%	-41
Accommodation & food services	336	6%	332	6%	-4
Transport, postal & warehousing	337	6%	286	6%	-51
Information media & telecommunications	41	1%	23	0%	-18
Financial & insurance services	71	1%	76	1%	5
Rental, hiring & real estate services	41	1%	48	1%	7
Professional, scientific & technical services	250	5%	230	4%	-20
Administrative & support services	103	2%	90	2%	-13
Public administration & safety	229	4%	231	4%	2
Education & training	373	7%	358	7%	-15
Health care & social assistance	424	8%	503	10%	79
Arts & recreation services	35	1%	26	1%	-9
Other services	247	5%	236	5%	-11
Inadequately described/Not stated	81	2%	49	1%	-32
Total	**5,349**	**100%**	**5,192**	**100%**	**-157**

Source: ABS (2013) 2011 Census and 2006 Census – Narrabri LGA

4.7 Agricultural support services and infrastructure

As discussed above, the Narrabri Shire has a diverse range of agricultural enterprises and this has resulted in the development of various support services and infrastructure including product storage, marketing, transport and processing facilities.

In addition, world-ranked agricultural research establishments are located in the Narrabri district, being; the I.A. Watson Grains Research Centre (operated by the University of Sydney), the Australian Cotton Research Institute (owned by the NSW Department of Primary Industries and used as its Centre of Excellence for Cotton, Pulses and Oilseed Improvements), the Cotton Catchment Communities Cooperative Research Centre (Cotton CRC) and the CSIRO Divisions of Plant Industry and Ecosystem Services (Cotton Research Unit).

The agricultural industries are supported by specialist supply, engineering, chemical and consulting firms. The Cargill Oilseeds plant at Narrabri processes about 250,000 tonnes of cottonseed each year and the Australia Milling Group is a processor and supplier of all types of Australian pulses and specialty crops. It should be noted that effluent disposal ponds for the aforementioned facility are located within the project boundary. This is discussed in the Contaminated Land Assessment technical appendix (GHD 2016d).

Namoi Cotton has the largest ginning network in Australia, comprising 14 cotton ginning sites strategically positioned throughout the cotton growing regions of NSW and southern Queensland, including a gin at Boggabri which is 60 kilometres south east of Narrabri.

GrainCorp and Louis Dreyfus have significant grain storage infrastructure in Narrabri and freight rail services are available to the Sydney and Newcastle port system for export markets. The region is serviced by the Newell and Kamilaroi highways and established regional road network that provides a reliable land transport corridor to Sydney, Brisbane and Melbourne.

The Narrabri Livestock Selling Centre hosts weekly sales of stock sourced from the region. The centre hosts sales of prime and store cattle and sheep on a regular basis. Teys Australia operates a livestock abattoir at Tamworth (170 kilometres from Narrabri) and Bindaree Beef has an abattoir at Inverell (180 kilometres from Narrabri).

5. Impact assessment

The components of the proposed development that may impact on agricultural land include:

- Installation of up to 850 individual production wells on up to 425 well pads.
- Gas and water gathering systems and access tracks.
- Up to 20 communication towers located on well pads.
- Off-site treated water storage (Leewood).

Well pads are proposed to be spaced approximately 750 to 1,500 metres apart, depending on surface and subsurface characteristics. Each well pad would be approximately one hectare in size during drilling and construction. Following well installation, the majority of the pad would be rehabilitated leaving an area of approximately one quarter hectare with surface facilities including a well head etc. during the operational phase, with the exception of those pads hosting communications equipment or water balance tanks which would remain at one hectare in size. However, as a conservative approach, GHD has assumed that only 50 % (or half of one hectare) of the well pads hosting gas wells would be available for cropping during the operational stage of the project. On privately owned land, well pads will generally be sited to address concerns or issues raised by the landholder and to minimise impacts on productive agricultural land.

Access to the well pads and other facilities will be required with access tracks having a maximum width of approximately 12-metre-wide (an average of 10 metres) for the construction phase, which would be reduced to approximately five metres during operations.

