Chapter 32

Justification and conclusion

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Chapter 32 Justification and conclusion

32.1 Summary of key project components

The proponent is seeking approval for a project to develop, operate and decommission a natural gas development. This EIS provides an assessment of the social and environmental impacts of the proposal using a 25-year assessment period.

The project would involve a range of exploration and production activities, and would involve continued use of some existing field infrastructure as well as installation of new facilities and infrastructure. The key components of the project, for which approval is being sought, are shown in Table 32-1.

Table 32-1 Key project components

Component	Infrastructure
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 • 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 refurbishment and recommissioning of two existing ponds • continued use of existing facilities such as the 5 ML 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 power (up to 132 kV), 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

Component	Infrastructure
coal seams	
Gas exploration, appraisal and production infrastructure	• seismic geophysical survey • installation of up to 850 new wells on a maximum of 425 new 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 or upgrade of existing exploration and appraisal wells to production in addition to the 850 new wells
Ancillary	• upgrades to intersections on the Newell Highway • expansion of workers' 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) off site from Leewood • operation of the irrigation scheme

32.2 Project justification

32.2.1 Project benefits

Economic and employment benefits

The project would create local and regional job opportunities. The construction of the project is expected to involve a nominal capital investment of $3.6 billion. This investment is forecast to directly create approximately 1,300 jobs during the construction phase and sustain approximately 200 jobs during the operational phase. The project would contribute $6.9 billion in real income to the NSW economy, including the regional economies of NSW, via the direct supply chain, in addition to the creation of indirect job opportunities.

Project construction is expected to involve a nominal capital investment of $3.6 billion, or around $3.0 billion in real terms, with a net present value of around $2.0 billion when a discount rate of 7 per cent is applied. The project would also involve ongoing operating costs over the 25-year assessment period, totalling a nominal investment of $5.5 billion, or a real investment of around $3.8 billion with a net present value of around $1.6 billion, applying a discount rate of 7 per cent.

The project is expected to generate a net positive economic impact for the economies of the Narrabri LGA, the wider region and NSW, including:

- real economic output of $11.9 billion (around $5.1 billion net present value; which is approximately one per cent of gross State product), including
  - $11.0 billion (around $4.5 billion net present value) in the Narrabri LGA
  - $572 million (around $348 million net present value) in the wider region
  - $384 million (around $295 million net present value) across the rest of NSW
- real income of $6.0 billion (around $2.8 billion net present value), including
  - $526 million (around $250 million net present value) in the Narrabri LGA
  - $690 million (around $396 million net present value) in the wider region
  - $4.8 billion (around $2.1 billion net present value) across the rest of NSW
- establishment of a Gas Community Benefit Fund which would receive an estimated $120 million through the life of the project. The NSW Government has committed that for every two dollars paid by a gas producer that holds a petroleum title into an authorised Gas Community Benefit Fund, the company will receive a one-dollar rebate on its gas royalties, up to a maximum of 10 per cent of the royalty due in each year.
- average direct and indirect employment over the 25-year assessment period of 512 full time equivalent jobs in NSW, including:
  - 127 full-time equivalent jobs in the Narrabri LGA
  - 161 full-time equivalent jobs in the wider region
  - 224 full-time equivalent jobs in the rest of NSW.

In addition, the settlement of a native title agreement under Section 31 of the Commonwealth *Native Title Act 1993*, and development of other programs delivering a broad package of benefits, would extend over the life of the project and beyond.

Energy benefits

The Narrabri Gas Project has significant energy benefits; including:

- The capacity to deliver up to 200 terajoules of gas per day.
- The capacity to produce sufficient gas to meet up to half of NSW's natural gas demand. The ability of the project to contribute substantially to the amount of gas available for the NSW market saw it designated as a strategic energy project by the State Government in 2014.
- Being an appropriate and positive response to the changing eastern Australian gas market. It would help NSW achieve greater energy security and economic sustainability. The project would also result in NSW being less reliant on gas from Victoria, and therefore, would help to reduce supply risk inherent in over-reliance on few gas sources.
- Lifecycle emissions for energy produced from the combustion of the natural gas delivered by the project will be nearly 50 per cent less than for electricity that is currently supplied to the NSW grid.
- The natural gas produced by the project would be made available to supply the NSW gas market.

In addition to the major benefits of supply security, the project would assist in the preservation of jobs, the creation of new employment and increased government revenue streams through royalty payments.

32.2.2 Consistency with planning approval requirements

Consistency with the objectives of the EP&A Act

Overview

The project is State Significant Development to which Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) applies in accordance with the *State Environmental Planning Policy* (*Mining, Petroleum and Extractive Industries*) *2007*. The EIS assesses the potential environmental impacts of the activity in accordance with Division 4.1 of Part 4 EP&A Act and related instruments, including the Secretary's Environmental Assessment Requirements.

The environmental assessment of the project was undertaken in accordance with the EP&A Act, including leading practice environmental and social standards. This process involved:

- a project compliance, risk and / or significance assessment (Chapter 10)
- stakeholder consultation to identify additional issues to be addressed in this EIS (Appendix D)
- technical assessments conducted in accordance with the Secretary's environmental assessment requirements (Appendix A)
- quantification of potential environmental impacts of certainty (Part C)
- the application of leading practice environmental and social management and mitigation measures, to which the proponent is committed (Chapter 31).

