

Chapter 5

Risk Assessment



NOONAMAH
RIDGE

INTRAPAC

5 RISK ASSESSMENT

5.1 INTRODUCTION

This chapter describes and undertakes the process of assessing the environmental, social and cultural risks within the Noonamah Ridge development's sphere of influence.

It is important to differentiate between these types of risks and *project* risks. The latter are focussed on an objective of the development – for example, whether there is sufficient market interest to sell the anticipated number of a certain lot size. Except where required by the EIS Terms of Reference, project risks are not addressed in this EIS.

The risk assessment approach adopted in this chapter is systematic and in line with the following international best practice standard methodologies:

- *AS/NZS ISO 31000-2009 Risk management – principles and guidelines* (Standards Australia & Standards New Zealand 2009)
- *HB 203-2006 Environmental risk management – principles and process* (Standards Australia 2006a)
- *HB 158-2010 Delivering assurance based on ISO 31000-2009 – risk management – principles and guidelines* (Standards Australia 2010a)

The development's key risks were identified by the NTEPA in the EIS Terms of Reference (Appendix A). Other risks identified during the development of this EIS are also presented and assessed.

5.1.1 Chapter structure

This chapter is divided into sections that refer to the key environmental, cultural and social aspects of the Noonamah Ridge project. For each of these, the objectives are stated, some context is given, potential impacts are summarised, and then an assessment of level of impact is undertaken as per the risk assessment methodology presented in the next section. In the first instance, this represents an inherent risk (i.e. if the development proceeded without any mitigation measures implemented). A summary of the mitigation measures proposed for the design, construction and occupancy phases of the development are then provided (detail is given in the Environmental Management Plan in Chapter 6), responsibility for implementing each of these measures is assigned, and then a residual risk score is presented based on the assumption that the mitigation measures will achieve the desired effect. Finally, an assessment of the certainty that the proposed management and design measures will mitigate the risk of an impact is presented.

The chapter concludes with a discussion of the potential cumulative impacts of the proposed development in the context of other existing, proposed or flagged developments.

Throughout this chapter, many mitigation measures have been labelled with a (C) to indicate that the measure is a commitment made by Intrapac that has been enshrined in the Specific Use zone text (see Section 1.6.4 for an explanation of the significance of this) or with a (P) to indicate an action that will be required and is typical within the planning process prior to subdivision approval being granted (see Section 1.6.5 for an explanation of the significance of this). The purpose of attributing measures thus is to provide the reader with certainty that the measures will be implemented.

5.1.2 Data supporting risk assessment

The sections and appendices of the EIS that contain the contextual information that supports this risk assessment are displayed in Table 5-1.

Table 5-1. EIS references relevant to this chapter

Topic	Section in the EIS	Corresponding technical report in the EIS
Transport	Section 2.4	Appendix C1 – Traffic Impact Assessment
Electricity	Section 2.5	-
Biodiversity	Section 3.7	Appendix I – Flora and Fauna Assessment Report
Threatened species	Section 3.9	Appendix I – Flora and Fauna Assessment Report
Surface water	Section 3.6.1	Appendix F – Surface Water Quality Monitoring Report Appendix J – Aquatic Ecology Report
Groundwater	Section 3.6.2	Appendix E – Groundwater Report
Sewerage	Section 2.10	Appendix H – Land Capability Assessment Appendix G – Land Suitability Assessment
Noise	Section 3.16	-
Air quality	Section 3.15	-
Biting insects	Section 3.13	Appendix K – Biting Insects Assessment Report
Bushfires	Section 3.7.2	-
Cultural heritage	Section 3.14	Appendix L – Archaeological Survey Report

5.1.3 Methodology

For the purposes of this EIS, risk is considered the probability of an activity having an impact on objectives. Assessment of risk examines both the likelihood of an event occurring and what can reasonably be considered the worst possible consequences if that event does occur.

For this risk assessment, an *activity* is defined as a project component, and each activity may contain one or more *aspects* that can interact with the environment. An *impact* is any change to the environment, human safety, socio-economic situation, and/or historic and cultural heritage due to that aspect. An example of the relationship between activities, aspects and impacts is provided below:

- **Disposal of treated sewerage in individual systems** (*activity*) associated with the development could cause **increased nutrients to waterways** (*aspect*) resulting in **health effects associated with downstream recreational contact with bacteria in contaminated water** (*impact*).

The likelihood and consequence of each potential impact – without and with mitigation measures – were determined with reference to the categories presented in Table 5-2 and Table 5-3. Risk scores were then assigned using the matrix in Table 5-4.

Mitigation measures may reduce the *likelihood* of the residual risks, but not necessarily the *consequence*. Only when the severity of an impact is reduced by mitigation is the *consequence* score reduced – for instance, implementing a weed management plan may minimise the abundance of high fuel load invasive grasses, leading to less severe bushfires.

Some of the risks assessed in this chapter are relevant to more than one component of the project. In those cases, reference is made to the relevant risk assessment section. The risk assessment of each component culminates in an assessment of the certainty that proposed mitigation measures will be effective in reducing the risks.

Table 5-2. Qualitative measures of likelihood

A	Rare	Highly unlikely, will only occur in exceptional circumstances. Has never occurred in association with an urban development in the region.
B	Unlikely	Could occur at some time but unlikely. Has only occasionally occurred in association with an urban development in the region.
C	Moderate	Might occur at some time. Has previously occurred in similar urban developments.
D	Likely	Known to occur or will probably occur. Has occurred several times in association with recent urban developments.
E	Almost certain	Common or repeating occurrence. Is expected to occur several times over the duration of an urban development project in the region.

Table 5-3. Consequence ranking

1	Insignificant	No measurable impact on the environment or social values No injuries Low-nil financial loss
2	Minor	Minor, temporary environmental and/or social impact No publicity likely and no stakeholder concerns First aid treatment required Medium-low financial loss
3	Moderate	Substantial temporary or permanent minor, localised environmental damage or social impact Stakeholder enquires (this may include government, unions or public) Medical attention required High-medium financial loss
4	Major	Substantial or permanent environmental damage or permanent social change Prosecution possible Loss of credibility with the government; high stakeholder interest Permanent injuries High financial loss
5	Catastrophic	Widespread, severe and permanent environmental damage and/or social impact Prosecution likely Major stakeholder and media interest Permanent injury or death Extreme financial loss

Table 5-4. Risk matrix

		Consequence				
Likelihood		1	2	3	4	5
	A	1	3	6	10	15
	B	2	5	9	14	19
	C	4	8	13	18	22
	D	7	12	17	21	24
	E	11	16	20	23	25

Red	Extreme risk	Intolerable
Orange	High risk	Intolerable or tolerable
Yellow	Moderate risk	Tolerable or acceptable
Green	Low risk	Acceptable

5.2 TRANSPORT

The environmental objective for transport is to limit the overall impacts of traffic from construction stages and occupancy of the development on people and the environment.

5.2.1 Context

There is an existing road network within the local area but only a few rough tracks within the project area. Figure 2-11 shows the existing road hierarchy and overall road network within the local area. The Stuart Highway – a key road within the study area – is a National Highway and only 3.5 km (closest point) from the project area. Both Stuart Highway (north of Cox Peninsula Road) and Arnhem Highway (west of Humpty Doo) have moderate traffic volumes (i.e. numbers of cars) with more than 3,000 vehicles per day per direction. Traffic volumes are otherwise generally quite low within the local area due to the rural setting.

The main road scheme being considered in the vicinity of the study area is a high-capacity road link between Stuart Highway and Palmerston via Channel Island Road, providing an alternative to Stuart Highway – see Figure 2-14. Two roads will soon be extended by DoI – Goode Road and Alverly Road – doubling the number of secondary roads between the site and the Stuart Highway.

The proposed street network within the development is highly interconnected and allows for direct access to neighbourhoods, reducing the need for traffic on local collector roads. It is proposed to have the main access to the town centre either as an extension of Elizabeth Valley Road or via an access road 800 m north of Elizabeth Valley Road.

Two bus routes currently provide services from Palmerston to the project area – see Figure 2-9. Services are provided for both routes Monday to Saturday, with neither having timetabled services on Sundays or public holidays. There are no footpaths or shared use paths in vicinity of the site due to the existing rural conditions and lack of development.

Traffic in the local area will increase as the development proceeds and the number of residences and businesses grows. Consequently, a number of road upgrades will be required – including widening of existing roads, upgrades of intersections, extensions and new road links. A Traffic Impact Assessment (TIA) completed for the EIS (see Appendix C1) – together with a preliminary *Conceptual Traffic Management Plan* (see Appendix C2) and a preliminary *Construction Traffic Monitoring Report* (see Appendix C2) – provide modelling of predicted traffic impacts and required works for each stage of the development. Intrapac will use the *Strategic Traffic Model* (currently being developed by the DoT) to validate the findings of the TIA.

5.2.2 Potential impacts

The main potential impacts concerning traffic are congestion, an increase in accidents and traffic noise.

5.2.3 Risk assessment

External road upgrades for works not associated with the development are the responsibility of the DoI. Intrapac will collaborate with these departments to ensure that the external road and junction upgrades required for each stage are undertaken as the development progresses. The environmental risks associated with external road upgrades are not considered within the scope of this risk assessment.

The following risk assessment is based on that presented in the TIA in Appendix C1.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction vehicles	Increased traffic	Decreased road safety and public amenity (congestion and noise)	1	D	7	CONTRACTOR • C P Devise a Traffic Management Plan in consultation with, and submitted for approval to, DoT for the construction of each stage of the subdivision. Base the TMP on the preliminary <i>Conceptual Traffic Management Plan</i> (see Appendix C2) and a preliminary <i>Construction Traffic Monitoring Report</i> (see Appendix C2) to ensure that each TMP clearly outlines all road works and traffic controls required at the subdivision stage (as described in Section 6.5), noise mitigation measures, and monitoring and reporting requirements.	1	B	2
	Increased loads on roads	Decreased road safety due to damage to pavement conditions	1	D	7	CONTRACTOR • C Undertake a survey of the existing road surface conditions prior to construction and implement an ongoing monitoring program. • C Remedy all road damage caused by construction traffic.	1	B	2
Residential occupancy	Increased traffic	Creation of a nuisance for residents and/or neighbours	3	E	20	INTRAPAC • Design the development to be relatively self-contained in the provision of residents' daily needs, thereby reducing the number of vehicle trips required leaving the development. • Design the proposed street network within the	2	C	8

		Traffic congestion at junctions in vicinity of the site	3	D	17	development to be highly interconnected and to allow for direct access to neighbourhoods, reducing the need for traffic on local collector roads and dispersing traffic into more than one collector road. • Create street connections from the north side to the south side of the Alverly Road corridor by underpass or bridge connections. • Collaborate with road and transport authorities as the project proceeds to ensure that: ◦ Staged upgrades and new road developments minimise congestion and ensure accessibility is maintained to the project area and surrounding regions, including access for emergency services. ◦ Staged upgrades to junctions address potential road safety issues at key intersections. • Reduce reliance on car-based travel internally by: ◦ C Implementing an interim park-and-ride facility within the site that will eventually becoming a bus interchange servicing local and regional areas. ◦ C Designing the development such more than 90 % of dwellings will be within 600 m of a bus stop. ◦ Designing a connected network of footpaths providing access to key land uses and centres. ◦ Making pedestrian crossing facilities standard at traffic signals and on key desire lines. ◦ Designing a core on-road cycle path network connecting to employment precincts. ◦ Designing an off-road bicycle path network. ◦ Including bicycle trip-end facilities at key land use destinations. ◦ Undertaking ongoing maintenance of cycling and pedestrian infrastructure.	2	B	5
		Traffic congestion along key roads in vicinity of the site.	3	C	13		2	B	5
		Increased number of crashes at the Arnhem Highway/Freds Pass Road intersection	3	D	17		2	C	8
		Increased number of crashes at the Redcliffe Road/Freds Pass Road intersection	3	D	17		1	B	2
		Increased response time for emergency services	3	C	13		2	B	5

5.2.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with traffic, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- For the development of Noonamah Ridge, Intrapac is determined to be guided by the principles of ecologically-sustainable development (as discussed in Section 2.2.1) – including reducing resident reliance on private vehicle use for travel both within, and external to, the development. The concept master plan has been designed with this in consideration by including cycle routes, location of social infrastructure, bus route extensions, and park-and-ride facilities. This is backed-up by Intrapac's track record (see Section 1.1.2). These principles are further enshrined in the Area Plan that, as well as the master plan, will be incorporated into the *NT Planning Scheme* through the process discussed in Section 1.6.4.
- Intrapac acknowledges that all road infrastructure that will be ceded to a responsible authority will require discussion and agreement with that authority, in order to reach an agreement on responsibility for the funding of upgrades and for ongoing maintenance.
- Prior to approval from Litchfield Council, Intrapac will need to have the approval of the responsible authority (e.g. DoI/DoT) with respect to the design and undertaking of roadworks and associated earthworks, drainage works, verges, pathways, street lighting, and street-scaping for all roads associated with the development. In addition, Litchfield Council requires an approved Traffic Management Plan prior to the commencement of any works in an existing road or road reserve. This will be incorporated into a development permit as a condition prior to commencement of construction. Development of a subdivision cannot proceed until all conditions have been met.

5.3 ELECTRICITY

The environmental objectives for electricity are:

- To maintain service levels for current users in and around the project area.
- To ensure that provision of services and infrastructure is sustainable in the long-term for development in the region.

5.3.1 Context

The proposed electrical reticulation within the subdivision will consist of a 22 kV underground supply. The existing PWC network in the rural area is 22 kV (overhead) along Redcliffe Road. There is inadequate spare capacity for this development within that network to accommodate the power needs of the development. A new substation (Strangways Zone Substation) is currently under construction and due to be commissioned in the next 12 months.

The proposed subdivision can be serviced with the provision of up to three dedicated feeders – one overhead and two underground – with the second underground feeder requirement to be assessed during the later stages of development. It has been communicated to Intrapac that PWC's preferred power supply solution is for Noonamah Ridge to be connected to the Strangways Zone Substation which is currently under construction, and that there is capacity for at least two feeders to be connected for such a purpose.

5.3.2 Potential impacts

The main potential impact concerning electricity supply is that current supply within the area surrounding the development will be compromised.

5.3.3 Risk assessment

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Electricity supply	Inadequate supply due to an insufficient capacity of proposed infrastructure	Inconvenience, disruption and/or economic loss to existing and/or new consumers	4	E	21	INTRAPAC • P Collaborate with PWC regarding capacity and required upgrades to existing infrastructure. • P Confirm availability of services prior to submission of subdivision applications.	4	A	10
	Inadequate or interrupted supply due to the effects of extreme weather events		3	E	20	CONTRACTOR • P Build infrastructure to PWC standards. • C Investigate generating some electricity using solar	3	D ¹	17

						power and/or the sewerage treatment process.			
	Limited options for future infrastructure construction and upgrades due to existing infrastructure and land use		3	A	6	Initial assessments have confirmed sufficient areas within road reserves and within the site to install new reticulated power supply infrastructure.	3	A	6

¹ Throughout Darwin, electrical storms during the wet season regularly cause blackouts regardless of the best efforts of PWC.

5.3.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with electricity supply because there exists, within the planning process, a requirement for a review and approval by PWC of the power supply plan for each subdivision. It is standard practice of PWC at the time of assessment of subdivision and development permit applications to provide comment that:

- Confirms the availability, or otherwise, of services in the area.
- Notes the upgrades to infrastructure required to service the proposed development.
- Requires plans for services to be provided to PWC for approval.
- Requires payment from the developer in accordance with any regulated contributions scheme relevant to an area.
- Requires that services be provided to PWC's satisfaction and in accordance with their guidelines and standards.

These are generally incorporated into a development permit as conditions, with the design of services requiring approval of PWC prior to commencement of construction. Development of a subdivision cannot proceed until all conditions have been met.

In addition:

- **All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.**
- **All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.**

The EIS Terms of Reference (Appendix A) request an assessment of the risk that development of the project will create a demand for upgrades or construction of new zone substations. This is considered a negligible project risk given that a new substation is being constructed nearby which PWC has indicated has the capacity to supply two feeders dedicated to Noonamah Ridge (which would provide adequate supply for the preliminary stages of subdivision). Intrapac acknowledges that all electricity infrastructure that will be ceded to PWC will require discussion and agreement with PWC, in order to reach an agreement on responsibility for the funding of upgrades and for ongoing maintenance.

5.4 POTABLE WATER

The environmental objectives for potable water are:

- To maintain equitable, sustainable and efficient use of water resources.
- To ensure that water supplies are maintained and current lawful users of water (such as entitlement holders and stock and domestic users) and other beneficial uses of water (such as spring flows and groundwater-dependent ecosystems) are not adversely impacted by the development.
- To ensure that surface water and groundwater resources and quality are protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.

5.4.1 Context

The key features of groundwater regionally, locally and within the project area are summarised below:

- The project area is situated within the Pine Creek Complex – a complex geological area with complex hydro-geology.
- There are numerous local users of groundwater in existing rural subdivisions concentrated to the west and north of the project area.
- Groundwater occurrence within the project area is variable in terms of yields, with at least one porous, high-yielding sandstone aquifer occurring adjacent to a major fault zone.
- The Koolpinyah Aquifer to the east and north-east of the project area provides high yields in areas where karstic development has occurred, although there has been an apparent overuse of the aquifer in some areas (Fell-Smith and Sumner 2011).
- Aquifer recharge is variable across the project area, depending on the occurrence of fracture zones (i.e. high recharge) or saprolitic clays in the low-lying areas (i.e. low recharge).
- Groundwater quality meets relevant drinking water quality guidelines.
- Two potential groundwater-dependent ecosystems (GDE's) have been identified on and adjacent to the project area – one in the central-eastern section and one just outside the project area to the south-east. The latter is also an Aboriginal sacred site – see Figure 3-22.

The NT Government has adopted an approach to assessing the sustainability of groundwater extraction – see Section 2.8.4. Using this approach, the annual recharge over the entire project area of 2,800 ha equates to approximately 1,120 ML. At standard rates of habitation and water use for rural/residential households (i.e. 3.5 persons, 1,100 L/person/day), this could supply water to approximately 800 residences. This is more than adequate for Stage 1.

It is proposed that 300 lots of Stage 1 will be serviced with potable water piped from bore-fields located within the project area. The remaining 100 lots of Stage 1 will be sized and located in areas in which it is possible for each lot to have its own bore (or for a number of lots to share a bore). Concurrently with Stage 1, Intrapac intends to investigate the viability of Koolpinyah Aquifer (offsite and to the east and north-east of the development) as an ongoing water supply for the remainder of the project. If the Koolpinyah Aquifer does not present as a feasible water supply for the project, Intrapac proposes to enter into an agreement with PWC to connect to mains water supply, and this may include a cost-sharing arrangement.

5.4.2 Potential impacts

The main potential impacts associated with provision of potable water relate to the reduced quality and quantity of groundwater due to contaminants, decreased recharge and over-extraction.

5.4.3 Risk assessment

The potential risks associated with the supply of potable water are discussed below in relation to local groundwater resources. Extracting water from Koolpinyah Aquifer is also not assessed, as there is currently insufficient information available to assess the viability of the aquifer as an ongoing water supply.

