Appendix A

Risk themes and mitigation summary

ID	Theme	Description / Issue	Management/Mitigation	Proof
• **Surface Water**				
SW 1	Water quality	Decrease in surface water quality as a result of a number of incidents, including: • Blowout • Equipment failure • Leak or loss of containment • Chemical storage • Flowback storage • Disposal of waste • Well integrity failure • Explosion or fire.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken surface water impact assessments as part of broader environmental assessment and management planning to verify environmental values and then demonstrate compliance against performance criteria to protect surface water quality. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, a Surface Water Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). Theses surface water quality assessments and management and monitoring plans provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical surface water quality management and mitigation measures applied to Santos' activities are listed below. • Baseline surface water monitoring is undertaken to characterise surface water quality and flow regime • Infrastructure such as chemical, waste, and fuel storages, including re-use of recycling facilities, will not be sited within or adjacent to sensitive surface water environments. • Fluid containment facilities will be constructed in accordance with regulatory standards. • Storing or handling of fuel, fuel using equipment, and chemicals will be in line with	CDM Smith (2016), "Water Monitoring Plan", Appendix G3 to the Narrabri Gas Project EIS CDM Smith (2016), "Water Baseline Report", Appendix G4 to the Narrabri Gas Project EIS Santos (2016), "EP-161 2016 Stratigraphic Corehole Program - Environment Plan Summary" Santos (2016), "EP-162 & EP-189, 2016 Corehole Program - Environment Plan

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			AS 1940-1993 The Storage and Handling of Flammable and Combustible Liquids. • Implement spill response procedures for spills or leaks. Personnel are to be trained in chemical and dangerous goods management and emergency spill response. Records of spills, leaks and associated clean ups are to be managed using the Incident Management System. Develop and implement a Trigger Action and Response Plan, to respond effectively and efficiently to spills and leaks. • Emergency shutdown systems are installed on equipment to prevent uncontrolled releases of flow-back water, fuel and/or other chemicals. Design, inspection and shutdown procedures for hydraulic stimulation equipment (i.e. high pressure equipment) reduce the risk of soil and shallow groundwater contamination from fluids used in hydraulic stimulation by minimising the potential volume of fluids released. • Routinely inspect flow-back lines, connections, high-pressure equipment and trip systems is undertaken to prevent operation above design limits; undertake repairs as required • Earthworks disturbance to drainage lines will be minimised/avoided wherever possible. Develop and implement an Erosion and Sediment Control Plan (ESCP) in accordance with IECA best practice guidance. • Where heavy rainfall or floodwaters pose a risk, produced fluids are removed from pits and transferred to tanks or facilities not subject to flood risk. • Undertake progressive rehabilitation to stabilise exposed surfaces and minimise concentration of surface flows. • Implement a surface water quality monitoring program to proactively check performance and effectiveness of mitigation measures.	Summary" URS Australia (2014) "Surface Water Assessment Report", Appendix N to the Santos GLNG Gas Field Development Project EIS
SW 2	Quantity	• Extraction of water • Diversion or change of surface water flows • Discharge	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken surface water hydrology impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against baseline flows to manage surface water hydrology. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water	CDM Smith (2016), "Water Monitoring Plan", Appendix G3 to the Narrabri Gas Project EIS CDM Smith

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		to surface water	Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, a Surface Water Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). These surface water hydrology assessments and management and monitoring plans provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operations. As examples, typical surface water quality management and mitigation measures applied to Santos' activities are listed below. • Baseline surface water monitoring is undertaken to characterise surface water quality and flow regime • With advances in stimulation fluid chemistry, potable quality water is no longer required for hydraulic stimulation, supporting reuse or recycling of flowback water or blending of other water sources. • When Santos moves from the exploration phase to development, facilities are set up to capture and recycle flowback fluid to the extent feasible reducing the amount of additional water required for each subsequent hydraulic stimulation operation • Fluid containment facilities will be constructed in accordance with regulatory standards. • Water will not be taken from surface water where there is a risk of an adverse impact to other users of water or dependant ecosystem can't be mitigated or managed or made-good. • Undertake progressive rehabilitation to stabilise exposed surfaces and minimise concentration of surface flows. • Implement a surface water hydrology monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows. • Report any discharges to surface water bodies to regulatory authorities.	(2016), "Water Baseline Report", Appendix G4 to the Narrabri Gas Project EIS URS Australia (2014) "Surface Water Assessment Report", Appendix N to the Santos GLNG Gas Field Development Project EIS
SW 3	Aquatic ecosystems and	Adverse impacts to aquatic	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs.	Eco Logical Australia (2016), "Ecological Impact

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	biodiversity	ecosystems and biodiversity may result from changes in the quality and/or quantity of surface water available to them.	Natural gas and other resource developments have undertaken aquatic ecology impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect aquatic ecology values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an aquatic ecology impact assessment, Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, an Aquatic Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). These surface water and aquatic ecology impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical aquatic ecology management and mitigation measures applied to Santos' activities are listed below: • Baseline aquatic surveys will be undertaken, to identify environmentally sensitive area and determine the extent of aquatic ecosystems and biodiversity within the study area. • Erosion and sediment control measures to be implemented and maintained. • Fluid containment facilities will be constructed in accordance with regulatory standards. • Undertake progressive rehabilitation to stabilise exposed surfaces and minimise concentration of surface flows • Implement a surface water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows. • Report any discharges to surface water bodies to regulatory authorities.	Assessment", Appendix J1 to the Narrabri Gas Project EIS CDM Smith (2016), "Water Monitoring Plan", Appendix G3 to the Narrabri Gas Project EIS CDM Smith (2016), "Water Baseline Report", Appendix G4 to the Narrabri Gas Project EIS URS Australia (2014), "Aquatic Ecology Assessment Report", Appendix S to the Santos Gas Field Development Project EIS
SW 4	Amenity values	Changes in the quality and/or quantity available may	The area of current prospective interest within Santos' tenements is remote areas of pastoral land that is not constrained by national parks, rangelands and recreational fishing areas. All watercourses are ephemeral in nature. Natural gas and other resource developments have undertaken surface water quality impact assessment as part of broader environmental assessment and management	CDM Smith (2016), "Water Monitoring Plan", Appendix G3 to the Narrabri Gas

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		impact on general amenity values such as national parks, rangelands and recreational fishing areas.	planning to verify environmental values and then demonstrate compliance against performance criteria to protect surface water quality. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, a Surface Water Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). Theses surface water quality assessments and management and monitoring plans provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical surface water quality management and mitigation measures applied to Santos' activities are listed below. • Baseline surface water monitoring is undertaken to characterise surface water quality and flow regime • Implement a surface water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows and quality .	Project EIS CDM Smith (2016), "Water Baseline Report", Appendix G4 to the Narrabri Gas Project EIS URS Australia (2014) "Surface Water Assessment Report", Appendix N to the Santos GLNG Gas Field Development Project EIS GHD (2016). "Landscape and Visual Impact Assessment Report", Appendix Q to the Narrabri Gas Project EIS JVP Visual Planning and Design (2014), "Landscape and Visual Amenity Assessment Report", Appendix

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				L to the Santos GLNG Gas field Development Project EIS
SW 5	Public health	There may be adverse impacts on human and livestock health due to changes to water quality, supply and distribution as a result of hydraulic fracturing and the associated activities.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken public health impact assessments, surface water quality impact assessment, and hydraulic fracturing risk assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect public health. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a public health impact assessment (which assessed the potential health impacts from water) was developed and will be implemented over the life of the Narrabri project (GHD 2016). Furthermore, a Water Baseline Report and Water Monitoring Plan can Chemical Risk Assessment (drilling chemicals) were developed and will implemented (CDM Smith 2016 and EHS Support 2016). As part of the Santos GLNG Gas Field Development Project and Hydraulic Fracturing Risk Assessment (EHS 2014) and Water Quality Management Plan and Chemical Risk Assessment (EHS 2017) were developed. These assessments contain extensive semi-quantitative and quantitative human health and ecological risk assessments. They demonstrate that the quantities and methodologies employed do not pose an unacceptable risk to human health or the environment. These chemicals and quantitative risk assessments have been peer reviewed as well as reviewed or assessed by the relevant government agencies and have had requisite Material Safety Data Sheets (MSDS) prepared. This information is publically available on Santos' website. These assessments and plans provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical public health management and surface water quality impact mitigation measures applied by Santos are listed below. • Baseline surface water monitoring is undertaken to characterise surface water quality and flow regime • Chemical storages or waste management facilities will not be sited within or adjacent to	http://ww2.health.wa.gov.au/~/media/Files/Corporate/Reports%20and%20publications/PDF/Hydraulic-Fracturing-HHRA-18June%202015.ashx EnRisks (2016), "Health Impact Assessment", Appendix T2 to the Narrabri Gas Project EIS EHS Support (2014), "Hydraulic Fracturing Risk Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS EHS Support (2017), Water

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			sensitive surface water environments. • Fluid containment facilities will be constructed in accordance with regulatory standards. • The details of chemicals used within Santos' petroleum activities are provided to the (former) NT Department of Mines and Energy (DME) as part of the Environment Plan approval process. These chemicals, and their associated MSDS, are made publicly available on the DME website. Santos supports full disclosure of the chemicals used in fracture stimulation operations to government • Implement a surface water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows	Quality Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project.
SW 6	Aboriginal people and their culture	Natural water bodies are central to traditional land use and many sites of significance to Aboriginal people relate to water. A reduction in either water quantity or quality may impair the traditional use and/or value of the sites.	In the NT, prior to undertaking any on-ground activities on pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease) or Aboriginal Land Rights land, Santos enters into an agreement with the appropriate Land Council (acting on behalf of the relevant Traditional Owners). This agreement covers many issues including the protection of sacred sites as well consultation with Traditional Owners to ensure they are informed of Santos' proposed activities. This cultural protection typically requires Santos to undertake a site clearance by the Traditional Owners to identify all sacred sites in the areas of Santos' proposed activities. Once a clearance has been undertaken, this triggers sacred site certification under the Sacred Sites Act which provides Santos with conditions where the company can and can't undertake activities. Santos has undertaken sacred site certifications for all project activities in the NT and works closely with the Northern Land Council, Central Land Council and the Aboriginal Areas Protection Authority to ensure compliance under the Sacred Site Act.	CQCHM (2016), "Aboriginal Cultural Heritage Assessment Report", Appendix N1 to the Narrabri Gas Project EIS Santos (2016), "Cultural Heritage Management Plan", Appendix N2 to the Narrabri Gas Project EIS
SW 7	Economic	Changes to water quality, supply and distribution may have an	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken surface water assessments	CDM Smith (2016), "Water Monitoring Plan", Appendix G3 to the Narrabri Gas

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		adverse impact on industries that may co-exist with the onshore unconventional gas industry, such as agriculture, pastoralism and tourism.	and management and monitoring plans and economic impact assessments to provide information and support applications for regulatory approvals. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water Baseline Report and Water Monitoring Plan (CDM Smith 2016) and an Economic Assessment (GHD 2016) were developed and will be implemented over the life of the Narrabri project. As part of Santos' GLNG Gas field Development Project EIS, a Surface Water Impact Assessment Report and Water Resource Management Plan (URS 2014) and an Economics Assessment (Santos 2014) were developed. As examples, typical surface water quality impact mitigation measures applied by Santos are listed below. • Baseline surface water monitoring is undertaken to characterise surface water quality and flow regime • Chemical storages or waste management facilities will not be sited within or adjacent to sensitive surface water environments. • Fluid containment facilities will be constructed in accordance with regulatory standards. • Erosion and sediment control measures to be implemented and maintained. • Undertake progressive rehabilitation to stabilise exposed surfaces and minimise concentration of surface flows • The details of chemicals used within Santos' petroleum activities are provided to the (former) NT Department of Mines and Energy (DME) as part of the Environment Plan approval process. These chemicals, and their associated MSDS, are made publicly available on the DME website. Santos supports full disclosure of the chemicals used in fracture stimulation operations to government • Implement a surface water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows.	Project EIS CDM Smith (2016), "Water Baseline Report", Appendix G4 to the Narrabri Gas Project EIS Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS
SW 8	Cumulative risk	There may be cumulative risks associated with some or all of the risks	The purpose of cumulative impact assessment is to: • Identify existing or proposed projects that are in the public domain • Screen the identified projects for their potential to interact • Assess the significance of potential cumulative impacts Natural gas and other resource developments have undertaken baseline monitoring and	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development

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		identified above.	surface water impact assessment as part of broader environmental assessment and management planning for use in cumulative impact assessments on surface water values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Cumulative Impact Assessment, Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). For the Santos GLNG Gas Field Development Project EIS, a Cumulative Impact Assessment and Water Resource Monitoring Plan were developed (Santos 2016). Cumulative impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical public health management and surface water quality impact mitigation measures applied by Santos are listed below • Explore opportunities for collaboration in cumulative impacts management through existing arrangements in consultation with State / Territory and local governments, industry and communities. • Contribute monitoring data to government agencies for use in cumulative management initiatives.	Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS
• **Groundwater**				
GW 1	Water quality	Risk of groundwater contamination Migration of water and/or hydrocarbons due to poorly designed/ constructed wells.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken baseline bore and ground water impact assessments as part of broader environmental assessment and management planning to verify environmental values and then demonstrate compliance against performance criteria to protect ground water values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a groundwater impact assessment and groundwater monitoring program were developed and will be implemented over the life of the Narrabri project. As part of the Santos GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report (Parsons Brinkerhoff 2014) and Water Resource Management Plan and Stimulation Impact Monitoring Program were developed (Santos 2014). As examples, previous management measures undertaken by Santos and the industry in	https://minerals.nt.gov.au/__data/assets/pdf_file/0005/370589/ep161-marmbulligan-environment-plan-summary.pdf CDM Smith (2016), "Groundwater Impact Assessment", Appendix F to the

ID	Theme	Description / Issue	Management/Mitigation	Proof
			general for a number of their projects are discussed below. **Initial baseline studies and risk assessments** • Baseline groundwater monitoring will be undertaken to provide a benchmark against which any future variations can be compared. Data obtained can include a record of a bore's groundwater level, water quality and usage, and provide information on bore construction. This assessment also confirms the location and status of existing bores and groundwater use within the vicinity of our operations (Santos 2017). • Landholders' bores that are active and proximal to hydraulic fracturing (2km radius) well will be included within the baseline assessment program. Santos will arrange for water quality testing of the bore water before and after hydraulic stimulation. These results can be made available to the landowners to provide confidence that their assets are protected and that risk control measures are successful (Santos 2017). • A groundwater risk assessment will be undertaken, which considers the local geology, hydrogeology, the design of the target formation, the location and status of existing wells and bores local to the planned activity and the design of the hydraulic stimulation activity itself. • If a hydraulic stimulation target is deemed to have an unacceptable risk of accessing a high water bearing zone, hydraulic stimulation will not be pursued. These factors will vary both regionally and locally, and risks are therefore assessed on a case-by-case basis (Santos 2017). • Assess the location and status of old wells and water bores, which have the potential to provide pathways that connect formally isolated aquifers and reservoirs. • The design of the well that is to be hydraulically stimulated must be checked. It must be demonstrated to comply with strict well construction standards that require integrity of engineered barriers to prevent flow between aquifers that may be hydraulically separate, and most importantly between the reservoir and overlying aquifers (Santos 2017). **Prevention of spills/leaks** • Established Santos spill response procedures shall be implemented for spills or leaks. Records of spills, leaks and associated clean ups are to be managed using the Incident Management System. • Emergency response systems shall be in place for responding to contaminant release	Narrabri Gas Project EIS Parsons Brinkerhoff (2014), "Groundwater Impact Assessment Report", Appendix O to the Santos GLNG Gas Field Development Project EIS EHS Support (2016), "Chemical Risk Assessment Report", Appendix T3 to the Narrabri Gas Project EIS EHS Support (2017), Water Quality Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project. EHS Support (2014), "Hydraulic

