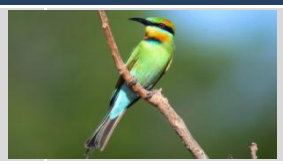
B Preliminary Environment Assessment

Noonamah Rural Village Development

Preliminary Environmental Risk Assessment

EZ13032: Intrapac

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Executive Summary

Intrapac in partnership with land owner Mr Laurence Ah Toy, aims to transform lots 4574, 3476 and 3477 on the outskirts of Darwin, to be a high profile demonstration of a tropical urban/rural village which is in tune with its surrounding environment and promotes a sense of community. The entire estate area covers approximately 26 km^2 currently zoned Rural Living and Rural with a minimum permitable allotment size of 2ha and 8ha respectively. This report contains a description of the key legislative context, the nature of the existing environment as well as potential risks of the proposed development and proposed mitigations. Key areas of environmental risk or areas in the need of further interrogation and specific designs include: surface and ground water integrity particularly with regard to waste water management and storm water design, integrity of landscape particularly with regard to erosion management, biodiversity, conservation of historic and cultural heritage, health, safety and amenity, socio-economic impacts and on-going maintenance of infrastructure.

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1 Introduction

1.1 Background

Intrapac, in partnership with land owner Mr Laurence Ah Toy, aims to transform lots 4574, 3476 and 3477 on the outskirts of Darwin, to be a high profile demonstration of a tropical urban/rural village, which is in tune with its surrounding environment and promotes a sense of community. The entire estate area covers approximately 26 km^2 currently zoned Rural Living and Rural which can be developed for minimum lot sizes of 2ha and 8ha respectively. The project area will require rezoning under the NT Planning Act through a submission to the Planning Authority.

The intention is to develop the project concept through a feasibility study and Master Plan proposal covering the entire estate. The Master Plan shall be used to seek rezoning to Specific Use (SU) under the planning Act, which If approved will be followed by a staged roll out and rezoning for sections of the estate with a detailed development proposal for an initial area to accommodate approximately 400 allotments in the north east portion as a starting point.

The project approval process commences with submitting a proposal to the NT Minister for Environment to determine the project to be assessed as a significant project through the planning authority. The project may have scope to produce environmental impacts which may trigger assessment under the NT Environmental Assessment Act. A notice of intent (NOI) is required for the EPA to determine whether the project requires assessment under this Act. The project outline which will be submitted to the Minister for Environment will provide sufficient detail that it may suffice as a Notice of Intent for the assessment by the NT EPA.

This document provides some of the baseline information and risk assessment to underpin the feasibility study and initial project proposal to the minister.

1.2 Scope

The purpose of this report is to scope the background environmental context (as agreed by the project management team) and identify potential environmental concerns and risks.

This report contains a description of the key legislative context, the nature of the existing environment as well as potential risks of the proposed development and their proposed mitigation under the sections and headings detailed below (Table 1-1).

Table 1-1 Report structure

Sections	Key Sub-headings
Legislative context	Northern Territory & Commonwealth Acts
Existing Environment	Local government Climate Land tenure and land use Surface water Ground water Topography and land resources Biodiversity Culture and heritage Socio-economic environment
Potential Risks to the Environment & Mitigations	As above (with some modifications)

2 Legislative Context

The following outlines some of key legislation and guidelines relevant to this project.

2.1 Northern Territory Legislation

2.1.1 Land Use & Assessment

Planning Act

The NT planning Act provides for appropriate and orderly planning and control of the use and development of zoned land.

Minimum lot sizes and requirements are outlined in Part 5 of the Planning Schedule. The Minimum lot size for Rural Residential are one ha, all unconstrained land in the Litchfield Shire, two ha with a minimum of one ha unconstrained land for land zoned Rural Living and 8ha with a minimum of one ha unconstrained land zoned Rural in greater Darwin region.