The risk to potable water from sewerage treatment is assessed in Section 5.6.3. The risks to biodiversity from aquifer over-extraction or contamination are assessed in Section 5.6.3.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Extraction of groundwater	Inadequate supply due to an insufficient capacity of the aquifers targeted for extraction	Inconvenience, disruption and/or economic loss to existing users and/or users associated with the development	4	E	23	INTRAPAC • C Undertake a Groundwater Sustainability Study prior to commissioning a bore-field in order to understand and predict the response of the aquifer to extraction. • C Gauge bore-fields and limit the extraction of groundwater from bore-fields and individual lots to within specified sustainable levels (i.e. 20 % of annual	3	B	9

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
	Inadequate supply due to over-extraction of aquifers					recharge). • C Investigate ways to manage and monitor water extraction by individual lots, including the possibility of having multiple lots connected to a single bore (i.e. five lots to a bore). • Promote minimisation of water use through community education. • Minimise water use by recycling of wastewater (e.g. irrigation of recreation areas). • C Monitor water quantity in key bores surrounding the development. ³ <i>Note: DLRM also monitors aquifer levels within the region.</i> • C Undertake further investigations of the viability of the Koolpinyah aquifer as a long-term water supply for the project. <i>Note: If Koolpinyah aquifer is found to be an insufficient resource, the option for connecting to mains water remains available.</i>			
	Decrease in aquifer water levels and/or flows								
Increase in impervious surfaces (e.g. roofs, roads, compacted soils)	Decreased recharge of local aquifers ¹	Insufficient groundwater for onsite and/or adjacent users	3	C	13	INTRAPAC • C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i> , which include maximising permeable surfaces available for infiltration (e.g. via swales and/or stormwater detention basins). • C Investigate the potential for active recharge of aquifers using excess stormwater.	3	B	9
Storage and use of hazardous chemicals during construction	Seepage of contaminants into aquifers	Non-potability of groundwater for onsite and/or adjacent users due to compromised water quality ²	3	C	13	CONTRACTOR • P Develop and implement a Construction Environmental Management Plan (CEMP) for each subdivision that specifies storage and handling requirements for hazardous materials during construction. INTRAPAC • C Monitor water quality in key bores surrounding the	3	B	9

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						development. ³			

¹ The development will result in the conversion of some of the recharge area to hard, impermeable surfaces (e.g. buildings, roads, car parks and hardstands) which could reduce the amount of direct rainfall infiltration and therefore reduce aquifer recharge.

² The inherent risk of contamination of groundwater is considered relatively low due to due to productive aquifer zones generally being located at depths of 30 m or more below ground level.

³ Refer to Water Monitoring Program in Section 6.6.4 of the EMP.

5.4.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with potable water supply, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- It is acknowledged that there are uncertainties associated with using the local aquifers to supply potable water for Stage 1 of the development, hence the commitment to undertaking a Groundwater Sustainability Study – including pump testing of groundwater bores – will be undertaken to verify the existence of a sustainable water supply for Stage 1 of the development, and to understand and predict the response of the aquifer to extraction. **In the unlikely event that it is found that the aquifers within the project area are not able to sustainably supply the water needs for Stage 1, there is the fall-back of connecting to mains supply, as discussed in Section 2.8.5.**
- If connection to mains supply is required, Intrapac proposes to enter into an agreement with PWC for this to occur which could include cost-sharing or development contributions/levies.
- A CEMP that addresses the storage and use of hazardous chemicals is a standard condition for a subdivision approval permit. Development of a subdivision cannot proceed until all conditions have been met.
- The proposed approach to stormwater management will ensure that across all stages of the development a wide range of drainage features are implemented (as appropriate) to mitigate any risks associated with surface water quality and quantity. Features such as detention ponds, swales and

gross pollutant traps are commonly used across the Northern Territory and have proven to be effective in managing floods, erosion and sedimentation in large infrastructure projects.

- For the development of Noonamah Ridge, Intrapac is determined to be guided by the principles of ecologically-sustainable development (as discussed in Section 2.2.1) – including sustainable use of water resources, minimising water usage and investigating the potential for aquifer recharge. This is backed-up by Intrapac’s environmental track record (see Section 1.1.2).
- The only mitigation measure that may be difficult to apply is maintaining sustainable groundwater extraction by individual lots. Intrapac has committed to investigating to do this; however, ultimate responsibility for managing and monitoring water extraction lies with DLRM.
- As discussed in Section 2.8.7, subdivision and development permit applications for each stage will not be approved without Intrapac providing a potable water supply, whether that is from groundwater or mains water supply. It is standard practice of PWC at the time of assessment of subdivision and development permit applications to provide comment that:
 - Confirms the availability, or otherwise of services in the area.
 - Notes the upgrades to infrastructure required to service the proposed development.
 - Requires plans for services to be provided to PWC for approval.
 - Requires payment from the developer in accordance with any regulated contributions scheme relevant to an area.
 - Requires that services are provided to PWC’s satisfaction and in accordance with their guidelines and standards.

These are generally incorporated into a development permit as conditions, with the design of services requiring approval of PWC prior to commencement of construction. Development of a subdivision cannot proceed until all conditions have been met.

5.5 STORMWATER

The environmental objectives for stormwater are:

- To ensure that water supplies are maintained and current lawful users of water (such as entitlement holders and stock and domestic users) and other beneficial uses of water (such as spring flows and groundwater-dependent ecosystems) are not adversely impacted by the development.
- To ensure that surface water and groundwater resources and quality are protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.
- To protect and improve waterway health by maintaining or restoring the natural hydrological regime.
- To minimise the impacts of stormwater on ecosystem health, flooding and drainage control, public health and safety, the economy, recreational opportunities and aesthetic values in the region.

5.5.1 Context

The surface water resources and environmental values regionally, locally and within the project area are described in Section 3.6.1 and Appendix F and can be summarised as follows:

- The project area lies within two surface water catchments, with the majority being in the upper Elizabeth River catchment (major tributary of the Darwin Harbour catchment) and the remainder located within the Adelaide River catchment.
- Drainage within the project area involves narrow, rapidly-draining gullies and upland drainage lines (first-order) in the ridges and upper slopes, which capture and divert run-off toward the broad drainage floors and seasonal creek lines (second-order).
- The tributaries of Elizabeth River that flow from the project area are ephemeral, flowing only during the wet season and ceasing to flow early in the dry season (either drying completely or contracting to occasional pools).
- There are no known downstream consumptive users of surface water (i.e. extraction for water supply) from the project area, but there are likely to be significant recreational (e.g. fishing) and aesthetic values held by both the general public and local land-owners along the Elizabeth River and its tributaries.
- Land within the project area that may be susceptible to flooding is minimised due to the relatively steep topography and rapid-draining upland areas. Modelling of the 1 % AEP undertaken for the largest catchment within the project area indicates that flooding may occur within 50 – 100 m of drainage lines.

- During the community consultation sessions held for this development, a number of residents of properties to the west of the project area indicated that since roadworks and drainage easement works were undertaken on Redcliffe Road approximately seven years ago, their properties have experienced seasonal flooding.
- The existing quality of water on the site is generally very good, with low turbidity and low concentrations of suspended solids, dissolved ions and heavy metals, but occasional elevated nutrient concentrations associated with seasonal flow conditions.
- Previous monitoring of water quality in the Elizabeth River indicates that some pollutants – mainly nutrients and suspended sediments – are often slightly elevated above guideline values; however, reporting by the NT Government has consistently assigned this system an ‘excellent’ water quality rating (DLRM 2014).

5.5.2 Potential impacts

The main potential impacts associated with stormwater relate to altered hydrology leading to an increase of flooding of downstream residents and change in biotic status of the river, and reduced surface water quality (particularly during first flush rainfall events – associated with run-off from construction activities and from urbanisation of the catchment).

Potential impacts on water quality are likely to be highest during the ‘first flush’ rainfall events during the wet season, when potential pollutants that have accumulated in the catchment over the dry season may be mobilised.

5.5.3 Risk assessment

The risks to biodiversity from activities relating to stormwater are assessed in Section 5.5.3.

Note: Some downstream residents experience seasonal flooding. Intrapac has committed to there being no significant changes to pre-development surface water quantity, quality and flows (as compared to baseline data). Consequently, the project design neither exacerbates nor improves flooding to these residents.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	R S
Stormwater drainage	Increased water volumes to downstream waterways due to an increase in impervious surfaces and/or inappropriate stormwater infrastructure design	Property damage and inconvenience due to <u>increased</u> inundation/flooding of adjacent properties and/or infrastructure (e.g. roads) downstream of project area	4	D	21	INTRAPAC • C Undertake prior to each stage of development hydrological modelling to predict potential changes in run-off characteristics (in each instance taking into account cumulative impact from any existing	3	C	13

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	R S
		<i>Note: Some downstream residents experience seasonal flooding</i>				development).			
	Altered flow pathways/rates in drainage lines and/or seasonally-saturated areas due to inappropriate stormwater infrastructure design	Reduction in aesthetic and recreational value for neighbours and residents due to lower creek levels and vegetation die-back	3	D	17	• C P Incorporate results of hydrological modelling and investigations into a Stormwater Management Plan that provides details of infrastructure design that limit off-site discharges to pre-development flows. • C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which includes maximising permeable surfaces available for infiltration (e.g. via swales and/or stormwater detention basins) and minimising water pollution.	3	C	13
Retention of flows via artificial water bodies (e.g. drains, swales, sedimentation basins, lakes)	Reduced flow volumes to downstream waterways	Reduction in aesthetic and recreational value for neighbours and residents due to lower creek levels and vegetation die-back	3	C	13	• C P Design subdivisions and associated drainage to take into account 1% AEP flood levels. • C P Design each subdivision to retain riparian vegetation as buffers and filters for stormwater run-off. • C Monitor creek flows using auto-loggers at stream gauging stations. The data will be compared with the flows expected from the hydrological modelling.¹ If monitoring indicates that stream flows are significantly modified because of development, implement remedial measures as required (e.g. modification of drainage structures). COUNCIL • Maintain stormwater treatment infrastructure.	3	B	9
Use of fertilisers	Increased nutrients to waterways, particularly during early wet season 'first flush' events	Reduced aesthetic and social amenity because of algal blooms on downstream waters due to increased nutrients	4	D	21	INTRAPAC • C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which includes treatment of stormwater. • C Monitor water quality at key locations in drainage lines downstream of the development.¹ COUNCIL • Maintain stormwater treatment infrastructure. <i>Note: Maintenance of recreation/common areas will be the responsibility of Litchfield Council and will occur in accordance with existing operating procedures.</i>	3 ²	C	13

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	R S
						Moreover, the occupancy phase of the development may involve rural land uses over which Intrapac has no control.			
Storage, transport and use of hazardous chemicals (e.g. hydrocarbons, herbicides, pesticides, wastewater treatment chemicals)	Introduction of pollutants to waterways, as a result of: - Chemical use in areas that flow offsite and/or - Spill/leak due to incorrect storage/handling	Health effects associated with downstream recreational contact with contaminated water (e.g. poisoning)	4	B	9	CONTRACTOR Develop and implement a CEMP for each subdivision that specifies storage and handling requirements for hazardous materials during construction.	3	A	6
		Reduced recreational amenity because of contaminated water restricting downstream use (e.g. fishing and swimming)	3	B	9	INTRAPAC Monitor water quality at key locations in drainage lines downstream of development.¹ <i>Note: The occupancy phase of the development may involve rural land uses over which Intrapac has no control.</i>	3	A	6
Run-off from infrastructure containing pollutants (e.g. roads, roofs)	Pollutants in waterways, particularly during early wet season 'first flush' events	Health effects associated with downstream recreational contact with contaminated water (e.g. poisoning)	3	B	9	INTRAPAC - Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which includes treatment of stormwater. - Monitor water quality at key locations in drainage lines downstream of development.¹	2	A	3
		Reduced recreational amenity because of contaminated water restricting downstream use (e.g. fishing and swimming)	2	B	5	COUNCIL Maintain stormwater treatment infrastructure.	2	A	3
Disturbance of soil	Erosion and subsequent introduction of sediments to waterways	Reduced aesthetic and social amenity because of increased turbidity in downstream waters	3	D	17	INTRAPAC - Use the <i>Land Suitability Assessment</i> (Appendix G) to ensure that the design and planning of each subdivision minimises erosion and sedimentation is minimised. - Develop and implement an Erosion and Sediment Control Plan (ESCP) for each stage of subdivision to ensure that construction activities do not result in erosion and sedimentation (see Section 6.7.2 of the EMP for detail) or significant dust emission (see Section 6.13.2 of the EMP for detail).	1	C	4

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	R S
						• Maintain ESCP infrastructure as required. • C P Develop a Stormwater Management Plan for each stage of the subdivision that provides details of infrastructure design that incorporate retention/sediment basins. • Landscape and maintain final landforms to maximise ground cover, and align with surrounding topography to avoid creating preferential flow paths. • Slash (rather than grade) fire breaks to maintain ground cover. • C Monitor water quality at key locations in drainage lines downstream of development.¹ • C Minimise clearing on individual lots using building envelopes. <i>Note: Clearing in excess of 1 ha requires approval under the Planning Scheme.</i>			

¹ Refer to Water Monitoring Program in Section 6.6.4 of the EMP.

5.5.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with stormwater management, for the following reasons:

- All of the measures labelled (**C**) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (**P**) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- Hydrological modelling for each stage of the development will be undertaken by engineers experienced in Top End conditions. This will predict potential changes in run-off characteristics; in each instance taking into account cumulative impact from any existing development.

- A *Land Suitability Assessment* (LSA) is required for such a development as Noonamah Ridge to demonstrate that the proposed development has sufficient unconstrained land to support planned uses. Such an assessment has been undertaken for the entire site – see Appendix G. The development will be guided by the LSA to ensure that each subdivision is designed and planned to, *inter alia*, minimise erosion and sedimentation.
- A CEMP that addresses the storage and use of hazardous chemicals is a standard condition for a subdivision approval permit. Development of a subdivision cannot proceed until all conditions have been met.
- The occupancy phase of the development may involve rural land uses over which Intrapac has no control, including use of fertilisers by residents and council. However, the development will employ features of WSUD that involve vegetation filters (e.g. grass swales) are designed to intercept nutrients from fertilisers before they enter natural waterways.
- The proposed approach to stormwater management will ensure that across all stages of the development a wide range of drainage features are implemented (as appropriate) to mitigate any risks associated with surface water quality and quantity. Features such as detention ponds, swales and gross pollutant traps are commonly used across the Northern Territory and have proven to be effective in managing floods, erosion and sedimentation in large infrastructure projects.
- Prior to the approval by DCA of each subdivision for this development, Intrapac will have to demonstrate to the NT Government and Litchfield Council that stormwater drainage is sufficient to deal with the anticipated loads (including flood events). Development of a subdivision cannot proceed until all conditions have been met.

5.6 SEWERAGE

The environmental objectives for sewerage are:

- To ensure that water supplies are maintained and current lawful users of water (such as entitlement holders and stock and domestic users) and other beneficial uses of water (such as spring flows and groundwater-dependent ecosystems) are not adversely impacted by the development.
- To ensure that surface water and groundwater resources and quality are protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.

5.6.1 Context

The existing environment as it pertains to groundwater and surface water is discussed in Section 5.4.1 and Section 5.5.1 respectively.

A community-scale, onsite treatment solution is the preferable wastewater management method for Noonamah Ridge, as reticulated municipal sewer treatment services are not proposed for the area in the foreseeable future.

Integrated Transpiration technology is proposed as suitable treatment facilities for reticulated wastewater. The system is an in-ground, enclosed, recirculating system, which uses a series of holding tanks and evapo-transpiration channels to treat and dispose of the effluent. It is modular, allowing for straightforward up-sizing.

Where individual lot sizes are suitably large (i.e. rural residential land) and suitable land is available for onsite wastewater management as per the requirements of the *Guidelines for Land Capability Assessment* (DoH 2014), individual wastewater management systems may be used.

5.6.2 Potential impacts

The potential impacts of disposal of treated sewerage include contamination of aquifers and/or downstream surface waters, primarily through increased nutrient concentrations.

5.6.3 Risk assessment

The risks to biodiversity from activities relating to sewerage are assessed in Section 5.7.3.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Disposal of treated sewerage – individual systems (e.g. septic tanks)	Increased nutrients to waterways	Health effects associated with downstream recreational contact with contaminated water (e.g. bacteria)	3	B	9	INTRAPAC • C P Locate septic systems away from groundwater bores (i.e. at least 100 m) and in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for every subdivision that contains lots that will have a residential septic system). • C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of septic systems (e.g. by licenced plumbers), including installation of non-conventional systems where soil limitations exist. • C Monitor water quality at key bores surrounding the development and at key locations in drainage lines downstream of the development.²	2	A	3
		Reduced aesthetic and social amenity because of algal blooms on downstream waters	3	B	9		2	A	3
	Seepage of contaminants into aquifers <i>Note: If this occurred, it would likely be in low volumes</i>	Non-potability of groundwater for onsite and/or adjacent users due to compromised water quality ¹	3	C	13		3	A	6
Disposal of treated sewerage – community-scale treatment plants	Increased nutrients to waterways	Health effects associated with downstream recreational contact with contaminated water (e.g. bacteria)	3	C	13	INTRAPAC • C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of community-scale wastewater treatment systems to tertiary standards. • C P Locate treated wastewater irrigation disposal areas away from groundwater bores (i.e. at least 100 m). • C P Locate treated wastewater irrigation disposal areas in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for each community-scale plant). • C P Ensure that the design and operation of irrigation system is appropriate (see Section 2.10.3 and 2.10.7) and has monitoring and management safeguards	3	A	6
		Reduced aesthetic and social amenity because of algal blooms on downstream waters	3	E	20		2 ³	B	5
	Seepage of contaminants into aquifers. <i>Note: If this occurred, volumes would be higher than for septic</i>	Non-potability of groundwater for onsite and/or adjacent users due to compromised water quality ¹	4	C	18		3 ³	B	9

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						(see Section 6.6.1 of EMP).			

¹ The inherent risk of contamination of groundwater is considered relatively low, due to productive aquifer zones generally being located at depths of 30 m or more below ground level.

² Refer to Water Monitoring Program in Section 6.6.4 of the EMP.

5.6.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with sewerage treatment and disposal, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- A preliminary *Land Capability Assessment* (see Appendix H) concluded that there are sufficient unconstrained soils within the sampled land units capable of supporting on-site wastewater management systems. However, the site has some areas that are not suitable for disposal – including a number of rocky ridges and some wetland areas. Prior to the detailed design stage, site-specific LCA's will be required to determine the location for every community-scale wastewater treatment facility, and for every subdivision that contains lots that will have a residential septic system,
- An identical community-scale treatment system to that proposed has been successfully used for the last two years in nearby Coolalinga – providing local practical experience and availability of data and feedback to assess the system's performance.
- There is a clear and established permit process associated with the installation of individual lot wastewater treatment systems, with approval required from DoH.
- Prior to the approval of each subdivision, Intrapac will need to have the approval of DLRM, DoH and NTEPA with respect to wastewater management for each stage of the development. This includes obtaining a Wastewater Works Design Approval from DoH, and compiling associated documents (e.g. Irrigation Management Plan) for irrigation of treated wastewater from community-scale treatment systems. It also includes demonstrating that there is sufficient capacity within the sewerage treatment system to service the new subdivision without impinging on the service provided to existing users. Development of a subdivision cannot proceed until all conditions have been met.