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			• Bunding of all areas using or storing or handling fuel, fuel using equipment, and chemicals, in line with AS 1940-1993; The Storage and Handling of Flammable and Combustible Liquids • No discharges to watercourses • Bunds to be inspected regularly for evidence of leakage • Development and implementation of a Well Integrity Program • Personnel trained in emergency spill response, chemicals and dangerous goods. • Emergency shutdown systems are installed on equipment to prevent uncontrolled release of flowback water or other chemicals, and there is routine inspection of flow-back lines, connections, and high pressure equipment and trip systems. • Routine inspection of flow-back lines, connections, high-pressure equipment and trip systems is undertaken to prevent operation above design limits; repairs are undertaken as required. Emergency shutdown systems are installed on equipment to prevent uncontrolled releases of flow-back water, fuel and/or other chemicals **Monitoring** • Implement a ground water quality monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with ground water quality.	Fracturing Risk Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS Santos (2014), "Stimulation Impact Monitoring Program", Appendix AE-D to the Santos GLNG Gas Field Development Project
GW 2	Quantity	Large amounts of water being extracted for use in hydraulic fracturing. There may be a risk of changes to the timing and/or quantity of surface water	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken ground water impact assessment as part of broader environmental assessment and management planning are undertaken to demonstrate compliance against performance criteria to protect ground water quality. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Groundwater Impact Assessment was developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of the Santos GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report (Parsons Brinkerhoff 2014) and Water Resource Management Plan and Stimulation Impact Monitoring Program were developed (Santos 2014)	Santos (2016), "Groundwater Impact Assessment", Appendix F to the Narrabri Gas Project EIS Parsons Brinkerhoff (2014), "Groundwater Impact Assessment

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		flows because of the discharge of produced water, which may be significant particularly in arid to semi-arid landscapes. There may be a risk to surface water and groundwater flow processes as the result of possible seismic activity caused by hydraulic fracturing or reinjection of water.	Groundwater impact assessments and management and monitoring plans provide information to support applications for regulatory approvals and licences. As an example, typical groundwater quality management and mitigation measures applied to Santos' activities are listed below. **Initial baseline studies and risk assessments** • Baseline groundwater monitoring will be undertaken to provide a benchmark against which any future variations can be compared. Data obtained can include a record of a bore's groundwater level, water quality and usage, and provide information on bore construction. This assessment also confirms the location and status of existing bores and groundwater use within the vicinity of our operations (Santos 2017). • Landholders' bores that are active and proximal to hydraulic fracturing (2km radius) will be included within the baseline assessment program. Santos will arrange for water quality testing of the bore water before and after hydraulic stimulation. These results can be made available to the landowners to provide confidence that their assets are protected and that risk control measures are successful (Santos 2017). • A groundwater risk assessment will be undertaken, which considers the local geology, hydrogeology, the design of the target formation, the location and status of existing wells and bores local to the planned activity and the design of the hydraulic stimulation activity itself. • If a hydraulic stimulation target is deemed to have an unacceptable risk of accessing a high water bearing zone, hydraulic stimulation will not be pursued. These factors will vary both regionally and locally, and risks are therefore assessed on a case-by-case basis (Santos 2017). • Assess the location and status of old wells and water bores, which have the potential to provide pathways that connect formally isolated aquifers and reservoirs. • The design of the well that is to be hydraulically stimulated must be checked. It must be demonstrated to comply with strict well construction standards that require integrity of engineered barriers to prevent flow between aquifers that may be hydraulically separate, and most importantly between the reservoir and overlying aquifers (Santos 2017). **Water usage** • When Santos moves from the exploration phase to development, facilities are set up to	Report", Appendix O to the Santos GLNG Gas Field Development Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			capture and recycle flowback fluid to the extent feasible reducing the amount of additional water required for each subsequent hydraulic stimulation operation • Fluid containment facilities will be constructed in accordance with regulatory standards. • Water will not be taken from a groundwater water source where there is a risk of an adverse impact to other users of water or dependant ecosystem can't be mitigated or managed or made-good. **Water usage** • Implement a ground water quality monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with ground water quality.	
GW 3	Aquatic ecosystems and biodiversity	Adverse impacts to aquatic ecosystems and biodiversity (including groundwater dependent ecosystem) may result from changes in the quality and/or quantity of surface and/or groundwater available to them.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken aquatic ecology impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect aquatic ecology values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an aquatic ecology impact assessment, Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, an Aquatic Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). These surface water, groundwater and aquatic ecology impact assessments and management and monitoring plans provide information to support applications for regulatory approvals. As examples, typical aquatic ecology management and mitigation measures applied to Santos' activities are listed below: • Baseline aquatic surveys will be undertaken, to identify environmentally sensitive area and determine the extent of aquatic ecosystems and biodiversity within the study area. • Erosion and sediment control measures to be implemented and maintained. • Fluid containment facilities will be constructed in accordance with regulatory standards.	Eco Logical Australia (2016), "Ecological Impact Assessment", Appendix J1 to the Narrabri Gas Project EIS URS Australia (2014), "Aquatic Ecology Assessment Report", Appendix S to the Santos Gas Field Development Project EIS Santos (2016), "Groundwater Impact

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			• Undertake progressive rehabilitation to stabilise exposed surfaces and minimise concentration of surface flows • Implement a surface water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows. • Report any discharges to surface water bodies to regulatory authorities • Implement a ground water quality monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with ground water quality.	Assessment", Appendix F to the Narrabri Gas Project EIS Parsons Brinkerhoff (2014), "Groundwater Impact Assessment Report", Appendix O to the Santos GLNG Gas Field Development Project EIS
GW 4	Amenity values	Changes in the quality and/or quantity available may impact on general amenity values such as national parks, rangelands and recreational fishing areas.	The area of current prospective interest within Santos' tenements is remote areas of pastoral land that is not constrained by national parks, rangelands and recreational fishing areas. All watercourses are ephemeral in nature. Natural gas and other resource developments have undertaken ground water impact assessments as part of broader environmental assessment and management planning to verify environmental values and then demonstrate compliance against performance criteria to protect surface water quality. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part of Santos' GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report and Water Resource Management Plan were developed (URS 2014). Theses surface water quality assessments and management and monitoring plans provide information to support applications for regulatory approvals and licences. As examples, typical ground water management and mitigation measures applied to Santos' activities are listed below. • Baseline ground water monitoring is undertaken	GHD (2016). "Landscape and Visual Impact Assessment Report", Appendix Q to the Narrabri Gas Project EIS JVP Visual Planning and Design (2014), "Landscape and Visual Amenity Assessment Report", Appendix L to the Santos GLNG Gas field Development Project EIS

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			• Implement a ground water monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with groundwater water level and quality.	
GW 5	Public health	There may be adverse impacts on human and livestock health due to changes to water quality, supply and distribution as a result of hydraulic fracturing and the associated activities.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken public health impact assessments, ground water quality impact assessment, and hydraulic fracturing risk assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect public health. For example as part of Santos' Narrabri Environmental Impact Statement (EIS), a public health impact assessment (which assessed the potential health impacts from water) was developed and will be implemented over the life of the Narrabri project (GHD 2016). Furthermore, a Water Baseline Report and Water Monitoring Plan and Chemical Risk Assessment (drilling chemicals) were developed and will implemented (CDM Smith 2016 and EHS Support 2016). As part of the Santos GLNG Gas Field Development Project EIS, a Hydraulic Fracturing Risk Assessment (EHS 2014), Water Quality Management Plan and Chemical Risk Assessment (EHS 2017) were developed. These assessments contain extensive semi-quantitative and quantitative human health and ecological risk assessments. They demonstrate that the quantities and methodologies employed do not pose an unacceptable risk to human health or the environment. These chemicals and quantitative risk assessments have been peer reviewed as well as reviewed or assessed by the relevant government agencies and have had requisite Material Safety Data Sheets (MSDS) prepared. This information is publically available on Santos' website. These assessments and plans provide information to support applications for regulatory approvals and licences. As examples, typical public health management and surface water quality impact mitigation measures applied by Santos are listed below. • Baseline ground water monitoring is undertaken to characterise surface water quality and level • Chemical storages or waste management facilities will not be sited within or adjacent to sensitive surface water environments.	http://ww2.health.wa.gov.au/~/media/Files/Corporate/Reports%20and%20publications/PDF/Hydraulic-Fracturing-HHRA-18June%202015.ashx EnRisks (2016), "Health Impact Assessment", Appendix T2 to the Narrabri Gas Project EIS EHS Support (2017), Water Quality Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project. EHS Support (2014), "Hydraulic Fracturing Risk

ID	Theme	Description / Issue	Management/Mitigation	Proof
			• Fluid containment facilities will be constructed in accordance with regulatory standards. • The details of chemicals used within Santos' petroleum activities are provided to the (former) NT Department of Mines and Energy (DME) as part of the Environment Plan approval process. These chemicals, and their associated MSDS, are made publicly available on the DME website. Santos supports full disclosure of the chemicals used in fracture stimulation operations to government • Implement a ground water monitoring program and a stimulation monitoring program to proactively check performance and effectiveness of mitigation measures in managing risks associated with surface water flows.	Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS
GW 6	Aboriginal people and their culture	Natural water bodies are central to traditional land use and many sites of significance to Aboriginal people relate to water. A reduction in either water quantity or quality may impair the traditional use and/or value of the sites.	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken baseline bore and ground water impact assessments as part of broader environmental assessment and management planning to verify environmental values and then demonstrate compliance against performance criteria to protect ground water values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a groundwater impact assessment and groundwater monitoring program were developed and will be implemented over the life of the Narrabri project. As part of the Santos GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report (Parsons Brinkerhoff 2014) and Water Resource Management Plan and Stimulation Impact Monitoring Program were developed (Santos 2014). In the NT, prior to undertaking any on-ground activities on pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease) or Aboriginal Land Rights land, Santos enters into an agreement with the appropriate Land Council (acting on behalf of the relevant Traditional Owners). This agreement covers many issues including the protection of sacred sites as well consultation with Traditional Owners to ensure they are informed of Santos' proposed activities. This cultural protection typically requires Santos to undertake a site clearance by the Traditional Owners to identify all sacred sites in the areas of Santos' proposed activities. Once a clearance has been undertaken, this triggers sacred site certification under the Sacred Sites Act which provides Santos with conditions where the company can and can't undertake activities. Santos has undertaken sacred site certifications for all project activities in the NT and works closely with the Northern Land Council, Central Land Council and the Aboriginal Areas Protection Authority to ensure	CQCHM (2016), "Aboriginal Cultural Heritage Assessment Report", Appendix N1 to the Narrabri Gas Project EIS Santos (2016), "Cultural Heritage Management Plan", Appendix N2 to the Narrabri Gas Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			compliance under the Sacred Site Act. In addition, Santos will: • Establish a dialogue with Indigenous groups covering potential issues of concern and development opportunities and formalising agreements. Santos will continue to engage actively with Traditional Owners over the life of the project. • Develop and implement a comprehensive Cultural Heritage Management System that supports the legislative framework on cultural heritage protection and requires all visitors to field locations, and those involved in managing projects with potential for ground disturbance, to undergo cultural heritage inductions. • Provides Traditional Owners with the opportunity to undertake site visits during project activities to gain a broader understanding of Santos operations. The site visit to Santos' 2016 McArthur Basin drilling program included a Welcome To Country by Traditional Owners, whilst the Central Land Council facilitated a site visit by the Imanpa community in January this year to view seismic practices during the Southern Amadeus seismic program. • Negotiate land use and compensation arrangements. Close to 50 agreements across the country (7 in the NT) have been entered into with Traditional Owners and statutory bodies without the need to go to arbitration.	
GW 7	Economic	Changes to water quality, supply and distribution may have an adverse impact on industries that may co-exist with the onshore unconvention al gas industry, such	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features such as waterways, wetlands, permanent waterholes and springs. Natural gas and other resource developments have undertaken ground water assessments and management and monitoring plans and economic impact assessments provide information to support applications for regulatory approvals and licences. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Water Baseline Report and Water Monitoring Plan (CDM Smith 2016) and an Economic Assessment (GHD 2016) were developed and will be implemented over the life of the Narrabri project. As part of Santos' GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report (Parsons Brinkerhoff 2014) and Water Resource Management Plan (URS 2014) and an Economics Assessment (Santos 2014) were developed.	Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
		as agriculture, pastoralism and tourism.	Previous examples of economic benefits delivered by oil and gas activities (including Santos activities) are discussed below. • Santos works collaboratively with stakeholders to locate and construct surface and sub-surface infrastructure to ensure that current and future uses of land are not negatively impacted. • There is a wide range of potential benefits for landholders as a result of natural gas activity on their properties, beyond the compensation paid to directly offset the footprint and inconvenience of natural gas activities (In 2015, Santos paid approximately $11 million in compensation to landholders across its onshore activities). • The economic contribution of oil and gas activities, from the exploration phase through to appraisal, development and production, can be significant for the local community, the region, the state and the nation • A 2014 PwC analysis identified the oil and gas industry as one of Australia's highest value-adding industries, with every dollar of production generating 70 cents of value-add compared to an average of 49 cents for all other industries. The PwC report found that the oil and gas industry's annual contribution to Australia's economic output was expected to more than double from $32 billion in 2012-13 to $67 billion by 2029-30 • A Deloitte Access Economics Report into the economic contribution of Santos' South Australian operations showed that in 2014, the company's activities were estimated to have contributed around $1,445 million in value added to the state economy. Santos' contribution to the national economy was estimated at $1,592 million in 2014. The demand generated by Santos' South Australian operations in 2014 was estimated to have added around 2,724 and 3,422 full-time jobs to the state and national workforces respectively • The Santos-operated GLNG project in Queensland is another good example of the positive economic impact flowing from oil and gas investment. Since January 2011, GLNG has purchased materials and services totalling approximately $16 billion. Of this, more than $8 billion has been invested in Queensland, with more than $1 billion in regional areas. Community investment, particularly in infrastructure such as roads, airports and medical services has been significant • In NSW, detailed economic modelling of Santos' proposed Narrabri gas project indicates it would generate a range of benefits including $3.1 billion of capital investment, direct creation of approximately 1,300 jobs during peak construction, about 200 ongoing jobs during operations, average direct and indirect employment over 25	

ID	Theme	Description / Issue	Management/Mitigation	Proof
			years of 750 full-time equivalent jobs, an increase in real income in the Narrabri region of $641 million, and the establishment of a Gas Community Benefit Fund that would receive an estimated $100 million through the life of the project.	
GW 8	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	The purpose of cumulative impact assessment is to: • Identify existing or proposed projects that are in the public domain • Screen the identified projects for their potential to interact • Assess the significance of potential cumulative impacts Baseline monitoring and ground water impact assessment form part of broader environmental assessment and management planning are undertaken for use in cumulative impact assessments on surface water values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Cumulative Impact Assessment, Water Baseline Report and Water Monitoring Plan were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). For the Santos GLNG Gas Field Development Project EIS, a Cumulative Impact Assessment and Water Resource Monitoring Plan was developed (Santos 2016). Cumulative impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. As examples, typical public health management and ground water impact mitigation measures applied by Santos are listed below • Explore opportunities for collaboration in cumulative impacts management through existing arrangements in consultation with State / Territory and local governments, industry and communities. • Contribute monitoring data to government agencies for use in cumulative management initiatives.	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS
• **Land**				
L1	Terrestrial ecosystems and their biodiversity	Risks to terrestrial ecosystems and	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features. Natural gas and other resource developments have undertaken ecological impact	https://minerals.nt.gov.au/__data/assets/pdf_file/0005/370589/ep161-