Gas and water gathering systems would be required with these services placed below ground at a depth of 0.75 but may be up to two metres depending on land type. It is proposed that these services would be co-located where practicable to minimise disturbance to land.

During construction and operation impacts to agricultural land use will include:

- disturbance to agricultural land including pastures, crops or native vegetation.
- short term isolation of areas of land during construction, including along gas and water gathering corridors.
- longer term land use change for sites selected for production wells, the gas processing and water treatment facilities (Leewood property) and other ancillary facilities – well sites will have an estimated five to 20-year life span.
- further disruption at the decommissioning stage.

The above impacts may cause direct losses to agricultural production due to the temporary and longer term unavailability of land and indirect losses associated with interruption to management of agricultural enterprises and consequent loss of production. It should be noted that the area directly impacted is relatively small in relation to a property size, and agricultural activities will still be able to occur. Landholders will also, where possible, influence the final location of infrastructure. Differing levels of direct and indirect impacts will occur during the construction, operational and decommissioning phases.

Following is a description of each potential direct and indirect impact, and the degree of temporary and longer term impact at each of the three project stages.

5.1 Direct impacts

5.1.1 Land use change

Table 5-1 and Table 5-2 denote the area of land that could be impacted by temporary and longer term land use changes respectively. The calculation of the areas of land impacted are based on the following assumptions:

- a maximum of 425 individual well pads
- well pad area of approximately one hectare during construction and approximately one quarter hectare during operation, with the exception of those well pads hosting communications towers (up to 20) and/or areas hosting water balance tanks (up to five) which will remain as approximately one hectare (GHD has adopted a conservative value of one half hectare per well pad during operation. As noted above, a conservative approach has been adopted whereby GHD has assumed that only 50 % (or half of one hectare) of the well pads hosting gas wells would be available for cropping during the operation stage of the project
- agricultural land comprises approximately 28 per cent of the total land area (27,000 ha within a total of 95,000 from Table 2-1)
- length of access roads and gas and water gathering systems for the total project area is estimated at 600 kilometres. As agricultural land comprises 28 per cent of the total project area, it is assumed that the length of access roads and gas and water gathering systems on areas of agricultural land use is proportionately 171 kilometres
- for the purpose of this assessment it has been assumed that access roads and gas and water gathering systems are co-located within the same corridor. Conservative corridor widths of 12 metres are assumed during construction and five metres during operation, where rehabilitation to five metres is possible for operational purposes
- for the purpose of this assessment it has been assumed that during the operational phase it is assumed that 50 per cent of the total access roads and gas and water gathering system distances will not be available for agricultural use. The remaining distances are assumed to be gas and water gathering system services that are buried below ground and have been rehabilitated to enable agricultural activities
- processing and ancillary facilities are estimated at 206 hectares of agricultural land within the property “Leewood” that accommodates the central water processing facility, the central gas processing facility and optional power plant.

Using the above assumptions, the area of agricultural land temporarily removed from production during the construction phase is calculated at 532 hectares (Table 5-1). Note that the calculations assume that agricultural land comprises approximately 28 per cent of the total project area (refer to Table 2-1). This represents approximately 2.0 per cent of the total agricultural land in the project area of 27,000 hectares.

Table 5-1 Area of temporary (construction) land use change (range)

Land use	Number	Total area (ha)	Agricultural land (ha)
Well pads	425	425	121
Access tracks; gas and water gathering lines	600 km @ 12 metre width	720	205
Processing facilities	Leewood	206	206
Total		**1,351**	**532**
	Per cent of agricultural land in project area		**2.0%**

The area of agricultural land removed from production for the longer term (i.e. for approximately five to 25 years) during the operation phase is calculated as being 351 hectares (refer to Table 5-2). This represents 1.3 per cent of the total agricultural land in the project area of 27,000 hectares. In the context of agricultural land in the Narrabri Shire (i.e. 737,600 hectares – refer to Table 4-5), this represents 0.05 per cent of total agricultural land in the Narrabri Shire. As such, the impact will have negligible threat to food security or impact on food prices.