Subdivisions of Land zoned Rural (as per clause 11.4) is required to conserve the site characteristics by:

- Avoiding the development of excessive slope, unstable or otherwise unsuitable soils (e.g. seasonally waterlogged) and natural drainage lines
- Retaining and protect significant natural and cultural features
- Minimising the number of lots in or exclude from subdivision, areas of high conservation significance and drainage protection areas
- Minimising alteration or disturbance to natural drainage systems including drainage areas, recognisable watercourses, lagoons and seepage areas
- Minimising potential for erosion, sedimentation and pollution of watercourses
  and
- Minimising potential for localised flooding

Applications within the Litchfield Shire are to recognise and conserve area Priority Environmental Management

Clauses 11.4.2-4 stipulates the requirements for infrastructure, lot size and configuration and mineral resources for land zoned Rural respectively.

Clause 11.4.5 outlines the requirements for subdividing land zoned Rural Residential.

Zonation to Specific Use (SU) is like a planning scheme within a planning scheme. It is necessary to demonstrate the land is capable of supporting the designated landuse.

The NT Planning Scheme (Clause 10.3 Clearing of Native Vegetation – Performance Criteria) specifies that applications for the clearing of native vegetation are to demonstrate consideration of:

- the Land Clearing Guidelines (as amended from time to time) by the Department of Land Resource Management
- the presence of threatened wildlife as declared under the *Territory Parks and Wildlife Conservation Act*
- the presence of sensitive or significant vegetation communities such as rainforest, vine thicket, closed forest or riparian vegetation
- the presence of essential habitats, within the meaning of the *Territory Parks and Wildlife Conservation Act*
- the impact of the clearing on regional biodiversity
- whether the clearing is necessary for the intended use
- whether there is sufficient water for the intended use

- whether the soils are suitable for the intended use
- whether the slope is suitable for the intended use
- the presence of permanent and seasonal water features such as billabongs and swamps
- the retention of native vegetation adjacent to waterways, wetlands and rainforests
- the retention of native vegetation buffers along boundaries
- the retention of native vegetation corridors between remnant native vegetation
- the presence of declared heritage places or archaeological sites within the meaning of the Heritage Conservation Act

NT Land Clearing Guidelines

The NT Land Clearing guidelines are recognised formally under the Planning Act and referenced in the NT Planning Scheme. Applicants who wish to clear native vegetation must demonstrate how they have considered the guidelines. The consent authority must have regard to the guidelines and ensure that an application to clear native vegetation is consistent with them. The clearing guidelines requires buffering of drainage areas and consideration of sensitive or significant vegetation communities such as rainforest, vine thicket, closed forest or riparian vegetation among other requirements.

Environmental Assessment Act

Environmental Assessment Act and the Environmental Assessment Administrative Procedures establish the framework for the assessment of potential or anticipated environmental impacts of development, and provide for protection of the environment. The object of the Act is to ensure that matters affecting the environment to a significant extent are fully examined and taken into account in decisions by the Northern Territory Government. The NT Environment Protection Authority (NT EPA) is responsible for administering the Environmental Assessment Act and Administrative Procedures.

The scale and complexity of a proposed development and the significance of potential impacts will determine if assessment is at the level of Public Environmental Report or Environmental Impact Statement. The NTEPA determine the level of assessment. The Department of Lands, Planning and the Environment provides staff to the NT EPA to enable it to undertake its functions. If the NT EPA considers that a PER or EIS is warranted, it must consult the responsible Minister and relevant advisory bodies. For proposed actions where a PER or an EIS is required, guidelines for the preparation of the PER or EIS are prepared, advertised for public review, and issued to the proponent by the NT EPA. If the project has implications under the EPBC Act the assessment process will be conducted under a bilateral agreement between the NT and Australian Governments. NT EPA provides an assessment report to the NT Minister.

Soil Conservation and Land Utilisation Act

This Act provides for the prevention of soil erosion and for the conservation and reclamation of soil. Actions must not exaggerate the natural rate of erosion and sediment movement. All developments require a Soil Erosion and Sediment Control Plan (ESCP).

Bushfires Act

The NT bushfires Act establishes the legal framework and responsibilities for bushfire management. The Act places the responsibility for bushfire management upon the landholder. Rural allotments require a 4m fire break within their perimeter. All reasonable attempts to contain wildfire must be implemented and fire bans must be observed.