On balance, the environmental, social and economic assessments reported in this EIS found that following the application of design and operational management and mitigation, the residual risks were generally negligible, very low or low, with very few medium residual risks. There were also positive benefits identified through the economics, social and health assessments.

Objectives of the EP&A Act

The objectives of the EP&A Act include:

- the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment
- the promotion and co-ordination of the orderly and economic use and development of land.

The project would satisfy these objectives, given:

- the project would facilitate the environmentally acceptable recovery of up to 200 terajoules per day of natural gas from coal seams for an assessment period of 25 years, while impacting approximately one per cent of the total project area
- the project would be compatible with ongoing management of State forests and is appropriate development in line with the *Brigalow and Nandewar Community Conservation Area Act 2005* and strategic objectives of the Brigalow and Nandewar Community Conservation Area Agreement

- the project would be generally compatible with ongoing agricultural uses, noting that estimated area subject to longer term operation impacts would equal 1.3 per cent of agricultural land in the project area, or around 0.05 per cent of agricultural land in the Narrabri local government area
- the project would have minimal impact on surface and groundwater regimes
- the project would generate material social and economic benefits, helping to sustain and improve the socio-economic viability of the Narrabri region.

Ecologically sustainable development

The EP&A Act adopts the principles of ecologically sustainable development (ESD). These principles are also articulated in Section 6 (2) (a) of the *Protection of the Environment Administration Act 1991*. The principles of ESD and the consistency of the project with each of these principles are discussed in Chapter 4. These principles are also articulated in the *Protection of the Environment Administration Act 1991*, which states that:

> Ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes.
>
> ESD can be achieved through the implementation of the following principles and programs…being the precautionary principle, inter-generational equity, conservation of biological diversity and ecological integrity, and improved valuation.

The project involves the sustainable development of natural gas resources and has been assessed against the principles of ecologically sustainable development. The development and use of this energy source is considered rational given the demonstrable associated social and economic benefits at the local, regional and State levels.

In 2005, the NSW Government completed a regional assessment of the Brigalow and Nandewar Bioregions, including a review of land use in the Pilliga to balance various values, extractive land uses and formal conservation reserves. The regional assessment was a landscape-scale land use planning project, involving detailed multidisciplinary studies. The assessment sought to balance various cultural, recreational, conservation and commercial activities (including resource extraction).

A key outcome of the assessment was to protect around 240,000 hectares, or almost half, of the Pilliga under the *National Parks and Wildlife Act 1974*. Other parts of the Pilliga were designated as State forest and Community Conservation Area under the *Brigalow and Nandewar Community Conservation Area Act 2005*. The purpose of the Community Conservation Area is to provide for permanent conservation of land, protection of areas of natural and cultural heritage significance to Aboriginal people and sustainable forestry, mining and other appropriate uses.

The Community Conservation Area is divided into four management zones with defined purposes and uses (refer to Figure 4-1). The parts of the Pilliga in which the project is located are designated as Zone 4, with the defined purpose of forestry, recreation and mineral extraction. The Brigalow and Nandewar Community Conservation Area Agreement states the following strategic aims for Zone 4:

- provide and encourage the use of timber, products and materials in accordance with the *Forestry Act 2012* and the Integrated Forestry Operations Approval for the Brigalow and Nandewar regions and, where relevant, the *Plantations and Reafforestation Act 1999*
- conserve, promote the growth of and utilise timber in the zone to the best advantage of the State
- provide for exploration, mining, petroleum production and extractive industry in accordance with the *Mining Act 1992* and the *Petroleum (Onshore) Act 1991* and associated Regulations and guidelines.

As the project would involve petroleum exploration and production in accordance with regulatory requirements and guidelines, it is considered to be appropriate development within the Community Conservation Area. Outside of the conservation area, the project is located on agricultural land with limited productive capability that does not comprise biophysical strategic agricultural land (BSAL). Furthermore, the project would be generally compatible with ongoing agricultural uses in such areas.

This EIS demonstrates that impacts associated with the project would have relatively low-scale and manageable impacts on the environment, due to the relatively small and diffuse presence of project infrastructure and the engineering controls that would be in place. This is particularly the case for impacts on important groundwater sources, surface water quality and ecological values of the Pilliga, Aboriginal heritage, agricultural productivity, and social values of Narrabri. The project infrastructure would directly impact a total area of approximately one per cent of the total project area. Land affected by the project would be progressively rehabilitated and returned to its previous use over the life of the project.

When balanced against its demonstrable social and economic benefits, it is considered that the project would be consistent with the principles of ESD. These principles are discussed in more detail below.

The precautionary principle

The precautionary principle states that if there are threats of serious environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In applying the principle, decisions should be guided by careful evaluation to avoid, wherever practicable, serious damage to the environment, including an assessment of the risks associated with various options. The project would be consistent with the precautionary principle for the reasons discussed below.