Table 5-2 Area of longer term land use change (range)

Land use	Number	Total area (ha)	Agricultural land (ha)
Well pads	425 @ 0.5 ha.	213	60
Access tracks; gas and water gathering lines	600 km @ 5 metre width.	300	85
Processing facilities	Leewood	206	206
Total		**719**	**351**
	Per cent of agricultural land in project area		**1.3%**

The land areas calculated in Table 5-1 and Table 5-2 do not differentiate on the land capability of the land that is temporarily removed from production. It is assumed however, that siting of the well pads will be decided in consultation with land owners and that selection will be sensitive to land use and wherever possible avoid the most productive areas of land.

Table 5-2 considers the longer term removal of agricultural land from production as a result of the project. However, it is proposed that water produced during gas extraction will be treated at the Leewood central water treatment facility and then be made available for irrigated agriculture. The peak produced water production is estimated to be approximately 10 megalitres per day (ML/day) in around years two to four of operation, declining rapidly to a long term yield of around four megalitres per day before tailing off. The average annual water production rate is estimated to be 1.5 GL per annum (refer to the Beneficial Reuse – Irrigation Report (Beneterra 2015 – Appendix G2) and the Groundwater Impact Assessment Report (CDM Smith 2016 – Appendix F)).

The Beneterra (2015) report estimates that approximately 12 megalitres per day could be beneficially reused through irrigation for the first two to four years (in excess of the estimated 10 megalitres per day treated water production to allow for operational flexibility) of the project and approximately three megalitres per day could be beneficially reused through irrigation for the remainder of the project (the other one megalitre being used for construction and dust suppression purpose). This is equivalent to approximately 4,380 megalitres and 1,060 megalitres per year respectively for irrigation of suitable crops and pastures. Irrigation water requirements vary depending on the choice of crops or pastures. Assuming 7.5 ML/ha/year water use requirement for the production of lucerne hay, these volumes of reuse water would be sufficient to irrigate approximately 500 hectares for two to four years and 150 hectares for the remainder of the project assessment period. The NSW Department of Primary Industries' website provides information on irrigation water usage, with examples being for surface irrigated lucerne that requires 8.8 ML/ha and for cotton that requires 7 ML/ha (see http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets/summer-crops). The increase in intensity of irrigated agricultural land use would partially compensate the permanent loss of agricultural land calculated in Table 5-2.

The application of irrigation water on land for crop and pasture production would require funds for irrigation supply infrastructure (pipes and pumps to deliver water to farms and then on-farm infrastructure with centre pivots or via gravity with suitable channels). There is no irrigated agriculture in the project area (and therefore no existing irrigation infrastructure). It is understood

that Santos will negotiate with prospective irrigators to determine cost sharing arrangements for this infrastructure. These negotiations would include developing a strategy that incorporates infrastructure requirements for the short term (the first two to four years) and the longer term (21 or so years).

5.1.2 Land capability, farm infrastructure and other damage

Construction and operation activities may result in damage to on-farm infrastructure and land capability which unless repaired will impact on the productive potential of agricultural land. Major types of infrastructure potentially impacted are:

- land and water capability
- internal property roads, tracks, creek crossings etc.
- fences
- water supplies (including reticulation systems for livestock water)
- weed incursions

Damage to infrastructure has the potential to impact on agricultural production as outlined in Table 5-3 below.