ID	Theme	Description / Issue	Management/Mitigation	Proof
		biodiversity in the Northern Territory include vegetation loss, fragmentation of fauna habitat, weed invasion, changes to fire regimes and adverse impacts from increased noise and light. Focus themes relevant: well integrity, induced seismicity, chemicals; waste management; construction noise and dust.	assessment as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect terrestrial ecology. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an Ecological Impact Assessment and Biodiversity Assessment Report were developed and will be implemented over the life of the Narrabri project (Eco Logical Australia 2016). As part for the Santos GLNG Gas Field Development Project, a Terrestrial Ecology Impact Assessment was developed (AURECON 2014). Ecology assessments and management and monitoring plans provide information and support applications for regulatory approvals and licences. As examples, typical mitigation measures adopted by industry include: **General disturbance** • Ecological assessment to be undertaken to identify environmentally sensitive areas (flora and fauna habitat). • Site selection surveys to be undertaken prior to on ground disturbance • Personnel will be prohibited from interfering with wildlife; • Driving off of approved areas is prohibited to all Santos personnel and contractors • Multi-well leases used to minimise disturbance **Vegetation loss** • Avoidance of native vegetation where feasible • Implementation of biodiversity management plans • Include strategic buffers around rivers, streams, wetlands and other sensitive areas. • Where areas of sensitive vegetation are identified, they are flagged off and signposted with restricted access. • Activities planned to minimise new land disturbance and make use of existing disturbance (where feasible) • Cleared vegetation will be stockpiled for later respreading during restoration. **Fragmentation of fauna habitat** • Co-location of pipelines and access tracks where feasible	marmbulligan-environment-plan-summary.pdf Eco Logical Australia (2016), "Ecological Impact Assessment", Appendix J1 to the Narrabri Gas Project EIS AURECON (2014), "Terrestrial Ecology Assessment Report", Appendix R to the Santos GLNG Gas Field Development Project EIS EnRisks (2016), "Health Impact Assessment", Appendix T2 to the Narrabri Gas Project EIS EHS Support (2017), Water Quality

ID	Theme	Description / Issue	Management/Mitigation	Proof
			• Full utilisation of established roads and tracks where possible • Rehabilitation of areas not required for on-going operations • Feral animal and pest plant control • Speed limits and dawn/dusk driving curfews **Pest plant and animals** • Weed control measures will be implemented. • All equipment will have weed wash-down completed prior to entry to the field. • Weed identification awareness training. • Weeds will be actively controlled in cleared/ hardstand areas. • Personnel will be prohibited from bringing firearms or traps into the lease areas, with the exception of those required for feral animal control. • Feral animal control measures will be implemented as required and in conjunction with landholders, Traditional Owners and local authorities (Parks and Wildlife). • Personnel will be prohibited from bringing domestic pets onto the area. **Change to fire regimes** • Adequate fire breaks maintained around flares to minimise the risk of fire. • Appropriate fuel and chemical handling and storage measures will be implemented. • Fire extinguishers and firefighting equipment will be provided at operational sites and for vehicles. • Emergency response systems will be in place and maintained. **Increased noise and light** • Due to the location of the Program wells and distance from sensitive receptors, it is anticipated that minimal noise impacts will occur. • Complaints shall be recorded (in Santos' EHS Toolbox), investigated and responded to appropriately. • The community shall be advised the likely timing and duration of noisy activities. • Campsites sites shall be located a sufficient distance to limit impact	Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project. EHS Support (2014), "Hydraulic Fracturing Risk Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			• Lighting will be designed to consider potential light impacts.	
L2	Soil health	Chemicals used in the drilling and hydraulic fracturing process may have an adverse impact on soil health, including as a result of spills of flow back water.	Natural gas and other resource developments have undertaken conduct soils impact assessment as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect soil health. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an Interpretative Soils Report and Contaminated Land Assessment were developed and will be implemented over the life of the Narrabri project (GHD 2016). For the Santos GLNG Gas Field Development Project, a chemical risk assessment was completed. Assessments and management and monitoring plans will provide information to provide data support applications for regulatory approvals and licences. As examples, typical mitigation measures adopted by industry include: **Chemicals** • Completion of chemical risk assessments. These include the assessment for potential impact to soil physical and chemicals conditions and structure. • Chemicals will be handled and stored in accordance with relevant Australian Standards, including AS 1940-2004 *The storage and handling of flammable and combustible liquids.* **Erosion and sediment control** • Erosion and sediment control plans that include: erosion and sediment controls for activity-based scenarios; guidance on determinations of site conditions, control selection criteria and soil types; design standards, technical notes and implementation considerations for erosion, drainage and sediment controls based on site conditions; monitoring requirements including water quality monitoring and site inspections. **Rehabilitation** • Implementation of a rehabilitation strategy, which provides guidance on soil stripping, handling, stockpiling, spreading and rehabilitation practices. The plans also include soil-specific guidance including measures to ameliorate erosion and dispersion.	GHD (2016), "Interpretive Soils Report", Appendix I1 to the Narrabri Gas Project EIS URS Australia (2014), "Land Resources Assessment Report", Appendix K to the Santos GLNG Gas Field Assessment Report EIS EHS Support (2017), Water Quality Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project
L3	Amenity values	The Northern Territory has iconic wilderness	The area of current prospective interest within Santos' tenements is remote pastoral land that is not constrained by national parks, rangelands, recreational fishing areas or wilderness areas.	GHD (2016). "Landscape and Visual Impact Assessment

ID	Theme	Description / Issue	Management/Mitigation	Proof
		values that are a core part of the Australian outback. There may be a risk that the development of the unconventional gas industry will have an adverse impact on the outback experience (e.g. tourism) through infrastructure development (e.g. the construction of pipelines and processing plants), and increased traffic, noise and light (from flaring).	Natural gas and other resource developments have undertaken ecological impact assessment and visual amenity impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect terrestrial ecology and amenity values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an Ecological Impact Assessment and Landscape and Visual Impact Assessment were developed and will be implemented over the life of the Narrabri project (GHD 2016). A Landscape and Visual Impact Assessment was also developed for the Narrabri Gas Project (GHD 2016) Assessments and management and monitoring plans will provide information and support applications for regulatory approvals and licences. The activity will be designed through these performance criterion to manage the risks associated with amenity values. Typical mitigation measures adopted by industry include: **Noise** • An impact assessment of noise and vibration to be developed as part of the approvals process. As an example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Noise and Vibration Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). • Activity locations will be determined in consultation with the landowner • Construction works will generally be conducted during daylight hours. Drilling activities are 24 hr operations and landholder notification is given prior to commencement of drilling • Equipment will be maintained in good working condition • Complaints will be responded to in a timely manner. Due to the remote location and small number of sensitive receptors within the area, it is anticipated that minimal impact will occur. **Light Disturbance** • The placement of camp and lease sites is conducted in consultation with the landholder and the potential for light disturbance is addressed in the scouting process.	Report", Appendix Q to the Narrabri Gas Project EIS JVP Visual Planning and Design (2014), "Landscape and Visual Amenity Assessment Report", Appendix L to the Santos GLNG Gas field Development Project EIS SLR Consulting Australia (2014), "Noise and Vibration Assessment Report", Appendix Q of the Santos GLNG Gas field Development Project EIS. GHD (2016), "Noise and Vibration Assessment", Appendix M to the Narrabri Gas Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			• Redirection of light towers • Angling of lights to be more directed at the ground • Complaints will be responded in a timely manner • Construction works will generally be conducted during daylight hours. Drilling activities are 24 hr operations and landholder notification is given prior to commencement of drilling Due to the small number of sensitive receptors within the study area, it is anticipated that minimal impact will occur	Cardno (2014), "Traffic and Transport Assessment", Appendix M to the Santos GLNG Gas Field Development Project GHD (2016), "Traffic Impact Assessment", Appendix P to the Narrabri Gas Project EIS
L4	Aboriginal people and their culture	The landscape, terrestrial ecosystems, plants and animals are central to traditional cultural values. Adverse impacts to these things may have an adverse impact on Aboriginal cultural	An Aboriginal Cultural Heritage Assessment will be undertaken, in addition to a Cultural Heritage Management Plan (CHMP), as part of the approvals process. For the recent Narrabri Gas Project EIS, Santos engaged Central Queensland Cultural Heritage Management (CQCHM) to undertake an assessment report for the Aboriginal Cultural Heritage within the study area. A CHMP was also developed as part of the project. These assessments as part of the EIS demonstrate compliance against performance criteria to protect Aboriginal people and their culture. Relevant approvals and licences will be obtained by Santos. The activity will be designed through these performance criterion to manage the risks associated with Aboriginal people and their culture. In the NT, prior to undertaking any on-ground activities on pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease) or Aboriginal Land Rights land, Santos enters into an agreement with the appropriate Land Council (acting on behalf of the relevant Traditional Owners). This agreement covers many issues including the protection of sacred sites as well consultation with Traditional Owners to ensure they are informed of Santos' proposed activities. This cultural protection typically requires Santos to undertake a site clearance by the Traditional Owners to identify all sacred sites in the areas of Santos' proposed activities. Once a clearance has been undertaken, this triggers sacred site	

ID	Theme	Description / Issue	Management/Mitigation	Proof
		values.	certification under the Sacred Sites Act which provides Santos with conditions where the company can and can't undertake activities. Santos has undertaken sacred site certifications for all project activities in the NT and works closely with the Northern Land Council, Central Land Council and the Aboriginal Areas Protection Authority to ensure compliance under the Sacred Site Act. In addition, Santos will: • Establish a dialogue with Indigenous groups covering potential issues of concern and development opportunities and formalising agreements. Santos will continue to engage actively with Traditional Owners over the life of the project. • Develop and implement a comprehensive Cultural Heritage Management System that supports the legislative framework on cultural heritage protection and requires all visitors to field locations, and those involved in managing projects with potential for ground disturbance, to undergo cultural heritage inductions. • Provides Traditional Owners with the opportunity to undertake site visits during project activities to gain a broader understanding of Santos operations. The site visit to Santos' 2016 McArthur Basin drilling program included a Welcome To Country by Traditional Owners, whilst the Central Land Council facilitated a site visit by the Imanpa community in January this year to view seismic practices during the Southern Amadeus seismic program. • Negotiate land use and compensation arrangements. Close to 50 agreements across the country (7 in the NT) have been entered into with Traditional Owners and statutory bodies without the need to go to arbitration.	
L5	Economic	An adverse impact on terrestrial ecosystems may be a risk to industries that co-exist with the onshore unconventional gas industry, such as agriculture,	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features. Natural gas and other resource developments have undertaken ecological impact assessment as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect terrestrial ecology. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an Ecological Impact Assessment and Biodiversity Assessment Report were developed and will be implemented over the life of the Narrabri project (Eco Logical Australia 2016). As part for the Santos GLNG Gas Field Development Project, a Terrestrial Ecology Impact Assessment was developed (AURECON 2014).	GHD (2016), "Agricultural Impact Assessment", Appendix K of the Narrabri Gas Project EIS Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri

ID	Theme	Description / Issue	Management/Mitigation	Proof
		pastoralism, fisheries and tourism.	Ecology assessments and management and monitoring plans provide information and support applications for regulatory approvals and licences. As further examples, Santos' Narrabri Environmental Impact Statement (EIS) an Economic Assessment (GHD 2016) was developed and will be implemented over the life of the Narrabri project. As part of Santos' GLNG Gas field Development Project EIS, a Ground Water Impact Assessment Report (Parsons Brinkerhoff 2014) and Water Resource Management Plan(URS 2014) and an Economics Assessment (Santos 2014) were developed. Due to the remote location and small number of sensitive receptors within the area, it is anticipated that minimal impact will occur.	Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS URS Australia (2014), "Land Resources Assessment Report", Appendix K to the Santos GLNG Gas Field Assessment Report EIS URS Australia (2014), "Landuse and Tenure Assessment", Appendix J to the Santos GLNG Gas Fields Development Project EIS Eco Logical Australia (2016), "Ecological Impact Assessment",

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				Appendix J1 to the Narrabri Gas Project EIS AURECON (2014), "Terrestrial Ecology Assessment Report", Appendix R to the Santos GLNG Gas Field Development Project EIS
L6	Proppant	There is a risk that the proppant material in the hydraulic fluid will cause adverse impacts to the land.	The human health and environmental risks associated with a range of hydraulic fracturing fluids and associated proppants has been assessed with the Santos GLNG Compendium of Assessed Hydraulic Fracturing Fluids (EHS 2014). To manage the risk of spills to land, a large, multi-compartment trailer holds proppant (natural sand or ceramic material) required for the treatment. When proppant is required, a conveyor system distributes proppant from the compartments to the blender unit for injection into the well. Should a spill occur then the proppant would be readily recovered through sweeping or scraping the surface	EHS Support (2014), "Hydraulic Fracturing Risk Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS
L7	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	The purpose of cumulative impact assessment is to: • Identify existing or proposed projects that are in the public domain • Screen the identified projects for their potential to interact • Assess the significance of potential cumulative impacts Natural gas and other resource developments have undertaken baseline ecology surveys and terrestrial impact assessment form part of broader environmental assessment and management planning are undertaken for use in cumulative impact assessments on	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS.