Sustainable options aimed at minimising environmental and social impacts are integrated into the design of the project (refer to Chapter 8 – Assessments of alternatives). Environmental impacts have been assessed and a Field Development Protocol developed to effectively mitigate and manage environmental impacts by situating field infrastructure with consideration of a range of environmental constraints.

Potential impacts of the project have been assessed and documented in this EIS to minimise the likelihood of serious damage to the environment, with necessary mitigation measures proposed as required. Conservative approaches in line with the precautionary principle, including contingencies in assumptions such that assessed impacts were likely to be worse than would actually occur, were applied in a number of environmental assessments.

Under the EIS, a compliance, risk, and / or significance-based approach to impact assessment (refer to Chapter 10 – Approach to the impact assessment) was implemented, whereby key project aspects that represented higher primary risks were mitigated through avoidance (including through the Field Development Protocol) or suitable management and mitigation strategies to an acceptable level of residual risk.

The project would adopt ‘leading practice’ environmental and social management and monitoring plans to manage, mitigate and monitor impacts identified in the EIS. These plans aim to ensure that impacts are within the range predicted in the EIS, and to ensure corrective action is taken if unpredicted impacts are identified. The environmental management of the project would be continually improved through a model known as adaptive management (refer to Chapter 30 – Environmental management and monitoring). For example, the Water Monitoring Plan for surface and groundwater is attached to this EIS as Appendix G3.

Intergenerational equity

The principle of intergenerational equity states that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations. The project would be consistent with the principle of intergenerational equity.

Given the alternatives considered (refer to Chapter 8), ongoing environmental management (refer to Chapter 30) and project commitments (refer to Chapter 31) the project would operate to ensure there is no significant impact that would diminish the health, diversity or productivity of the environment for future generations. For example, the extraction of groundwater from the deep coal seams would require a license in accordance with a water sharing plan under the *Water Management Act 2000*. The objects of the *Water Management Act 2000* are to provide for the sustainable and integrated management of the water resources of the State for the benefit of both present and future generations. Water sharing plans are in place to protect the long term ecological integrity and productivity of the water source. The groundwater impact assessment (Appendix F) reported drawdown of less than a 0.5 metres in the Pilliga sandstone. Ongoing groundwater monitoring would confirm the modelled impact during the life of the project, and post decommissioning in accordance with approved Decommissioning and Rehabilitation Plans.

The Field Development Protocol provides flexibility in the location of field infrastructure as it is progressively developed over time. The flexibility will provide for intergenerational equity with respect to the preservation and management of environmental values (including cultural heritage). Avoidance and management of environmental issues can unfold progressively and take full advantage of changing conditions or technologies. This would also mean that the current generation is not required to make decisions that prevent subsequent generations from making decisions in light of such changes.

Management of intergenerational equity is explicitly considered in the assessment of potential impacts to Aboriginal cultural heritage (refer to Appendix N1). The flexible and progressive nature of the field development would again provide opportunities for intergenerational equity and decision making that takes full advantage of changing conditions and technologies. Agreements under the *Native Title Act 1993* and development of programs as part of the project would also deliver a broad range of benefits over the life of the project and beyond. Where impacts to heritage could not be avoided, cultural heritage offsets would have the potential to provide new contributions in perpetuity for future generations.

A Rehabilitation Strategy (refer to Appendix V) has been developed to ensure land disturbed by the Narrabri Gas Project is rehabilitated to a high standard. The final land use of rehabilitated areas will be consistent with previous land uses strategies and relevant planning instruments. Rehabilitation will include the re-establishment of native forest, woodland and agricultural lands where appropriate.

The proposed development has the potential to reduce greenhouse gas emissions from energy production in NSW. Such a reduction would support the principle of intergenerational equity by reducing the impact of greenhouse gas emissions on future generations. Coal combustion currently comprises the majority of the NSW energy mix. The replacement of this energy supply with gas produced from the project could result in a net reduction in greenhouse gas emissions, as electricity generated from gas is relatively less emissions intensive than electricity generated from coal combustion (refer to Appendix R).

In addition, the project would generate a range of social and economic benefits that would add to intergenerational equity through wealth creation (refer to Appendices T1, U1 and U2). These benefits would include:

- a net positive impact for the economics of Narrabri, the wider region and NSW
- direct employment of approximately 1,300 jobs during the initial construction phase, and sustaining around 200 jobs through operations (including around 50 existing jobs), in addition to the creation of indirect job opportunities

- generation of around $1.1 billion in NSW Government revenues and the establishment of a Gas Community Benefit Fund that would receive up to an estimated $120 million through the life of the project.

Biodiversity conservation

The principle of biodiversity conservation states that the conservation of biological diversity and ecological integrity should be a fundamental consideration of development proposals. The project would be consistent with this principle.

As noted above, the project is situated in areas of the Pilliga that provide for exploration, mining, petroleum production and extractive industry under the *Brigalow and Nandewar Community Conservation Area Act 2005*. The project area was delineated to avoid Pilliga conservation areas including the Pilliga National Park, Pilliga State Conservation Area, Pilliga Nature Reserve, Brigalow Park Nature Reserve and the Brigalow State Conservation Area. Whilst the Brigalow State Conservation Area would be surrounded by the project area, it would be protected by a 50 metre surface development exclusion zone.