5.7 BIODIVERSITY

The project area contributes to regional biodiversity in two ways – by the project area's regional ecological contribution of habitat and ecological corridors; and by the species that are found within the project area's boundaries (particularly threatened species). In this section, the former is considered. Threatened species are assessed in Section 5.8.

The environmental objectives for biodiversity are:

- To maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts.
- To prevent the spread of weeds onto the project area, off the project area and within the project area.

5.7.1 Context

Wet and dry season flora and fauna surveys were undertaken across the project area in 2014 – 15 (see *Flora and Fauna Assessment Report* in Appendix I). The surveys recorded 196 flora species, including three species listed as Vulnerable and one listed as Near Threatened under the *TPWC Act* (see Section 3.9.2). Four weed species were recorded in low densities. The surveys also recorded 127 fauna species, of which four are threatened species under the *EPBC Act* and/or *TPWC Act* (see Section 3.9.3) and six are introduced species. The type and abundance of non-threatened flora and fauna species within the project area are typical of that expected in tropical savannah woodland in this region.

Twelve distinct vegetation communities occur within the project area, of which 74.2 % is *Eucalyptus tetrodonta* and *E. miniata* woodland. The remaining vegetation types are associated with drainage lines or areas of seasonal inundation. The habitats found within the project area – predominately Eucalyptus woodland – are common across the area. Moreover, the project area sits to the south and east of areas either already developed or that have had substantially modified habitat. Consequently, there are no significant wildlife corridors within the project area, apart from the strips of riparian vegetation mentioned above which form the initial sections of that habitat type extending to the west. The project area has endured widespread fires in 13 of the past 14 years.

Four sensitive vegetation types were identified within the project area. Of these, the following occurrences are considered to be of conservation significance (see Figure 4-15 and Figure 4-16):

- One area of sandsheet heath in the north-west
- All areas of riparian vegetation
- The only patch of dry monsoon forest (in the north-east)
- All the wetlands.

No ecological communities listed as threatened under the *EPBC Act* were identified within the project area.

Parts of the project area are considered Priority Environmental Management (PEM) Areas within the Municipality of Litchfield. Development proposals of land identified as PEM Areas must demonstrate consideration of the environmental significance of natural vegetation and other landscape features, and the retention and protection of those areas identified by this evaluation to be significant (DIPE 2002). The PEM Areas within the project area largely align with the more substantial waterways along the western boundary.

5.7.2 Potential impacts

Direct mortality of flora and fauna will occur during land clearing activities. In addition, there are a number of activities associated with the development that may affect habitat condition and quality resulting in a reduction in biodiversity. These are:

- Reduction in habitat due to land clearing.
- Altered hydrology due to stormwater infrastructure and/or use of groundwater.
- Altered surface and/or groundwater quality because of sedimentation or pollution.
- Introduction or proliferation of weed species (particularly during construction).
- Introduction or proliferation of feral fauna species due to residential occupancy (e.g. cats and rodents).
- Disturbance from dust or noise (particularly during construction).
- Disturbance and/or injury from human activities (e.g. traffic and usage of green spaces).
- Altered fire regimes (e.g. more frequent or later fires).

Although Intrapac is committed to minimising the area of land cleared for this development, there will still be an impact on both local (i.e. within the project area) and regional biodiversity due to direct mortality, habitat clearing and/or reduction in habitat quality. In order to contextualise the impact, the risk assessment below assesses the impact that the loss of local biodiversity will have on regional biodiversity.

5.7.3 Risk assessment

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Vegetation removal	Loss of regional biodiversity due to removal of sensitive vegetation (which includes Priority Environmental Management areas)	4	D	23	INTRAPAC • C Contain all sensitive vegetation types of conservation significance (as defined in 3.9.4) within buffered green spaces. The management of these is discussed in Section 6.8 of the EMP.	3	B	9

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
		Loss of regional biodiversity (flora) due to direct mortality during land clearing	2	C	8	INTRAPAC - Vegetation clearing will be undertaken stage-by-stage, and only where required. C Maintain green spaces that retain remnant vegetation throughout the development. C P Apply the standard land clearing requirements for lots 2 ha and larger which are contained in the <i>NT Planning Scheme</i>. These exist to minimise unnecessary clearing. For lots smaller than 2 ha, a permit will be required by the landholder to clear more than 1,000 m² of native vegetation (exclusive of the assigned building envelope). <i>Note: There will be a loss of plants across the development area. The species affected, however, are common within the region and so their loss does not contribute greatly to net loss of regional biodiversity (see Section 5.8 re threatened species).</i>	2	C	8
		Loss of regional biodiversity due to reduction in habitat for fauna							
		Loss of regional biodiversity due to death and/or injury to fauna during land clearing	2	C	8		2	B	5
	Habitat fragmentation	Loss of regional biodiversity due to reduction in habitat for fauna which require areas of contiguous habitat and due to reduced opportunities for gene flow via ecological corridors	3	C	13	INTRAPAC C P Apply standard land clearing requirements for lots 2 ha and larger which are contained in the <i>NT Planning Scheme</i>. These exist to minimise unnecessary clearing. For lots smaller than 2 ha, a permit will be required by the landholder to clear more than 1,000 m² of native vegetation (exclusive of the assigned building envelope).	1	B	3

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						• C P Retain buffers around riparian corridors that provide important habitats for dispersal of fauna. • C Maintain green spaces that retain remnant vegetation throughout the development <i>Note: While available habitat will be reduced for this development, the species assemblage is generally common – therefore there will be no significant impact on regional biodiversity.</i> <i>The project area sits to the south and east of areas either developed or that have had substantially modified habitat; thus continuity from the eastern areas across this development will not be substantially affected.</i>			
	Weed introduction and/or proliferation from disturbed areas into surrounding bushland	Loss of regional biodiversity due to reduced habitat quantity or quality because of weed invasion (including increase in fires due to some weeds – e.g. Gamba Grass).	2	B	5	CONTRACTOR • C P Develop a CEMP for each subdivision that includes a map of existing weed infestations and a Weed Management Plan (see Section 6.8 for the general measures that will be the basis of each plan).	1	A	1
	Fire from construction activities	Loss of regional biodiversity through direct mortality and reduced habitat quality due to bushfire	2	B	5	CONTRACTOR • C P Install fire breaks around all infrastructure, laydowns and work areas in line with Bushfire Regulations. • C P Develop an Emergency Response Plan for construction period. • C P Stockpile all material in line with Fire and Emergency Regulations. • C P Adopt all other actions as per Section 6.10.2 of the EMP.	1	A	1
	Erosion and subsequent introduction of sediments to waterways	Loss of regional biodiversity from reduced habitat condition (smothering and/or increased turbidity) due to compromised downstream surface water quality	3	D	17	INTRAPAC • C P Develop and implement an Erosion and Sediment Control Plan (ESCP) for each stage of subdivision. • C Monitor water quality at key locations in drainage	2	B	5

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						lines downstream of development. ¹ CONTRACTOR • Maintain ESCP infrastructure.			
	Generation of airborne and depositional dust during land clearing, earthworks, quarrying and crushing	Loss of regional biodiversity due to reduced habitat area and quality due to dust covering vegetation	2	B	5	CONTRACTOR • C P Develop and implement a CEMP for each stage of the subdivision that specifies management measures for reducing dust (as per Section 6.13.2 of the EMP).	1	A	1
		Loss of regional biodiversity from reduced habitat condition (smothering and/or increased turbidity) due to compromised downstream surface water quality	3	B	9	• C P Install and maintain drainage and sediment controls as per the ESCP to capture run-off and allow settling of suspended sediment prior to discharge to receiving waterways. INTRAPAC • C Monitor water quality at key locations in drainage lines downstream of development. ¹	2	A	3
Residential occupancy	Avoidance of early dry season fuel reduction burning due to site occupancy	Loss of regional biodiversity through direct mortality and reduced habitat quality due to bushfires being higher than normal in intensity (because they are later in the season when fuel loads are bigger)	2	B	5	COUNCIL • Undertake back-burning around all green spaces in the early dry season to provide fire breaks.	1	A	1
	Altered fire regimes through 'fire-bug' activities	Loss of regional biodiversity through direct mortality and reduced habitat quality due to bushfires being higher than normal in intensity (because they are later in the season when fuel loads are bigger)				COUNCIL • Maintain fire breaks around green spaces. INTRAPAC • C Install signage around all green spaces to inform residents about impacts of fire.			
	Individual fire management (stockpiling and/or burning off)	Loss of regional biodiversity through direct mortality and reduced habitat quality due to bushfire	2	B	5	INTRAPAC • Provide education material to lot owners regarding maintenance of 4 m boundary fire breaks by rural lot owners in line with Bushfires Regulations. • Design subdivisions with fire breaks around higher density areas.	1	A	1

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						COUNCIL • Install and maintain fire breaks around higher density areas. • Implement boundary fire breaks around project area to minimise risk of spread to neighbouring properties.			
	Increased traffic	Loss of regional biodiversity due to fauna mortality because of vehicle strikes	1	A	1	<i>Note: There will be a loss of fauna across the development area due to vehicle strike or disturbance by users of green spaces. The species affected, however, are common within the region and so their loss does not contribute greatly to net loss of regional biodiversity (see Section 5.8 re threatened species).</i>	1	A	1
	Human disturbance	Loss of regional biodiversity due to fauna and/or flora mortality and/or disturbance because of accidental or deliberate actions by users of green spaces (e.g. off-road cyclists, bushwalkers or wrongdoers)	1	A	5		1	A	1
Stormwater drainage and/or retention of flows via artificial water bodies	Increased flow volumes to downstream waterways due to an increase in impervious surfaces and/or inappropriate stormwater infrastructure design	Reduction in regional biodiversity due to loss of habitat for flora and fauna that cannot tolerate deeper water levels and/or faster water flows	3	C	13	INTRAPAC • C Undertake prior to each stage of development hydrological modelling to predict potential changes in run-off characteristics (in each instance taking into account cumulative impact from any existing development). • C P Incorporate results of hydrological modelling and investigations into a Stormwater Management Plan that provides details of infrastructure design that limit off-site discharges to pre-development flows. • C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which includes maximising permeable surfaces available for infiltration (e.g. via swales and/or stormwater detention basins) and minimising water pollution. • C P Design subdivisions and associated drainage to take into account 1% AEP flood levels. • C P Design each subdivision to retain riparian	2	B	5
	Altered flow pathways/rates in drainage lines and/or seasonally-saturated areas	Reduction in regional biodiversity due to compromised aquatic ecosystems dependent on existing flow regime (e.g. breeding/migration of fish, reduced habitat areas/volumes, vegetation mortality for aquatic species, water quality from 'flushing')	3	C	13		2	B	5
		Reduction in regional biodiversity due to loss of habitat for flora/fauna species requiring soils that are	3	C	13		2	B	5

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
		seasonally saturated/inundated as a result of existing hydrological conditions				vegetation as buffers and filters for stormwater run-off • C Monitor creek flows using auto-loggers at stream gauging stations. The data will be compared with the flows expected from the hydrological modelling. ¹ • If monitoring indicates that stream flows are significantly modified because of development, implement remedial measures as required (e.g. modification of drainage structures). COUNCIL • Maintain stormwater treatment infrastructure.			
Changes to surface water quality	Increased nutrients to waterways due to fertiliser use, particularly during early wet season 'first flush' events	Loss of regional biodiversity from reduced habitat condition (eutrophication) due to compromised downstream surface water quality	3	C	13	INTRAPAC • C P Integrate within the subdivision design the relevant principles of <i>water-sensitive urban design</i> , which includes treatment of stormwater. • C Monitor water quality at key locations in drainage lines downstream of development. ¹ COUNCIL • Maintain stormwater treatment infrastructure. <i>Note: The occupancy phase of the development may involve rural land uses over which Intrapac has no control.</i>	2	B	5
	Increased nutrients to waterways due to disposal of treated sewerage (individual systems), particularly during early wet season 'first flush' events	Loss of biodiversity from reduced habitat condition (eutrophication) due to compromised downstream surface water quality	2	C	8	INTRAPAC • C P Locate septic systems away from groundwater bores (i.e. at least 100 m) and in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for every subdivision that contains lots that will have a residential septic system).	1	B	2
	Seepage of contaminants into aquifers due to disposal of treated sewerage (individual systems) <i>Note: If this occurred, it would likely be in low volumes and would probably only infiltrate into</i>	Where there is ground-surface water connectivity, loss of regional biodiversity from reduced habitat condition (eutrophication) due to compromised downstream surface water quality	2	C	8	• C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of septic systems (e.g. by licenced plumbers), including installation of non-conventional systems where soil	1	B	2

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
	<i>surface water if septic systems are located adjacent to waterways</i>					limitations exist. C Monitor water quality at key bores surrounding the development and at key locations in drainage lines downstream of the development. ¹			
	Increased nutrients to waterways due to disposal of treated sewerage (community-scale treatment plants), particularly during early wet season 'first flush' events	Loss of regional biodiversity from reduced habitat condition (eutrophication) due to compromised downstream surface water quality	3	C	13	INTRAPAC • C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of community-scale wastewater treatment systems to tertiary standards. • C P Locate treated wastewater irrigation disposal areas away from groundwater bores (i.e. at least 100 m). • C P Locate treated wastewater irrigation disposal areas in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for each community-scale plant). • C P Ensure that the design and operation of irrigation system is appropriate (see Section 2.10.3 and 2.10.7) and has monitoring and management safeguards (see Section 6.6.1 of EMP).	2	B	5
	Seepage of contaminants into aquifers due to disposal of treated sewerage (community-scale treatment plants) <i>Note: If this occurred, volumes would likely be higher than for septic systems</i>	Where there is ground-surface water connectivity, loss of regional biodiversity from reduced habitat condition (eutrophication) due to compromised downstream surface water quality	2	C	8		1	B	2
Storage, transport and use of hazardous chemicals (e.g. hydrocarbons, herbicides/pesticides, wastewater treatment chemicals)	Introduction of pollutants to waterways, as a result of: • Chemical use in areas that flow offsite and/or • Spill/leak due to incorrect storage/handling	Loss of regional biodiversity from reduced habitat condition (toxic effect) due to compromised downstream surface water quality	3	C	13	CONTRACTOR • P Develop and implement a CEMP for each subdivision that specifies storage and handling requirements for hazardous materials during construction.	3	A	6
	Seepage of contaminants into aquifers	Where there is ground-surface water connectivity, loss of regional biodiversity from reduced habitat condition (toxicity or eutrophication) due to compromised downstream surface water quality	2	C	8	INTRAPAC • C Monitor water quality in key bores surrounding the development. ¹ <i>Note: The occupancy phase of the development may involve rural land uses over which Intrapac has no control.</i>	2	B	5
Infrastructure (e.g. roads,	Run-off, resulting in introduction of pollutants to waterways,	Loss of regional biodiversity from reduced habitat condition	2	B	5	INTRAPAC	2	A	3

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
roofs)	particularly during early wet season 'first flush' events	(toxic effect) due to compromised downstream surface water quality				• C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which includes treatment of stormwater. • C Monitor water quality at key locations in drainage lines downstream of development.¹ COUNCIL • Maintain stormwater treatment infrastructure.			
Extraction of groundwater	Decrease in aquifer water levels and/or flows	Loss of regional biodiversity due to habitat deterioration because of insufficient water for groundwater-dependent ecosystems	3	C	13	INTRAPAC • C Undertake a Groundwater Sustainability Study prior to commissioning a bore-field in order to understand and predict the response of the aquifer to extraction. • C Gauge bore-fields and limit the extraction of groundwater from bore-fields and individual lots to within specified sustainable levels (i.e. 20 % of annual recharge). • C Investigate ways to manage and monitor water extraction by individual lots, including the possibility of having multiple lots connected to a single bore (i.e. five lots to a bore). • Promote minimisation of water use through community education. • Minimise water use by recycling of wastewater (e.g. irrigation of recreation areas). • C Monitor water quantity in key bores surrounding the development.¹	3	B	9
Increase in impervious surfaces (e.g. roofs, roads, compacted soils)	Decreased recharge of local aquifers								

¹ Refer to Water Monitoring Program in Section 6.6.4 of the EMP.

5.7.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks to regional biodiversity, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- For the development of Noonamah Ridge, Intrapac is determined to be guided by the principles of ecologically-sustainable development (as discussed in Section 2.2.1). This is backed-up by Intrapac's track record (see Section 1.1.2).
- A CEMP that contains specific weed management actions is a standard expectation for a subdivision approval application.

Little can be done, unfortunately, to reduce the likelihood of a fire-bug deliberately starting a fire within the project area. The best strategy is to minimise the damage such fires cause, primarily through controlled burns, and the establishment and maintenance of fire breaks. During the occupancy phase of the development, the responsibility for bushfire management will lie with Litchfield Council, landowners and Bushfires NT. Intrapac is limited in the influence it has on these actors and cannot vouch for that they will effectively manage for bushfire.

The commitment to a green space network (as detailed in Section 2.3.4) – which is enshrined within Area Plan and the SU zoning text (see Section 1.6.4) – will reduce the impact of land clearing. Within these green spaces, it is contended that there is a high level of certainty that management of fire, weeds and human use is possible. This is because the requisite management of these threats is not expected to be especially technical given the previous fire history of the site; that weed infestations are small and there are established control methods; and that disturbance by human activities such as quad-biking can be minimised through signage and vehicle access restriction. What is not yet certain is which entity will be responsible for undertaking such management actions within green spaces that contain conservation-significant values. Intrapac is intent of resolving this uncertainty, hence the commitment to engage relevant authorities in a workshop to determine the appropriate size of green spaces, the optimum zoning (and, as a consequence, responsibility management), the degree of public accessibility to key areas, management of key areas (including fire and weed management), monitoring programs (and responsibility for undertaking these), and how to promote within the community an understanding and appreciation of the values 'on their doorstep'.

5.8 THREATENED SPECIES

The project area contributes to regional biodiversity in two ways – firstly, by the project area’s regional ecological contribution of habitat and ecological corridors; secondly, by the species that are found within the project area’s boundaries (particularly threatened species). In this section, the threatened species that have been recorded in the project area are considered. General biodiversity is assessed in Section 5.7.

The environmental objectives for threatened species are to maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts.