ID	Theme	Description / Issue	Management/Mitigation	Proof
			surface water values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Cumulative Impact Assessment and Ecological Impact Assessment and Biodiversity Assessment Report were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). As part for the Santos GLNG Gas Field Development Project, a Terrestrial Ecology Impact Assessment was developed (AURECON 2014) and Cumulative Impacts Report (Santos 2014) were developed. Cumulative impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences. As examples, typical public health management and ground water impact mitigation measures applied by Santos are listed below • Explore opportunities for collaboration in cumulative impacts management through existing arrangements in consultation with State / Territory and local governments, industry and communities. • Contribute monitoring data to government agencies for use in cumulative management initiatives.	Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS
• **Air**				
A1	Public health	There is a risk that the hydraulic fracturing will cause changes in the air quality, leading to issues in public health. Such risks include: • Fuel burnin	To manage the risk of adverse impacts, no-go zones or buffers, may be used to inform location selections of activities and infrastructure in relation to sensitive environmental features and minimise potential impacts to air quality values. Natural gas and other resource developments have undertaken public health impact assessment and air quality impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect amenity values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), Health Impact Assessment (which assessed the potential health impacts from air) was developed and will be implemented over the life of the Narrabri project (GHD 2016). Assessments and management and monitoring plans will provide information and support applications for regulatory approvals and licences. As examples, typical mitigation measures adopted by industry include:	https://minerals.nt.gov.au/__data/assets/pdf_file/0005/370589/ep161-marmbulligan-environment-plan-summary.pdf EnRisks (2016), "Health Impact Assessment", Appendix T2 to the Narrabri Gas

ID	Theme	Description / Issue	Management/Mitigation	Proof
		g • PM, VOCs, NOx • Fugitive emissions • Flaring and venting	**Dust suppression and emission management measures** • Baseline air quality monitoring • Application of water to unsealed road and construction area surfaces used for mobile plant and vehicle traffic • Application of misting water sprays in areas where earthworks are being conducted. • Reducing the speed of vehicles on field roads. • Fuel buring equipment is designed to meet risk based heath regulatory criteria • Use of air dispersion modelling to inform design • Ensuring plant and equipment is maintained to reduce potential fugitive emissions and leaks; • Minimising flaring or burning of waste products. • Complaints will be investigated and responded to appropriately, and emergency response systems will be in place.	Project EIS Air Environment Consulting (2016), "Air Quality Impact Assessment", Appendix L to the Narrabri Gas Project EIS SLR Consulting (2014), "Air Quality Assessment Report", Appendix P to the Santos GLNG Gas Field Development Project
A2	Climate change	There may be a risk that greenhouse gases, including hydrocarbons (methane and ethane) and carbon dioxide, will be released during hydraulic fracturing and the associated	Natural gas and other resource developments have undertaken greenhouse gas assessment and air quality impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect amenity values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Greenhouse Gas Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). Assessments and management and monitoring plans will provide information and support applications for regulatory approvals and licences Typical mitigation measures adopted by industry include: • Baseline methane and air quality monitoring • Adoption of best practice codes and standards for the construction and decommissioning of petroleum wells • Reports all air pollutant and greenhouse gas emissions from the Roma area to the	Kargbo, Wilhelm and Campbell 2010 http://pubs.acs.org/doi/pdf/10.1021/es903811p (uq library) Santos 2016, "Climate change", https://www.santos.com/sustainability/environment/climate-change/

ID	Theme	Description / Issue	Management/Mitigation	Proof
		activities. Emissions may be from sources such as well heads, pipelines, compression stations and final use.	National Pollutant Inventory (NPI) and the Commonwealth Government Greenhouse Challenge Program (Santos 2016). • Actively engaging in emission reduction and energy efficiency through maintenance (including use of an infra-red camera to detect fugitive emissions at flanges, gauges and couplings), technology and use of flaring as opposed to venting.	Santos 2016, "Greenhouse gas assessment", Appendix R to the Narrabri Gas Project EIS Santos (2014), "Greenhouse Gases" Chapter 16 to the Santos GLNG Gas Field Development Project EIS
A3	Amenity values	There may be a risk that there will be adverse impacts on amenity values such as national parks and rangelands due to gaseous emissions and flaring. Such risks include: • Ozone	The area of current prospective interest within Santos' tenements is remote areas of pastoral land that is not constrained by national parks, rangelands, recreational fishing areas or wilderness areas. Natural gas and other resource developments have undertaken public health impact assessment and air quality impact assessments as part of broader environmental assessment and management planning to demonstrate compliance against performance criteria to protect amenity values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), Health Impact Assessment (which assessed the potential health impacts from air) was developed and will be implemented over the life of the Narrabri project (GHD 2016). Assessments and management and monitoring plans will provide information and support applications for regulatory approvals and licences. As examples, typical mitigation measures adopted by industry include: **Dust suppression and emission management measures** • Baseline air quality monitoring • Application of water to unsealed road and construction area surfaces used for mobile	Air Environment Consulting (2016), "Air Quality Impact Assessment", Appendix L to the Narrabri Gas Project EIS SLR Consulting (2014), "Air Quality Assessment Report", Appendix P to the Santos GLNG Gas Field Development Project

ID	Theme	Description / Issue	Management/Mitigation	Proof
		• Smog • VOC and NOx in sunlight • Dust • Heat • Fugitive emissions	plant and vehicle traffic • Application of misting water sprays in areas where earthworks are being conducted. • Reducing the speed of vehicles on field roads. • Fuel buring equipment is designed to meet risk based heath regulatory criteria • Use of air dispersion modelling to inform design • Ensuring plant and equipment is maintained to reduce potential fugitive emissions and leaks; • Minimising flaring or burning of waste products. • Complaints will be investigated and responded to appropriately, and emergency response systems will be in place.	
A4	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	The purpose of cumulative impact assessment is to: • Identify existing or proposed projects that are in the public domain • Screen the identified projects for their potential to interact • Assess the significance of potential cumulative impacts Baseline monitoring and air impact assessment form part of broader environmental assessment and management planning are undertaken for use in cumulative impact assessments on air quality values. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), a Cumulative Impact Assessment, Water Baseline Report and Air Impact assessment were developed and will be implemented over the life of the Narrabri project (CDM Smith 2016). For the Santos GLNG Gas Field Development Project EIS, a Cumulative Impact Assessment and Air Impact Assessment was developed (Santos 2016). Cumulative impact assessments and management and monitoring plans will provide	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			information to support applications for regulatory approvals and licences that will be obtained. As examples, typical public health management and air quality impact mitigation measures applied by Santos are listed below • Explore opportunities for collaboration in cumulative impacts management through existing arrangements in consultation with State / Territory and local governments, industry and communities. • Contribute monitoring data to government agencies for use in cumulative management initiatives.	
• **Public health**				
PH 1	Drilling and fracking chemicals	Exposure to chemicals	A public health impact assessments are typically undertaken as part of approvals process. For example, As part of Santos' Narrabri Environmental Impact Statement (EIS), a Health Impact Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). A Chemical Risk Assessment Report was also developed as part of the Narrabri Gas Project (EHS Support 2016). As examples, previous management measures undertaken by Santos and research from other literature bodies are discussed below: • The chemicals used in hydraulic stimulation, in the quantities and methodologies employed, do not pose an unacceptable risk to human health or the environment. Extensive quantitative human health and ecological risk assessments have been undertaken for developments in Queensland. These chemicals and quantitative risk assessments have been reviewed or assessed by the relevant government agencies and have had requisite Material Safety Data Sheets (MSDS) prepared. This information is publically available on Santos' website. • All chemicals used within Santos' petroleum activities are provided to the (former) NT Department of Mines and Energy (DME) as part of the Environment Plan approval process. These chemicals, and their associated MSDS, are made publicly available on the DME website. Santos supports full disclosure of the chemicals used in fracture stimulation operations. • All chemicals are approved for use by the Australian Government (Department of Health) and listed on the Australian Inventory of Chemical Substances (AICS) (maintained under the National Industrial Chemicals Notification and Assessment	EnRisks (2016), "Health Impact Assessment", Appendix T2 to the Narrabri Gas Project EIS EHS Support (2017), Water Quality Management Plan and Chemical Risk Assessment, Santos Gas Field Development Project. EHS Support (2014), "Hydraulic Fracturing Risk Assessment Report", Appendix

ID	Theme	Description / Issue	Management/Mitigation	Proof
			Scheme (NICNAS)). • Even in low concentrations, Santos handles these additives with care to avoid potential for impacts on human health or the environment. With appropriate management controls in place, the overall or residual risk to the environment associated with the chemicals used in hydraulic stimulation is low.	Y-P to the Santos GLNG Gas Field Development Project EIS
PH 2	Hydrocarbons and BTEX	Potential sources of pollution including hydrocarbons, BTEX extraction, although BTEX is less likely to be a prominent feature of gas extracted from shale deposits. The use of BTEX in drilling and fracking fluids is currently prohibited in the Northern Territory.	The chemical additives used by Santos in the hydraulic stimulation process do not contain BTEX as additives. Groundwater baseline monitoring will include analysis for BTEX compounds.	
PH 3	Radioactive substances	There may be a risk that radioactive materials from underground come into contact with	Naturally Occurring Radioactive Materials (NORM) are materials which contain primordial radionuclides as they occur in nature, such as isotopes of radium, uranium, thorium, potassium and the products of their radioactive decay. The levels of NORM are highly dependent on the local geology. A public health impact assessment will be developed as part of the approvals process. As part of Santos' Narrabri Environmental Impact Statement (EIS), a Health Impact Assessment was developed and will be implemented over the life of the Narrabri project	EHS Support (2017), Water Quality Management Plan and Chemical Risk Assessment, Santos Gas Field

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		humans or livestock as a result of the drilling or hydraulic fracturing process.	(GHD 2016). In addition, a Chemical Risk Assessment Report was developed as part of the Narrabri Gas Project (EHS Support 2016). These assessments as part of the EIS demonstrate compliance against performance criteria to minimise the impacts of potential radioactive substances. Relevant approvals and licences will be obtained by Santos. Baseline assessments will be undertaken to determine the potential presence and/or extent or radioactive substances in the prospective area.	Development Project. EHS Support (2014), "Hydraulic Fracturing Risk Assessment Report", Appendix Y-P to the Santos GLNG Gas Field Development Project EIS
PH 4	Mental health and wellbeing	The mental health and wellbeing of persons could be affected by an unconventional gas project. These factors could include increased costs of living associated with changing property values, access to social services, business failures,	A social impact assessment and public health impact assessment are typically developed as part of the approvals process. As part of Santos' Narrabri Environmental Impact Statement (EIS), a Health Impact Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). As part of Santos' Narrabri Environmental Impact Statement (EIS), a Social Impact Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016).	GHD (2016), "Social Impact Assessment Report", Appendix T1 to the Narrabri Gas Project EIS URS Australia (2014), "Social Impact Assessment Report", Appendix V to the Santos GLNG Gas Field Development Project EIS

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		increased traffic, effects on the natural environment and concerns about the amenity of the local area.		
PH 5	Diesel fumes	There may be a risk of emissions from plant and equipment, such as diesel fumes from drilling equipment and pumps and from off-site increases in road traffic.	Air quality and public health impact assessment are typically developed as part of the approvals process. • As part of the Santos GLNG Gas Field Development Project, a detailed air quality impact assessment was developed to demonstrate compliance against health-related performance criteria and mitigation measures relating to diesel fumes will be implemented over the life of the project. • As part of Santos' Narrabri Environmental Impact Statement (EIS), a Health Impact Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). A Chemical Risk Assessment Report was developed as part of the Narrabri Gas Project (EHS Support 2016). These assessments as part of the EIS demonstrate compliance against performance criteria to minimise the impacts of potential air emissions. Relevant approvals and licences will be obtained by Santos and checks will monitor effective implementation of controls. The currently available evidence indicates that the potential risks to public health from exposure to the emissions associated with shale gas extraction are low if the operations properly run and regulated. When potential risks have been identified in the literature, the reported problems are typically a result of operational failure and a poor regulatory environment. Therefore, good on-site management and appropriate regulation of all aspects including exploratory drilling, gas capture, use and storage of hydraulic fracturing fluid, and post-operations decommissioning are essential to minimise the risk to the environment and public health (UK Public Health 2013).	Air Environment Consulting (2016), "Air Quality Impact Assessment", Appendix L to the Narrabri Gas Project EIS SLR Consulting (2014), "Air Quality Assessment Report", Appendix P to the Santos GLNG Gas Field Development Project Cardno (2014), "Traffic and Transport Assessment", Appendix M to the Santos GLNG Gas Field Development Project

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				GHD (2016), "Traffic Impact Assessment", Appendix P to the Narrabri Gas Project EIS
PH 6	Physical safety	Physical safety may be comprised by factors associated with hydraulic fracturing including road transport accidents and seismic activity.	A public health impact assessment and hazard and risk assessment are typically developed as part of the approvals process. As part of Santos' Narrabri Environmental Impact Statement (EIS), a Health Impact Assessment was developed and will be implemented over the life of the Narrabri project (GHD 2016). A Hazard and Risk Assessment was also developed (GHD 2016). These assessments as part of the EIS demonstrate compliance against performance criteria to minimise the impacts of potential radioactive substances. Relevant approvals and licences will be obtained by Santos. As an example, previous management measures undertaken by Santos are discussed below: • Santos publishes data about its health and safety performance in its annual sustainability reports (available on the Santos website), as part of our commitment to satisfy and exceed community expectations. • Potential sources of risk to the public and other third parties as a result of hydraulic stimulation activities could principally arise from unauthorised access resulting in exposure to site hazards, and the use of roads and movement of vehicles and heavy machinery. • Hydraulic stimulation operations are undertaken at established well leases where public access is restricted. Most sites are relatively remote from public roads and have little or no public access. Measures such as signage and fencing are in place to warn of hazards at the site and restrict access into the site. Potentially hazardous areas such as sumps and lined pits are securely fenced with warning signs in place. • Hydraulic stimulation operations can result in short term and localised increase in vehicle traffic. Santos employs controls to manage the risks of road use, including adherence to specified speed limits, In Vehicle Monitoring (IVMS) of speed, route and	GHD (2016), "Hazard and Risk Assessment", Appendix S to the Narrabri Gas Project EIS Sherpa Consulting (2014), Hazard and Risk Assessment, Appendix C to the Santos GLNG Gas Field Development Project Cardno (2014), "Traffic and Transport Assessment", Appendix M to the Santos GLNG Gas Field Development Project GHD (2016),

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			harsh breaking, minimising night-time driving and driver education programs. • Signage will be installed in accordance with Australian standards to alert of underground infrastructure. • Job Hazard Analysis will be conducted for new tasks or new use of equipment to ensure appropriate control measures are identified. • Develop and implement a bushfire management plan. • All facilities will be designed and operated under the applicable Australian safety standards and protocols. • Dangerous goods will be stored and transported in accordance with the *Australian Dangerous Goods Code.* In addition to mitigation measures for physical safety, monitoring and reporting will be undertaken to proactively manage the safety of workers and the public. Complaints will be investigated and responded to appropriately.	"Traffic Impact Assessment", Appendix P to the Narrabri Gas Project EIS
PH 7	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	The prospective area is remote and sparsely populated. There is no Australian data to suggest that major health risks are likely to arise from shale gas operations (ACOLA 2013). The potential for health impacts will need considered attention in Australia, including the collection of baseline information for populated areas that are likely to have nearby shale gas operations. In addition, Monash University's release of the Australia Institute of Petroleum's (AIP) 14th Health Watch Report in 2013 showed that petroleum industry employees have better health than the general Australian community and are less likely to die from cancer, heart disease, respiratory and digestive diseases. Running since 1980, the study monitors the health of 20,000 past and current employees who have been exposed to oil and natural gas in the course of their work. The study uses robust data collected during and post-employment, and includes detailed analysis of job types, workplace practices, lifestyle influences, and illness and cases of death. More broadly, Santos is aware of concerns expressed by some in the community regarding the impact of natural gas activities on human and animal health. While Santos is not in a position to comment on specific claims, we make the following point: "Our company – along with the rest of the sector – has thousands of employees and contractors who work every day in and around oil and gas wells, processing and transmission facilities. None of these people seem to experience the symptoms sometimes claimed by industry opponents."	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS

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• **Aboriginal people and their culture**				
CH 1	Land ownership	There may be a risk that hydraulic fracturing or the associated activities will disrupt traditional practices that connect Aboriginal landowning groups with their country and underpin recognition of their ownership of that land.	Previous management measures undertaken by Santos are discussed below. In the NT, prior to undertaking any on-ground activities on pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease) or Aboriginal Land Rights land, Santos enters into an agreement with the appropriate Land Council (acting on behalf of the relevant Traditional Owners). This agreement covers many issues including the protection of sacred sites as well consultation with Traditional Owners to ensure they are informed of Santos' proposed activities. This cultural protection typically requires Santos to undertake a site clearance by the Traditional Owners to identify all sacred sites in the areas of Santos' proposed activities. Once a clearance has been undertaken, this triggers sacred site certification under the Sacred Sites Act which provides Santos with conditions where the company can and can't undertake activities. Santos has undertaken sacred site certifications for all project activities in the NT and works closely with the Northern Land Council, Central Land Council and the Aboriginal Areas Protection Authority to ensure compliance under the Sacred Site Act. In addition, Santos will: • Establish a dialogue with Indigenous groups covering potential issues of concern and development opportunities and formalising agreements. Santos will continue to engage actively with Traditional Owners over the life of the project. • Develop and implement a comprehensive Cultural Heritage Management System that supports the legislative framework on cultural heritage protection and requires all visitors to field locations, and those involved in managing projects with potential for ground disturbance, to undergo cultural heritage inductions. • Provides Traditional Owners with the opportunity to undertake site visits during project activities to gain a broader understanding of Santos operations. The site visit to Santos' 2016 McArthur Basin drilling program included a Welcome To Country by Traditional Owners, whilst the Central Land Council facilitated a site visit by the Imanpa community in January this year to view seismic practices during the Southern Amadeus seismic program. • Negotiate land use compensation arrangements. Close to 50 agreements across the country (7 in the NT) have been entered into with Traditional Owners and statutory bodies without the need to go to arbitration.	Santos 2016, "Northern territory", https://www.santos.com/what-we-do/activities/northern-territory/