The project is also designed to minimise impacts on sensitive ecological areas and minimise clearing of native vegetation more generally. For example:

- the central gas processing facility and water management facilities would be situated on Leewood which is a previously cleared property outside the forested area, which is currently utilised for water management for gas exploration and appraisal activities
- the Field Development Protocol provides the framework to minimise impacts on more sensitive ecological areas including riparian zones, identified watercourses and buffer zones around Yarrie Lake
- clearing for field infrastructure would be minimised by the implementation of lateral well technology, co-location of up to three wells per well pad, limiting the construction footprint to approximately one hectare per well, and partial rehabilitation of well pads following construction.

The project's Rehabilitation Strategy (refer to Appendix V) is based on the results of rehabilitation trials in the State forest. The trials demonstrate that appropriate topsoil management practices can maintain seedbank integrity to produce rapid regrowth of native species with diversity and densities equivalent to those of pre-clearance landscapes. Significant residual impacts on threatened and migratory species and ecological communities would be offset as part of the project biodiversity offset strategy (refer to Appendix J1).

The extraction of groundwater from deep coal seams would require a license in accordance with a water sharing plan under the *Water Management Act 2000*. Water sharing plans are in place to protect the long term ecological integrity and productivity of the water source. All water taken would be extracted under this licensing framework established by the NSW Government, as applies to activities that extract water from a regulated water source in NSW. The project would take an average of 1.5 GL each year over the life of the project, or approximately 1.3 per cent of the maximum limit identified for the Gunnedah-Oxley Basin water source (114.5 gigalitres). In this regard the ecological integrity of relevant groundwater sources has been considered, and the potential impacts would be well within the limits anticipated by the regulatory framework.

Improved valuation

The principle of improved valuation states that environmental factors should be considered in the valuation of assets and services. The principle is implicit in such concepts as 'polluter pays', lifecycle costing, and triple bottom line accounting. The project would be consistent with this principle as environmental factors were integrated into its assessment and costing, as follows:

- the cost of environmental externalities, including noise and biodiversity impacts, was integrated into the cost benefit model for the project
- the cost of foregone agricultural production was integrated into the cost benefit model for the project and was also assessed in the agricultural impact statement (refer to Appendix K)
- the assessment of project greenhouse gas emissions (refer to Chapter 24) considered lifecycle emissions including embodied emissions in upstream extraction or production of construction material and downstream emissions associated with disposal of waste or use of product gas.

Consistency with the objectives of the EPBC Act

The EPBC Act is the principal environmental law administered by the Commonwealth Government through the Department of the Environment and Energy. The EPBC Act provides for the protection matters of national environmental significance.

The project was referred to the Minister in October 2014 due to potential for significant impacts on matters of national environmental significance. The project was decided to be a controlled action in December 2014 with the 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 – namely Siding Spring Observatory.

Following the controlled action decision, the Department provided environmental assessment requirements relating to potential impacts on matters of national environmental significance under the EPBC Act. These requirements supplement the Secretary's environmental assessment requirements.

Listed threatened species and ecological communities

Potential impacts on listed species and ecological communities were primarily assessed in the ecological impact assessment in Appendix J1. The ecological impact assessment draws on extensive field work in the project area, including more than 13,000 hours of flora and fauna survey effort carried out since 2002.

The assessment concluded that the project would be unlikely to have a significant impact on listed species and ecological communities as the magnitude of direct, indirect and cumulative impacts would be unlikely to affect their long-term survival. This is primarily due to:

- the small proportion of habitat being removed relative to that retained in the project area
- the removal of habitat at a scale unlikely to result in the isolation or fragmentation of populations
- the project being unlikely to result in invasive species or diseases becoming established
- the progressive rehabilitation of disturbed areas as part of the project
- implementation of the Field Development Protocol and proposed avoidance, minimisation and mitigation measures.

Residual impacts on threatened species and endangered ecological communities would be offset as part of a biodiversity offset strategy.

A water resource, in relation to coal seam gas development and large coal mining development

Potential impacts to water resources, including the management of produced water and salt, were addressed through a range of technical assessments including the:

- groundwater impact assessment (refer to Appendix F)
- managed release of treated water to Bohena Creek (refer to Appendix G1)
- irrigation of treated and amended water (refer to Appendix G2)
- Water Monitoring Plan (refer to Appendix G3)
- water baseline report (refer to Appendix G4)
- hydrology and geomorphology assessment (refer to Appendix H).

The groundwater impact assessment utilised conceptual and numerical models to simulate potential impacts. The assessment considered potential impacts to the Bohena Creek Alluvium, Namoi Alluvium, Pilliga Sandstone and a number of other relevant groundwater resources. The assessment also considered impacts on groundwater dependant ecosystems.

The assessment concluded that the project is unlikely to have a significant impact on ground water resources in the project area and surrounds in terms of water availability and quality, as well as ecosystem functions. This is primarily due to:

- Relatively low value of groundwater in target coal seams and surrounding rock
- Limited groundwater drawdown in the higher value Pilliga Sandstone and Namoi Alluvium
- Negligible inter-aquifer flow rates and volumes and associated changes to groundwater quality
- Compliance with licensing requirements of the *Water Management Act 2000* and the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011*.