2.1.2 Culture and Heritage

Heritage Act

The Northern Territory's *Heritage Act 2011* is administered by the Department of Lands, Planning and the Environment. The object of this Act is to provide for the conservation of the Territory's cultural and natural

heritage. The Heritage Council is the body responsible for assessing the heritage significance of places and making recommendations to the Minister for Lands, Planning and the Environment about whether or not a place should be declared as a heritage place. The Heritage Council is also responsible for making decisions about whether or not to approve works to heritage places (other than major works, which must be approved by the Minister for Lands, Planning and the Environment).

Sacred Sites Act

The *Northern Territory Aboriginal Sacred Sites Act* recognises the need to preserve and enhance Aboriginal cultural tradition in relation to certain land in the NT and Aboriginal self-determination. The Act provides for the protection and registration of sacred sites by the traditional owners of the sacred sites or the custodians who have the responsibility for protecting a sacred site in accordance with Aboriginal tradition.

The Aboriginal Areas Protection Authority (AAPA) is responsible for administering the Act and records and maintains a sacred sites register. Custodians may apply to the AAPA to have a sacred site included in the Register and may also include, amongst other things, restrictions on activities that may be carried out on or in the vicinity of the sacred site.

2.1.3 Water and Biodiversity

Water Act

The *Water Act* is administered by the Department of Land Resource Management and provides for the investigation, allocation, use, control, protection and management of surface water and groundwater resources, as well as the administrative process for licensing these activities. The Act allows the enforceable allocation of water to various declared beneficial uses including; agriculture, aquaculture, public water supply, riparian and industry, while ensuring that adequate provisions are made to maintain cultural and environmental requirements.

Water Control Districts are declared in areas where it is recognised that increasing development and demand for water have the potential to cause degradation to water quality and reduce flows required to maintain water dependent ecosystems in the region. The project area is located within the Darwin Water Control District.

Territory Parks and Wildlife Conservation Act

The *Territory Parks and Wildlife Conservation Act* is administered by the Territory Parks and Wildlife Commission and makes provision for the establishment of Territory Parks and other Parks and Reserves as well as the study, protection, conservation and sustainable utilisation of wildlife.

Weed Management Act

The NT *Weeds Management Act* (2001) is administered by the Department of Land Resource Management. This legislation declares certain plants to be weeds, classifies weeds according to management requirements, and places obligations on land owners and occupiers to manage weeds. Section 9 of the Act establishes the responsibilities of land owners and occupiers for managing 'declared weeds'.

2.1.4 Waste Management, Air Quality & Noise

Waste Management and Pollution Control Act

This Act provides for the protection of the environment by encouraging effective waste management and pollution prevention and control practices. The Act establishes environmental nuisances (including noise) as an offence. Any water discharge or waste management must comply with relevant sections of the Act. The NTEPA issues licences to regulate activities under the Waste Management and Pollution Control Act.

Water Supply and Sewerage Services Act

The *Water Supply and Sewerage Services Act* provides for the protection of the Northern Territory's water supply system, or any water source from which water is drawn for human consumption. Any abstraction or diversion of water from the Northern Territory's supply system must not be undertaken unless authorized by the appropriate authorities. Penalties are in place for pollution of any water supply or source.

Public and Environmental Health Act

This Act establishes public health nuisances as offences and defines such offences as anything that puts, has put or will put at risk or damages, has damaged or will damage public health. Public health means the physical, mental and social wellbeing of the community. The Act relates to dust, fumes, vapour or other emissions, water, and refuse.

Part II of these regulations relates to general sanitation (including food waste, protection of water supplies, and installation of septic tanks).

Part III pertains to mosquito prevention.

If a site has been used for agriculture (spray herbicides/pesticides) or there are any potential contamination sources (dumped rubbish, old sheds, army armaments etc) a contamination assessment may be required.

2.2 Commonwealth Legislation

2.2.1 EPBC Act

Under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* actions that have, or are likely to have, a significant impact on a matter of national environmental significance require approval from the Australian Government Minister for Sustainability, Environment, Water, Population and Communities (the federal minister).