Table 5-3 Potential land capability and farm infrastructure impacts

Land, water, infrastructure	Damage	Potential Impacts
Land and water capability	Soil and/or surface/groundwater resources are compromised by construction and operation activities.	Soil erosion and/or contamination cause productivity declines for crops and livestock. Livestock are unable to obtain adequate quantity and/or quality of drinking water.
Internal roads	Heavy construction vehicles/ equipment could damage internal roads, crossings etc. and temporarily limit access throughout a property.	Inability to access paddocks at critical times (e.g. planting, harvesting) impact on crop yields and/or product quality. Disruption to transport of grain or livestock could impact on marketing opportunities resulting in reduced prices.
Fences	Preferred location of wells and gathering systems may result in construction activities that require fences to be temporarily cut and/or permanently realigned to improve access efficiency.	Unless repaired or appropriately planned, cut fences could result in unintended livestock mixing which in turn could disrupt planned breeding programs, require added costs to muster and draft livestock. Inappropriate fence realignment could reduce the future efficiency of completing crop and livestock activities.
Water supply	Construction activities could damage water pipelines, dams etc. thus temporarily cutting livestock supplies.	Unless repaired or appropriately planned, damaged water supplies could seriously reduce livestock production and may cause mortality.
Weeds	Construction activities create the possibility of introducing novel weeds onto a property and/or increasing the growth of existing weed species through soil disturbance and consequent reduction in competition by pasture species.	Weed incursions or proliferation will reduce crop and livestock production unless properly controlled.

The extent of damage to farm infrastructure and consequent impact on production cannot be accurately quantified due to the evolving nature of the gas field development. However, the damages can be limited by adopting appropriate mitigation measures which are discussed in Section 6. Consultation with landholders will limit damage caused as collaborative planning with regard to location and timing of disruption could be jointly decided to fit in with planned farming activities. Such consultation is also important in minimising potential indirect impacts discussed below in section 5.2. Such consultation should be a condition of a Services Agreement between Santos and the landholders. This is discussed further in section 6.

5.2 Potential indirect impacts

Indirect impacts may occur as a result of both construction and operational activities which alter the ability of landholders to fully utilise the productive capacity of their land. The impacts are outlined in Table 5-4.

5.2.1 Dust

Construction activities will generate dust that has the potential to settle on crops and pastures, however dust suppression protocols will reduce the occurrence and the impacts on production are likely to be insignificant. No literature that specifically addresses dust impacts caused by natural gas from coal seam infrastructure construction activities has been located for inclusion herein. However, similar research is available from the mining sector and summarised below.

Doley (2003) concluded that mineral dusts resulting from mining and other operations may be deposited on vegetation to the extent that they impede growth and threaten plant survival. Chemically inert dusts adversely affect plant growth if the dust load is greater than 5 g/m^2. However, depositions of this magnitude appear to be unlikely. Connell Hatch (2008) adopted a dust deposition rate of 500 mg/m^2/day (15 g/m^2/month) as a threshold for adverse impacts in its study.

Even if deposition rates approach 15 g/m^2/month there is unlikely to be an adverse impact on livestock grazing. A study undertaken at the University of Western Sydney on dairy cows (Andrews and Skriskandarajah 1992) found that:

- Cattle did not find feed unpalatable if coal mine dust was present at a level equivalent to a dust deposition rate of 4,000 mg/m^2/day (120 g/m^2/month).
- The presence of coal mine dust in feed did not affect the amount of feed that the cattle ate or the amount of milk that the cattle produced at a level equivalent to a dust deposition rate of 4,000 mg/m^2/day (120 g/m^2/month).
- Cattle did not preferentially eat feed that did not contain coal mine dust. The cattle were able to choose between: feed that was free of coal mine dust; feed that contained 4,000 mg/m^2/day (120 g/m^2/month) of coal mine dust; and feed that contained 8,000 mg/m^2/day (240g/m^2/month) of coal mine dust.

The air quality assessment report (Air Environment Consulting 2015) reviewed construction dust from the project as total suspended particulate, PM_{10}, $PM_{2.5}$, and deposited dust. The primary emission of concern during the construction phase was found to be dust as PM_{10} meaning that compliance with this parameter would result in compliance with dust deposition. The distance at which the PM_{10} criterion is predicted to be met from construction of access roads and the pipeline is 140 m. Given that construction of the pipeline and access road moves along the alignment, these activities would contribute a lot less than then the allowable deposition level of 2 g/m^2/month for human health and many times lower than identified thresholds for agricultural land.

For additional information on the potential impacts from construction dust generation, refer to the Air Quality Technical Appendix (Air Environment Consulting 2015).