Commonwealth land

Potential impacts to Commonwealth land were limited to Siding Spring observatory, about 80 kilometres south-west of the project area. The referral identified five other Commonwealth lands without around 10 kilometres of the project area, however no potential impacts were identified.

Potential impacts to Siding Spring Observatory were primarily addressed through the landscape and visual impact assessment (refer to Appendix Q); however, other aspects such as the historic and social value of Siding Spring Observatory were considered in the historic heritage impact assessment (refer to Appendix O) and social impact assessment (refer to Appendix T1) respectively.

Consultation with the Australian National University and Australian Astronomical Observatory has indicated that operations at Siding Spring Observatory have been affected by lighting from urban and resource developments in the region. As such, potential lighting impacts were considered to be the main potential impact of the project on Siding Spring Observatory.

The main sources of light from the project would be safety flares at Leewood and Bibblewindi and up to six small pilot flares operating during well appraisal, if required. Site lighting would also be present at Leewood, Bibblewindi and Westport workers' accommodation.

Consultation with relevant representatives from Siding Spring Observatory has indicated the potential for impacts to observing conditions at the observatory as result of the project is negligible given the limited flame height of safety flares, the small number and dispersed location of potential pilot flares, and the minimal operational night lighting requirements.

If the safety flare is required to be operated at its full capacity at night, it may be visible at the observatory. However, the use of the safety flare to this extent is limited to during commissioning and maintenance activities and in non-routine situations, which are expected to occur infrequently. Accordingly, the landscape and visual impact assessment found that the pilot well flares and safety flares is unlikely to cause an impact on the long-term operation of Siding Spring Observatory.

Due to the nature of the project and the significant distance to Siding Spring Observatory, no direct, indirect, cumulative, facilitated or residual impacts upon the environment of Commonwealth land on which the observatory is situated are expected. Given this, no social or cultural impacts on people and communities who work, visit or otherwise benefit from Siding Spring Observatory are expected. Consequently, monitoring for Commonwealth land impacts of the project is not required.

The design and operation of the project would give due consideration to the Good lighting design principles in the *Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring* (NSW Department of Planning and Environment 2016) and Australian Standard *AS 4282-1997 Control of the obtrusive effects of outdoor lighting* and the Australian/New Zealand Standard *AS/NZS 1158-2010 Lighting for roads and public spaces for roadways and plant*, as applicable.

32.3 Key findings and residual risk

32.3.1 Key findings

This EIS finds that all environmental and social risks can be effectively mitigated through design and / or operational level controls. A number of measures would be included in the design of the project in order to avoid potential impacts. These measures include the implementation of a Field Development Protocol, which would take into account a range of environmental issues including ecology, noise, heritage and watercourses when determining the placement of field infrastructure. Where impacts are not avoidable, mitigation and management measures would be employed. The proposed mitigation and management measures would be incorporated into management plans; including for example, the:

- Biodiversity Management Plan
- Cultural Heritage Management Plan
- Historic Heritage Management Plan
- Produced Water Management Plan.

On the basis of groundwater modelling, the project is not expected to have significant adverse effects on groundwater or related environmental values such as groundwater dependant ecosystems and registered private bores. The modelling results show that after depressurisation of the target coal seams has taken place, the low hydraulic conductivity of deep basin strata would act to limit the adverse impact of groundwater replenishment from overlying groundwater sources. All lines of evidence indicate that registered groundwater extraction bores in the project area target the Pilliga Sandstone or overlying aquifers, which are separated from the project's targeted abandoned and associated groundwater units by numerous, very impermeable geological layers. This geological separation minimises the risk of inter-formation water migration, which in turn, minimises the risks to groundwater users in the Pilliga Sandstone or overlying aquifers.

Managed release of treated water to Bohena Creek would only occur when natural flow conditions of greater than, or equal to, 100 megalitres per day as measured at the Newell Highway gauging station.

Modelling of managed release of treated water to Bohena Creek during such conditions indicates that a minimum ten-fold dilution of the relatively small volume released would occur. As a result of this dilution, the managed release would not result in an ionic imbalance.

Potential impacts from irrigation on surface water was conservatively assessed by modelling the application of amended water at above the expected peak production levels. The assessment found that the quality of water in terms of salt load would be consistent with regional irrigation water. Irrigation of treated water would therefore present a low level of environmental risk that would nonetheless be monitored during the operation of irrigation areas. Potential impacts from irrigation on soils showed that slightly over half of the salts that would be applied to the land through irrigation water would be calcium sulphate salts added during treated water amendment to reduce sodium adsorption ratios. Application of these kinds of salts to land is routinely practiced by irrigators and would actually improve soil cationic balance and agricultural capacity. The treated and amended water to be used for irrigation would have an average salinity similar to that of irrigation water from the Upper Namoi Alluvium, which is used regionally for irrigation. Accordingly, the amount of salt applied to the irrigation area over the course of an average year would also be similar to the amounts applied by other irrigators.

Potential impacts of using treated and / or amended water for dust suppression, stock watering, and construction would also be minimal due to the quality of water used and the nature of the activity.