2.2.2 National Environment Protection Measures (Implementation) Act 1998

Under the *National Environment Protection Measures (Implementation) Act* 1994, the National Environmental Protection Council (NEPC) was established to set national environmental objectives and standards for Australia through the development of National Environment Protection Measures (NEPMs). The NEPC is part of the Environment Protection and Heritage Council (EPHC).

Section 14(1) of the NEPC Act prescribes that NEPMs may relate to any one or more of the following: ambient air quality, ambient marine, estuarine and fresh water quality, the protection of amenity in relation to noise, general guidelines for the assessment of site contamination, environmental impacts associated with hazardous wastes and the re-use and recycling of used materials.

NEMP's are made by NEPC ministers and implemented in each jurisdiction.

3 Assessment Methods

3.1 Desktop Review

The existing environment and potential environmental constraints for the Noonamah Ridges estate has firstly been scoped using existing data. The data enquiry has included broad scale reviews of climate data, geomorphology, land system and vegetation mapping, the existing flora and fauna records, known distributions and preferred habitats for flora and fauna species, as well as the current status of disturbance in the region. A list of the primary sources of information which have been interrogated towards this review is presented in (Table 1-1). This information has been supplemented with knowledge of the site from preliminary on-ground surveys where possible.

Table 3-1 Primary information sources interrogated for the desktop review of the existing environment for the Noonamah Ridges Estate

Aspect	Primary Information Sources
Climate	The Bureau of Meteorology online data
Land Tenure	NTLIS – NT Land Information Systems
Surface and Ground Water	Catchment boundaries sourced from National Geochem Survey of Australia NGSA Existing locations and attributes available for registered bores through NR Maps NT Dept. of Land Resource Management
Geology	Pietsch, BA and Stuart-Smith, PG 1987, Geology for Darwin at 1: 250,000 scale. Northern Territory Geological Survey in collaboration with the Bureau of Mineral Resources, Geology and Geophysics, Department of Resources and Energy. Doyle, N 2001, Extractive minerals within the outer Darwin area. Department of Business Industry & Resource Development.
Land Units & Vegetation Mapping	Fogarty, PJ, Lynch, B, & Wood, B 1984, *Land Resources of the Elizabeth, Darwin and Blackmore Rivers. Technical Report Number 15*. Conservation Commission of the Northern Territory, Darwin. Wilson, B, Brocklehurst, P, Clark, M and Dickinson, K 1990, *Vegetation Survey of the Northern Territory - Technical Report No. 49*, Conservation Commission of the Northern Territory, Darwin. Department of Planning Infrastructure & Environment (DPI&E), 2002, Litchfield Shire remnant vegetation mapping at 1:25,000 scale Department of Planning Infrastructure & Environment, Northern Territory Government, Darwin. Hempel, C 2003, Sand sheet mapping for the greater Darwin area
Dry land salinity & Acid Sulphate potential	Tickell SJ 1994, Dryland Salinity Hazard Map of the Northern Territory. Report 94/54 Power and Water Authority Hill JV, Edmeade BFJ 2008, Acid Sulphate Soil of the Darwin Region. Report 09/2008D. Department of Natural Resources Environment the Arts and Sports
Bioregions	Baker B, Price O, Woinarski J, Gold S, Connors G, Fisher A & Hempel C 2005, *Northern Territory Bioregions – Assessment of Key Biodiversity Values and Threat.* Department of Natural Resources, Environment and The Arts, Palmerston, Northern Territory. NRETA, 2005, *Northern Territory Draft Parks Master Plan: Darwin Coastal Bioregion Conservation Values and Environmental Resources.* Department of Natural Resource Environment and The Arts.
Sites of	Environment Australia, 2001, *A Directory of Important Wetlands in Australia*, Third