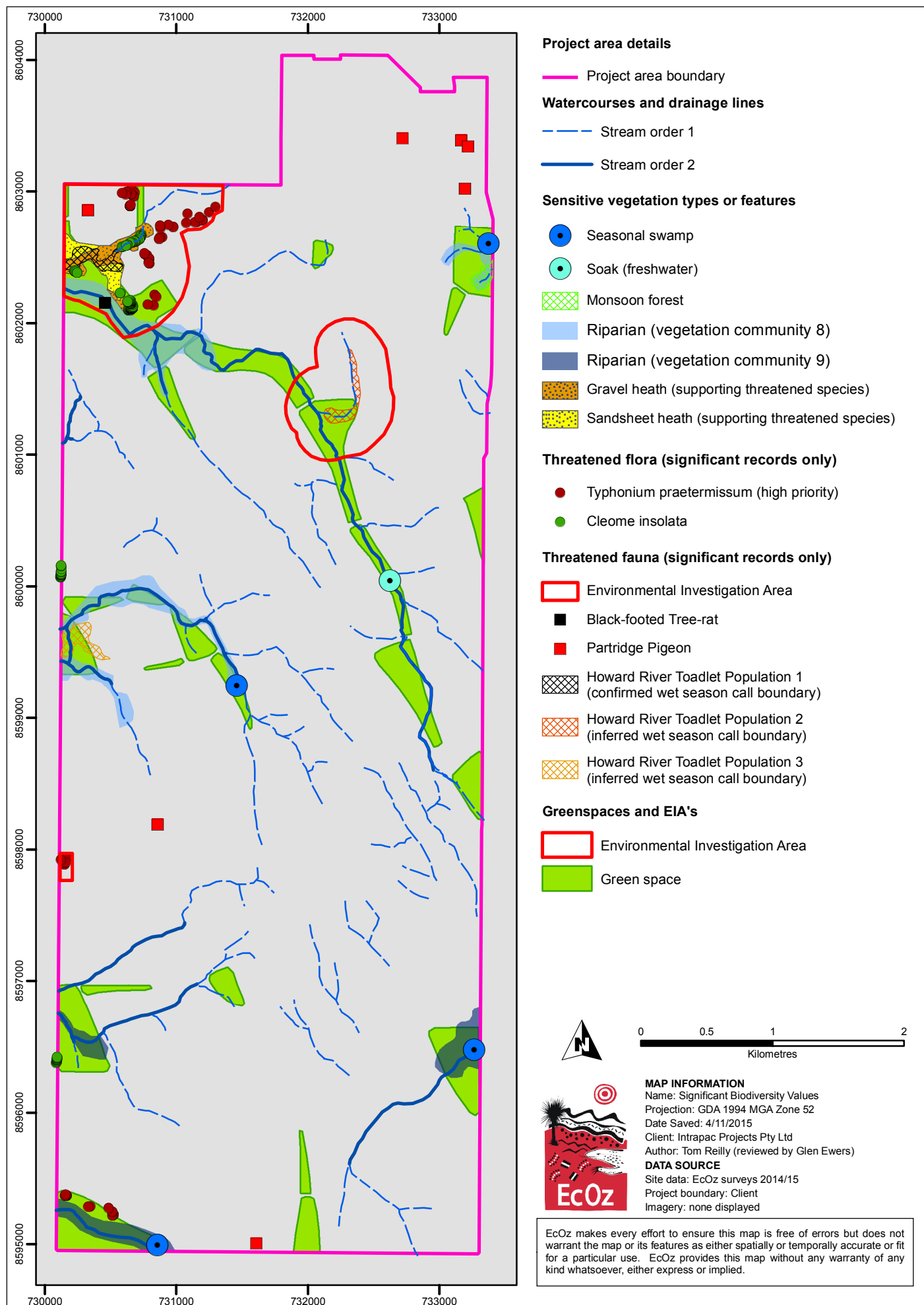
5.8.1 Context

Thirty-nine species were analysed in the *Flora and Fauna Assessment Report* (Appendix I) as part of a threatened species’ likelihood of occurrence assessment for the project area. The results of the assessment were that 20 species were ranked as having a ‘high’ or ‘medium’ chance of occurring within the project area. Therefore, these species were targeted during field studies. Surveys recorded seven threatened species within the project area. These are listed in Table 5-5, and the important populations of these species depicted in Figure 5-1 and Figure 5-2.

Table 5-5. Threatened species recorded within the project area

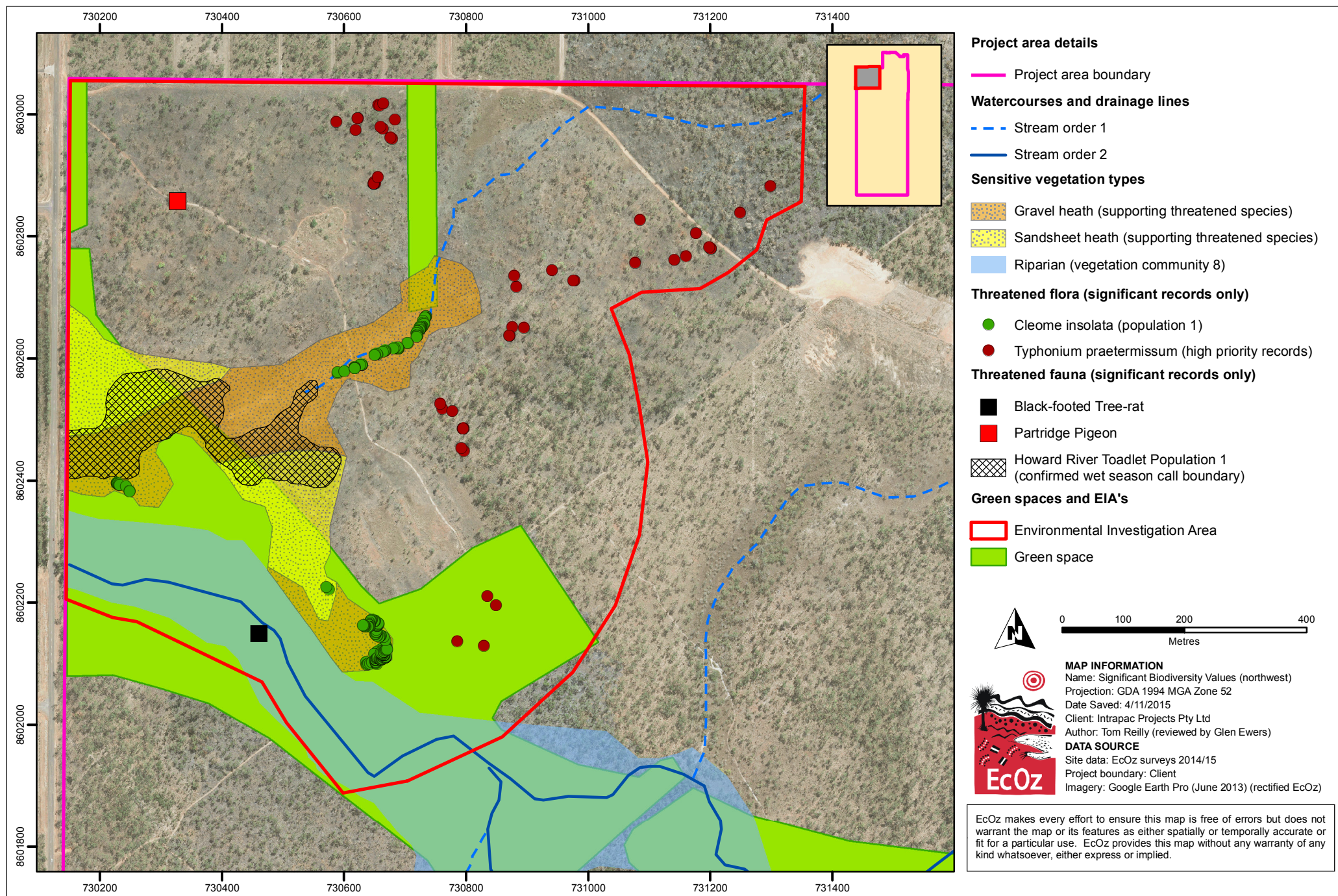
	Species	Federal status	NT status
Flora	Spiderflower (<i>Cleome insolata</i>)	-	VULNERABLE
	Darwin Cycad (<i>Cycas armstrongii</i>)	-	VULNERABLE
	a Typhonium (<i>Typhonium praetermissum</i>)	-	VULNERABLE
Fauna	Howard River Toadlet (<i>Uperoleia daviesae</i>)	-	VULNERABLE
	Mertens’ Water Monitor (<i>Varanus mertensi</i>)	-	VULNERABLE
	Partridge Pigeon (<i>Geophaps smithii smithii</i>)	VULNERABLE	VULNERABLE
	Black-footed Tree-rat (<i>Mesembriomys gouldii</i>)	ENDANGERED	VULNERABLE

As shown in the concept master plan (see Figure 2-2), Noonamah Ridge contains a network of green spaces. All conservation-significant values (including important populations of threatened species) identified in Section 3.9 are contained within the green space network. The green spaces that incorporate conservation-significant values will need to be carefully managed to ensure that the values within them are not compromised. Ongoing, active management will be needed, and responsibility for that is still to be determined (see Section 6.8.3 of the EMP for the strategy for determining this).



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ14400 - Noonamah Ridge Estates EIS\01 Project Files\Flora and Fauna Baseline\Significant Biodiversity Values.mxd

Figure 5-1. Map of the conservation-significant values and the green space network within the project area



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ14400 - Noonamah Ridge Estates EIS\01 Project Files\Flora and Fauna Baseline\Significant Biodiversity Values (northwest).mxd

Figure 5-2. Map of the conservation-significant values and the green space network (north-west corner of the project area)

5.8.2 Potential impacts

The potential impacts to threatened species are land clearing leading to loss of habitat and/or mortality; spread of weeds; increases in fire, dust, noise, feral animals; and changes to hydrology and water quality. Impacts to groundwater are also not considered relevant to this suite of threatened species because none of them occur in habitat that is groundwater-dependent.

5.8.3 Risk assessment

The EIS Terms of Reference expressly require threatened species risk assessment to refer to the *EPBC Significant Impact Guidelines* (Commonwealth of Australia 2013) as a guide to determine whether or not the development is likely to have a significant impact on species of conservation significance. This is a two-step process involving firstly determining the importance of the populations of threatened species that are known to be present or may be present; and then determining whether or not the development will have a significant impact on any of these populations. Important populations identified in the project area are discussed in Section 3.9.

In accordance with the guidelines, for Endangered species, any occurrence of the species within the project area constitutes a population, and all populations are 'important'. For Vulnerable species, an 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity
- Populations that are near the limit of the species' range.

The following threatened species' populations that occur within the project area satisfy the criteria for being an 'important population' (as detailed in Section 3.9):

- Spiderflower (*Cleome insolata*) – the sole population
- *Typhonium praetermissum* – the populations shown in in Figure 5-1 and Figure 5-2
- Howard River Toadlet (*Uperoleia daviesae*) – the populations shown in in Figure 5-1 and Figure 5-2
- Black-footed Tree-rat (*Mesembriomys gouldii*) – the entire population
- Partridge Pigeon (*Geophaps smithii smithii*) – the entire population.

For each species that has important populations within the Noonamah Ridge project area, the significant impact assessment criteria contained within the *EPBC Significant Impact Guidelines* were used to assess the 'inherent likelihood' of significant impact, which is an assessment of the likelihood (high, moderate or low) of impacting the threatened species population if a development proceeded without any mitigation measures implemented. Where the likelihood of significant impact was deemed unacceptable – either High (almost certain) or Moderate (likely) – mitigation measures were developed to avoid or reduce the likelihood of a significant impact occurring, and the likelihood was reassessed to provide a 'residual likelihood' rating based on the assumption that the mitigation measures will

achieve the desired effect. This is followed by an assessment of the certainty that proposed mitigation measures will be effective in avoiding a significant impact, and then a statement on the residual likelihood of the significant impact on the species.

The measures available for reducing the likelihood of a significant impact on each of the five important threatened species populations identified within the project area vary based on the species' status, ecology and behaviour (as well as level of certainty of occurrence). They can be divided into two broad categories – those that have a restricted habitat (and hence a small area of occupancy) within the project area, and the Partridge Pigeon which occurs throughout the dominant vegetation community (*Eucalyptus* woodland) within the project area that will be impacted by land clearing. The 'restricted habitat' species will have their habitat buffered and managed within the development green space network; the potential impacts of the development upon the Partridge Pigeon cannot be avoided, but will be lessened by the fact that only *Eucalyptus* woodlands that occur within the project area are affected, leaving adjoining woodland habitats available for ongoing utilisation by the species

5.8.4 Spiderflower (*Cleome insolata*)

This species is listed as Vulnerable under the *TPWC Act* but is not listed under the *EPBC Act*. An important population of this species occurs in the north-west of the project area (see Figure 3-17). There are two small populations that occur on the edge of Redcliffe Road adjacent, but external, to the project area; these fall outside the responsibility of Intrapac. Potential impacts to this species are land clearing leading to direct mortality and loss of habitat, weeds, fire, dust, human disturbance and changes to hydrology.

Risk assessment

The likelihood of significant impact of this development on this Vulnerable species is assessed against the criteria contained within the *EPBC Significant Impact Guidelines* in the table below:

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Lead to a long-term decrease in the size of an important population	High	The development has been designed such that the Spiderflower population and core habitat within the project area is reserved within a buffered green space that will not be developed. The security of this green space will be ensured within the Area Plan. Management is discussed in Section 6.8 of the EMP.	Low
Reduce the area of occupancy of an important population	High	Retaining the existing hydrology and water quality for this site is imperative. One of the Spiderflower's sub-population's habitat receives water down a drainage line originating off the project area in the north-west – the entire length of this drainage line that occurs within the project area will be contained within green spaces and will not be disturbed. The hydrology of the other two sub-population is not yet clear, but it seems likely that the same drainage line forks or turns to sheet flow, and that that supplies each sub-population. Numerous measures are proposed for the management of stormwater (as described in Section 6.6 of the EMP) in order to maintain existing water quality and quantity. An ESCP will also be developed and implemented for each stage of subdivision to ensure that construction activities do not result in sedimentation downstream (see Section 6.7 of	Low
Fragment an existing important population	High		Low
Adversely affect critical habitat	High		Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Disrupt the breeding cycle of an important population	High	the EMP).	Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent the species is likely to decline	High	Although contained within green spaces, there remains some potential for the population to be impacted upon by human disturbance. To mitigate this, within the relevant green space signage will be installed to inform residents of the conservation-significant species present. If deemed necessary, access restrictions – such as bollards or fences – will be installed around areas where unauthorised access is likely to occur. The potential for reduced habitat area and quality due to dust from construction activities will be minimised through the design, planning and dust suppression measures outlined in Section 6.13 of the EMP. The habitat within which the Spiderflower population occurs is subject to annual fires and yet the population persists, indicating a level of resilience. Nevertheless, each green space that contains conservation-significant species will have its own Fire Management Plan (see Section 6.10 for the general measures that will be the basis of each plan) which will include maintaining fire breaks around the perimeter. Finally, it is mentioned in Westaway and Cowie (2012a) that other populations of this species occur in paddocks and on roadsides (including roadside drains adjacent to the project area). This species therefore appears to be capable of coping with a certain level of disturbance. Therefore, because the population in question will not be disturbed by the development and the species appears to have some resilience to disturbance, it is considered unlikely that the population and critical habitat of this species that occurs within the project area will be detrimentally impacted upon.	Low
Result in invasive species, that are harmful to the species, becoming established in the species' habitat	Moderate	Although not formally identified as such, the spread of introduced perennial grass species such as Gamba Grass and Mission Grass is likely a threat to this species. These high biomass species are known to hinder recruitment of native herbaceous flora such as Spiderflower. They also dramatically increase fuel loads, resulting in more intense fires that may reduce habitat quality for this species. The Spiderflower population within the project area is in proximity to a Mission Grass infestation. However, the micro-habitat supporting the population is not conducive for weed growth, as shown in the photographs of the site in the <i>Flora and Fauna Assessment Report</i> (Figure 4-10 in Appendix I). Nevertheless – left undeveloped – weed abundances onsite could increase over time, threatening this species. As indicated in Section 6.8 of the EMP, the green space within which the Spiderflower population is located will be subject to a site-specific Weed Management Plan – the details of which are yet to be determined (pending the determination of responsibility for the management of the site).	Low
Introduce disease that may cause the species to decline	Low	Disease is not listed as a threatening process for this species. Intrapac is not aware of any literature on diseases that could be introduced by the project and that would detrimentally affect this species.	Low
Interfere with the recovery of a species	High	There is no recovery plan for this species. Conservation objectives, as described in Westaway and Cowie (2012a), are to undertake targeted surveys in suitable potential habitat and to secure the (then) only known site of the species. The surveys for the Noonamah Ridge project have identified additional populations of this species. As described above, the	Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
		population within the project area will be managed within a green space; the two known populations that occur adjacent to the project area are not the responsibility of Intrapac.	

Effectiveness of mitigation

The commitment to buffer the important population of Spiderflower within the green space network – which is enshrined within Area Plan and the SU zoning text (see Section 1.6.4) – greatly reduces the risk of the population being impacted upon by land clearing. Of the remaining potential threats, it is contended that there is a high level of certainty that management of fire, weeds and human use is possible. The requisite management of these threats is not expected to be especially technical; the fire management should be straightforward because the locations of the sub-populations have low levels of vegetation; weed infestations are small and there are established control methods; and disturbance by human activities such as quad-biking can be minimised through signage and vehicle access restriction. What is not yet certain is which entity will be responsible for undertaking such management actions within green spaces that contain conservation-significant values.

There is also a level of uncertainty associated with the hydrology to this species' habitat. Field experience and contour map suggests that the entire population receives its water from a drainage line originating off the project area in the north-west. The entire length of this drainage line that occurs within the project area will be contained within green spaces and will not be disturbed. The catchment of this drainage line, however, is an undeveloped site not within Intrapac's control and so, despite best efforts, the hydrology to this site could be compromised in the future.

Intrapac is intent of resolving both of these uncertainties, hence the establishment of 'environmental investigation areas' and the commitment to engage relevant authorities in a workshop to determine the appropriate size of green spaces, the optimum zoning (and, as a consequence, responsibility management), the degree of public accessibility to key areas, management of key areas (including fire and weed management), monitoring programs (and responsibility for undertaking these), and how to promote within the community an understanding and appreciation of the values 'on their doorstep'. These will be addressed prior any development taking place that could impact upon either 'environmental investigation area' (i.e. Stage 4 scheduled to commence in 12 years' time – see staging map in Figure 2-8).

Conclusion

The important population of Spiderflower will be protected from land clearing within a managed green space. Although management responsibility for this spaces is yet to be resolved, it is likely that fire, weeds and human usage of this space can be managed under a site-specific management plan such that the quality of habitat supporting this population is maintained. Assuming this, and that the hydrology supporting this population is not compromised – something which may be largely out of Intrapac's control – then it is **unlikely** that there will be a significant impact by the development on an important population of this species.

5.8.5 *Typhonium praetermissum*

This species is listed as Vulnerable under the *TPWC Act* but is not listed under the *EPBC Act*. A number of important populations of this species occur within the project area (see Figure 3-16). Potential impacts are land clearing leading to direct mortality and loss of habitat, weeds, fire, dust and human disturbance.