Table 5-4 Indirect impacts of construction and operation activities

Item	Issue	Potential Impacts
Impeded access, severance	Construction activities may temporarily block access to land which is not otherwise directly associated with the footprints required for constructing and operating wells and gathering systems. This includes instances of paddocks being temporarily severed with the effect that grazing by livestock is temporarily constrained e.g. due to the unavailability of drinking water. Access tracks are required for beekeepers to allow timely placement and retrieval of hives.	Impacts will depend on the enterprise type (crop or livestock) and the timing and duration of the impeded access. Production losses could vary from zero up to a substantial percentage of annual production. A multiplier has been adopted to reflect the costs. It is unlikely that impeded access impacts will be present during the operation phase. Interrupted access to beekeepers could reduce honey production depending on the timing of events.
Interrupted management	Construction activities could cause a delay to land owners completing various crop and livestock husbandry operations (e.g. weed spraying, harvesting, animal health treatments etc.).	Delays could reduce pasture and crop yields, reduce livestock growth rates, reduce product quality and therefore price, increase livestock mortality. A multiplier has been adopted to reflect the cost of impacts if appropriate mitigation measures are not adopted.
Dust, noise	Construction will generate dust which will settle on crops and pastures, and noise which could affect grazing patterns of livestock.	Dust suppression will reduce risk of dust settling on crops and pasture. Also, dust accretions are removed at each rainfall event resulting in negligible impact. Livestock generally become habituated to noise and although grazing patterns may be altered productivity is not affected. Refer to further discussion in the text.
Labour supply	Construction and operation will require labour resources resulting in competition for labour required for agriculture.	The cost of labour could rise. A multiplier has been adopted to reflect the costs.
Bushfires	Refer to the Hazards and Risk Technical Appendix (GHD 2016e).	Refer to the Hazards and Risk Technical Appendix (GHD 2016e).
Livestock drinking water supplies	Refer to the Hydrology and Geomorphology Report (GHD 2016b) and the Groundwater Impact Assessment (CDM Smith 2016).	Refer to the Hydrology and Geomorphology Report (GHD 2016b) and the Groundwater Impact Assessment (CDM Smith 2016).
Regional services	There will be an expected reduction in total agricultural production as a result of the construction and operational activities thus reducing throughput for local agricultural supply, marketing and transport services.	Reduced area of production of 2.0 per cent during construction and 1.1 per cent per year during operation will reduce throughput of supply for marketing and transport services. The reduction is small from a regional perspective and will be offset by compensation agreements.

5.2.2 Noise

Research has shown that animals will readily adapt to reasonable levels of continuous sound, such as white noise and miscellaneous sounds. While some experiments found continuous exposure to sounds over 100 dB reduced daily weight gain in sheep, other trials showed that continuous background sound can actually improve weight gain (Grandin 2014). While anecdotal evidence suggests sudden noise can upset livestock and potentially result in miscarriage of young, no published studies could be found to link such noises (e.g. mine blasting) with stock miscarriage (Grandin 2014).

Noise during construction may alter livestock grazing patterns but this is not expected to have an impact on productivity. There will be little noise generated during the operation phase and therefore no impact on livestock is expected.

Refer to the Noise and Vibration Technical Appendix (GHD 2015b) for additional information on the potential impacts from construction noise generation, which concluded that noise from project activities would meet the NSW guideline noise levels at occupied residences unless a written agreement is in place with the landholder.

5.3 Economic impact

The economic impact of the above physical impacts is denoted in Table 5-5 for the construction phase. The impacts are calculated by multiplying the area of agricultural land impacted (refer to Table 5-1) by the average adopted gross income of $533 per hectare (refer to Table 4-11). The impacts range between $326,000 and $368,000 over the duration of construction activities. These values represent between 2.3 per cent and 2.6 per cent of the annual value of agriculture in the project area and between 0.08 per cent and 0.09 per cent of the annual value of agriculture in the Narrabri LGA. Note that there is some uncertainty around the estimates, especially for those of an indirect nature. The value is spatially rather than temporally driven, and uses an estimate of impacted land, noting the relatively short duration of drilling activities per well (up to around 30 days) relative to the project assessment period (25 years).