Aspect	Primary Information Sources
Conservation Significance (SoCS)	Edition. Environment Australia, Canberra. Harrison, L, McGuire, L, Ward, S, Fisher, A, Pavey, C Fegan, M and Lynch, B 2009, An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Northern Territory, Darwin.
Notable Flora and Fauna Species (inclusive of invasive species)	EPBC Protected Matters Search Tool, Department of the Sustainability, Environment, Water, Populations, and Communities (DSEWPC) holds mapped locations of World Heritage properties, Ramsar wetlands, threatened species, migratory species, marine species, threatened ecological communities and protected areas. NT NRM INFONET – a map-based profiler for natural resource information from a variety of sources. This is a collaboration between the NT NRM Board, the Tropical Savannas Cooperative Research Centre and the Northern Territory Department of Natural Resources, Environment and the Arts. NT Flora & Fauna Atlas, Department of Land Resource Management and the Conservation Commission of the Northern Territory
Fire Frequency	North Australian Fire Information (NAFI) - a web-based dataset (managed by the NT Government, CDU, Australian Government, and Bushfires NT), which records the fire history of any given area. Information such as the time of the last burn, the frequency of fires and the frequency of late burns can be accessed and an idea of the overall fire impact of the region can be suggested from the available information.
Culture and Heritage Sites	The Aboriginal Areas Protection Authority (AAPA) sacred sites and issued certificates register Department of Lands, Planning and the Environment register of listed heritage sites under the NT Heritage Act

Due to the proximity to Darwin city there is a fair degree of existing environmental assessment and background information for the Noonamah Ridges Estate. However, there are also several information gaps which require further local studies and ground truthing survey to clarify the context, potential risks and appropriate mitigations.

4 Environmental Context

4.1 Local government

The Noonamah Ridges Estate is situated within the Litchfield Shire (Figure 4-1). Litchfield Shire covers approximately 3100 km2 with a population of 19,414 persons (ABS 2010). Litchfield Council has 5 members - a Mayor, and four Councillors. One Councillor represents each of the 4 wards that make up the Municipality (North, South, East and Central Wards). The Estate land is located within the Southern Ward in the Lloyd Creek area. Noonamah Ridges Estate is approximately 45km South of Darwin (Figure 4-2).