Risk assessment

The likelihood of significant impact of this development on this Vulnerable species is assessed against the criteria contained within the *EPBC Significant Impact Guidelines* in the table below:

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Lead to a long-term decrease in the size of an important population	High	The development has been designed such that all the known important <i>Typhonium praetermissum</i> populations within the project area are reserved within buffered green spaces that will not be developed. The security of these green spaces will be ensured within the Area Plan. Management is discussed in Section 6.8 of the EMP.	Low
Reduce the area of occupancy of an important population	High	Although contained within green spaces, there remains some potential for the populations to be impacted upon by human disturbance. To mitigate this, within the relevant green space will be installed signage to inform residents of the conservation-significant species present. If deemed necessary, access restrictions – such as bollards or fences – will be installed around areas where unauthorised access is likely to occur.	Low
Fragment an existing important population	High	<i>Typhonium praetermissum</i> is significantly less vulnerable to changes in hydrology in comparisons to other threatened flora species in the area. Nevertheless, numerous measures are proposed for the management of stormwater (as described in Section 6.6 of the EMP) in order to maintain existing water quality and quantity. An ESCP will also be developed and implemented for each stage of subdivision to ensure that construction activities do not result in sedimentation downstream (see Section 6.7 of the EMP).	Low
Adversely affect critical habitat	High		Low
Disrupt the breeding cycle of an important population	High		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent the species is likely to decline	High	The habitat within which the populations occur are subject to annual fires and yet they persist, indicating a level of resilience in this regard. Nevertheless, each green space that contains conservation-significant species will have its own Fire Management Plan (see Section 6.10 for the general measures that will be the basis of each plan) which will include maintaining fire breaks around the perimeter. Therefore, because the populations in question will not be disturbed by the development, and the species appears to have some resilience to disturbance, it is considered unlikely that the populations and critical habitat of this species that occurs within the project area will be detrimentally impacted upon.	Low
Result in invasive species, that are harmful to the	Moderate	The spread of introduced perennial grass species such as Gamba Grass and Mission Grass has been identified as a threat to this species. These high biomass species are known to hinder recruitment of native herbaceous flora. They also dramatically	Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
species, becoming established in the species' habitat		increase fuel loads resulting in more intense fires that may reduce habitat quality for this species. One of the populations of this species within the project area is in proximity to a small Gamba Grass infestation. Left undeveloped, weed abundances onsite would likely increase over time, threatening this species. As indicated in Section 6.8 of the EMP, the green spaces within which the important <i>Typhonium praetermissum</i> populations are located will be subject to a site-specific Weed Management Plan – the details of which are yet to be determined (pending the determination of who is responsible for the management of the site).	
Introduce disease that may cause the species to decline	Low	Disease is not listed as a threatening process for this species. Intrapac is not aware of any literature on diseases that could be introduced by the project and that would detrimentally affect this species.	Low
Interfere with the recovery of a species	High	There is no recovery plan for this species. Conservation objectives, as described in Westaway and Cowie (2012b), are to determine the extent of existing populations, to undertake targeted surveys in suitable potential habitat and to protect known sites from disturbance by feral pigs. The surveys for the Noonamah Ridge project have identified additional important populations of this species. As described above, the populations will be contained within green spaces that will be managed to, amongst other things, exclude disturbance by feral pigs.	Low

Effectiveness of mitigation

The commitment to buffer the important populations of *Typhonium praetermissum* (but not, note, every occurrence of this species in the project area) within the green space network – which is enshrined within Area Plan and the SU zoning text (see Section 1.6.4) – greatly reduces the risk of the population being impacted upon by land clearing. Of the remaining potential threats, it is contended that there is a high level of certainty that management of fire, weeds and human use is possible. The requisite management of these threats is not expected to be especially technical; the fire management should be straightforward because the locations of important populations are already subject to fire management; weed infestations are small and there are established control methods; and disturbance by human activities such as quad-biking can be minimised through signage and vehicle access restriction. What is not yet certain is which entity will be responsible for undertaking such management actions within green spaces that contain conservation-significant values.

Intrapac is intent of resolving both of these uncertainties, hence the establishment of 'environmental investigation areas' and the commitment to engage relevant authorities in a workshop to determine the appropriate size of green spaces, the optimum zoning (and, as a consequence, responsibility management), the degree of public accessibility to key areas, management of key areas (including fire and weed management), monitoring programs (and responsibility for undertaking these), and how to promote within the community an understanding and appreciation of the values 'on their doorstep'. These will be addressed prior any development taking place that could impact upon either 'environmental investigation area' (i.e. Stage 4 scheduled to commence in 12 years' time – see staging map in Figure 2-8).

Conclusion

The important populations of *Typhonium praetermissum* will be protected from land clearing within managed green spaces. Although management responsibility for these spaces is yet to be resolved, it is likely that fire, weeds and human disturbance of these spaces can be managed under site-specific management plans such that the quality of habitat supporting this population is maintained. Assuming this, then it is **unlikely** that there will be a significant impact by the development on the important populations of this species.

Habitat containing other populations of this species that are not considered 'important' may be disturbed or destroyed due to activities associated with this development. Further detail in relation to the assessment process applied to determine the importance of the populations identified within the project area is provided in Section 3.9.

5.8.6 Howard River Toadlet (*Uperoleia daviesae*)

This species is listed as Vulnerable under the *TPWC Act* but is not listed under the *EPBC Act*. A number of important populations of this species occur within the project area (see Figure 3-16 and Figure 3-17). Potential impacts are land clearing leading to mortality and loss of habitat, feral animals, human disturbance, water quality and changes to hydrology.

Risk assessment

The likelihood of significant impact of this development on this Vulnerable species is assessed against the criteria contained within the *EPBC Significant Impact Guidelines* in the table below:

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Lead to a long-term decrease in the size of an important population	High	The development has been designed such that all the important Howard River Toadlet populations and supporting habitat within the project area are reserved within buffered green spaces that will not be developed. The extent of these is yet to be determined, pending further environmental investigations (as discussed in Section 2.2.4). The security of these green spaces will be ensured within the within the Area Plan. Management is discussed in Section 6.8 of the EMP.	Low
Reduce the area of occupancy of an important population	High	Retaining the existing hydrology and water quality for these sites is imperative. Whilst the 'environmental investigation area' (see Section 2.2.4) in the north-west is adjacent to the major drainage line from the project area, that section of the drainage line appears to be confined to a defined channel (with riparian vegetation either side) and the Howard River Toadlet habitat in question instead likely receives its water down a drainage path originating off the project area in the north-west. Likewise, contour mapping indicates that the other 'environmental investigation area' relevant to Howard River Toadlet likely receives its water from a clearly-defined catchment that is not influenced by the major drainage line. Therefore, although not expected to occur, even if there are changes to the quality or quantity of water flows down the major drainage line, these would not affect the Howard River Toadlet habitat within these 'environmental investigation areas'.	Low
Fragment an existing important population	High		Low
Adversely affect critical habitat	High	Nevertheless, numerous measures are proposed for the management of stormwater (as described in Section 6.6) in order to	Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
		maintain existing water quality and quantity. An ESCP will also be developed and implemented for each stage of subdivision to ensure that construction activities do not result in sedimentation downstream (see Section 6.7 of the EMP). Although contained within green spaces, there remains some potential for the populations to be impacted upon by human disturbance. To mitigate this, within the relevant green space will be installed signage to inform residents of the conservation-significant species present. If deemed necessary, access restrictions – such as bollards or fences – will be installed around areas where unauthorised access is likely to occur. Therefore, because the populations in question will not be disturbed by the development, it is considered unlikely that the populations and critical habitat of this species will be detrimentally impacted upon.	
Disrupt the breeding cycle of an important population	High	An increase in noise above ambient levels has been identified as having a negative impact on the richness and abundance of amphibian populations (Eigenbrod et al. 2009). This is likely because amphibians use calling as the primary method for species recognition, territorial interaction and mate choice that may be impacted by increase in background noise. Female frogs may have harder times finding mates in noisy areas (Bee and Swanson 2007), and males have been shown to change call frequency (Parris et al. 2009; Hoskin & Goosem 2010) and call rate (Sun & Narins 2005; Hoskin & Goosen 2010) in the presence of increased noise.	Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent the species is likely to decline	High	Similarly, artificial light has the potential to negatively impact the physiology and behaviour of amphibians. Increased night-time ambient light has been linked to modified calling rate (Baker & Richardson 2006), reproductive behaviour (Buchanan 2006), general behaviour (Baker & Richardson 2006) and foraging (Henderson & Powell 2001). Changes in calling rate and reproductive behaviour can lead to reduced reproductive success, whilst changes in changes in foraging behaviour can include congregation of animals around light sources (Henderson & Powell 2001) which, in turn, can lead to increased predation or mortality (Buchanan 2006). The potential for noise and light to impact upon the important Howard River Toadlet populations has been ameliorated through the project design. Specifically, areas of calling habitat have been buffered within the green space network – with one consequence being a separation between potential light/noise sources and that habitat. This method of impact minimisation is reflected in the recommendations of Newport et al. (2014) who describe careful planning of urban development that reduces the impact of noise on animals as a suitable control method. Similarly, the separation reduces the intensity of light at the habitat location, and thus likely impacts. Additionally, Intrapac has committed to minimising the use of street lights (as described in Section 2.6).	Low
Result in invasive species, that are harmful to the species, becoming established in the species' habitat	Low	There is no documentation of an invasive species being a threat to <i>Uperoleia daviesae</i>. Cane Toads may prey upon this species; however, this pest species is already well-established onsite. It is possible that Cane Toad abundances will be reduced once the site is developed, as has happened in other developed areas in the greater Darwin region. Likewise, Feral Pigs that may currently disturb this species' core habitat will likely be eradicated once the project area is developed. Although not formally identified as such, the spread of introduced perennial grass species such as Gamba Grass and Mission Grass may be a threat to this species. These high biomass species are known to hinder recruitment of native herbaceous flora that, in turn, could be detrimental to the micro-habitat requirements of Howard River Toadlet.	Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Introduce disease that may cause the species to decline	Low	Disease is not listed as a threatening process for this species. Intrapac is not aware of any literature on diseases that could be introduced by the project and that would detrimentally affect this species.	Low
Interfere with the recovery of a species	High	There is no recovery plan for this species. Conservation objectives – as described in Ward et al. (2012) – are to ‘protect’ known populations from development and mining, and to undertake further research to more precisely delineate distribution, habitat preferences and ecology of the species. The surveys for the Noonamah Ridge project have identified additional populations of this species. As described above, the important populations will be managed within green spaces.	Low

Effectiveness of mitigation

The commitment to buffer the important populations of Howard River Toadlet (but not, note, every occurrence of this species in the project area) within the green space network – which is enshrined within Area Plan and the SU zoning text (see Section 1.6.4) – greatly reduces the risk of the population being impacted upon by land clearing, as well as by light and noise. Of the remaining potential threats, it is contended that there is a high level of certainty that management of weeds and human use is possible. The requisite management of these threats is not expected to be especially technical; weed infestations are small and there are established control methods; and disturbance by human activities such as quad-biking can be minimised through signage and vehicle access restriction. What is not yet certain is which entity will be responsible for undertaking such management actions within green spaces that contain conservation-significant values.

There is also a level of uncertainty associated with the hydrology to this species’ habitat. Field experience and contour map suggests that the population in the north-west of the project area receives its water from a drainage line originating off the project area in the north-west. The entire length of this drainage line that occurs within the project area will be contained within green spaces and will not be disturbed. The catchment of this drainage line, however, is an undeveloped site not within Intrapac’s control and so, despite best efforts the hydrology to this site could be compromised in the future. Contour mapping indicates that the other ‘environmental investigation area’ relevant to Howard River Toadlet likely receives its water from a clearly-defined catchment that is not influenced by the major drainage line.

Intrapac is intent of resolving both of these uncertainties, hence the establishment of ‘environmental investigation areas’ and the commitment to engage relevant authorities in a workshop to determine the appropriate size of green spaces, the optimum zoning (and, as a consequence, responsibility management), the degree of public accessibility to key areas, management of key areas (including fire and weed management), monitoring programs (and responsibility for undertaking these), and how to promote within the community an understanding and appreciation of the values ‘on their doorstep’. These will be addressed prior any development taking place that could impact upon either ‘environmental investigation area’ (i.e. Stage 3 scheduled to commence in 8 years’ time – see staging map in Figure 2-8).

Conclusion

The important populations of Howard River Toadlet will be protected from land clearing within managed green spaces. Although management responsibility for these spaces is yet to be resolved, it is likely that weeds and human disturbance of these spaces can be managed under site-specific management plans such that the quality of habitat supporting these population is maintained. Assuming this, and that the hydrology supporting these populations are not compromised – something which may be largely out of Intrapac’s control for the north-west population – then it is **unlikely** that there will be a significant impact by the development on the important populations of this species.

Habitat containing other populations of this species that are not considered ‘important’ may be disturbed or destroyed due to activities associated with this development. Further detail in relation to the assessment process applied to determine the importance of the populations identified within the project area is provided in Section 3.9.

5.8.7 Black-footed Tree-rat (*Mesembriomys gouldii*)

This species is listed under the *EPBC Act* as Endangered and under the *TPWC Act* as Vulnerable. A population of this species occurs within the project area (see Figure 3-16). Potential impacts are land clearing leading to direct mortality and loss of habitat, weeds, fire, noise, dust and human disturbance.

Risk assessment

The likelihood of significant impact of this development on this Endangered species is assessed against the criteria contained within the *EPBC Significant Impact Guidelines* in the table below:

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Lead to a long-term decrease in the size of the population	High	The development has been designed such that the Black-footed Tree-rat population and core riparian vegetation habitat within the project area is reserved within buffered green spaces that will not be developed. The current connectivity between the core riparian habitat within the project area and the adjacent habitats outside of the project area will not be diminished. The security of these green spaces will be ensured within the Area Plan. Management is discussed in Section 6.8 of the EMP. The potential for mortality of animals to occur during land clearing and construction will be reduced using a fauna spotter-catcher onsite during all vegetation clearing activities. They will follow the Vegetation Clearing Management Procedure and Wildlife Rescue Procedure (see Section 6.8 of the EMP). Although contained within green spaces, there remains some potential for the population to be impacted upon by human disturbance. To mitigate this, within the relevant green space will be installed signage to inform residents of the conservation-significant species present. If deemed necessary, access restrictions – such as bollards or fences – will be installed around areas where unauthorised access is likely to occur. The potential for reduced habitat area and quality due to dust from construction activities will be minimised through the design,	Low
Reduce the area of occupancy	High		Low
Fragment the existing population	High		Low
Disrupt the breeding cycle of a population	High		Low
Modify, destroy, remove, isolate or decrease the availability or quality	High		Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
of habitat to the extent the species is likely to decline		planning and dust suppression measures outlined in Section 6.13 of the EMP. Likewise, specific noise management actions will be outlined in each future CEMP based on the standard measures provided in Section 6.12 of the EMP.	
Adversely affect critical habitat	High	The habitat within which the population occurs is subject to annual fires and yet Black-footed Tree-rat persists, indicating a level of resilience in this regard. Nevertheless, each green space that contains conservation-significant species will have its own Fire Management Plan (see Section 6.10 for the general measures that will be the basis of each plan) which will include maintaining fire breaks around the perimeter. Therefore, because the populations in question will not be disturbed by the development, it is considered unlikely that the populations and critical habitat of this species will be detrimentally impacted upon.	Low
Result in invasive species, that are harmful to the species, becoming established in the species' habitat	Moderate	Predation by Feral Cats is considered a plausible but not demonstrated threat to Black-footed Tree-rat (DoE 2015). Regardless, this development should not lead to a significant increase in Feral Cats. Likewise, Cane Toads are considered a possible but not demonstrated threat to this species. This threat may be indirect if Cane Toads reduced both cat-eating pythons and food-competing (for cats) goannas (DoE 2015). It is possible that Cane Toad abundances will be reduced once the site is developed, as has happened in other developed areas in the greater Darwin region. Weeds are also considered a plausible but not demonstrated threat to this species (DoE 2015). Invasive grasses change the ability of this species to forage effectively on the ground, and result in fires that are far more intense. As indicated in Section 6.8 of the EMP, the green spaces within which the Black-footed Tree-rat population is located will be subject to a Weed Management Plan – the details of which are yet to be determined (pending the determination of who is responsible for the management of the site).	Low
Introduce disease that may cause the species to decline	Low	Disease is not listed as a threatening process for this species. Intrapac is not aware of any literature on diseases that could be introduced by the project and that would detrimentally affect this species.	Low
Interfere with the recovery of a species	High	The Conservation Advice (DoE 2015) provided to support this species' nomination for federal listing as an Endangered species is considered to provide sufficient direction to implement priority actions and militate against key threats. That document contains a large number of conservation and management actions, none of which will be interfered with by this development. In fact, the actions relating to reducing fire frequency and intensity, constraining invasive pasture grasses, maintaining habitat patch integrity, and increasing the profile of the species in the Darwin peri-urban area to advocate for its protection, will likely be advanced through this development.	Low

Effectiveness of mitigation

The commitment to buffer all riparian habitat within the green space network – which is enshrined within Area Plan and the SU zoning text (see Section 1.6.4) – greatly reduces the risk of the Black-footed Tree-rat population being impacted upon by land clearing, and also maintains current connectivity between the core riparian habitat within the project area and the adjacent habitats outside of the project area. Anecdotally, this species has some resilience to rural development and remains relatively common in the rural area where there are large blocks with remnant vegetation.

Of the remaining potential threats, it is contended that there is a high level of certainty that management of fire, weeds and human use is possible. The requisite management of these threats is not expected to be especially technical; weed infestations are small and there are established control methods; and disturbance by human activities can be minimised through signage and access restriction. Fire management should be straightforward because riparian areas are less susceptible to fire and also because there will be less adjacent woodland within which fires can be generated. Moreover, given the development will result in less frequent and less intense fires within the project area, a better mosaic of fire ages (and hence a denser mid-story) is likely to be established. As a consequence, this species may return or increase in population size once food resources and roost locations become more abundant. What is not yet certain is which entity will be responsible for undertaking such management actions within green spaces that contain conservation-significant values.

Intrapac is intent of resolving this uncertainties, hence the commitment to engage relevant authorities in a workshop to determine the appropriate size of green spaces, the optimum zoning (and, as a consequence, responsibility management), the degree of public accessibility to key areas, management of key areas (including fire and weed management), monitoring programs (and responsibility for undertaking these), and how to promote within the community an understanding and appreciation of the values 'on their doorstep'.

Conclusion

The population of Black-footed Tree-rat will be protected from land clearing within managed green spaces. Although management responsibility for these spaces is yet to be resolved, it is likely that weeds and human disturbance of these spaces can be managed under site-specific management plans such that the quality of habitat supporting these population is maintained. Assuming this, then it is **unlikely** that there will be a significant impact by the development on the important populations of this species.

5.8.8 Partridge Pigeon (*Geophaps smithii smithii*)

This species is listed as Vulnerable under the *EPBC Act* and the *TPWC Act*. Surveys confirm that Partridge Pigeon utilise habitat within the project area (see Figure 3-16). All sightings occurred within the dominant onsite vegetation community – *Eucalyptus* woodland. Given there is similar such habitat immediately to the east of the project area, it is unlikely that the local population of this species is confined to the project area only; however, the degree to which that population depends on the project area is unknown. In the absence of longer term and more widespread studies (in suitable habitat to the east of the project area), and the fact that the records of this species within the project area are the closest recent records to Darwin, the local population of this species is considered a population near the limit of the species' range, and therefore an 'important population'.

Potential impacts to this species are land clearing leading to direct mortality and loss of habitat, weeds (namely the resultant increase in fire fuel loads) and fire.