Table 5-5 Value of impacts on agriculture (construction)

Impact	Agricultural land (ha)		Annual value of agricultural production	
	Low	High	Low	High
Direct	532	532	$ 283,120	$ 283,120
Indirect				
Impeded access	5%	10%	$ 14,156	$ 28,312
Interrupted management	5%	10%	$ 14,156	$ 28,312
Labour costs	5%	10%	$ 14,156	$ 28,312
Other			$ -	$ -
Total			**$ 325,588**	**$ 368,056**
Per cent of project area total			**2.3%**	**2.6%**
Per cent of Narrabri LGA total			**0.08%**	**0.09%**

The economic impact of the physical impacts for the operation phase is set out in Table 5-6. The impacts are calculated by multiplying the area of agricultural land impacted (refer to Table 5-2) by the average adopted gross income of $533 per hectare (refer to Table 4-11). The impacts vary between $215,000 and $244,000 per year. These values represent between 1.5 per cent and 1.7 per cent of the annual value of agriculture in the project area and approximately 0.05 per cent of the annual value of agriculture in the Narrabri LGA. When considered with respect to the value of Australian agricultural production, the impact will have negligible threat to food security or impact on food prices.

The estimates are based on values of production averages adopted within the AIS as described in section 4.5.1 due to the absence of specific data on the actual production and values within the project area. However, the values adopted are considered to be a conservative over-estimate of the impacts. Landholders will be compensated for impacts during construction and operation phases, and this is discussed below.

Table 5-6 Value of impacts on agriculture (operation)

Impact	Agricultural land (ha)		Annual value of agricultural production	
	Low	High	Low	High
Direct	351	351	$ 187,349	$ 187,349
Indirect				
Impeded access	5%	10%	$ 9,367	$ 18,735
Interrupted management	5%	10%	$ 9,367	$ 18,735
Labour costs	5%	10%	$ 9,367	$ 18,735
Other			$ -	$ -
Total			**$ 215,452**	**$ 243,554**
Per cent of project area total			**1.5%**	**1.7%**
Per cent of Narrabri LGA total			**0.05%**	**0.06%**

Offsetting the potential reduction in the value of agriculture during the operation phase as calculated in Table 5-6 would be the benefits from the production of irrigated crops and pastures as discussed in Section 5.1.1. For example, if an irrigated crop generated net returns of $500/ha after allowing for irrigation infrastructure development costs, the total net benefits from 500 hectares (first two to four years) and 150 hectares (remaining 21 or so years) would be $250,000 and $75,000 per year, respectively, which would partially offset the value of impacts calculated in Table 5-6.

Note that the above calculations are dependent on the maintenance of current agricultural capability within the project area. If the capability is compromised by the project, the calculation of the costs of the impacts on agricultural land would need to be recalculated.

In addition, economic impacts will be offset via payment of compensation by Santos to landholders directly impacted by construction and operational activities. The key elements of Santos' NSW Landholder Compensation Framework are described in the working with landholders fact sheet (Source: http://www.santos.com/Archive/NewsDetail.aspx?id=1336 accessed 8 September 2014).

During exploration a private landholder would receive a written and agreed Farm Management Plan (FMP) Land Access Agreement prior to exploration activity taking place. The Access Agreement would ensure that the profitability and sustainability of food and fibre production is not compromised:

- A first year payment equal to 120 per cent of the value of the land utilised by Santos;
- An ongoing yearly payment equal to 60 per cent of the value of the land utilised; and
- An annual payment of $30,000 per landholder for certain services associated with the upkeep and monitoring of the facilities associated with the Santos work program.

During production a private landholder would receive:

- An ongoing annual payment of $30,000 per landholder for certain services associated with the upkeep and monitoring of the facilities associated with the Santos development;
- A payment equal to 120 per cent of the value of the land utilised in the first year of production; and
- In subsequent years, an annual share of an additional compensation pool (an annual amount equal to 5 per cent of Santos' royalty payments associated with private land within a production licence area). A private landholder's compensation will be based on the proportion of their land utilised by Santos as compared to the total area used for our operations.