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CH 2	Benefits	There may be a risk that the development of the industry will occur without short and long term benefits flowing to local Aboriginal communities.	Short and long term benefits flowing to local Aboriginal communities would be agreed and captured in land use and contractor agreements. Previous management measures undertaken by Santos are discussed below. • Around half of the NT is covered by the Aboriginal Lands Right Act (ALRA). Some gas developments can be expected to take place on ALRA land. The Commonwealth makes matching payments to the Land Councils equal to the value of royalties paid by resource companies to the NT Government. The Land Councils distribute these funds to communities. • Santos has negotiated compensation arrangements in relation to native title, and works with closely with Traditional Owners on cultural heritage, including engaging Aboriginal people to help identify, and manage the risk to, cultural heritage arising from our activities. Santos is committed to working compliantly within the legislative framework across all of its assets. All these agreements – close to 50 across the country (7 in the NT) – with Traditional Owners and statutory bodies have been struck without the need to go to arbitration. • Additionally, Santos has specific programs, managed in-house, to create employment resulting from our projects, and supports programs that focus on school retention and participation in education and training along with targeted 'caring for country' programs (for example, the Port Curtis Coral Coast (PCCC) Traditional Owners in Queensland are engaged to assist with an environmental offset program that was a requirement for the GLNG pipeline project. It's a program of collaboration with the Traditional Owners which ensures environmental compliance, builds capacity within the PCCC as well as providing ongoing economic benefit to the PCCC community. Another example is through Darwin LNG (DLNG), in which Santos is a joint venture partner. DLNG funds the West Arnhem Land Fire Abatement project, which sees the reduction of greenhouse gas emissions by the equivalent of over 100 000 tonnes of CO^2 each year through traditional fire management practices undertaken by Indigenous fire managers). • In Santos' NT activities in the past few years, opportunities were provided for Aboriginal employment and on-the-job training through: • Intract Indigenous Contractors undertaking civil works for the Mereenie Appraisal Development Drilling project (this activity allowed Intract to explore for new work in other industries and opened the door to opportunities in the Cooper Basin).	APPEA 2016 Report to the CoAG Energy Council - Unconventional Gas in Australia https://www.appea.com.au/wp-content/uploads/2017/02/Final-APPEA-Report-to-CoAG-Unconventional-Gas-in-Australia-2016.pdf

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			• Terrex Seismic for Southern Amadeus Seismic Program • Rusca Bros Services while undertaking McArthur Basin drilling activities in 2014 (preparation of access road and lease pad for the exploration well hole. Rusca had an impressive record for Aboriginal employment, but on this project increased its workforce through employment of local Traditional Owners). Santos will continue to engage actively with Traditional Owners to ensure risks to Aboriginal people and their culture are minimised.	
CH 3	Culture, values and traditions	There may be a risk that the above and/or below ground disturbance associated with drilling and hydraulic fracturing or as the result of seismic activity caused by hydraulic fracturing or reinjection of water will have an adverse impact on Aboriginal culture, values and the traditions that connect landowning groups with their country	• In the NT, prior to undertaking any on-ground activities on pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease) or Aboriginal Land Rights land, Santos enters into an agreement with the appropriate Land Council (acting on behalf of the relevant Traditional Owners). This agreement covers many issues including the protection of sacred sites as well consultation with Traditional Owners to ensure they are informed of Santos' proposed activities. This cultural protection typically requires Santos to undertake a site clearance by the Traditional Owners to identify all sacred sites in the areas of Santos' proposed activities. Once a clearance has been undertaken, this triggers sacred site certification under the Sacred Sites Act which provides Santos with conditions where the company can and can't undertake activities. Santos has undertaken sacred site certifications for all project activities in the NT and works closely with the Northern Land Council, Central Land Council and the Aboriginal Areas Protection Authority to ensure compliance under the Sacred Site Act. • For our 2014-15 McArthur Basin exploration program, Santos faced the challenge of identifying preferred areas for field geographical mapping while protecting cultural heritage in an area covering several thousands of square kilometres of rugged land and with the wet season fast approaching. The company approached the Northern Land Council to help form an agreement for Traditional Owners to work on site with the Santos exploration team to collect data and conduct clearance scouting. Concurrent cultural heritage assessment and field geological mapping proved to be an efficient, effective process in which Traditional Owners and scientists shared their technical knowledge and understanding of country. • Santos also provides Traditional Owners with the opportunity to undertake site visits during project activities to gain a broader understanding of Santos operations. The site visit to Santos' 2016 McArthur Basin drilling program included a Welcome To Country by Traditional Owners, whilst the Central Land Council facilitated a site visit by the	

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		and sustain community cohesion.	Imanpa community in January this year to view seismic practices during the Southern Amadeus seismic program.	
CH 4	Community wellbeing	The development of the unconventional gas industry may have an adverse impact on the wellbeing of Aboriginal communities.	See commentary above and below. In 2012, GLNG launched its three-year Aboriginal cadetship program in Queensland, with five cadets commencing positions ranging from human resources roles to working in environment and gas supply teams. The cadetships provide on-the-job experience alongside gaining relevant work qualifications, and ensure cadets develop professionally in order to be competitive in the oil and gas industry or wherever they choose to work.	
CH 5	Aquatic and terrestrial ecosystems	The development of the unconventional gas industry may have an adverse impact on aquatic and terrestrial ecosystems important to Aboriginal culture.	Ecological impact assessment are typically undertaken as part of the approvals process. For example, as part of Santos' Narrabri Environmental Impact Statement (EIS), an Ecological Impact Assessment and Biodiversity Assessment Report was undertaken, which included an assessment on the impact of terrestrial and aquatic ecosystems and biodiversity (Eco Logical Australia 2016).These assessments as part of the EIS demonstrate compliance against performance criteria to protect aquatic ecosystems and associated biodiversity. Relevant approvals and licences will be obtained by Santos prior to operation. The activity will be designed through these performance criterion to manage the risks associated with aquatic and terrestrial biodiversity. Previous management measures undertaken by Santos and the industry in general for a number of their projects are discussed below. • Baseline aquatic surveys will be undertaken, to identify environmentally sensitive area and determine the extent of aquatic ecosystems and biodiversity within the study area. • Personnel will be prohibited from interfering with wildlife; • Erosion and sediment control measures to be implemented and maintained	Eco Logical Australia (2016), "Ecological Impact Assessment", Appendix J1 to the Narrabri Gas Project EIS URS Australia (2014), "Aquatic Ecology Assessment Report", Appendix S to the Santos Gas Field Development Project EIS

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			• Biodiversity offsets for disturbance to conservation significant communities. • Activities and vehicle movements are restricted to existing, defined well leases and access tracks. • Activities to be planned to minimise new land disturbance and make use of existing disturbance (where possible) • Co-location of pipelines • Feral animal and pest plant control • Ecological monitoring and field surveys are conducted.	URS Australia (2014), "Terrestrial Ecology Assessment Report", Appendix R to the Santos GLNG Gas Field Development Project EIS
CH 6	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	Operating onshore in South Australia, Queensland, New South Wales and the NT, Santos' approach is to engage early with Aboriginal stakeholders, and where appropriate use interpreters so that communication is in language to ensure informed discussions on the oil and gas industry. Santos' agreements with Aboriginal stakeholders reflect the principle of the Santos Aboriginal Engagement Policy which prescribes Santos commitment to working with Aboriginal communities in a way that respects Aboriginal cultures and supports the development of those communities in which the company operates. The industry has the potential to address the aspirations of Aboriginal people to build greater economic self-sufficiency. In relation to Aboriginal Land Rights land, Traditional Owners can place any conditions on the grant of the exploration/production tenure they see fit including a ban on hydraulic fracturing. In other words, they have the power of veto over any activity. In relation to pastoral leasehold land (or land where native title survives or co-exists with a pastoral lease), the Traditional Owners are not legally able to ban or impose conditions on petroleum activities including hydraulic fracturing. However, the Native Title Act prescribes the terms to be negotiated including compensation. • In the NT, these agreements are struck with the relevant Land Council (acting on behalf of the relevant Traditional Owners). Compensation payments under these agreements (usually a percentage of the project on-ground spend e.g. a percentage of how much the company might spend on the ground in an exploration program) are made to the relevant Land Council and Santos has no oversight of how the compensation is shared with the relevant Traditional Owners and their community. The compensation is applied at the discretion of the relevant Land Council.	Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS

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			• Complete pre-clearance surveys with the involvement of Aboriginal community Project employees and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects. Aboriginal cultural heritage will be integrated into the project's offset strategy, where available.	
• **Social**				
S1	Housing and rent	There may be impacts on local housing, which may decrease or increase rents and house prices as a result of an increased population.	A social impact assessment and economic impact assessment are typically developed as part of the approvals process. Social assessments will draw on extensive government and community consultation. As part of Santos' Narrabri Environmental Impact Statement (EIS), a Social Impact Assessment was developed and identified mitigation measures, in consultation with government and local community, which will be implemented over the life of the Narrabri project (GHD 2016). An Economic Impact Assessment was also developed (GHD 2016). Although the prospective area is limited to pastoral leases held by two landholders and accommodation needs will be limited, the activity will be designed to manage the potential social impacts, and create social and economic benefits. These assessments as part of an EIS demonstrate how the project will minimise the adverse impacts and create benefits on infrastructure, housing and rent, local health services and education. Santos puts in place necessary landholder access, conduct and compensation agreements as well as legislated insurances and regulatory securities and bonds to ensure the government and community do not bear any costs for rehabilitation. • Initiate community consultation and awareness campaign to promote project benefits to the community. • Develop and implement project sponsorship/community support program to enhance corporate investment in the community, and specific community events. • Prioritise local employment over non-local employment where practicable. Improve local skill levels through investment in skills development and training. Monitor recruitment from the local community, including information on previous place of employment. Development measures to address workers transition impacts (URS 2009). • Indirect employment will occur through infrastructure upgrades, the need to increase public services etc. (URS 2009).	GHD (2016), "Social Impact Assessment Report", Appendix T1 to the Narrabri Gas Project EIS URS Australia (2014), "Social Impact Assessment Report", Appendix V to the Santos GLNG Gas Field Development Project EIS
S2	Insurance	There may be a risk that there will be an increase in insurance costs and liabilities of landowners, occupiers, and traditional owners.		
S3	Health services	There may be impacts on the local health system (hospitals, health		

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		services etc.) as a result of an increased population, including that there may be increased health services in remote communities as a result of industry's presence.	• Liaise with local accommodation and health services providers to outline likely service requirements prior to commencing activity in the area • Develop policy on procurement of local suppliers and inventory of self-identified suppliers (URS 2009). • A Stakeholder Management Plan will be prepared. • A record of complaints and incidents causing environmental harm and the follow-up actions taken in response to each complaint or incident will be maintained in the Santos EHS Toolbox. • All personnel and site visitors will complete the appropriate inductions. • Cultural Heritage Clearance (and identification of sites of Aboriginal significance in conjunction with NLC) will be conducted prior to commencement of disturbance activities or operations. • Work will cease immediately upon encounter of a site/suspected site or artefact. • The discovery of a suspected Aboriginal heritage site, artefact or human remains will be reported immediately. Cultural Heritage Report forms will be completed for site/suspected site encountered. • Operations personnel will avoid known heritage sites. • Ongoing community consultation will continue over the life of the project. • Listen to and address concerns or queries • Educate the community, landholders, business operators and Traditional Owners on why and how Santos operates. The key components of the engagement program have been: • Briefing sessions – face-to-face with key individuals and groups with timely feedback on issues and concerns • Distribution of key information via media engagement, websites, social media and letter writing • Community capacity building through employment (local and aboriginal), contracts and procurement	
S4	Education	There may be an impact on the local education system as a result of an increased population.		
S5	Infrastructure	There may be an impact on infrastructure, such as roads, as a result of increased traffic.		
S6	Livelihoods	There may be an impact on peoples'		

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		livelihoods.		
S7	Long term benefits	There may be a risk that the development of the industry will occur without short and long term benefits flowing to the local community.		
S8	Community cohesion	There may be an impact on community cohesion and resilience, particularly in relation to fly-in, fly-out workers. Real or perceived fear of social dysfunction as a result of external workers in the community.		
S9	Crime	There may be an increase in crime.		

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S10	Employment	There may be an increase on local employment and skill levels.		
S11	Business			
S12	Cumulative risk			Santos 2014, "Cumulative Impacts", Chapter 26 to the Santos GLNG Gas Field Development Project EIS. Santos (2016), "Cumulative Impact", Chapter 29 to the Narrabri Gas Project EIS
• **Economic**				
E1	Distribution	There may be a risk that any economic benefits will not be shared by the regions that are directly affected by the industry,	An economic impact assessment are typically developed as part of the approvals process. The activity will be designed through these performance criterion to manage the risks associated with economic distribution. Management measures are discussed below. • Several studies and reports published over the last five years have confirmed that the unconventional gas sector can contribute significantly to prosperity of the nation as a whole and specific regions in particular ref. • Onshore shale and tight gas production has the potential to drive significant economic growth and provide substantial benefits to the NT economy (DAE 2015). • DAE estimated that from 2020 to 2040, the net present value of additional capital	APPEA 2016 Report to the CoAG Energy Council - Unconventional Gas in Australia https://www.appea.com.au/wp-content/uploads/2017/02/Final-

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		and/or will not be shared equitably between the gas companies, the government, and the community.	expenditure in the Territory from developing shale and tight gas resources would be $10.1 billion under the 'Success' scenario, with a peak annual estimate of $3.3 billion invested in 2027 (DAE 2015). • Estimates of the incremental effects of shale and tight gas development on output and jobs were compared against levels likely under a base case of no such development. The analysis showed that developing shale and tight gas will have significant effects on the NT's output and employment. By 2040, again under the Success scenario, NT gross state product (GSP) is projected to be almost $5.1 billion higher than the base case in real terms. This represents an increase of more than 26 per cent on current GSP estimates for the NT ($19.9 billion in 2012-13). In NPV terms (2015 dollars) over the entire period to 2040, the increase in GSP under the Success scenario is cumulatively $17.2 billion (DAE 2015). • Developing these gas resources is also expected to significantly increase employment in the NT. Under the Success scenario, job creation is estimated to increase up to 4,200 full time equivalents (FTEs) by 2040. Developing this sector is projected to add up to $200 million to NT Government revenues. From 2020 to 2040, this increase is cumulatively (in NPV terms) up to $700 million (DAE 2015). • Around half of the NT is covered by the Aboriginal Lands Right Act (ALRA). Some gas developments can be expected to take place on ALRA land. The Commonwealth makes matching payments to the Land Councils equal to the value of royalties paid by resource companies to the NT Government. The Land Councils distribute these funds to communities. • I**mproved community infrastructure and services.** Santos has a strong track record of contributing to communities with a focus on health, education, infrastructure, the environment, youth, indigenous opportunities, local businesses, the arts, community organisations and events, and volunteering. In Queensland, GLNG has made over $200 million worth of contributions to regional communities, including important legacy investments in major infrastructure including: ○ $140 million for road upgrades and maintenance across regional Queensland, with a further $63 million committed over the next five years. ○ $20 million over the life of our project to the CareFlight aeromedical service. ○ $2.5 million towards the upgrade of the Roma Airport (an LNG industry joint	APPEA-Report-to-CoAG-Unconventional-Gas-in-Australia-2016.pdf *Economic Impact of Shale and Tight Gas Development in the NT (Deloitte Access Economics, 2015)* Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS

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			○ Investment of $10.5 million to fund an instrument landing system at Gladstone Airport that has improved safety, particularly for landings in difficult weather conditions). ○ $1 million to Roma Allied Health. ○ $5.5 million to affordable housing and rent assistance initiatives in the Maranoa. ○ $1 million for significant upgrades to Roma's underground sewerage infrastructure. ○ Over $1 million for weed and pest management programs, including a significant upgrade to the Roma saleyards vehicle wash-down.	
E2	Property values	There may be a risk that there will be a decrease or increase in existing property values.	The activity will be designed to coexist with current and future land uses to manage the risks associated with property values. Management measures are discussed below. • Santos works collaboratively with stakeholders to locate and construct surface and sub-surface infrastructure to ensure that current and future uses of land are not negatively impacted. • There is a wide range of potential benefits for landholders as a result of natural gas activity on their properties, beyond the compensation paid to directly offset the footprint and inconvenience of natural gas activities (In 2015, Santos paid approximately $11 million in compensation to landholders across its onshore activities). These include: • **Additional income streams** from natural gas activity would be a welcome addition to any farming business grappling with the adverse effects of ongoing drought conditions. Income can be generated through, for example, the sale of raw materials such as gravel for road construction. • **New farm infrastructure** that enhances the farming business. For example: ○ Access roads to gas wells located to the advantage of the landholder – principally along fence lines to minimise disturbance to paddocks but additionally along routes that improve the functionality of the property. ○ Water monitoring bores, which are drilled in locations that will make them useful for the landholder when monitoring activity has ceased. • **Opportunities for employment**. There are numerous examples of landholders gaining employment with companies or their contractors. Employment opportunities	Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS

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			for young people in particular are helping to reverse the trend of regional population decline by providing additional career options in regional area. • **Additional selling point** for properties on the market. There is anecdotal evidence of properties being advertised in Queensland for sale with 'gas wells' listed as a selling feature over recent years, and this is likely to continue. • **Voluntary support.** As well as supporting community infrastructure and services, Santos' employees regularly devote their own time and money to support important causes, and pitch in when others are in need. As a recent example, in 2015, Santos was the main sponsor of the TourXOz, a cycling event in October that helped to raise $320,000 for the Black Dog Institute – one of the largest fundraisers in the organisation's history – and raise awareness of mental health issues in remote Aboriginal communities. In addition to sponsorship funding, nine Santos employees took on the gruelling 3500-kilometre cycle from Adelaide to Darwin and made a major contribution to fundraising efforts. In Queensland, Santos has been a strong supporter of Tie Up The Black Dog, which provides common sense, practical assistance to the community in helping to maintain mental health and wellbeing. Financial contributions from Santos have helped facilitate free community forums in Injune, Wallumbilla and Roma. In addition, Santos has provided supplies and volunteer staff to run barbecues at the forums, and supported Tie Up The Black Dog fundraisers held by other community organisations.	
E3	Other industries	There may be a risk that there will be an adverse impact on other businesses, such as tourism, fishing, agricultural and pastoral businesses.	Economic impact assessments are typically undertaken as part of regulatory approvals processes. The activity will be designed through these performance criterion to manage the risks associated with other industries. Management measures are discussed below. • The Santos-operated GLNG project in Queensland is a good example of the positive economic impact flowing from oil and gas investment. Between January 2011 and December 2014, GLNG purchased materials and services totalling $15.4 billion. Of this, $7.9 billion was spent in Queensland, with about $1 billion in regional areas. Community investment, particularly in infrastructure such as roads, airports and medical services – discussed below - has been significant. • Risk of loss of income to grazing activities – The risk associated with the disturbance of land is managed though the access and compensation agreement. The magnitude of the disturbance initially minimized through the use of horizontal wells and multi-well	Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS

ID	Theme	Description / Issue	Management/Mitigation	Proof
			pads. The timing and nature of a landholders activities are discussed and documented so that the activities can be planned, timed and managed to avoid or minimize this risk. Natural gas activities are at their highest during construction and development. Access to well pads is by heavy and light vehicles and the intensity of activity may last for 2-3 months at a well pad. Once operational, access is generally infrequent and generally only accessed by light vehicles (4WD) with heavy equipment only required for specific and non-routine activities. • The willingness of our people to respond in times of great need was exemplified in 2010, 2011 and 2012 when the Roma region suffered severe flooding. Each time, Santos staff volunteered many hours to assist the local community with relief efforts. Santos' Brisbane employees also volunteered many hours to assist with clean-up and recovery in metropolitan areas. In response to the 2010-11 Queensland floods, Santos donated $500,000 to flood recovery including $200,000 of direct support for farmers via an Agforce program. In Western Australia, Santos donated $50,000 to assist with flood recovery in the Gascoyne and Carnarvon regions. More recently in Queensland, Santos has contributed to drought relief initiatives as the impact of ongoing drought conditions continues to be strongly felt.	
E4	Energy security	There may be a risk that energy security in the Territory will be jeopardised if the gas is undeveloped.	Santos is confident that the exploration and production of shale gas will provide greater energy security to not only the Northern Territory, but also the nation. Santos will engage and consult with stakeholders to discuss opportunities and risks regarding energy security over the life of the project. • Australia has more than enough gas for both domestic and export markets. The country's supply is growing as new technology allows companies to produce from large reserves that were too difficult to access until recently. Australia has more than 800 trillion cubic feet (TCF) of gas resources (including proven and contingent resources) – enough to meet Australia's rising electricity needs for up to 80 years. • Greater development of the country's extensive gas reserves would greatly enhance energy security as gas has the best combination of abundance, cleanness, affordability, reliability and flexibility of any fuel. • Unlike renewable energy, gas is reliable and flexible – unaffected by weather or the time of day, it can provide constant power. Unlike coal, gas produces relatively low emissions and can be easily turned on and off to meet spikes in demand or to fill gaps in other forms of power production (such as renewables).	https://www.appea.com.au/oil-gas-explained/benefits/energy-security/ https://gisera.org.au/wp-content/uploads/2017/03/CoC.Alice_.Springs.April_.2016.pdf Unconventional gas - Damian Barrett CSIRO 2016

ID	Theme	Description / Issue	Management/Mitigation	Proof
E5	Net impacts	There may be a risk that any economic benefits will not outweigh economic detriments.	The Inquiry has instigated a process for the analysis of this risk in the context of the NT. But data relating to other projects in which Santos has been involved, referenced above, would strongly suggest otherwise.	Acil Allen (2016) "Economic Impact Report", Appendix U2 to the Narrabri Gas Project EIS GHD (2016), Cost Benefit Analysis, Appendix U1 to the Narrabri Gas Project EIS Santos (2014) "Economics", Chapter 22 to the Santos GLNG Gas Field Development Project EIS
E6	Management	There may be a risk that, if not properly managed, any economic benefits will result in 'boom and bust' economic activity.	Advanced and comprehensive engagement with stakeholders, including government, on issues like workforce planning will greatly assist in reducing the impact of 'boom and bust' economic activity.	Santos 2016, "Shale gas", https://www.santos.com/what-we-do/production/natural-gas/shale-gas/
E7	Cumulative	There may be	The oil and gas industry is a major contributor to Australia's current prosperity in numerous	https://www.appea.

ID	Theme	Description / Issue	Management/Mitigation	Proof
	risk	cumulative risks associated with some or all of the risks identified above.	ways, including: • Investment • Direct and indirect job creation • Regional development • Export revenue • Taxation • Energy security. Shale gas has the potential to contribute to domestic energy use, especially for remote energy users (ACOLA 2013) • A 2014 PwC analysis identified the oil and gas industry as one of Australia's highest value-adding industries, with every dollar of production generating 70 cents of value-add compared to an average of 49 cents for all other industries. The PwC report found that the oil and gas industry's annual contribution to Australia's economic output was expected to more than double from $32 billion in 2012-13 to $67 billion by 2029-30. • The economic contribution of oil and gas activities, from the exploration phase through to appraisal, development and production, can be significant for the local community, the region, the state and the nation. • Indeed, in August 2015, a Deloitte Access Economics (DAE) study found that developing a shale gas industry in the Northern Territory could drive significant long-term economic growth, creating thousands of new jobs and generating up to $1 billion of government revenue. • DAE found that, under the highest growth scenario explained, the cumulative increase in Gross State Product could reach $22.4 billion in net present value (NPV) terms. This same growth scenario could result in a long-term employment boost of up to 6,300 full time positions in the NT (DAE 2015).	com.au/oil-gas-explained/benefits/economic-benefits/
• **Land access**				
LA 1	Consultation	Timely and effective consultation with traditional	Santos works collaboratively with stakeholders to locate and construct surface and sub-surface infrastructure to ensure that current and future uses of land are not negatively impacted. The surface footprint of hydrocarbon extraction is generally minimal and temporary. Access	Santos (2016), Community and Stakeholder Consultation, Chapter 9 to the

ID	Theme	Description / Issue	Management/Mitigation	Proof
		owners, landholders, community, businesses and government stakeholders	roads and surface infrastructure such as processing facilities, compressor stations, and some water management facilities are in place for a longer period. These are located and constructed in ongoing consultation with landholders. Access roads are also planned with landholders to accommodate shared use. • Our existing onshore operations in eastern Australia demonstrate that agriculture and natural gas extraction can coexist in a safe and sustainable manner. • We have a clear understanding of the needs and challenges of agricultural businesses – not only through those years of co-existence but also as landholders ourselves. Several properties owned by Santos in the Fairview, Wallumbilla, Arcadia Valley and Roma fields are used to locate infrastructure and run herds of up to 4,500 head of high quality Droughtmaster cattle. • Santos has successfully coexisted with agriculture for more than 60 years. • Across the business in 2015, Santos undertook nearly 9,000 discrete interactions with landholders across its Australian operations. This included emails, workshops, briefings, letters, one-on-one meetings, phone calls and SMS messages. • Santos pays a landholder's legal fees (up to an agreed amount) to allow for the independent review of a proposed Conduct and Compensation Agreement. • The NT Government has stakeholder engagement guidelines for land access that state the oil and gas permit holder and the landholder must reach an agreement prior to the start of an exploration program, and the required government approvals will not be granted in the absence of proof of an agreement. • The guideline also provides a dispute resolution process. The parties have 60 days to reach a land access agreement, commencing from the date that the oil and gas permit holder sends a notice of intention to commence negotiations to reach an access agreement to the landholder. If an agreement cannot be reached within 60 days, either party may refer negotiations to the Arbitration Panel to make a determination on the conditions of access. By agreement, parties can commence arbitration before the expiry of the initial 60 day negotiation period. The Arbitration Panel will comprise the Chief Executives of the Departments of Mines and Energy, Primary Industries and Fisheries, Land Resources Management, and Lands Planning and the Environment and experienced industry representatives. It will have up to 21 days to make its recommendations. Once an access agreement has been reached, either by mutual consent of the parties or through a determination by the Arbitration Panel, an	Narrabri Gas Project EIS Santos (2014), Consultation Report, Appendix D to the Santos GLNG Gas Field Development Project EIS
LA 2	Consent	There may be a risk that gas companies enter the land without, where required, obtaining the consent of the landowner, occupier, or traditional owners, causing conflict.		
LA 3	Conditions	There may be a risk that gas companies and landowners, occupiers, and traditional owners, do not negotiate mutually beneficial conditions		

ID	Theme	Description / Issue	Management/Mitigation	Proof

		associated with any agreement permitting access.	exploration program may commence once the requirements are met and after providing 14 days' notice to the landholder. If either party does not agree with the determination of the Arbitration Panel, they retain the right to seek further review through the judicial system. However, this does not affect the approval that has been granted as a result of the arbitration determination or the right of the operator to commence activity. Santos supports this process despite it potentially causing scheduling issues through the addition of up to 95 (or more) days to the time already spent trying to reach an access agreement directly with the landholder (or its lawyer).
			• Noise and vibration commitments will be provided in a written agreement between Santos and the landholder.
			• The compensation framework for our NT exploration program is based on the following and meets the requirements of the NT Petroleum Act. Compensation is paid for:
			  • Loss of land i.e. wells, borrow pits and roads
			  • Loss of productivity i.e. buffers along roads
			  • Pipeline construction & rehabilitation
			  • 2D and 3D seismic survey disturbance
			  • Livestock losses
			  • Management time
			  • Extraordinary disturbances (Santos, 2017).
			• When benchmarked against other states and the SA Petroleum Act, the compensation provisions in the NT Petroleum Act are very similar i.e. compensation based on deprivation/damage to land on a one-off basis – not an annual emolument (or 'annualised' for the period that the disturbance remains on the land) (Santos 2017).
			• Our view is that this model is a functional compensation framework and is fit for purpose. It is also consistent with the principle that the rights to the resources in the ground are held by the Crown, and in the NT context, for the benefit of all Territorians (Santos, 2017).
			• Santos is committed to treating landholders with respect at all times. We have a strong track record of respectful and constructive engagement with landholders. Consultation seeks to ensure the right information is provided in a timely manner and in an appropriate fashion, recognising the busy lives and pressures already placed on landholders. We work through a series of steps encompassing phases of initial	

LA 4	Compensation	There may be a risk that compensation paid for access and/or disturbance to land will not be adequate. There may be a risk that if there is an incident in the exploration, extraction or production of any gas, the land may not be properly remediated or the land owners, occupiers, or traditional owners may not be adequately compensated.		
LA 5	Cumulative risk	There may be cumulative		

ID	Theme	Description / Issue	Management/Mitigation	Proof
		risks associated with some or all of the risks identified above.	meetings and property mapping, negotiating agreements including location of infrastructure, compensation and conditions specific to the property, the construction period, and then ongoing engagement as required (Santos 2017). • In Queensland, since January 2011, GLNG has secured approximately 1450 agreements with more than 410 landholders for long-term gas infrastructure alongside their farming businesses. Many hundreds more agreements have been signed for activities such as exploration and pipeline easements. In addition, GLNG has achieved pleasing results in independent surveys of landholder sentiment conducted by Nielsen Australia. Surveys took place in 2013 and 2014 in areas around Roma, Injune, Arcadia, Taroom, Wandoan and Rolleston. Among the results of the 2014 survey: • 92% of respondents said they would allow Santos back onto their property. This was the same result from the 2013 survey. • 94% were satisfied or more satisfied with the relationship than 12 months prior. • 92% said they had sufficient time to prepare, understand and negotiate a Conduct and Compensation Agreement (CCA). • Notably, 75% of the respondents had construction work taking place on their properties at the time of the survey – the period of highest activity and inconvenience for landholders (Santos 2017). • To date, Santos has negotiated and executed 29 CCA's with pastoralists across our NT exploration permits, without the need for arbitration or judicial recourse. Our approach is modelled on the landholder framework that has been employed in the Cooper Basin (SA-QLD) over many years (Santos 2017).	
• **Regulatory framework**				
R1	Failure to protect the environment	There may be a risk the regulatory framework does not adequately protect the environment (water, land,	Impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. The activity or infrastructure will be optimised through design and engineering and implement necessary mitigation measures via an EMP – examples of an EMP are available for current exploration activities in the NT. Baseline monitoring of groundwater, surface water, air and soils will be undertaken Pending the outcomes of this Inquiry, Santos would be supporting of legislative or	https://gisera.org.au/wp-content/uploads/2017/03/CoC.Alice_.Springs.April_.2016.pdf Unconventional gas - Damian Barrett CSIRO