Risk assessment

The likelihood of significant impact of this development on this Vulnerable species is assessed against the criteria contained within the *EPBC Significant Impact Guidelines* in the table below:

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
Lead to a long-term decrease in the size of an important population	Unknown	Partridge Pigeon appears to prefer large areas of contiguous habitat; there is a strong negative correlation between development and this species' presence. Once developed, the project area will unlikely constitute suitable habitat for the species. The local population of Partridge Pigeon is likely associated with the extensive area of bushland to the east – possibly utilising the project area during the wet season when there is drinking water available onsite, and retracting to the east as water sources disappear. It is unknown the degree to which the local population is dependent on the habitat within the project area, and therefore inconclusive as to whether the loss of habitat will lead to a long-term decrease in the size of that population.	Unknown
Reduce the area of occupancy of an important population	High	Land clearing for this development will reduce the area of occupancy of the local population – especially given that this species appears to prefer large areas of contiguous habitat. However, vegetation clearing will be undertake stage-by-stage, and only where required.	High
Fragment an existing important population	Low	This species is considered unlikely to occur directly to the north, south or west of the project area. The project area constitutes suitable habitat for Partridge Pigeon; however, whilst land clearing will reduce the area of occupancy for this species, it will not fragment the local population associated with the bushland to the east.	Low
Adversely affect critical habitat	Unknown	What constitutes critical habitat for this species is unclear, but most likely relates to the influence of fire on availability of food species and ground cover. The lack of dry season water sources and low number of records within the project area – despite numerous site visits and comprehensive surveys - indicates that the site may constitute sub-optimal or fringe habitat. It is unknown the degree to which the local population is dependent on the habitat within the project area.	Unknown
Disrupt the breeding cycle of an important population	Low	It is not known if the species nests in the project area; if it does, then construction activities occurring during the dry season could impact on nesting success. Each CEMP will include a Weed Management Plan (see Section 6.8 for the general measures that will be the basis of each plan) and controls to ensure that any bushfires started by project activities do not spread into surrounding areas. The implementation of a Fire Management Plan should ensure that controlled burning within the project area is undertaken with spatial heterogeneity (patchiness) in mind, which is preferred by the Partridge Pigeon.	Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent the species is likely to decline	Unknown	Land clearing and modification resulting from this development will modify, destroy, remove and/or decrease the availability or quality of habitat for the local population. However, given the extent of suitable habitat contiguous to the east of the project area, a reduction in habitat availability and quality will not necessarily correlate with a decline in the local population of this species. It is unknown the degree to which the local population is dependent on the habitat within the project area, and therefore inconclusive as to whether the loss of habitat will lead to a decline in the species.	Unknown
Result in invasive species, that are harmful to the	Low	Despite the presence of Feral Cats, the population of Partridge Pigeon persists within the project area. It is not expected that this development will lead to a significant increase in Feral Cats.	Low

Criterion	Inherent likelihood	Summary of mitigation measures and significant impact assessment	Residual likelihood
species, becoming established in the species' habitat			
Introduce disease that may cause the species to decline	Low	Disease is not listed as a threatening process for this species. Intrapac is not aware of any literature on diseases that could be introduced by the project and that would detrimentally affect this species.	Low
Interfere with the recovery of a species	Low	There is a joint recovery plan for this species and three other savannah bird species (Woinarski 2004). None of the recovery plan actions are taking place within the project development area, therefore thus this development will not interfere with the recovery of the species.	Low

Effectiveness of mitigation

Partridge Pigeon utilise the Eucalyptus woodland that covers most of the project area and surrounding region. The extent to which the Partridge Pigeon use the project area is not well understood and, given the ephemeral nature of surface water availability, it is hypothesised that use may be restricted to periods when water is available, and the project area may therefore constitute fringe habitat of a population associated with the extensive area of bushland to the east. Nevertheless, this habitat will be cleared for development – reducing feeding and possibly breeding opportunities – and it is therefore highly likely that this species will not persist within the project area once development is complete.

Conclusion

Whether or not this will lead to a significant impact upon the local population of this species is **unknown**, and depends on two yet-to-be-determined factors – the size of the local population and the extent to which that population utilises and relies upon the project area.

5.8.9 Summary

There are five species for which one or more important populations have been identified as occurring within the project area. For four of these it is considered unlikely that they will be significantly impacted upon by the development. For the remaining species – Partridge Pigeon – it is unknown whether there will be a significant impact on the local population (which utilises, but is likely not confined to, the project area). Once developed, it is likely that the project area will no longer constitute suitable habitat for the population; however, it is not known whether this will lead to a decline in that population, because the degree to which that population is dependent upon that area cannot be determined.

5.9 CULTURAL HERITAGE

The environmental objectives for cultural heritage are to identify, understand and mitigate the potential impacts of the project on items or places that have historic and/or cultural heritage values and are protected under heritage legislation.

5.9.1 Context

An Aboriginal Areas Protection Authority certificate (C2015/111) has been acquired for the project area – see Appendix M. It identifies a sacred site immediately to the south-east of the project area, with an associated Restricted Works Area that extends into the project area – see Figure 3-22. The sacred site (5172-61) features a spring.

An archaeological survey was conducted in November 2014 – see Appendix L for full report. Seven stone artefact scatters were found, predominately on low laterite ridges adjacent to creeks. One of the scatters was found in a rock shelter, sufficiently large enough to hold deep deposits. The site is of high significance because of the excavation potential it offers. The remaining artefact sites are regarded as being of medium or low significance.

A World War II (WWII) bomber crash site is located in the within the project area. The wreck is of a 15 tonne B-25D 'Mitchell', a twin-engine medium bomber. The pilot was killed in the crash and was buried in an Indonesian cemetery; the site is therefore not a war grave. Despite its intrinsic significance, the aircraft, its crew and the crash event is poorly known, and the site is not listed on the Northern Territory Heritage Register.

5.9.2 Potential impacts

The main potential impacts concerning cultural heritage are damage to, or loss of, archaeological and cultural sites during construction, and/or deliberate disturbance/vandalism of heritage sites protected within the green space network during occupancy – see Figure 5-3.

The sacred site is a water-dependent ecosystem, thus any on-site activities that lead to a reduction in water quality or quantity may deleteriously affect this site.



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Figure 5-3. Map of the significant archaeological sites and the green space network

5.9.3 Risk assessment

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Operation of machinery, land clearing, laydown and stockpile activities	Damage to, or loss of, known high significance archaeological and cultural sites	4	E	23	CONTRACTOR • C P Develop a CEMP for each subdivision that includes a Heritage Management Plan detailing requirements for site avoidance and the procedures to follow for unknown sites (based on Section 6.9.2 of the EMP).	4	A	10
		Damage to, or loss of, known low significance archaeological artefacts	2	E	16	CONTRACTOR • C Prior to construction commencing, an archaeologist will, in consultation with the Heritage Branch, identify, collect, label, bag, group and bury all artefacts together in a sealed box at a keeping place within the project area (see Section 6.9.2 of EMP).	2	A	3
		Damage to, or loss of, as yet unknown archaeological and cultural sites ¹	3	B	9	CONTRACTOR • C P Develop a CEMP for each subdivision that includes a Heritage Management Plan detailing the procedures to follow for new discoveries (based on Section 6.9.2 of the EMP).	3	B	9
Residential occupancy	Residents use of future parks and reserves	Disturbance or damage to archaeological or heritage sites by recreational users of the green spaces containing these sites ²	4	D	21	INTRAPAC • C Conserve <i>in situ</i> high value archaeological sites within reserves that are part of the green space network – see Figure 5-3. • C Install information signs and/or bollards in vicinity of archaeological sites to minimise accidental interference or damage to sites. • C Preserve the bomber site in-situ and investigate listing the bomber wreck on the NT Heritage Register. COUNCIL • Maintain reserves to preserve the fabric ³ of the sites from weeds and fires.	4	C	18
Storage and use of hazardous chemicals	Seepage of contaminants into aquifers	Habitat deterioration leading to desecration of a groundwater-dependent sacred site to the	3	C	13	CONTRACTOR • P Develop and implement a Construction Environmental Management Plan (CEMP) for each	3	B	9

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
		east of the project area due to compromised water quality				subdivision that specifies storage and handling requirements for hazardous materials during construction. INTRAPAC • C Monitor water quality in key bores surrounding the development. ⁴			
Disposal of treated sewerage - individual systems (e.g. septic tanks)	Seepage of contaminants into aquifers <i>Note: If this occurred, it would likely be in low volumes</i>		3	C	13	INTRAPAC • C P Locate septic systems away from groundwater bores (i.e. at least 100 m) and in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for every subdivision that contains lots that will have a residential septic system). • C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of septic systems (e.g. by licenced plumbers), including installation of non-conventional systems where soil limitations exist. • C Monitor water quality at key bores surrounding the development and at key locations in drainage lines downstream of the development. ⁴	2	A	3
Disposal of treated sewerage - community-scale treatment plants	Seepage of contaminants into aquifers. <i>Note: If this occurred, volumes would likely be higher than for septs.</i>		4	C	18	INTRAPAC • C P Require appropriate design (i.e. in accordance with DoH guidelines) and construction of community-scale wastewater treatment systems to tertiary standards. • C P Locate treated wastewater irrigation disposal areas away from groundwater bores (i.e. at least 100 m). • C P Locate treated wastewater irrigation disposal areas in suitable soils (as identified in the preliminary <i>Land Capability Assessment</i> in Appendix H, as well as in the subsequent LCA's undertaken for each community-scale plant). • C P Ensure that the design and operation of irrigation	3	A	6

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
						system is appropriate (see Section 2.10.3 and 2.10.7) and has monitoring and management safeguards (see Section 6.6.1 of EMP).			
Extraction of groundwater	Decrease in aquifer water levels and/or flows	Habitat deterioration leading to desecration of a groundwater-dependent sacred site to the east of the project area because of insufficient water	4	C	18	INTRAPAC • C Undertake a Groundwater Sustainability Study prior to commissioning a bore-field in order to understand and predict the response of the aquifer to extraction. • C Gauge bore-fields and limit the extraction of groundwater from bore-fields and individual lots to within specified sustainable levels (i.e. 20 % of annual recharge). • C Investigate ways to manage and monitor water extraction by individual lots, including the possibility of having multiple lots connected to a single bore (i.e. five lots to a bore). • Promote minimisation of water use through community education. • Minimise water use by recycling of wastewater (e.g. irrigation of recreation areas). • C Monitor water quantity in key bores surrounding the development.³	3	B	9
Increase in impervious surfaces (e.g. roofs, roads, compacted soils)	Decreased recharge of local aquifers		3	C	13	INTRAPAC • C P Integrate within the subdivision design relevant principles of <i>water-sensitive urban design</i>, which include maximising permeable surfaces available for infiltration (e.g. via swales and/or stormwater detention basins). • C Investigate the potential for active recharge of aquifers using excess stormwater.	3	B	9

¹ A comprehensive and systematic archaeological survey has been undertaken – see Appendix L. It is assumed that all high significance sites have been identified within the project area.

² The bomber site is considered particularly high risk due to looters and/or people interacting with the wreckage.

³ This is the term used in the Burra Charter (see Section 6.9 of the EMP) and refers to all the physical material of the place – including components, fixtures, contents and objects.

⁴ Refer to Water Monitoring Program in Section 6.6.4 of the EMP.

5.9.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with cultural heritage, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- A comprehensive and systematic archaeological survey has been undertaken – see Appendix L – and so it can be assumed with a high degree of confidence that all high significance sites have been identified within the project area.
- The management approach proposed for low and medium significance sites is standard and condoned with the Heritage Branch's interpretation of the *Heritage Act*.
- Prior to commencement of works, it is a standard condition for a subdivision approval permit that a Heritage Management Plan be submitted and approved by the consent authority. Development of a subdivision cannot proceed until all conditions have been met.
- It is acknowledged that there remains a risk of wilful disturbance of, or damage to, culturally significant sites – particularly of people 'souveniring' artefacts. Beyond installing information signs and/or bollards, little can be done to prevent a determined individual from such acts.
- There is a high level of certainty around the management of the risks associated with groundwater contamination from wastewater treatment systems (see Section 5.6.4).

5.10 BUSHFIRE

The environmental objectives for bushfires are:

- To minimise the impact of major bushfires on human life as the highest priority, communities, essential and community infrastructure, industries, the economy and the environment. Human life will be afforded priority over all other considerations.
- To maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water and carbon storage.

5.10.1 Context

The project area is located within a rural, largely vegetated region that requires management for bushfires. Currently, onsite fire management is undertaken by the Elizabeth Valley Fire Brigade on behalf of the landowner, and involves one annual (early dry season) burn along the western, northern and southern boundaries of the project area to create a firebreak. The remaining project area is frequently burnt in the mid-to-late dry season due to the actions of 'fire-bugs' deliberately lighting fires.

Bushfires NT is responsible for implementing the *Bushfires Act* and supporting rural landholders with fire mitigation. Urban fire management is overseen by the Northern Territory Fire and Rescue Service (NTFRS). Maintenance of higher density urban areas within the Municipality of Litchfield is managed by the Litchfield Council, who undertake activities such as slashing, mowing and spraying of verges and parks to reduce fuel loads. House fires are not covered by Bushfires NT or volunteer fire brigades, and the project area is outside of the emergency response area for the Darwin and Berrimah region. As such, NTFRS are obliged to prioritise house fires within the emergency response area before responding to house fires in the project area. During business hours, the nearest response brigade is the Humpty Doo Volunteer Fire Brigade, and after hours, the Palmerston Fire Brigade is closest.

5.10.2 Potential impacts

The main potential impacts associated with bushfires are injury to humans, damage to property and infrastructure, and loss of biodiversity. This includes the possibility that project-related activities may increase the severity and/or frequency of bushfires. This, in turn, may increase the burden on existing fire-fighting resources.

5.10.3 Risk assessment

The risks to biodiversity from bushfire are assessed in Section 5.7.3. Risks to people and property are assessed below.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C ¹	L	RS		C	L	RS
Construction works	Use of power tools and construction machinery (e.g. bulldozers) igniting a fire	Injury to humans, as well as property and infrastructure damage, due to bushfire	4	B	14	CONTRACTOR • Develop a CEMP for each subdivision that includes construction-specific management measures to comply with Fire and Emergency Regulations (as described in Section 6.10.2 of the EMP). • C P Install fire breaks around all infrastructure, laydowns and work areas in line with Bushfire Regulations. • C P Develop an Emergency Response Plan for construction period. • C P Stockpile all material in line with Fire and Emergency Regulations. • C P Adopt all other actions as per Section 6.10.2 of the EMP.	3	A	6
Subdivision design	Unmanaged interfaces between rural and urban allotments	Injury to humans, as well as property and infrastructure damage, due to bushfire	4	D	21	INTRAPAC • C Design subdivisions to avoid creating large tracts of land for which there is not a clear fire management responsibility.	3	B	9
	Location of lots within fire prone areas (especially those near the eastern, undeveloped boundary of the project area)		4	E	23	INTRAPAC • C Design subdivisions to include emergency evacuation routes. • Design subdivisions with firebreaks around higher density areas. COUNCIL • Install and maintain fire breaks around higher density areas. • Manage public vegetation areas within urban or higher density areas to reduce fuel loads (e.g. mowing curbs/spraying weeds).	4	B	14
	Increased population, fire	Strain on resources for fire	3	C	13	INTRAPAC	3	A	6

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C ¹	L	RS		C	L	RS
	management activities and fire response areas	response and fire management (Bushfires NT, NTFRS, Volunteers, Litchfield Council)				• C Lobby to have the emergency response area extended to include the project area. • C Provide land for the establishment of a new volunteer fire brigade within Village One			
Residential occupancy	Individual fire management (stockpiling and/or burning off)	Injury to humans, as well as property and infrastructure damage, due to bushfire	4	B	14	INTRAPAC • Provide education material to lot owners regarding maintenance of 4 m boundary firebreaks by rural lot owners in line with Bushfires Regulations. • C Allocate emergency evacuation routes within subdivision design. • Design subdivisions with firebreaks around higher density areas. COUNCIL • Install and maintain fire breaks around higher density areas. • Implement boundary firebreaks around project area to minimise risk of spread to neighbouring properties.	3	A	6
	'Fire-bug' activities		4	D	21		3	C	13

¹ Although death can be a consequence of a bushfire in the southern states, in the Top End, fires are usually not as intense and severe, and Bushfires NT have no documented cases of human fatalities due to bushfire in the NT. As such, the inherent consequence rating has been assigned as 4.

5.10.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of most of the mitigation measures proposed to reduce risks associated with bushfire, for the following reasons:

- All of the measures labelled (**C**) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (**P**) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- A CEMP that includes management measures to comply with fire and emergency regulations is a standard condition for a subdivision approval permit. Development of a subdivision cannot proceed until all conditions have been met.

- The emergency response area is regularly extended to incorporate new developments. Lobbying for this occur in order to incorporate the project area is expected to be a formality once the population of Noonamah Ridge justifies such an extension.

Little can be done, unfortunately, to reduce the likelihood of a fire-bug deliberately starting a fire within the project area. The best strategy is to minimise the damage such fires cause, primarily through controlled burns, and the establishment and maintenance of fire breaks. During the occupancy phase of the development, the responsibility for bushfire management will lie with Litchfield Council, landowners and Bushfires NT. Intrapac is limited in the influence it has on these actors and cannot vouch for that they will effectively manage for bushfire.

5.11 BITING INSECTS

The environmental objectives for biting insects are:

- Reduction in existing onsite mosquito breeding habitat to reduce existing mosquito numbers.
- Avoid exposure of construction staff, future residents and users of the site to mosquito-borne diseases.

5.11.1 Context

An assessment of biting insects within the project area was completed by Medical Entomology, Department of Health (see Appendix K). The survey trapping identified 21 mosquito species. Certain species that can be vectors for mosquito-borne diseases were abundant. Breeding sites were identified within the project area – including borrow pits, vehicle tracks in grassy drainage lines and swamps in the south-west corner. Additionally, the large seasonally-inundated areas external to the project area in the north and west appear to provide significant breeding habitats and are located within mosquito dispersal distance to the project area.

5.11.2 Potential impacts

The main potential impacts concerning biting insects are the health effects of exposure to mosquito-borne diseases, as well as reduced social amenity due to pest mosquitoes.