A case study of landholder compensation is provided in Section 6-1.

5.3.1 Industry and regional effects

The industry and regional effects of the impact that the Narrabri Gas Project will have on domestic industries has been estimated in the *Economic Impact Report* (ACIL Allen 2016). This report estimates that during construction, direct employment is anticipated to peak at over 1,300 while operations are expected to add a further 150 jobs (in addition to the 50 Santos employees currently working in Narrabri). This report also notes that the peak levels of construction labour demand will last for approximately two to three years with estimates of 10% construction labour to comprise of residents in Narrabri LGA with a further 20% from areas surrounding Narrabri.

6. Mitigation measures

Section 5 above outlined direct and indirect impacts from project operations on agricultural land use. These impacts and the mitigation measures required to ensure minimal disruption to agricultural activities and therefore, protect income earning ability of land holders are provided in Table 6-1. Note that these mitigation measures are based on the assumption that drilling activities are conducted according to the various Codes of Practice in place (e.g. NSW Code of Practice for Coal Seam Gas Well Integrity and Aquifer Interference Policy requirements) and that adherence to the codes does not result in deterioration of land and water capability on agricultural land.

Table 6-1 Proposed mitigation and management measures

Impact/issue	Mitigation/management	Applicable area	Timing
Loss of income, inconvenience and disruption of farm management activities of private landholders	Land access agreements, service agreements and farm management plans would be developed in consultation with affected landholders. These would include: • landholder engagement protocols • land access arrangements • notification processes • compensation provisions • infrastructure locations • rehabilitation • other property-specific mitigation as agreed with the landholder, including an Irrigation Management Plan if applicable. A Field Development Protocol will be developed to guide location of access roads, waterway crossings and locations for development on agricultural land. A rehabilitation plan to include measures to restore disturbed sites to a state that is as close as reasonably practical to the preconstruction condition or better, or to the satisfaction of landowners. A traffic management plan that addresses issues associated with machinery, transport and livestock movements on properties will consider impacts that are year-round and also seasonal (e.g. harvesting, calving, lambing).	Gas field	Pre-construction and on-going as required
Potential disruption to forestry activities	The Forestry Corporation of NSW would be consulted with regard to a forest permit and: • mitigation and management of impacts to forestry operations in the project area and related activities, such as road maintenance, pest management and controlled burns • the appropriate management of marketable timber in proposed clearing areas. • the interests of the apiary industry would also be considered during this process.	Gas field Bibblewindi Bibblewindi to Leewood Westport workers' accommodation	Construction

6.1 Compensation case study

Compensation for landholders is explained in a Santos publication titled “The Narrabri Gas Project – Working with landholders”. The elements of the compensation package were outlined in section 5.3.

Table 6-2 is a case study example of compensation provided to landholders based on a compensation framework that provides an income stream for landholders who host Santos infrastructure. The framework features a land-value based payment to compensate for the amount of land utilised by Santos’ surface facilities and a fee for service to the landholder. In exchange for the fee for service, the landholder signs a Services Agreement and agrees to assist with general monitoring and upkeep of the sites located on their land.

Table 6-2 shows that in Year One of the operation phase, the landholder would receive total compensation of $33,600 assuming three hectares of land was impacted and the land value was $1,000 per hectare. In Year Two and onwards, the compensation would be approximately $50,000 per year.

These compensation values compare to the annual loss of agricultural production of approximately $700 per hectare (calculated from Table 5-6). For the equivalent loss of three hectares of land, the landowner would lose approximately $2,100 per year. The compensation payments clearly recompense landholders for the expected loss in agricultural production.