Other potential impacts on water quality such as sedimentation during construction across watercourses, and spills or leaks of chemicals or other fuels are typical of construction projects and would be readily managed to a low level of environmental risk. Potential impacts to watercourses would be minimised by undertaking construction during no-flow conditions and by implementing erosion and sediment controls.

Flood modelling confirmed that there would be very limited change to flood levels as a result of project infrastructure, due to its relatively small and dispersed footprint. Predicted flood impacts were minimal, with predicted changes in flood levels of less than 5 millimetres immediately downstream of Leewood, for both the 10 per cent and one per cent AEP events.

A soil survey was undertaken on cleared land within the project area that identified a complex mix of soil types. The assessment indicated that the project area is limited to very limited in its fertility and productive capacity. A site verification certificate acknowledging the absence of biophysical strategic agricultural land (BSAL) in the project area was issued by the NSW Department of Planning and the Environment (refer to Appendix I2).

Other potential soil impacts such as erosion, sedimentation, and degradation of soil fertility are typical of construction projects and would be readily managed to a low level of environmental risk. Accordingly, standard drainage, erosion and sediment controls would be implemented. Potential spills or leaks were also considered to be readily avoided, mitigated and managed through standard controls.

Construction and operation of the project would result in the direct removal of up to 988.8 hectares of native vegetation, while the indirect impacts of the project would be equivalent to the removal of an additional 181.1 hectares of native vegetation. The project was assessed as unlikely to cause a significant impact on the threatened flora, threatened fauna or threatened ecological communities. This is primarily due to:

- the small proportion of habitat being removed relative to that retained in the project area
- the removal of habitat not being at a scale likely to result in the isolation or fragmentation of populations
- the unlikelihood that the project would result in invasive species or diseases becoming established
- the progressive rehabilitation of disturbed areas as part of the project.

Plant community types would be impacted by less than three per cent of their occurrence in the project area respectively.

There would likely be very little change to the natural pattern of wetting and drying in Bohena Creek given that managed releases would only be made during specified natural flow conditions of 100 megalitres or greater per day. As noted above, modelling has shown the managed release would not result in an ionic

imbalance, ensuring that ecological risks from potential toxicants or chemical stressors would be low due to the water chemistry in Bohena Creek maintaining water chemistry relatively consistent with natural conditions during managed release. Therefore, the proposed managed release of treated water to Bohena Creek under high flow conditions would have negligible impacts on aquatic ecology.

The main land uses in the project area are agriculture and activities (including forestry and recreation) associated with State forests, which include Pilliga East State Forest, Bibblewindi State Forest and Jacks Creek State Forest. Some relatively minor changes to existing land use would occur as a result of the project.

Gas wells will only be drilled on a landholder's property where there is a landholder agreement in place. Where a landholder chose to work with the proponent, a Land Access Agreement and a Farm Management Plan will be developed. The location of infrastructure is agreed with the landowner. Temporary loss of income from agricultural production would be offset by compensation agreements with landholders. A case study of landholder compensation indicated that compensation would effectively recompense landholders for agricultural production losses (refer to Appendix K).

Ongoing consultation with landholders and relevant administering authorities including the Forestry Corporation of NSW would also be inputs into field development.

Modelled air emissions during construction and operation were assessed against relevant air quality criteria and found to be negligible, avoidable or otherwise readily manageable. The main project emission that would occur during construction was assessed to be fugitive dust from construction sites. In most cases, the distance between sensitive receivers and construction sites would be sufficient to achieve compliance with the relevant air quality criteria with standard mitigation. Where necessary, further mitigation measures would be implemented to ensure the air quality criteria are met. The main project emissions that would occur during operation were assessed to be oxides of nitrogen from operational infrastructure including the central gas processing facility and optional power generation facility at Leewood. Air emissions during operation of the project are expected to meet the relevant air quality criteria at all identified sensitive receivers. All reasonable and feasible measures would be implemented to ensure that project emissions would not exceed the relevant air quality criteria at occupied residences on private land.

In accordance with the Industrial Noise Policy, all reasonable and feasible construction noise mitigations would be implemented where noise exceeds the 40 dB(A) noise level during standard construction hours, and 35 dB(A) outside of those hours, unless otherwise agreed through private negotiated agreements. The operation of the project would also comply with the noise management level of 35 dB(A), unless otherwise resolved through private negotiated agreements. These noise management levels are considered appropriate for the identification and minimisation of potential noise impacts. With the implementation of mitigation treatments, operational noise levels from Leewood are predicted to comply with the noise criteria at all sensitive receivers during all meteorological conditions. Similarly, operational noise levels from the Bibblewindi are also predicted to comply with the noise criteria at all identified sensitive receivers.