5.11.3 Risk assessment

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Pooling water (e.g. in laydown areas, stockpiles, tracks, in drum/tyres)	Reduced human health from mosquito-borne diseases due to the creation of mosquito breeding habitat	4 ¹	D	21	CONTRACTOR • C Undertake drainage work to avoid the creation of pooling water. • C Remove materials that may hold water (e.g. drums/pipes). • C Inspect laydowns weekly for pooling water (during wet season).	4 ¹	C	18
		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	C	8		2	B	5
	Presence of construction staff onsite	Reduced human health from mosquito-borne diseases due to the exposure of construction staff to mosquitoes	4 ¹	D	21		4 ¹	C	18
Drainage infrastructure (e.g. drains, swales, sedimentation basins, lakes)	Increased area of standing waterbodies	Reduced human health from mosquito-borne diseases due to the creation of mosquito breeding habitat	4 ¹	D	21	INTRAPAC • C Install drainage which does not pool or create mosquito breeding habitat (as per the Stormwater MP for each subdivision – see Section 6.6.1 of the EMP). • C P Design future ponds, retention basins and wetlands as per DoH guidelines to ensure drainage to them is free, and that lakes are sufficiently sized and constructed to reduce mosquito-breeding habitat (steep sides and creation of fish habitat). COUNCIL • Maintain lakes and waterways to remove vegetation and built-up of sediment.	4 ¹	C	18
		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	D	12		2	C	8
Residential occupancy	Recreational use of parks, lakes and waterway areas	Reduced human health from mosquito-borne diseases due to the exposure of residents to mosquitoes	4 ¹	D	21	INTRAPAC • C Design lakes to minimise breeding habitat. • Spray insecticide if required.	4 ¹	C	18
		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	C	8		2	B	5

	Location of lots within high risk mosquito areas	Reduced human health from mosquito-borne diseases due to the exposure of residents to mosquitoes	4 ¹	D	21	INTRAPAC • C Rectify drainage in all onsite mosquito-breeding areas within 1.6 km of the village centres (as identified in the Biting Insect Assessment in Appendix K); specific actions will be to drain and/or fill borrow pits, scrapes and disturbed seasonally-waterlogged areas to reduce mosquito-breeding habitat. • Where possible, locate larger lots closest to seasonally-flooded areas and smaller lots furthest from seasonally-inundated areas to create a rural or industrial buffer around major sources of biting insects. • If necessary, discuss management options with neighbouring landholders upon whose land there are potential mosquito breeding areas (as identified in the <i>Biting Insect Assessment Report</i> in Appendix K). • Spray insecticide if required. • C P Incorporate the standard clause currently imposed on rural living lots in the greater Darwin region in relation to living close to mosquito breeding areas into contracts of sale, as well as by way of covenant on property titles. • C Subject dwellings located within an identified buffer from a potential mosquito breeding area to architectural guidelines requiring the installation of appropriate mosquito screening on all external doors and windows, as well as recommendations to screen outdoor entertainment areas.	4 ¹	C	18
		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	D	12		2	C	8
	Standing water bodies and septic systems within individual lots (e.g. pools, ponds, tyres)	Reduced human health from mosquito-borne diseases due to the creation of mosquito breeding habitat	4 ¹	D	21	INTRAPAC • Notify residents of how to avoid potential mosquito nuisance through signage and information sheets	4 ¹	C	18
		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	C	8		2	B	5
	Disposal of treated sewerage - community-	Irrigation of treated wastewater	4 ¹	B	19	INTRAPAC • C Design, operate and maintain systems to avoid creating pooling water, and irrigate within the capacity	4 ¹	A	15

scale treatment plants		Reduced amenity because of pest mosquitoes due to the creation of mosquito breeding habitat	2	B	5	of the irrigation area to ensure water evaporates and/or is absorbed effectively.	2	A	3
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¹ Although it is possible to contract the potentially fatal mosquito-borne Murray Valley encephalitis virus disease in the Top End, there are only 1 to 2 cases reported per year. The other mosquito-borne diseases in the NT are not fatal and so the consequence score has been based on these.

5.11.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with biting insects, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- Management of potential offsite mosquito breeding habitat, as identified in the *Biting Insects Assessment Report* (in Appendix K), will be difficult because the sites are on private land. The most prudent approach is to rectify potential habitat onsite first, consult with residents and Medical Entomology as to whether there remains an ongoing problem with high levels of biting insects and, if so, then discuss management options with neighbouring landholders.
- Prior to the approval of each subdivision, Medical Entomology (DoH) will have the opportunity comment on the development application and, if deemed necessary, recommend conditions relating to mitigating the impacts of biting insects. Development of a subdivision cannot proceed until all conditions have been met.

Despite best efforts, however, exposure to biting insects is an inherently high risk in the rural area and there would be few rural residents (and few urban resident for that matter) who are not affected.

5.12 NOISE

The environmental objective for noise is to minimise the impacts of noise resulting from the construction stages of the project, particularly on sensitive receptors including residents and the community.

5.12.1 Context

The noise amenity in the vicinity of the project area comprises natural noise sources (e.g. birds and insects), traffic along Redcliffe and Goode Road, use of motorbikes and quad bikes on the site, and occasional noise associated with residential rural living. On the eastern side of the project area there is also an operating quarry with associated blasting and truck traffic.

5.12.2 Potential impacts

The main potential impacts of noise are from construction activities producing nuisance noise levels that impact upon neighbours, residents and/or construction workers.

The areas north and west of the project area are more populated, with a greater number of rural and rural living lots. Areas east and south of the project area are relatively undeveloped, with the exception of the quarry east of the project area. As such, the potential impacts of noise may be greater when prevailing winds are from the south and/or east (i.e. dry season breezes), while prevailing winds from the north-west (i.e. wet season) will generally carry noise away from populated areas.

5.12.3 Risk assessment

The risks to biodiversity from activities relating to noise are assessed in Section 5.7.3.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Noise from machinery, excavating, dumping etc.	Creation of a nuisance for residents and/or neighbours	3	D	17	CONTRACTOR • C P Develop a CEMP for each subdivision that contains specific noise management actions. General measures are provided in Section 6.12 of the EMP for guidance in future management.	2	C	8
		Hearing damage to workers from noise exposure	4	E	23		4	A	10
Residential occupancy	Increased traffic	Creation of a noise nuisance for residents and/or	3	E	20	INTRAPAC • Design the proposed street network within the	2	C	8

		neighbours			development to be highly interconnected and to allow for direct access to neighbourhoods, reducing the need for traffic on local collector roads and dispersing traffic into more than one collector road.		
					CONTRACTOR		
					• C P Devise a Traffic Management Plan in consultation with, and submitted for approval to, DoT for the construction of each stage of the subdivision. Each TMP will clearly outline, <i>inter alia</i>, noise mitigation measures.		

5.12.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with noise, for the following reasons:

- All of the measures labelled **(C)** are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled **(P)** are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- Litchfield Council requires an approved Traffic Management Plan prior to the commencement of any works in an existing road or road reserve. This will be incorporated into a development permit as a condition prior to commencement of construction. Development of a subdivision cannot proceed until all conditions have been met. The mitigation measures described in Section 6.12 of the EMP are standard for inclusion in CEMP's.
- A CEMP that contains specific noise management actions is a standard condition for a subdivision approval permit. Development of a subdivision cannot proceed until all conditions have been met.

5.13 AIR QUALITY

The environmental objective for air quality is to avoid changes in ambient air quality such that an environmental nuisance is caused (through either dust, smoke, odour or emissions).

5.13.1 Context

The ambient air quality within the project area is equivalent to that of a natural environmental setting where air quality is generally good, with the exception of occasional dust and smoke emissions relating to wind and bushfires. These would usually occur during the dry season months.

Environmental values include the amenity and social values of good air quality and visibility, particularly on neighbouring rural properties and, in the case of onsite wastewater management, on future residents. The health of employees and contractors during the construction phases has also been considered. Habitat and ecosystem health is also relevant, both terrestrial and aquatic.

5.13.2 Potential impacts

The main potential impacts concerning air quality relate to negative effects of dust from construction on human health, safety and amenity, as well as biodiversity. Odour from sewage treatment could also reduce amenity. Accidental or controlled burning – during both the construction and occupancy phases of the development – may produce smoke, with possible negative effects on human health, safety and amenity.

The operation of machinery results in greenhouse gas emissions. These are considered inherent and as having a relatively low potential impact; as such they have not been addressed in this risk assessment.

5.13.3 Risk assessment

The risks to biodiversity from activities relating to air quality are assessed in Section 5.7.3.

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Generation of airborne and depositional dust from land clearing, bulldozing, stockpiling, machinery, vehicle movements, quarrying and crushing	Reduced visual amenity for residents and/or neighbours	3	D	17	CONTRACTOR • C P Develop a CEMP for each subdivision that contains specific air quality management actions. Standard measures are provided in Section 6.13 of the EMP for guidance in future management.	3	C	13
		Increased respiratory illness for residents, neighbours and/or construction workers due to reduced air quality	3	B	9		3	A	6
		Reduced safety for construction workers due to reduced visibility	4	C	18		4	B	14
		Reduced aesthetic and social amenity because of increased turbidity in downstream waters	2	B	8	CONTRACTOR • C P Undertake dust suppression and engineering as per Section 6.13.2 of the EMP. • C P Install and maintain drainage and sediment controls as per ESCP in order to capture run-off and allow settling of suspended sediment prior to discharge to receiving waterways. INTRAPAC • C Monitor water quality at key locations in drainage lines downstream of development (refer to Water Monitoring Program in Section 6.6.4 of the EMP).	1	B	2
		Increased respiratory illness for workers exposed to harmful respirable dust (i.e. PM10)	4	C	18	CONTRACTOR • C P Undertake dust suppression, engineering and PPE as per Section 6.13.2 of the EMP.	4	A	10
Residential occupancy	Generation of smoke during back-burning or accidental bushfire	Reduced visual amenity for residents and/or neighbours	3	D	17	COUNCIL • Undertake fire management as per Section 6.10 of the EMP.	3	C	13
		Increased respiratory illness for residents and/or neighbours due to reduced air quality	3	B	9		3	A	6
		Reduced safety for road users due to reduced visibility	4	D	21		4	C	18

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	R S
Sewerage – individual systems (e.g. septic tanks)	Odour generation from sewage treatment and irrigation	Reduced amenity for neighbours and residents as a result of odour	2	C	8	INTRAPAC • C P Require appropriate design, siting (i.e. in accordance with DoH guidelines) and construction of septic systems (e.g. by licenced plumbers).	2	B	5
Sewerage – community-scale treatment plants	Odour generation from treatment and irrigation	Reduced amenity for neighbours and residents as a result of odour	3	C	13	INTRAPAC • C P Detailed design and planning of the sewage treatment system will include assessment and mitigation of potential odour impacts during the design and siting phase. The final system design and location will require approval by DoH and through the subdivision development approval process.	3	A	6

5.13.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with cultural heritage, for the following reasons:

- All of the measures labelled (**C**) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit.
- All of the mitigation measures labelled (**P**) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- A CEMP that contains specific dust management actions is a standard condition for a subdivision approval permit. Development of a subdivision cannot proceed until all conditions have been met. The mitigation measures described in Section 6.12 of the EMP are standard for inclusion in CEMP's.
- Odour is well controlled in IT technology community-scale treatment plants because the system is contained and secondary treatment occurs underground through the evapo-transpiration channels.

5.14 SOCIAL

This section constitutes the economic and social impact assessment (ESIA) for Noonamah Ridge that has been undertaken in accordance with the Guidelines for the Preparation of an *Economic and Social Impact Assessment* (NTEPA 2013). Those guidelines acknowledge that all developments bring change that can lead to “positive and/or negative impacts on the Territory and regional economies, and the social well-being of the population”. Developments are based on the concept of a ‘social licence to operate’, which is about operating in a manner than “aligns with community expectations and acknowledges that businesses have a shared responsibility with government and society to help facilitate development of strong and sustainable communities”.

The socio-economic objectives are to analyse, monitor and manage the intended and unintended social consequences – both positive and negative – of the project and any social change processes.

5.14.1 Context

A demographic profile based on data from the Australian Bureau of Statistics (ABS) *2011 Census of Population and Housing* is summarised in Table 4-1. There are differences between the region and the Municipality of Litchfield, but none that would alter service delivery.

There is little in the way of social infrastructure in the immediate vicinity of Noonamah Ridge, but there are many local-level facilities in the various rural communities near the site – specifically Humpty Doo, Bees Creek, Coolalinga and Howard Springs. These can be relatively easily accessed by vehicle. In addition, there are a large number of local, district and regional level facilities and services on offer within Palmerston and surrounding areas, which are within approximately 20 km (a 20-minute drive) of the site. There are also many natural areas for recreational activities within a similar distance.

The range of existing facilities and services is appropriate for the current population and could accommodate some growth over time. However, given the significant increase in local population expected at Noonamah Ridge, there will be a need for new local- and district-level community facilities and services to meet the needs of this new population. Some will be provided within the Noonamah Ridge development – see Section 2.3.1 for detail – while others will be accommodated within existing facilities in the region.

There is no intention for Noonamah Ridge to be restricted to high-income earners or developed as a ‘gated community’. Rather, the range of lot sizes will encourage a diversity of residents and households from across life cycle stages to locate within the site, and many would be expected to be attracted from other nearby communities.

5.14.2 Potential impacts

A number of potential social issues associated with the development were raised during the community consultation process described in Section 1.7.2:

- Decreased social amenity
- Social isolation
- Increased crime
- Inadequate social infrastructure and services.

These are all possible consequences of developing a greenfield site and thereby creating an increased density of blocks and increase in local population.

Additional potential impacts are:

- Decreased amenity due to increased noise (in the construction phase) and light (in the occupancy phase)
- Decreased road safety and amenity due to increased traffic (in both the construction and occupancy phases).

5.14.3 Risk assessment

Activity	Aspect	Impact	Inherent risk			Mitigation measures (and responsible entities)	Residual risk		
			C	L	RS		C	L	RS
Construction works	Noise from machinery, excavating, dumping etc.	Creation of a nuisance for residents and/or neighbours	3	D	17	INTRAPAC • Mitigation measures to minimise the risks to social amenity from noise are described in Section 5.12.3. • C Establish a stakeholder engagement strategy that identifies appropriate stakeholders, level of engagement and means of engagement. • Monitor the engagement against agreed benchmarks and performance indicators, and adapt as required.	2	C	8
	Increased traffic	Decreased road safety and public amenity (congestion and noise)	1	D	7		1	B	2
Residential occupancy	Development of a greenfield site creating an increased density of blocks and increase in local population	Change to the existing character of the area leading to reduced amenity for existing residents <i>Note: The area can currently be developed in accordance with existing zoning and so this development is broadly consistent within the expected</i>	4	E	23	INTRAPAC • Undertake community consultation from project conception to identify existing residents' concerns and needs, and to incorporate concerns and ideas into the master plan. • C Design the development as a high quality, master-planned, rural character estate with a range of lot sizes and an emphasis on rural living options.	3	D	17

		range of change.				• C Deliver social infrastructure that meets the needs of the existing population, as well as the new population. • C Commit to the minimum lot size of 800 m² for single dwelling properties. • C Introduce into the <i>NT Planning Scheme</i> a relevant controlling clause to ensure that, once developed, no further subdivision of individual properties will be permitted. • C Ensure with the Area Plan that lot sizes along Redcliffe Road and to the northern boundary are complementary to existing lots/homes, creating an interface with existing adjacent landholdings. • C P Provide within subdivisions setbacks in accordance with the requirements of the <i>NT Planning Scheme</i> and endorse these through the application of building envelopes. • C Develop and incorporate high-level architectural design guidelines into each sale agreement. • C Place a covenant on the title of each property requiring an assessment of building plans against the guidelines, and approval before construction can commence. • C Ensure within the Area Plan that the proportion of public green space within the project area is no less than 15 %. <i>Note: Evidence from other greenfield development projects in the greater Darwin region indicate that developments such as Noonamah Ridge typically attract first- and second- home buyers, often from nearby urban areas or other rural communities.</i>			
		Increase in crime <i>Note: It is not expected that there will be particular issues with crime in Noonamah Ridge (based on ABS data on crime statistics).</i>	2	C	8	INTRAPAC • Design the subdivisions to be broadly grid-shaped to facilitate access and connectivity with surrounding areas and to create good lines of sight. • C Employ Crime Prevention Through Environmental Design (CPTED) principles in the design of each stage (see Section 7.1.1). • Investigate the incorporation of a neighbourhood	1	B	2

						watch or some similar community organisation.			
		Street light – and light from residential and commercial buildings – reducing rural amenity for existing local residents	3	D	17	INTRAPAC • C Provide low/ground level street lighting (only) in the rural activity centres and on roads where the average lot size is 2000 m² or smaller. • C Not use overhead street lights. Ongoing light intrusion will be managed through the adoption of rural road standards that do not include street lighting, and through considering alternate street lighting – including motion sensor-activated lighting in the more built-up parts of the development (see Section 2.6).	1	B	2
	Inadequate public transport, cycling and pedestrian options for residents who do not drive	Residents experiencing social isolation and/or physical isolation from community services and facilities. <i>Note: This is a particularly important consideration for some segments of the population such as older people, new parents, teenagers, households or individuals without a car, people with limited physical mobility, from non-English speaking backgrounds, or with few family or friends for support.</i>	3	D	17	INTRAPAC • Design the development such that social infrastructure is centrally-located, easily accessible and linked into public transport routes. • C Reduce reliance on car-based travel internally by: ◦ Implementing an interim park-and-ride facility within the site that will eventually becoming a bus interchange servicing local and regional areas. ◦ Designing the development such more than 90 % of dwellings will be within 600 m of a bus stop. ◦ Designing a connected network of footpaths providing access to key land uses and centres. ◦ Designing a core on-road cycle path network connecting to employment precincts. ◦ Including bicycle trip-end facilities at key land use destinations.	1	C	4
	Delays in construction of stages		4	C	18	INTRAPAC • Ensure public transport is available from Stage 1. • Ensure roads associated with Stage 1 are constructed and completed prior to occupation. • Deliver social infrastructure such as a school and day care within Stage 1, or as required, to support both existing needs and needs arising from the proposed development.	1	A	1

	Insufficient social or sporting activities and clubs, or other places where residents can meet and socialise		4	C	18	INTRAPAC • Design the development such that casual/incidental contacts between people are facilitated in open spaces and shopping areas. • Establish a community facility that runs activities and programs (e.g. classes, courses, exercise programs and educational sessions). • Employ a community development worker in the early stages of settlement charged with introducing new residents to their neighbours and organising social events to encourage interactions and social cohesion.	1	B	2
	Increased traffic	Traffic congestion in the vicinity of the site, increased number of crashes at key intersections and increased response time for emergency services	3	E	20	INTRAPAC • Mitigation measures to minimise the risks to social amenity from noise are described in Section 5.12.3.	2	C	8
	Increased local population	Inadequate social infrastructure and services	5	D	21	INTRAPAC • Provide appropriate social infrastructure as per relevant benchmarks (described in Section 2.3.1). • Provide a rural village within Stage 1 of the development that will reserve land for commercial purposes, a community garden, a public school and sports-fields, a volunteer fire brigade and a community centre. • Ensure within the master plan that there is sufficient land in appropriate locations for future facilities and services provided by local government and Territory agencies (such as schools). • Undertake a stage-by-stage demographic review to determine whether existing and proposed social infrastructure is appropriate and/or adequate. • Employ a community development worker to facilitate the development of a community body responsible for community areas such as the community garden. • Liaise with NT Government and Litchfield Council to ensure the timely provision of social infrastructure and services the provision of which they are	3	C	13

					responsible. <i>Note: Community needs for higher order services and facilities will be met by accessing those available in nearby urban centres, such as Palmerston and Darwin.</i>			
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5.14.4 Effectiveness of mitigation

There is a high level of certainty associated with the effectiveness of the mitigation measures proposed to reduce risks associated with social impacts, for the following reasons:

- All of the measures labelled (C) are commitments made in this EIS, and have been incorporated as conditions into the Specific Use Zone text. As such, all subdivision applications will be required to address these conditions, and the Development Consent Authority will assess the application against these conditions prior to issuing a development permit. All of the mitigation measures labelled (P) are actions that will be required to be taken within the planning process prior to subdivision approval being granted.
- Each application for subdivision will be required to provide an updated 'social infrastructure needs' assessment that takes into account other development in the area, and ensures that social infrastructure is provided in a timely manner and in accordance with demand. This will not only ensure provision of appropriate infrastructure, but also ensure the sustainable operation, funding and management of facilities into the future.
- Prior to the approval of each subdivision, responsible departments (e.g. Department of Education, Department of Children and Families) will have the opportunity comment on the development application and recommend conditions relating to the provision of appropriate community infrastructure. Development of a subdivision cannot proceed until all conditions have been met.
- Similarly, prior to approval of each subdivision, Litchfield Shire Council will have the opportunity to comment on the development application and recommend conditions relating to the provision of appropriate community and social infrastructure (in accordance with any relevant Council policy), as well as to assume ownership of such facility where this is required under the *Local Government Act*.
- As is common practice in many master-planned communities, a community development worker will be employed at Noonamah Ridge in the early stages of settlement to plan and implement activities to connect residents to each other, and to local facilities and services, as a practical way to encourage interactions and build social cohesion.
- The requirement of an ongoing community consultation process will ensure that existing and future residents have the opportunity to provide input into the social facilities needs assessment.