Table 6-2 Case study of landholder compensation – operation phase

Item	Values
Land area impacted	3 ha
Assumed value of land ($/ha)*	$1,000
Value of land impacted	$3,000
Year One compensation	
a) 120% of land value	$3,600
b) $30,000 fee for service	$30,000
Total Year One	**$33,600**
Year Two onwards compensation	
a) $30,000 fee for service	$30,000
b) Share of Santos’ royalty payments	$20,000
Total Year Two onwards	**$50,000**

* Assumed value of land. This is an estimate only and was derived from information obtained from the NSW Land and Property Information (LPI) website (http://www.valuergeneral.nsw.gov.au/land_values/historical_land_values). This website provides guidance only, and is designed to assist landholders in understanding typical land values and market trends over time in local government areas, but noting that there is a wide variety of land types, sizes and landforms. There are quotes of wheat properties in Narrabri of $1,930/ha and grazing properties in Mudgee (Narrabri not listed) of $760/ha. Based on 25% of agricultural land in the project area being for wheat production and 75% for grazing, the weighted average of values is calculated as $1,052/ha. Adopt $1,000 for illustrative purposes only in Table 6-2.

7. Conclusion

The Narrabri Gas Project is proposed to develop gas wells, gas and water gathering systems, and supporting infrastructure on agricultural land within the Narrabri LGA. This AIS has completed the following with respect to the impacted land and in doing so meets the conditions outlined in the Secretary's Environmental Assessment Requirements for the project:

- detailed assessment of the agricultural resources and agricultural production of the project area
- identification of the agricultural resources and current enterprises within the surrounding locality of the project area
- identification and assessment of the impacts of the project on agricultural resources or industries
- mitigation measures
- consultation.

This AIS report should also be read in conjunction with a range of technical reports that directly or indirectly address the impacts on agriculture. The reports of major relevance to the AIS include the:

- Site Verification of Biophysical Strategic Agricultural Land (BSAL) report (GHD 2015a).
- Soils technical report (GHD 2016a).
- Groundwater Impact Assessment (CDM Smith 2016).
- Hydrology and Geomorphology technical appendix (GHD 2016b).

The project area extends over 95,000 ha of which 27,000 ha (28 per cent) is agricultural land. The remaining land is comprised of State Forest. The agricultural land is used predominantly for livestock grazing with occasional dryland cropping depending on seasonal conditions. There is no irrigated agriculture in the project area.

Development of the Narrabri Gas Project will have both direct and indirect impacts on agricultural production during both the construction and operation phases. The direct impacts will be the removal of land required for the construction of well pads and various storage and treatment facilities. Indirect impacts relate to the temporary interruption of farming activities during construction and operation which could reduce agricultural production and therefore landholder profitability.

The maintenance of land and soil capability as well as groundwater and surface water integrity during and after the project will be a critical requirement. Wells need to be designed and constructed in accordance with the NSW Coal Seam Gas Code of Practice Well Integrity (DTIRIS 2012b) or similar to ensure impact on aquifers is minimised or eliminated.

The removal of relatively small areas of agricultural land from production on a temporary basis during construction and on a longer term basis over the assessment life of the project (25 years) cannot be avoided. In addition, there will be indirect impacts related to short term interruption to farm management activities. Also, most land will revert to agricultural use following project completion.

These impacts can be mitigated via a number of different actions to be adopted by the proponents that will minimise the outcomes of the interference. In the first instance, agreements with landholders will need to be concluded. Such agreements should include field development planning protocols completed in consultation with landholders which recognise the site and temporal sensitivity of activities. In addition, there will be compensation for loss of productive areas and/or increased costs caused by development activities. The compensation framework developed by Santos clearly recompenses landholders for the expected loss in agricultural production.

This AIS has assessed the agricultural resources and agricultural production of the project area and surrounding locality and has identified and assessed the impacts of the project on the agricultural resources, landholders and industries. It also provides a range of mitigation measures that could be adopted to limit the identified impacts.

The assessment included consultation with selected landholders and representatives to ensure that a comprehensive assessment has been completed. Additional consultation has also been completed by other technical specialists who have contributed reports for the EIS process.

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GHD

133 Castlereagh St Sydney NSW 2000

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T: +61 2 9239 7100 F: +61 2 9239 7199 E: sydmail@ghd.com.au

www.ghd.com