An Aboriginal cultural heritage assessment was undertaken in accordance with the NSW Office of Environment and Heritage Guide to Investigation, Assessing and Reporting on Aboriginal Cultural Heritage in NSW. The assessment identified 90 Aboriginal cultural heritage sites, however it is recognised that the project area is likely to contain additional sites that have not yet been identified. Due to the diffuse and flexible nature of the field, potential impacts on Aboriginal heritage would be largely avoided. This avoidance would be facilitated through the Field Development Protocol, which would include Aboriginal heritage as one of many important constraints on the placement of field infrastructure. In particular, this would include the avoidance of all 90 known sites within the project area and the complete avoidance of the most sensitive site types. Pre-clearance surveys would be undertaken with representatives of the Aboriginal community in accordance with a Cultural Heritage Management Plan. Residual impacts would be restricted to four categories of sites (isolated stone artefacts, non-complex stone artefact scatters, non-complex shell middens and hearths or ovens identified during construction) and only after attempts have been made to apply the avoidance principle.

An historic heritage assessment was undertaken in accordance with the NSW Government policies and guidelines including the NSW Heritage Manual. The assessment identified 53 sites of potential historic heritage significance in the project area. The sites were predominantly related to historic logging and included timber extraction areas, loading ramps and camp sites forming part of the broader Pilliga East Logging Cultural Landscape. A small number of sites not related to historic logging were also identified which included an oil well understood to have been established in 1964 and ground pits used by the Sydney University physics community to record air showers. Due to the diffuse and flexible nature of the field, potential impacts on historic heritage would be largely avoided. This avoidance would be facilitated through the Field Development Protocol, which would include historic heritage as one of many constraints to consider in the placement of field infrastructure. In particular, impacts would be avoided at a range of historic logging sites, the identified oil well and the identified ground pits. An Historic Heritage Management Plan would be developed to manage residual risks to historic heritage, including a procedure to ensure unexpected finds are recorded and assessed.

A traffic and transport assessment undertaken found that the project would generate varying amount of traffic during construction and operation. To be conservative, absolute peak traffic volumes expected during the project were assessed. This absolute peak would be relatively short in duration (a few days) and would occur on relatively few occasions during the three-year (peak) construction period, although it is noted that lower daily peaks would occur during this time when material and equipment would be brought to construction sites, or when drill rigs are moved. The assessment of absolute peak traffic found that the road network would accommodate project traffic to an acceptable standard. Safety risks would be suitably managed with the implementation of the project's Traffic Management Plan, driver behaviour management and associated consultation with relevant traffic management authorities. Furthermore, two intersections on the Newell Highway would be upgraded at the appropriate time during the project to provide safe and reliable access to Leewood, Bibblewindi and the field.

The majority of landscape and visual impacts are most likely to occur at residences on cleared, predominantly agricultural properties that comprise about a third of the project area. As the remainder of the project area is vegetated, potential views of project infrastructure would be substantially screened. Major facilities at Leewood and Bibblewindi would be screened by vegetation and potential visual impacts are considered limited. In most cases, the landscape and visual impact assessment reported in Chapter 23 and Appendix Q found that with appropriate management and mitigation, the field infrastructure would be located a sufficient distance from residences to results in negligible visual impacts.

Field infrastructure would be sited in consultation with landholders and no infrastructure would be placed on a property without written agreement from the landholder. Field infrastructure would be situated in accordance with the Field Development Protocol, which constrains the placement of infrastructure within the vicinity of homesteads. Light generated during construction would be designed and managed to accepted standards that minimise impacts of light spill at residences. No significant impacts to activities at Siding Spring Observatory are expected as a result of the operation of the project.

A greenhouse gas assessment undertaken for the project found that annual direct emissions in a typical operating year will be less than 0.2 per cent of Australia's current annual greenhouse gas emissions, which were approximately 523 million tonnes of carbon dioxide equivalents in 2014.

Low-carbon energy sources such as natural gas can help to meet growing global energy demand while reducing relative global greenhouse gas emissions. For example, lifecycle emissions for energy produced from the combustion of the natural gas delivered by the project will be nearly 50 per cent less than for electricity that is currently supplied to the NSW grid.

The proponent has a strong track record of working cooperatively with government, industry and the community to address greenhouse gas emissions with specific focus on addressing energy efficiency, the transition to low emission technologies and reporting transparency. The proponent is committed to implementing reasonable and practicable measures to reduce, monitor and disclose its greenhouse gas emissions throughout the life of the project. As such, the residual environmental risk presented by the project with regard to greenhouse gas emissions is low.

A hazard and risk assessment was undertaken to identify the potential safety issues associated with the project. The assessment included a preliminary hazard analysis undertaken consistent with the requirements of *State Environmental Planning Policy No 33—Hazardous and Offensive Development*. The findings of the preliminary hazard analysis were as follows:

- Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year (5 x 10^{-5} p.a.).
- Incident explosion overpressure at residential and sensitive use areas should not exceed 7.0 kPa at frequencies of more than 50 chances in a million per year (5 x 10^{-5} p.a.).
- Toxic concentrations in residential and sensitive use areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of 10 in a million per year (1 x 10^{-5} p.a.).
- Toxic concentrations in residential and sensitive use areas should not cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year (5 x 10^{-5} p.a.).

The PHA of the loss of containment of Class 2.1 Flammable Gases (methane) assessed the risk of fires and explosions in further detail using a semi quantitative approach. It was determined the risk of 4.7 kW/m^2 heat radiation exposure meets the relevant risk criteria as it would not exceed 50 chances in a million per year (5 x 10^{-5} p.a.) at sensitive receivers. It was also determined that the risk of 7 kPa explosion overpressure meets the HIPAP 4 risk criteria as it would not exceed 50 chances in a million per year (5 x 10^{-5} p.a.) at sensitive receivers.