ID	Theme	Description / Issue	Management/Mitigation	Proof
		and air) from risks associated with hydraulic fracturing and associated activities.	regulatory amendment: • Prohibiting hydraulic fracturing within townships and urban centres plus a 2km buffer. • Best practice code such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute.	2016
R2	Land access	There may be a risk the regulatory framework does not appropriately balance the rights of landowners, occupiers, and traditional owners with those of gas companies.	The existing regulatory framework adequately protects the rights of landowners, occupiers, and traditional owners. See above commentary.	
R3	Public health	There may be a risk the regulatory framework does not adequately mitigate public health risks associated with the unconvention al shale gas	Santos will comply with relevant legislative and regulatory requirements relating to the risks and management of public health and environmental protection and with best practice standards and codes. Santos has adhered to a wide range of international, national and regional regulations. Pending the outcomes of this Inquiry, Santos would be supporting of legislative or regulatory amendment to enable best practice such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute. Conduct of comprehensive environmental impact assessment and management planning will demonstrate how compliance against performance criteria will be met. As part of Santos' Narrabri EIS (GHD, 2016) and Santos GLNG Gas Field Development Project (Santos GLNG, 2015), an EIS was developed and will be implemented over the life of the	

ID	Theme	Description / Issue	Management/Mitigation	Proof
		industry.	project. Santos conducted a comprehensive public health impact assessment as part of broader environmental assessment and management planning undertaken to demonstrate compliance against performance criteria to protect public health as part of Santos' Narrabri EIS. Extensive quantitative human health and ecological risk assessments have been undertaken for developments in Queensland to demonstrate the quantities and methodologies employed, do not pose an unacceptable risk to human health or the environment. These chemicals and quantitative risk assessments have been peer reviewed and reviewed or assessed by the relevant government agencies and have had requisite Material Safety Data Sheets (MSDS) prepared. This information is publically available on Santos' website. Public health impact assessments and management and monitoring plans will provide information to facilitate land access and support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. Baseline and ongoing monitoring and reporting will verify performance	
R4	Aboriginal cultures and communities	There may be a risk the regulatory framework does not adequately protect Aboriginal culture, values, traditions and communities from risks associated with the unconvention al shale gas industry.	Santos will comply with relevant legislative and regulatory requirements relating to the risks and management of public health and environmental protection and with best practice standards and codes. Santos has adhered to a wide range of international, national and regional regulations. Pending the outcomes of this Inquiry, Santos would be supporting of legislative or regulatory amendment to enable best practice such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute. Conduct of comprehensive environmental impact assessment and management planning will demonstrate how compliance against performance criteria will be met. As part of Santos' Narrabri EIS (GHD, 2016) and Santos GLNG Gas Field Development Project (Santos GLNG, 2015), an EIS was developed and will be implemented over the life of the project. Environmental and social impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation.	

ID	Theme	Description / Issue	Management/Mitigation	Proof
R5	Social impacts	There may be a risk the regulatory framework does not adequately mitigate the social risks associated with the unconventional shale gas industry.	Baseline and ongoing monitoring and reporting will verify performance.	
R6	Economic impacts	There may be a risk the regulatory framework does not ensure that any economic benefits are appropriately distributed between the gas companies, the government and the community.		
R7	Compliance and enforcement	There may be a risk of inadequate monitoring or	Santos will comply with relevant legislative and regulatory requirements relating to the risks and management of public health and environmental protection and with best practice standards and codes. Santos has adhered to a wide range of international, national and regional regulations.	

ID	Theme	Description / Issue	Management/Mitigation	Proof
		enforcement of compliance with the regulatory framework. This may arise from, for example, inadequate resourcing of the regulatory agency or inadequate training of relevant officers. There may be a risk that sanctions provided for in the regulatory framework are inadequate or are not utilised by the regulator. There may be a risk that the cost of complying with the regulatory framework is too high for	Pending the outcomes of this Inquiry, Santos would be supporting of legislative or regulatory amendment to enable best practice such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute. Conduct of comprehensive environmental impact assessment and management planning will demonstrate how compliance against performance criteria will be met. As part of Santos' Narrabri EIS (GHD, 2016) and Santos GLNG Gas Field Development Project (Santos GLNG, 2015), an EIS was developed and will be implemented over the life of the project. Environmental and social impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. Baseline and ongoing monitoring and reporting will verify performance.	

ID	Theme	Description / Issue	Management/Mitigation	Proof
		industry and the industry becomes uneconomic.		
R8	Complexity	There may be a risk that the regulatory framework is needlessly complex.	Santos will comply with relevant legislative and regulatory requirements relating to the risks and management of public health and environmental protection and with best practice standards and codes. Santos has adhered to a wide range of international, national and regional regulations. Pending the outcomes of this Inquiry, Santos would be supporting of legislative or regulatory amendment to enable best practice such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute. Conduct of comprehensive environmental impact assessment and management planning will demonstrate how compliance against performance criteria will be met. As part of Santos' Narrabri EIS (GHD, 2016) and Santos GLNG Gas Field Development Project (Santos GLNG, 2015), an EIS was developed and will be implemented over the life of the project. Environmental and social impact assessments and management and monitoring plans will provide information to support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. Baseline and ongoing monitoring and reporting will verify performance.	
R9	Regulatory capture	There may be a risk of 'regulatory capture' whereby the regulatory body becomes inappropriatel y aligned with industry and reluctant to	Comply with relevant legislative and regulatory requirements relating to the risks and management of public health, and with best practice standards and codes. In previous work, Santos has adhered to a wide range of international, national and regional regulations. Pending the outcomes of this Inquiry, Santos would be supporting of legislative or regulatory amendment to enable best practice such as the Code of Practice for Constructing and Abandoning Petroleum Wells and Associated Bores in Queensland or Guidance and Specifications provided by American Petroleum Institute. Environmental and social impact assessments and management and monitoring plans will provide information to facilitate land access and support applications for regulatory approvals and licences that will be obtained by Santos prior to operation. Baseline and ongoing monitoring and reporting will verify performance.	

ID	Theme	Description / Issue	Management/Mitigation	Proof
		regulate.		
R10	Cumulative risk	There may be cumulative risks associated with some or all of the risks identified above.	The environmental risks associated with hydraulic fracturing can be managed effectively with a robust regulatory regime.	Hawke 2014

1.0 Bibliography

AECOM. (2016). *Exploration Environmental Plan - Beetaloo Basin, Northern Territory.* Darwin.

CDM Smith. (2016). *Narrabri Gas Project - Water Monitoring Plan.*

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Santos. (2016). *EP-161 2016 Stratigraphic Corehole Program - Environment Plan Summary.*

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Appendix B

Chemical Risk Assessment Methodology

1 Introduction

This document provides a terms of reference for a chemical risk assessment of the chemicals proposed for use in the development of natural gas. This document incorporates best practice risk assessment methodology for the assessment of the potential impacts of the chemicals proposed to be used on human health and the environment including matters of national environmental significance.

1.1 Statement of Aim

The risk assessment will evaluate the potential for human health and environmental effects from chemicals used throughout the drilling and completions (including hydraulic fracturing) process.

This assessment will evaluate the potential risks posed by the combined mixture of various chemicals as represents various drilling and fracturing products and importantly, the anthropogenic chemicals and the geo-genic constituents (from analytical data) as present in flowback water or make up water used for drilling and hydraulic fracturing fluids.

The goal of the chemical risk assessment is to demonstrate that potential risks have been eliminated or reduced as much as is reasonably practicable to potentially exposed human receptors and Matters of National Environmental Significance (MNES) including terrestrial and aquatic ecological receptors and water resources.

1.2 Summary of Best Practices

The approval defines “best practice risk assessment methodology” as follows:

- A chemical risk assessment in accordance with best practice national or international standards and guidelines may be based on the following:
    - United States Environmental Protection Agency (USEPA) (2014). EPA-Expo-Box (A Toolbox for Exposure Assessors), available at http://www.epa.gov/expobox
    - Organisation for Economic Co-operation and Development (OECD) (2014). The OECD Environmental Risk Assessment Toolkit: Tools for Environmental Risk Assessment and Management, available at http://www.oecd.org/chemicalsafety/risk-assessment/theoecdenvironmentalriskassessmenttoolkittoolsforenvironmentalriskassessmentandmanagement.htm
    - The most recently published and approved guideline recommended by the Minister

In addition, the chemical risk assessment will be based following best practice guidance:

- The National Environment Protection (Assessment of Site Contamination) Measure (NEPM) 1999 as amended 2013; specifically, Volume 5: Schedule B4 Guideline on Site-Specific Health Risk Assessment
- Environmental health risk assessment: Guidelines for assessing human health risks from environmental hazards, enHealth Subcommittee (enHealth) of the Australian Health Protection Principal Committee, Canberra, Australia, 2012a
- Australian exposure factor guidance, enHealth Subcommittee (enHealth) of the Australian Health Protection Principal Committee, Canberra, Australia, 2012b

USEPA’s EXPOsure toolBOX (EPA-Expo-Box) was developed by USEPA Office of Research and Development, as a compendium of exposure assessment tools that links to exposure assessment guidance, databases, models, key references and related resources. The toolbox provides a variety of exposure assessment resources organized into six Tool Sets, each containing a series of modules as shown in the table below:

EPA-Expo-Box Tool Sets

Approaches	Media	Routes
• Direct Measurement (Point-of-Contact) • Indirect Estimation (Scenario Evaluation) • Exposure Reconstruction (Biomonitoring and Reverse Dosimetry)	• Air • Water and Sediment • Soil and Dust • Food • Aquatic Biota • Consumer Products	• Inhalation • Ingestion • Dermal
Tiers and Types	**Life stages and Populations**	**Chemical Classes**
• Screening-Level and Refined • Deterministic and Probabilistic • Aggregate and Cumulative	• General Population • Residential Consumer • Occupational Workers • Life stages • Highly Exposed	• Pesticides • Other Organics • Inorganics and Fibers • Nanomaterials

For example, the inhalation module under the route tool set provides the following:

- Method used in the dose-response
- Calculations for exposure concentrations and potential dose
- Estimating media-specific concentrations
- Exposure scenarios and potential receptors
- Exposure factors
- Guidance and references.

OECD Environmental Risk Assessment Toolkit provides access to practical tools on environmental risk assessment of chemicals. It describes the general work flow of environmental risk assessment and provides examples of risk assessment. The toolkit also provides links to relevant tools developed by OECD and member countries that can be used in each step of the work flow. The examples provide a roadmap of the process, showing the steps involved in each case and the tools that were used.

The OECD general risk assessment process for environmental risk assessment includes four steps: hazard identification, hazard characterisation, exposure assessment, and risk characterization. The following table summarizes the available tools for the risk assessment process.

Summary of Available Tools for Risk Assessment

Categories		Links to Available Materials	Explanation
Hazard Assessment	Gathering existing information	OECD Existing Chemicals database	OECD-wide agreed hazard assessments elaborated in the OECD Co-operative Chemicals Assessment Programme
		eChemPortal	Global Portal to Information on Chemical Substances
		Manual for the Assessment of Chemicals (Chapter 2)	A set of guidance documents for (initial) risk assessment developed for the OECD Co-operative Chemicals Assessment Programme. See chapter 2 for gathering data
	Evaluating existing information	Manual for the Assessment of Chemicals (Chapter 3)	See chapter 3.1 for determining the quality of existing data
	Generating new data	Test guidelines	Test methods for assessing (hazard) properties of chemicals
		The OECD (Q)SAR Project	Guidance and tools for filling data gaps by non-testing methods.
	Assessing the hazards	Manual for the Assessment of Chemicals (Chapter 4) & (Chapter 5)	Chapter 4 provides guidance assessing the hazards of chemical substances to man and the environment Chapter 5 provides guidance on elaborating a hazard assessment report.
		Series on Testing and Assessment	Guidance documents and reports related to assessment of several inherent effects
Exposure Assessment	General guidance for exposure assessment	Environmental Exposure Assessment Strategies for Existing Industrial Chemicals in Member Countries	An overview of the approaches on environmental exposure assessment used in the late 1990s by OECD member countries
		Manual for the Assessment of Chemicals (Chapter 6)	Guidance on reporting exposure information (Section 6.2) and on initial exposure assessment. (Sections 6.3 and 6.4)
	Measuring or estimating releases to the environment	Emission Scenario Documents	Estimating emission of chemicals in specific industry and use categories
		Global Portal to PRTR Information (PRTR net)	A gateway and databases of global information on Pollutant Release and Transfer Registers (PRTRs)
		Resource Centre for PRTR Release Estimation Techniques	
		Centre for PRTR Data	
	Environmental fate and pathways	Test guidelines	Test methods for assessing (hazard) properties of chemicals
		The OECD (Q)SAR Project	Guidance and tools for filling data gaps by non-testing methods.

Categories		Links to Available Materials	Explanation
		Pov and LRTP Screening Tool	A tool for screening overall persistence and long-range transport potential of chemicals
		Guidance Document on the Use of Multimedia Models for Estimating Overall Environmental Persistence and Long-range Transport	Guidance on the models estimating Pov and LRTP
		EPISuite™	The EPI (Estimation Programs Interface) Suite™ is a Windows®-based suite of physical/chemical property and environmental fate estimation programs developed by the USEPA's Office of Pollution Prevention Toxics and Syracuse Research Corporation (SRC).
	Measuring or estimating concentrations in the environment	Report on improving the use of monitoring data	The workshop report on the use of monitoring data in exposure assessment
		Available tools and models for exposure assessment	A list of tools and models developed and used in OECD member countries for different tiers of exposure assessment.
Other Relevant Materials/ Risk Assessment of Specific Chemicals		New Chemical Assessment Comparisons and Implications for Work Sharing	Comparison of risk assessment of new chemicals.
		Policy Dialogue on Exposure Assessment	Comparison of approaches to exposure assessment in OECD member countries
		Pesticide Testing and Assessment	Guidance documents etc. on hazard and exposure assessment of pesticides and biocides respectively.
		Biocides	

The tool boxes are all based around the principles contained within USEPA's risk assessment guidelines. As a toolbox, not all of the tools are to be utilized, rather only those tools that are appropriate to the chemical, its functional toxicity, and the exposure pathway being used for assessment should be used.

As with all risk assessment methods, a hierarchy is applied in the use and assessment of data on exposure point concentrations and toxicity, with direct measurements and toxicity values provided by epidemiological studies providing the least uncertainty in the risk assessment process.

As noted in the following section describing the risk assessment program, in addition to enHealth and NEPM guidance, the methods contained within the EPA-Expo-Box Toolkit and the OECD Environmental Risk Assessment Toolkit will be utilised (as applicable) throughout the risk assessments proposed for the chemicals proposed to be used.

2 Risk Assessment Program

Santos has already completed extensive risk evaluations on hydraulic fracturing fluid chemicals systems that comply with these international standards and the published and approved Australian and International guidelines. The following terms of reference leverage these standards and the knowledge developed by Santos to date.

It is proposed that the risk assessment program be conducted by a team suitably qualified chemical risk assessment experts. This team has the technical expertise (e.g., toxicologists, human health and ecological risk assessors) and the knowledge of the chemicals and fluid systems used. Peer review will be conducted by a suitably qualified chemical risk assessment expert(s).

Collectively, this team has extensive experience on ecological and human health risk assessments involving broad range of chemicals as wells as leadership roles in toxicological assessment and product registration.

2.1 Risk Assessment Methodology

Santos will employ a risk assessment program in accordance with best practice risk assessment methodologies including those contained within the previously referenced international standards and Australian risk assessment guidance documents (e.g., NEPM, 2013; enHealth, 2012a,b).