Noting that the majority of social risks can be mitigated through good subdivision design and through appropriate provision of social facilities and amenities, no significant risks are expected to occur. The development process, and the fact that the development has been master planned, ensures that social impacts are considered for each stage. This is in contrast to what currently occurs in the *ad hoc* subdivision of properties in the rural area.

5.15 CUMULATIVE IMPACTS – ENVIRONMENTAL

Cumulative impacts on the environment are described by Franks et al. (2010) as:

...the successive, incremental and combined impacts of one or more activities on society, the economy and the environment. Cumulative impacts result from the aggregation and interaction of impacts on a receptor and may be the product of past, present or future activities. Cumulative impacts can be both positive and negative, and can vary in intensity as well as spatial and temporal extent. Cumulative impacts may interact such that they trigger or are associated with other impacts. They may aggregate linearly, exponentially or reach 'tipping points', after which major changes in environmental, social and economic systems may follow.

The only guidelines that exist for assessing cumulative impacts in Australia are those developed for the coal mining industry (Franks et al. 2010). This section has been prepared with reference to that document, as well as to the *IFC Good Practice Handbook: Cumulative Impact Assessment and Management* (IFC 2013).

The approach adopted to assess the cumulative environmental impacts of the Noonamah Ridge development on the regional environment is to:

1. Determine the spatial and temporal boundaries of the assessment as informed by the type and scale of regional environmental attributes that are considered important.
2. Identify existing and predicted future developments in the region.
3. Predict the future condition of the regional environmental attributes in light of the combined effect of existing and predicted future developments, together with external natural environmental drivers.
4. Describe how the Noonamah Ridge development could affect regional environmental attributes.
5. Identify how, and the degree to which, the development's effect on those environmental attributes – with all the mitigation and design measures in place – may contribute to a cumulative impact.
6. Repeat Steps 4 and 5 for the alternative scenario whereby the Noonamah Ridge site is not developed according to a master plan, but instead in a piecemeal fashion.
7. Compare the cumulative impact of a master-planned development (the outcome in Step 4) with that of unplanned subdivision (the outcome in Step 6).

Note: Cumulative social impacts are addressed in Section 5.16.

Regional environmental attributes

The natural environment consists of watersheds, airsheds and ecosystems. There are two major river catchments within the greater Darwin region – Adelaide River and Darwin Harbour. Regional groundwater consists of predominantly fractured and weathered rock aquifers with variable yields and water quality. The flat topography of the region creates a generally homogenous airshed throughout. Much of the north-western area of the region has been subjected to residential development. The extent of the region that is undeveloped in the east and south is largely Eucalyptus woodland supporting a regional biodiversity that includes some threatened species. This woodland, while ostensibly intact, has been subject to long-term grazing, human activity and fire regimes that are likely to have been detrimental to the values contained within. To the north are patches of sand sheet heath, wetlands and adjacent floodplains. Patches of rainforest occur throughout.

Existing and future developments within the region

Proximate to Darwin, the project site is located in an area with substantial development activity and development potential. This includes a suite of recent, rural, residential subdivisions; ongoing development activity around the Humpty Doo Rural Activity Centre and Coolalinga Activity Centre; and commercial development in the form of the expanded, light, industrial state (a Northern Territory Government development).

Much of the development is *ad hoc* as landowners subdivide in a piece-meal fashion. Examples of this are adjacent to the project site immediately to the north-west and north-east.

Private owners of land next to, or relatively near to, the Stuart Highway (generally south and east of Noonamah) propose to develop residential lots in a range of sizes and styles, including urban and peri-urban, rural residential and rural lifestyle lots at Noonamah and Hughes. Initial proposals suggest some 13,500 lots may be developed in stages, eventually accommodating up to 45,000 residents.

Other relevant proposed developments are:

- The Holtze locality (to the north of Palmerston, within the Municipality of Litchfield) which is the selected site for the new hospital. Preliminary proposals for residential development in this locality will be refined in the context of ongoing investigations related to the hospital and required new infrastructure. Early estimates suggest a potential total yield of 9,500 lots ranging from mixed use and compact urban development in association with activity centres, traditional urban residential lots and rural residential lots.
- The future city of Weddell (south of Palmerston and bounded by the Elizabeth and Blackmore rivers, Middle Arm Peninsula and the Stuart Highway) has been a key component of all Darwin regional plans since 1984. Various scenarios for future development of this city have been investigated. Although details are still evolving, Weddell remains a strategic opportunity to accommodate growth, with capacity to provide for at least 50,000 residents.

To the east of the project site is largely undeveloped pastoral land. It is possible that in the future, as Darwin inevitably expands, this area may become the subject of residential development.

Future condition of the regional environment

Future development in the greater Darwin region will inevitably place pressures on the natural environment. The key pressures are summarised below:

- Surface water drainage and hydrology will be altered by land clearing and introduction of constructed drainage systems. Despite the insistence by regulating bodies on erosion and sediment control and water-sensitive urban design for new developments, development history indicates that urbanised catchments usually alter water flows and affect water quality due to sedimentation, increased nutrients from fertilisers and sewage, and pollutants.
- Extraction of groundwater will increase with the expansion of development, as many of the larger blocks will not be connected to mains water and will be serviced by bores. The prognosis of the groundwater situation in the region is poor, with many of the aquifers over-extracted due to difficulties associated with regulation on private landholdings.
- Air quality will improve due to reduced incidences and intensities of bushfires because of vegetation clearing. This may be offset, however, by an increase in exhaust emissions from vehicle use of a population living further away from centres of employment.
- Large areas of land will be cleared for infrastructure, roads, residential blocks and commercial use – leading to loss of vegetation and habitat, and therefore compromised ecosystems. This will lead to loss of regional biodiversity, and could elevate the status of threatened species into higher categories.

Effects of the Noonamah Ridge development on environmental attributes

The Noonamah Ridge development will have the following effect on regional environmental attributes:

- **Surface water** – The project area encompasses approximately 22 % of the upper Elizabeth River catchment, and so any changes to water quality or quantity due to the development could have impacts extending all the way to Darwin Harbour. The eastern side of the project area drains towards the Adelaide River; however, this incorporates less of the project site (32 %) and there are fewer (and smaller) drainage lines leading from the site towards the Adelaide River.

Intrapac has committed to no significant changes to pre-development surface water quantity, quality and flows (as compared to baseline data), and will adopt design and management measures to achieve this goal. The Noonamah Ridge development will be staged, and each subdivision will be planned, using modelling that takes into account the previous subdivisions in order to avoid a cumulative impact within the site. As such, the development should not have any downstream impacts on environmental attributes.

- **Groundwater** – The activities of the development could impact on groundwater in two ways – contamination and over-extraction. Intrapac has committed to neither of these occurring. All groundwater extraction will be undertaken after a thorough investigation of the relevant aquifer/s (including recharge rates) and the needs of both current off-site users and groundwater-dependent ecosystems. Active recharge of aquifers is also currently a consideration. The design of sewerage treatment systems and stormwater drainage will ensure that no contaminants will enter aquifers.

Rural residential development combined with agricultural land-uses in Darwin's rural areas has led to over-extraction of groundwater in some areas. It is intended that much of Noonamah Ridge be serviced by groundwater extracted from local aquifers; however, the capability of aquifers to provide a sustainable supply is yet to be confirmed. If a sustainable supply is confirmed and all water is supplied by groundwater, the combination of extraction for Noonamah Ridge supply, other new rural residential developments and other rural land uses in the region has potential to lead to over-extraction, if extraction is not adequately regulated. The location of the Noonamah Ridge development in an area surrounded by large landholdings that can accommodate land-uses with a high water demand (i.e. agricultural production, aquaculture), may lead to competing pressures on the aquifer in the future. However, it is also possible, due to the highly complex geology of the project site, that some of onsite aquifers that may be accessed for the development may be localised in extent – therefore not affecting surrounding groundwater users.

Alternatively, if connection to mains water is required due to the lack of a sustainable groundwater resource, this will contribute to increasing demand on Darwin's water supply.

The use of septic systems has potential to contribute to groundwater contamination where these systems are not appropriately sited and maintained. Whilst DoH guidelines are in place to reduce the risks of contamination from septic systems, increasing residential densities in areas without sewerage systems does increase the risk of environmental contamination occurring. It is in response to this risk that Intrapac is proposing the installation of community-scale sewerage systems for the higher density parts of the Noonamah Ridge development, thereby reducing the development's contribution to cumulative impacts.

- **Air quality** – As mentioned above, because the main impact of the region's air quality comes from bushfire smoke, the development will lead to less bushland to burn and better fire control, resulting in a reduction in bushfires and an increase in air quality. This may be offset, however, by an increase in vehicle use and therefore exhaust emissions.
- **Ecosystems** – To the east of the project area is largely remnant bushland, although there has been some large-scale quarrying activity within. There is rural residential development immediately adjacent to the north, west and south of the project area. Many of those lots have retained most of the remnant bushland; however, the presence of buildings, fences, firebreaks, roads and, in many

cases, dogs, means that the landscape is a mosaic of habitat patches. Patches of habitat are more susceptible to edge effects (compromised quality due to weather exposure, weed encroachment, susceptibility to fire etc. – see, e.g., Murcia 1995) and may not constitute sufficient habitat area for many fauna species.

This development will involve large-scale vegetation removal and habitat reduction. Almost all of that will be Eucalypt woodland – the dominant vegetation type within greater Darwin and the Top End. Because of this abundance, the removal of this habitat type has less of a cumulative impact on biodiversity than the removal of other more restricted habitats in the region – such as sandsheet heath, riparian vegetation and rainforest – which are being retained and buffered in this development. Moreover, the large degree of modification and disintegration of habitat to the north, south and west of the project area means that the project area is unlikely to represent an ecological corridor. Therefore, the footprint of ecosystem disturbance from this development arguably only impacts the east of the project area where there is remnant bushland. The reduction, due to development, in the quality of habitat within the project area will impact upon the distribution and population size of certain fauna species that prefer larger territories – e.g. macropods (wallabies, Euros etc.)

Contribution of the Noonamah Ridge development to the cumulative impact on the regional environment

Noonamah Ridge is being designed and planned, and will be constructed and managed, such that the contribution of this development to the cumulative impact on the region's natural environment is – for three of the four aspects discussed above – minimal. Because of the commitments undertaken by Intrapac, downstream surface water and regional groundwater quality and quantity should not be compromised. Air quality will likely be improved due to fewer bushfires.

The project area is a greenfield site and so land clearing and habitat disturbance due to this development will contribute to regional habitat and biodiversity loss. This is reduced, however, because of the abundance of the habitat type in the region. Additionally, buffered areas and managed reserves within the project area will protect threatened species and sensitive vegetation types, both of which are currently unmanaged and hence vulnerable to disturbance.

Alternative scenario

That the project area is proximate to existing residential areas means it is inevitable that it will be subject to some form of residential development. It is Intrapac's contention that a master-planned development such as this is superior to *ad hoc* development for a multitude of reasons, including minimising impacts on the natural environment. It is therefore worthwhile considering the cumulative impact that would come from developing the site in an *ad hoc* manner in order to compare that impact with the one described above for this master-planned development.

It can be assumed in such a situation that subdivisions would require the same detail with regards to mitigation through design and management plans; however, in the absence of a master plan there is a much greater risk of mitigation measures being inadequate. There are a number of examples of how this may manifest:

- **Water supply** – Piece-meal subdivisions in the Darwin rural area are usually not connected to mains water supply and instead access groundwater using individual bores. There is little regulation of these bores and so aquifers are being over-extracted in a 'death by a thousand cuts' situation.

The Noonamah Ridge development is at scale that justifies and expedites the provision of mains water to the site (if required). If further groundwater investigation studies demonstrate that groundwater extraction to supply some of the water requirements of the development is sustainable

and economic, then that extraction will be gauged and managed such that extraction does not outstrip recharge.

- **Sewerage** – Piece-meal subdivisions in the Darwin rural area are usually not connected to the main sewer and instead utilise individual septic tanks. With the situation of there being thousands of septic systems dotted throughout the landscape, there is a high chance that some of them are compromised and hence leak contaminants into the surrounding environment.

Again, the Noonamah Ridge development is at scale that justifies the provision of community-scale sewerage treatment plants (using bio-remediation technology) within the site. These will be subject to high degree of scrutiny and regulation, and so the likelihood of contamination is negligible.

- **Drainage and erosion** – Standard conditions precedent for rural subdivisions are the development and approval of an Erosion and Sediment Control Plan, and of a schematic plan demonstrating the methods of onsite collection of stormwater. The advantage of a master-planned development is that each subdivision will more readily be able to take into account both the previous subdivisions and those proposed for the future, and that quite possibly the same engineering and construction companies will be involved for consecutive subdivisions. The development involves integrated stormwater management that greatly improves the ability to manage stormwater flows and quality – something not feasible in smaller subdivisions.
- **Biodiversity** – Piece-meal subdivisions are subject to less comprehensive environmental impact assessment processes as, occurring in isolation, they do not trigger assessment requirements. In contrast, Noonamah Ridge has been subject to arguably the most comprehensive biodiversity survey for a development of this type in the NT. Consequently, there is a good understanding of the biodiversity values, sensitive vegetation types and threatened species (flora and fauna) that exists within the project area. This knowledge means that the development master plan can allow for the adequate provision of green spaces to buffer and protect the significant biodiversity values within the project area. It also allows for discussions amongst stakeholders as to the optimum means for managing these green spaces to occur well before development takes place.

In addition to the advantages associated with Noonamah Ridge being master-planned, the fact that the developer, Intrapac, has determined to applying the principles of ecologically sustainable development to this development in a myriad of ways (see Section 2.2.1 for details) distinguishes this development from others. This is backed-up by Intrapac's track record (see Section 1.1.2). In particular, the extent of vegetation cleared in *ad hoc* subdivisions would likely be substantially higher than for this development because Intrapac has a vision and a commitment to retaining as much vegetation as possible.

5.16 CUMULATIVE IMPACTS – SOCIAL

A qualitative assessment of the potential cumulative social impacts of this development has been undertaken. When evaluating the potential for significant impacts there is often considerable uncertainty in the assessment, especially associated with predicting the form, scale and timing of future developments in the area. It is possible that other planning applications will be made during the determination of this EIS, which are not included in this assessment.

In order to assess cumulative impacts as a result of proposed developments in the vicinity Noonamah Ridge, consideration has been given to existing and proposed development outlined in the *Darwin Regional Land Use Plan* (DLPE 2015) within a five-kilometre radius of the site.

Specifically, the following developments have been considered:

- Development in the Hughes/Noonamah vicinity indicated as providing up to 45,000 new residents over time.
- Intensification of use around the Humpty Doo rural activity centre.

Table 5-6 outlines potential cumulative social impacts as a result of Noonamah Ridge.

Table 5-6. Potential cumulative social impacts

Aspect	Potential impact
Visual amenity	Given that the subject site is currently undeveloped, the construction of new dwellings – particularly where smaller lots are proposed – and associated infrastructure could affect the visual amenity of the area. Once established and completed, landscaping will mitigate any long-term, cumulative, visual amenity impacts. Lot sizes along Redcliffe Road and to the northern boundary will be complementary to existing lots/homes, creating an interface with existing adjacent landholdings. In addition, the emphasis on creating well-landscaped, open spaces should improve the overall visual amenity of the locality. The introduction within the <i>NT Planning Scheme</i> of a relevant controlling clause to ensure that, once developed, no further subdivision of individual properties will be permitted is an assurance not provided in <i>ad hoc</i> subdivisions. Finally, large areas of remnant bushland will be retained in some parts of the development. These mitigation and design measures should ensure that there are no significant adverse cumulative impacts from Noonamah Ridge to visual. The changes to the visual amenity of the area will largely be in keeping with the character of the existing and surrounding areas, and mostly in keeping with community expectations.
Social amenity	Locals are protective of their 'rural way of life' and are therefore concerned about the prospect of a development comprising mixed lot sizes, together with an increase in population and a perceived greater potential for crime. The development has been designed as a high quality, master-planned, rural character estate with a range of lot sizes and an emphasis on rural living options. To this end, Intrapac has undertaken community consultation from project conception to identify existing residents' concerns and needs, and to incorporate concerns and ideas into the master plan. This will include delivering social infrastructure that meets the needs of the existing population, as well as the new population. These mitigation and design measures will ensure the logical delivery of staged infrastructure, while Crime Prevention Through Environmental Design (CPTED) principles will limit anti-social behaviour and mitigate crime/security concerns. In addition, the increased population and development will result in the delivery of additional social infrastructure and facilities to the benefit of the broader region. This would not have been the case if the development was not master planned.
Light intrusion	Additional street lighting and smaller lots can result in elevated levels of light intrusion into the atmosphere, reducing the rural character of the locality. Within the development, low/ground level street lighting (only) will be provided in the rural activity centres and on roads where the average lot size is 2000 m² or smaller. There will not be any overhead streetlights. Whilst background light will inevitably increase as the area is developed from unpopulated bushland to rural living, due to these mitigation and design measures, no significant adverse cumulative impacts due to lighting are anticipated.
Traffic	The cumulative impacts of an increased population in the area are likely to require substantial additional road and transport infrastructure, including public transport. Increased traffic will result in actual and perceived noise and amenity issues on existing road networks. In response, additional new road infrastructure will be put in place at the appropriate stage to improve accessibility, travel times and options in the case of road closure or traffic. A large number of additional mitigation and design measures are proposed in Section 5.12.3. These, together with timely communication with relevant service authorities and responsible departments, mean that no significant adverse

	cumulative impacts from traffic are anticipated.
Social infrastructure	Cumulative impacts of the increased population in the area are likely to require additional social infrastructure investment. This needs to be considered in the context of other proposed development in the area. Intrapac has committed to providing appropriate social infrastructure as per relevant benchmarks (described in Section 2.3.1) and undertaking a stage-by-stage demographic review to determine whether existing and proposed social infrastructure is appropriate and/or adequate. These would not have been the case if the development was not master planned. Due to these mitigation and design measures, and with timely communication with relevant service authorities and responsible departments, no significant adverse cumulative impacts to social infrastructure are anticipated.

5.17 SUMMARY

This development is being designed and planned, and will be constructed and managed, such that no residual risk of any potential impact remains 'intolerable'. Some residual risks remain high – mostly for impacts that have low likelihoods because of mitigation measures but still have significant consequences (e.g. biting insects and bushfire). Intrapac argues that these are 'tolerable' as they can be considered a normal part of undertaking such a development in the Top End.