Bushfires have historically occurred in the Pilliga, where part of the project is situated. As such, the hazard and risk assessment recognised the chance that a bushfire could occur over the life of the project. The proponent has identified mitigation measures to reduce the potential for fires to start on, and escape from, work sites and project infrastructure locations. A Bushfire Management Plan would be prepared in conjunction with landholders and the NSW Rural Fire Service, which would be reviewed and updated annually with key stakeholders. The proponent would implement and maintain all components under its reasonable control.

The key social benefits for the project would be job creation, job diversity and potential gradual increases to the resident population. Around 1,300 workers would be employed during the peak construction phase of the project, which would occur over a period of three to four years. About 200 workers would be employed for the ongoing operation of the project, which would be a combination of existing and new jobs mostly based in Narrabri. A key potential social impact would be housing and accommodation demands associated with the increase in resident population during the operation of the project. The majority of the workforce during construction would be accommodated at camp facilities in the township of Narrabri, or Westport workers' accommodation, located in the project area. During operations, employees relocating with their families would find accommodation within existing housing stock in Narrabri.

A range of policies, strategies and initiatives would be implemented to maximise potential benefits and opportunities of the project, while minimising negative social and health impacts. The involvement of local business and contractors in the project would be supported through a procurement and logistics strategy. Although the impacts of the project on housing and accommodation are not expected to be significant, workforce housing and accommodation strategies would be implemented and be adapted as needed throughout future project planning phases. Throughout the life of the project, consultation with landholders or leaseholders would continue to occur regarding activities on their land. Workforce management strategies including a code of conduct would also be implemented to promote the health, safety and wellbeing of the project workforce, and their integration with the Narrabri community.

Economics benefits from the project were discussed in Section 32.2.1. The project's economic assessment reported a real economic output from the project of around $11.9 billion (around $5.1 billion net present value; or approximately one per cent of gross State product). The project would leverage economic benefits toward local industry through a Gas Community Benefit Fund and a locally focussed procurement and logistics strategy.

A waste management assessment undertaken for the project found that the main waste types generated by the project would include:

- salt generated through the operation of the water treatment facility
- general construction waste (such as paper, plastic and cardboard)
- construction and demolition waste (such as concrete, wood and glass)
- general domestic, commercial and putrescible waste generated at site offices and workers' accommodation (such as food and food packaging)
- drill cuttings and fluid generated during drilling and completion of wells
- sewage effluent generated at construction and operational sites.

The waste management assessment found that implementation of the project's Waste Management Plan would satisfactorily manage the potential impacts of waste on human health and environmental values.

A cumulative impacts assessment completed for the project found that impacts from the project, when combined with other existing and proposed projects in the region, are not anticipated to result in significant impacts. Cumulative impacts with other existing or proposed projects were assessed to be unlikely given the limited scale and intensity of potential impacts and the remoteness of the project.

32.3.2 Residual risk

Table 32-2 provides a summary of residual risk for the identified social and environmental values, following the implementation of avoidance, mitigation or management measures. In some cases, a range of residual risks are provided where impacts may vary from place to place.

Residual risk has been characterised in accordance with the impact assessment methodologies detailed in Chapter 10 (Approach to the impact assessment). A range of sub-plans have been presented in Chapter 30 (Environmental management and monitoring), each specifically detailing the respective management and mitigation approaches reported by chapter in this EIS to ensure residual risk is consistent with that identified during the impact assessment.

Table 32-2 Residual risk

Environmental or social value	Construction	Operation	Decommissioning
Groundwater and geology	Low	Low	Low
Surface water quality	Low	Low	Low
Hydrology and geomorphology	Low	Low	Low
Soils and land contamination	Low	Negligible to Low	Negligible to Low
Terrestrial ecology	Low to Medium	Very Low to low	Very Low to low
Aquatic ecology	Very Low	Very Low to Low	Very Low
Property and land use	Negligible to Low	Negligible to Low	Negligible to Low
Air quality	All reasonable and feasible measures will be implemented to ensure that air emissions from the activity will be within the relevant air quality criteria at occupied residences on privately owned land.		
Noise and vibration	Noise from the activity will meet the relevant noise criteria at occupied residences unless a written agreement is in place with the landholder.		
Aboriginal cultural heritage	Low to Medium	Very low to Medium	Very low to Medium
Historic heritage	Low to Medium	Low	Low
Traffic and transport	Low to Medium	Low to Medium	Low to Medium
Landscape and visual	Negligible to Moderate	Negligible to Low	Negligible to Moderate
Greenhouse gas	Low	Low	Low
Hazard and risk	Very Low to Medium	Very low to Medium	Very low to Medium
Social and health	Very low to Low (negative)	Very Low to Medium (negative)	Very Low to Low (negative)
	Medium to Very high (positive)	High to Very high (positive)	High to Very high (positive)
Economics	The project is expected to generate a net positive economic impact on the economies of the Narrabri LGA, the wider region and NSW.		
Waste management	Very low to Low	Very low to Low	Very low