This risk assessment program will provide a rigorous assessment of the physico-chemical, environmental fate and transport, human health and ecological toxicological properties of the chemicals, and the potential exposures and risks to human and ecological receptors (terrestrial and aquatic).

The risk assessment program employed, which is consistent with the Australian and international guidance, will combine qualitative and quantitative risk assessment methodologies to assess the potential risks posed by individual chemicals and the mixture of chemicals. The potential exposure pathways and risk are identified and characterized through this risk assessment process to inform the risk managers of the appropriate approaches for mitigation or elimination of risk in accordance with Australian Guidelines (e.g., draft guidance for ecological risk assessment provided by the Environment Protection Authority [EPA] Victoria [Gibson et al., 1997]).

2.1.1 Step 1 – Problem Formulation and Issue Identification

This step in the chemical risk assessment process involves defining the bounds of the human health risk assessment to ensure the risk managers are informed properly and utilizing the best practices guidance identified previously.

It identifies the key issues with regard to the potential concern from the potential exposure to the individual and mixture of chemicals, such as: 1) what is the concern, 2) why is it a concern, 3) the urgency of the concern, and 4) the perception of the concern.

A description of the current environmental setting includes identifying potential receiving environments and susceptible or vulnerable populations and the site-specific details each of the components of exposure (i.e., source, transport, route, receptor) that are potentially complete exposure pathways. This step involves a conceptual exposure model and assessment endpoints; and an analysis plan that outlines the goals, scope and complexity of the chemical risk assessment.

Potential management options may be proposed that may mitigate those hazards and exposures pathways that may be the most significant contributors to the overall risks.

2.1.2 Step 2 – Hazard Assessment

The hazard assessment evaluates human health and environmental hazard of the chemicals identified in the problem formulation and issue identification step.

The identification of relevant national or international guideline values for each chemical is presented. The next level of the hazard assessment compiles the relevant risk assessment information into a risk assessment dossier. The following is the outline of the dossier:

1. Chemical identification
2. Physical and chemical properties
3. Environmental Fate Properties
4. Human Health Hazard Assessment
5. Derivation of Non-cancer and cancer screening levels
6. Human Health Hazard Assessment of Physico-chemical Properties
7. Environmental Hazard Assessment
8. Persistence, Bioaccumulation and Toxicity (PBT) Assessment
9. Classification and Labelling
10. Handling and Safety Information (occupational limits and transportation requirements)
11. Treatment and Disposal Management
12. Regulatory status
13. References.

The data sources for the risk assessment dossier will be consistent with the following guidance of information on the chemical and physical properties of the drilling and hydraulic fracturing chemicals.

In additional, environmental fate/transport and human and ecological toxicological information will be referenced, as applicable, in the chemical risk assessment:

- Environmental Risk Assessment Guidance Manual – for industrial chemicals (Environmental Protection and Heritage Council [EPHC], 2009)
- Environmental Risk Assessment Guidance Manual – for agricultural and veterinary chemicals (EPHC, 2009)
- Environmental Health Risk Assessment – Guidelines for assessing human health risks from environmental hazards (enHealth, 2012).
- Risk management – Principles and guidelines. The Australian / New Zealand Standards (AS/NZS ISO 31000:2009) (AS/NZS, 2009)
- Managing environment-related risk. Australian / New Zealand Standard (AS/NZS Handbook HB 203:2012) (AS/NZS, 2012)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000a) and Australian Drinking Water Guidelines (National Health and Medical Research Council [NHMRC], 2011)
- Other risk assessment toolboxes, including United States Environmental Protection Agency (USEPA, 2015), Organisation for Economic Co-operation and Development (OECD, 2014), and Inventory Multi-Tiered Assessment and Prioritisation (IMAP) framework through NICNAS.

As part of the hazard assessment, a PBT substances assessment will be conducted on all chemicals used, based on the Australian and EU Reach Criteria methodology (European Chemicals Agency [ECHA], 2008; enHealth, 2012).

The primary source of information for physico-chemical properties, environmental fate and transport parameters, ecological toxicological data, and mammalian toxicology data will be obtained from databases linked to the OECD eChemPortal (www.echemportal.org), which is part of the OECD Environmental Risk Assessment toolkit.

In addition, data will be obtained from the following sources:

- Chemical and physical properties data:
    - TOXNET
    - The Material Safety Datasheet (MSDSs)
    - Modelled data from USEPA (2009) EPISUITE™ including outputs.
- Environmental and human health drinking water guidelines:
    - Australian and New Zealand Guidelines for Fresh and Marine Water Quality for protection of aquatic ecosystems and stock watering (ANZECC and ARMCANZ, 2000)
    - Australian Drinking Water Guidelines (NHMRC and NRMMC, 2011, Update 2016)
    - World Health Organisation (WHO, 2006) Guidelines for Drinking-water Quality (Third Edition)
    - USEPA National Recommended Water Quality Criteria (2009) for protection of aquatic life and human health
    - Drinking-water Standards for New Zealand 2005 (Revised 2008, Ministry of Health).
- Human health toxicity data:
    - U.S. Toxic Substances Control Act Test Submissions 2.0 (TSCATS 2.0) database https://catalog.data.gov/dataset/toxic-substances-control-act-test-submissions-2-0-tscats-2-0
    - Literature search (using PubMed and ToxLine)
    - Internet search (i.e., Google Scholar)
- Ecological toxicological and environmental fate and transport data:
    - USEPA ECOTOX database
    - Canada Screening Assessment Reports
    - USEPA TSCATS database
    - Google Search (for regulatory agency documents such as U.S. EPA RED (Re-registration Eligibility Decision) documents for pesticide applications)
    - Literature search of peer-review journals
    - Safety Data Sheets (SDSs)
    - QSAR modelling (i.e., EPI Suite and PetroTox).

The ecological toxicological data will be based on guidance provided by the European Chemicals Bureau (ECB) (2003) and by National Environmental Protection Council (NEPC, 2013). Through this process, soil and water guideline values protective of ecological receptors can be used as indicators of toxicity and therefore hazards, if they are based on toxicological data.

Databases that will be searched will include NEPC (2013), Risk Assessment Information System (RAIS), USEPA Eco Soil Screening Levels (2011), National Institute for Public Health and Environmental Protection (RIVM) Target and Intervention levels (1994) and soil guidelines (such as predicted no effect concentration [PNEC] values) derived as part of a chemical assessment (e.g., International Uniform Chemical Information Database [IUCLID], Concise International Chemical Assessment Document [CICAD]).

To ensure reliability of the data, the physico-chemical properties, environmental fate and transport mechanisms, and ecotoxicity and toxicology data will be evaluated for data quality to address data quality requirements (i.e., reliability) using the Klimisch scoring system (Klimisch et al., 2007). For in vitro studies and studies that do not have internationally accepted guidelines, the software tool ToxRTool (Schneider et al., 2009) will be used.

2.1.3 Step 3 - Exposure Assessment

The exposure assessment comprises an evaluation of surface and subsurface exposure pathways and mass balance calculation to identify the amount of each chemical used in the process, and the estimated or actual potential exposure point concentration in the affected media (e.g., soil, groundwater, air).

For the chemicals selected as constituents of potential concern (COPC), fate and transport modelling is used to characterize the degradation of chemicals over time and their potential transport (e.g. in groundwater) or partitioning into other phases. Depending on the complexity of the model, a calibration and validation phase will be included.

The fate and transport modelling processes may also include a sensitivity analyses. Deterministic input parameters to the exposure assessment are used for most chemical risk assessment; however, if appropriate, probabilistic input parameters will be used based on an assessment of uncertainty in the risk characterization and subsequent risk management decision making process.

The assessment of exposure in the qualitative risk assessment process involves the evaluation of the data available for the project, the details associated with the surrounding environment, the nature of the exposure identified, and the potential mobility of the COPC.

For an exposure pathway to be considered complete, there must be all of the following:

- Source of COPC – how the chemical got into the environment and which environmental media are affected
- A transport media – how the chemical moves or migrates through the environment from one location to another, or from one environmental medium to another
- An exposure point – how organisms can come into contact with the chemicals (e.g., direct contact or via the food web)
- An exposure route – how the chemical could enter the organism (e.g., inhalation, ingestion or dermal contact).

The identification of exposure pathways and receptors has been split into those considered relevant for onsite (i.e., within the well lease boundary) and those relevant for offsite (i.e., anything beyond the well lease boundary).

For each potential complete exposure pathway for both human health and environmental receptors (i.e., terrestrial and aquatic and water resource), each of the above steps are evaluated. If any one of these steps (source, transport media, exposure point or route) is not present, the exposure pathway is incomplete and further assessment of risks is not required.

The assessment of potential risks is evaluated further if there is a complete exposure pathway. Thus, even if the COPC was considered a high hazard based on the outcomes of the PBT assessment, if there is no threshold concentration at the point of exposure, the potential risk to environmental and human receptors is considered acceptable and would not require mitigated measures to be considered.

The exposure assessment information will be compiled from the enHealth (2012b) Australian Exposure Factors Guidance. In addition, as noted in enHealth guidance (2012a), guidance from World Health Organization (WHO) and USEPA will be used to supplement the Australian guidance, as appropriate. The exposure assessment calculations presented in the enHealth guidance (2012a) will be used to estimate intake of the COPCs by the receptors.

2.1.4 Step 4 Risk Characterisation

This step includes characterising environmental and human health risk based on the identification of the following:

- Complete exposure pathways and hazard identification for each of the processes involving chemicals and exposure assessment;
- The level of risk for COPCs by exposure pathway, route, and cumulative; and
- Uncertainty in quality and estimates of risk are included in the step.

The risk characterization evaluates the toxicity of the individual substances and characterises the cumulative risks of the total effluent toxicity and ecotoxicity for specific exposure pathways identified in the conceptual exposure model.

The cumulative risk will be calculated and specifically refers to the summation of risks for each receptor across exposure pathways, routes of exposure (e.g., ingestion, inhalation, dermal contact), and chemicals.

The time is factored into the exposure over duration specified in the exposure assessment. This methodology will be consistent with the requirements outlined in the National Water Quality Management Strategy (NWQMS). The ANZECC (2000) methodologies and international guidance on risk assessment will be used for assessment of risks to aquatic receptors.

These methodologies include identification of the hazards posed by constituents in media that potentially come into contact with receptors. Risks to workers from undertaking the activities are specifically addressed through Health and Safety Plans and work safety procedures and associated legislation and will not be discussed within the risk assessment.

Threshold risk estimates will be based on the ratio of the intake of each COPC for each exposure pathway and exposure route divided by the appropriate toxicity criteria to produce a hazard quotient (HQ). The HQs for all exposure pathways for each COPC are summed for each receptor to produce a hazard index (HI). The target risk level of threshold risk estimates is an HI of 1 (enHealth, 2012a).

For non-threshold risk estimates, risks are identified as the additional probability of an individual developing cancer over a lifetime as a result of exposure. The estimated intake of each COPC for each exposure pathway and exposure route are multiplied by the appropriate risk criteria to estimate the increased lifetime cancer risks (ILCR). The ILCRs for all exposure pathways and COPCs are summed to produce a total ILCR. The target risk level for non-threshold risk estimates is an ILCR for single and multiple COPCs is 1×10^{-5} (enHealth, 2012a).

The risk characterisation will also identify the main or significant contributors to the overall risk assessment by the relevant exposure pathways. It will include an evaluation of the overall quality of the assessment and the degree of confidence in the estimates of risks and the conclusions from the results. This will be based on an uncertainty analysis and sensitivity analysis.

3 Report Structure

As described, a weight-of-evidence approach will be used by Santos to evaluate the potential for human health and environmental (e.g., ecological) risks as a result of chemical usage.

The risk assessment will involve a systematic assessment of the toxicity of the chemicals and the potential for exposures to humans, ecological receptors and water resources during and after completion of activities. During this process, key COPCs are identified and the effectiveness of existing industry exposure controls are considered. Through the process of evaluating potential exposure pathways, fate and transport modelling will be conducted to assess the mobility of chemicals within the target gas reservoir.

To facilitate problem definition, the document will include a discussion of the site setting, hydrogeology and the type and nature of chemicals used. Subsequent sections of the report will then define the conceptual exposure model (the problem definition process) and systematically evaluate the risks posed by individual chemicals and the mixture of chemicals that make up different drilling and hydraulic fracturing fluid systems.

The report will focus on the risk assessment and toxicology of the chemicals assessed, and Sections 1-4 on background and introduction will be kept to a minimum relative to the total content of the report. Information will be provided in these sections to aid in the problem formulation, development of the conceptual exposure models and discussion of fate and transport of chemicals in the environment. Furthermore, the structure of this report and background information will serve to meet State regulatory requirements associated with assessment of chemicals and risks.

Santos will potentially over time utilise a range of different drilling and hydraulic fracturing fluid systems. In order to assess the risks of the various mixtures of chemicals used in each fluid system, the report will be structured with a consolidated assessment of the individual chemicals and a summary of the risk assessment findings for the fluid systems, with separate appendices provided of detailed risk assessment tables for each of the different fluid systems.

Safety Data Sheets and the Risk Assessment Dossiers for each chemical will be provided in supporting technical appendices. These summaries are critical to understand the physical properties and human and ecological toxicology of all chemicals used.

The key sections of the assessment report will comprise:

Section 1: Outlines the regulatory requirements, objectives and scope of the study.

Section 2: Provides information on the setting and geologic framework within which the activities that are being undertaken.

Section 3: Evaluates the hydrogeologic framework, groundwater and surface water resources and the environmental values associated with groundwater, surface water and land resources in the area

Section 4: Describes the processes used in gas production activities including the drilling and completion processes (including hydraulic fracturing). Through describing these processes, the full life cycle of chemical management will be described including the modes of potential exposure associated with handling and use of chemicals and management of wastes. A detailed discussion of the design,

implementation procedures, monitoring and contingency plans for chemicals used will be provided in this section.

Section 5: Presents the problem formulation and issue identification (Step 1) of the chemical risk assessment. This will include the conceptual exposure model which will be defined based on the information provided in Sections 2, 3 and 4

Section 6: The hazard assessment (Step 2) included in this section evaluates human health and environmental hazard of the chemicals identified in the problem formulation and issue identification step using relevant national or international guideline values for each chemical; and compiles the relevant risk assessment information into a risk assessment dossier.

Section 7: Outlines the exposure assessment (Step 3) process and quantifies the potentially complete exposure pathways (e.g., intake estimates) and the exposure assumptions to be used in the chemical risk assessment.

Section 8: Provides the integration of the hazard assessment, conceptual exposure model, and the exposure assessment to characterize the potential risks (Step 4). Also included in this section is the uncertainty analysis.

Section 9: Describes the supplemental Direct Toxicity Assessments (DTAs) being conducted jointly by the major gas proponents in Queensland. This DTA is being conducted at the request of The Commonwealth Government and will support and collaborate the assessments already completed by Santos.

Section 10: Provides recommendations for mitigation, management, monitoring and reporting. This section will firstly assess the adequacy of existing controls (used in Section 5 to address issue identification), and provide recommendations for additional mitigation and management if required. A framework for inspection and monitoring will be provided including activities conducted to verify and validate the assumptions contained within the risk assessment and the potential for impacts on other environmental media. As part of this section, a schedule for update and review of the plan will be provided.

Section 11: References used in the risk assessment.

Appendices to the document will include the following:

- Fluid (per vendor) and Process specific risks assessments
- Safety Data Sheets
- Risk Assessment Dossiers
- Statement from the suitably qualified risk assessment expert(s)

4 Key References

The following provides key references have been identified for inclusion in the evaluation. Additional references will be identified as part of the development of dossiers for each of the chemicals used by Santos. This listing of references should not be considered complete but is provided for initial reference.

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