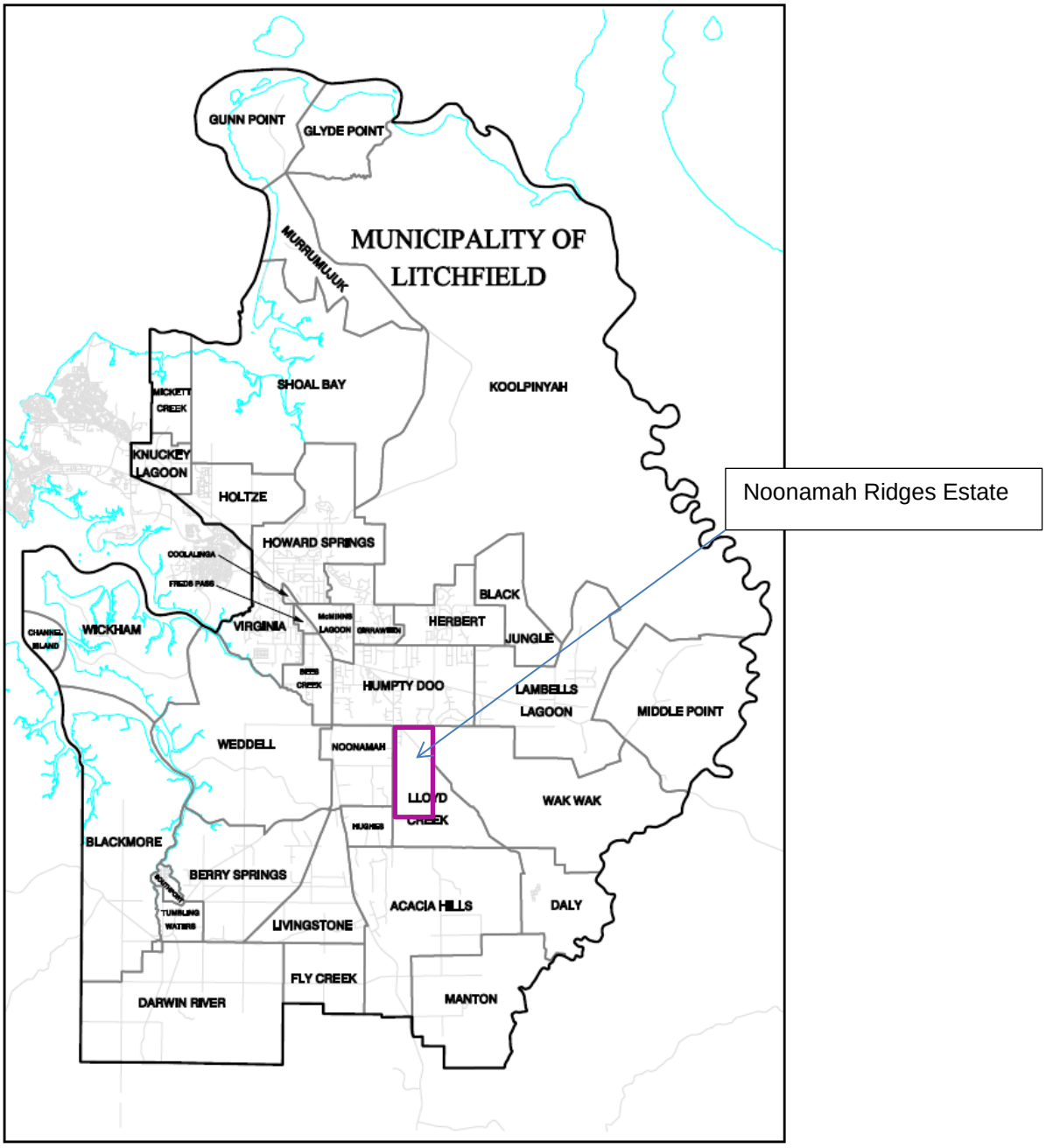


Figure 4-1 Noonamah Ridges Estate in relation to the Litchfield Shire boundary

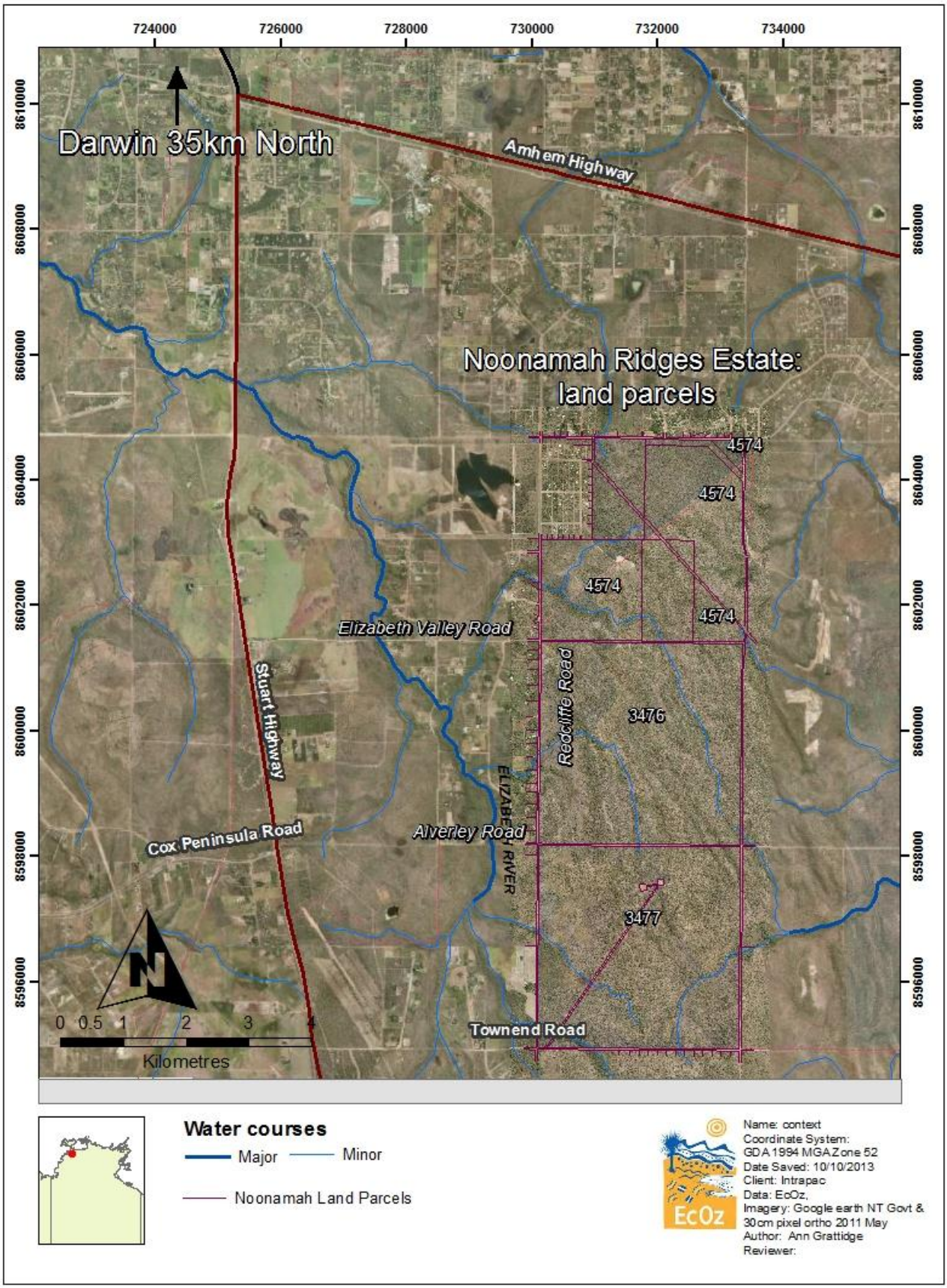


Figure 4-2 Location of Noonamah Ridges Estate relative to the intersection of the Stuart and Arnhem Highways.

4.2 Land tenure and land use

Land use within the Elizabeth catchment is 50% undeveloped, 39% rural or defence and 2% urban (Australian Collaborative Land Use Mapping Program, 2004 data, cited in Skinner et al. 2009).

Land Tenure surrounding the Noonamah estate (Figure 4-4) consists of a majority of freehold land directly to the north, west and south of the development, with a large area of perpetual pastoral lease land (Station, NT Koolpinyah portion 4477) neighbouring on the eastern side of the boundary. The nearest conservation area is Fogg dam which is 16km to the north-east of the land parcels.

Zoning

Land parcels within the Noonamah Ridges Estate project area are currently zoned Rural Living for parcels (4574 and 3476) and Rural (parcel 3477) which can be developed to allotments with a minimum size of two ha and eight ha respectively with a minimum of one ha unconstrained land (refer to Figure 4-5).

The area immediate surrounding the proposed development (to the north and west) is largely zoned Rural and Rural Living. These surrounding areas feature agriculture, including mango orchards and areas for animal husbandry such as the Noonamah Export Yards. Koolpinyah, NT portion 4477 to the east is largely zoned Rural with the portion abutting parcels 3476 and 4574 zoned Rural Living. This parcel features active extractive tenements.

The Hughes Airstrip operates 4km to the west of the proposed development site, is utilised primarily by Bushfires NT for fire fighting aircraft. The AACO Darwin Meat Processing Facility is also being constructed in the local area, with this site being over 5km from the western boundary of proposed development.

The nearest Rural Residential area (~ nine km^2), which can be developed with a minimum lot size of one ha (all unconstrained land) is located five km to the north-west of the estate (Figure 4-5) on the Stuart highway just south of Jenkins Road.

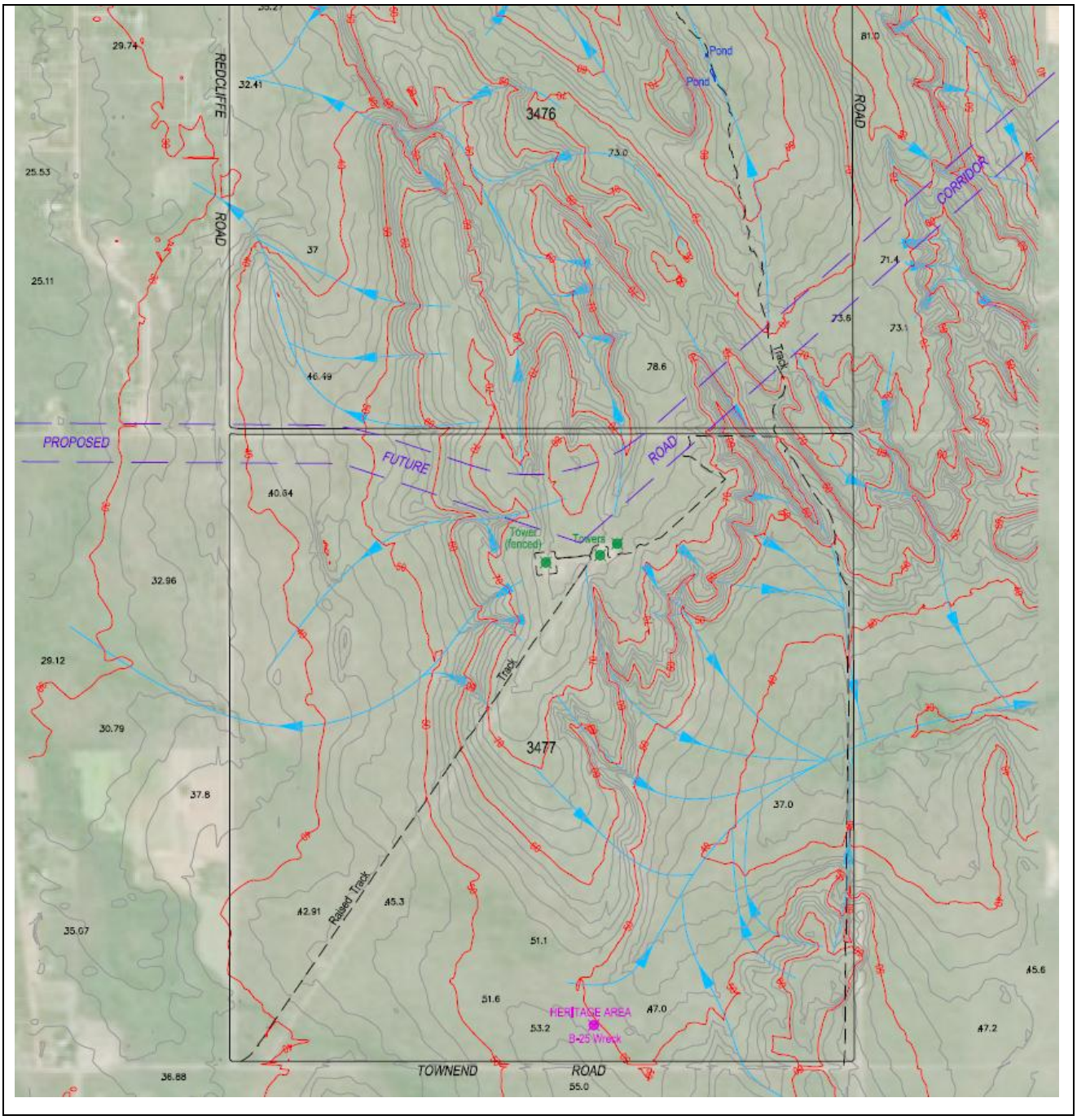
4.2.1 Tenure within the estate

Within the land parcels associated with the Noonamah Ridges Estate there are number of excisions and granted extractive tenements.

Parcel 3477 includes an area of land containing a Telstra tower (Hughes Communication Facility, parcel 1707 owned by Telstra) and associated Telecom transponder site (proposed crown land, parcel 3732) and electrical supply site (proposed crown land, parcel 2556) with an access easement from the south-western corner (Figure 4-3). At least the Telstra tower requires a buffer to protect against radiation.

There is also a 100m corridor running between parcels 3477 and 3476 for a proposed Heavy Vehicle connector road to Gunn and Glyde Point (Figure 4-3). This proposed road is referred to as the Arterial Links to Glyde and Gunn Point and is intended to carry a mixture industrial and light vehicle

Noonamah Ridges Estate also features some granted extractive licence in the north most parcels and these are all held by the land owner, Laurence Ah Toy.



*scoured from Fyfe, 2013 Plan 70255

Figure 4-3 Tenures within Parcel 3477 and 3476

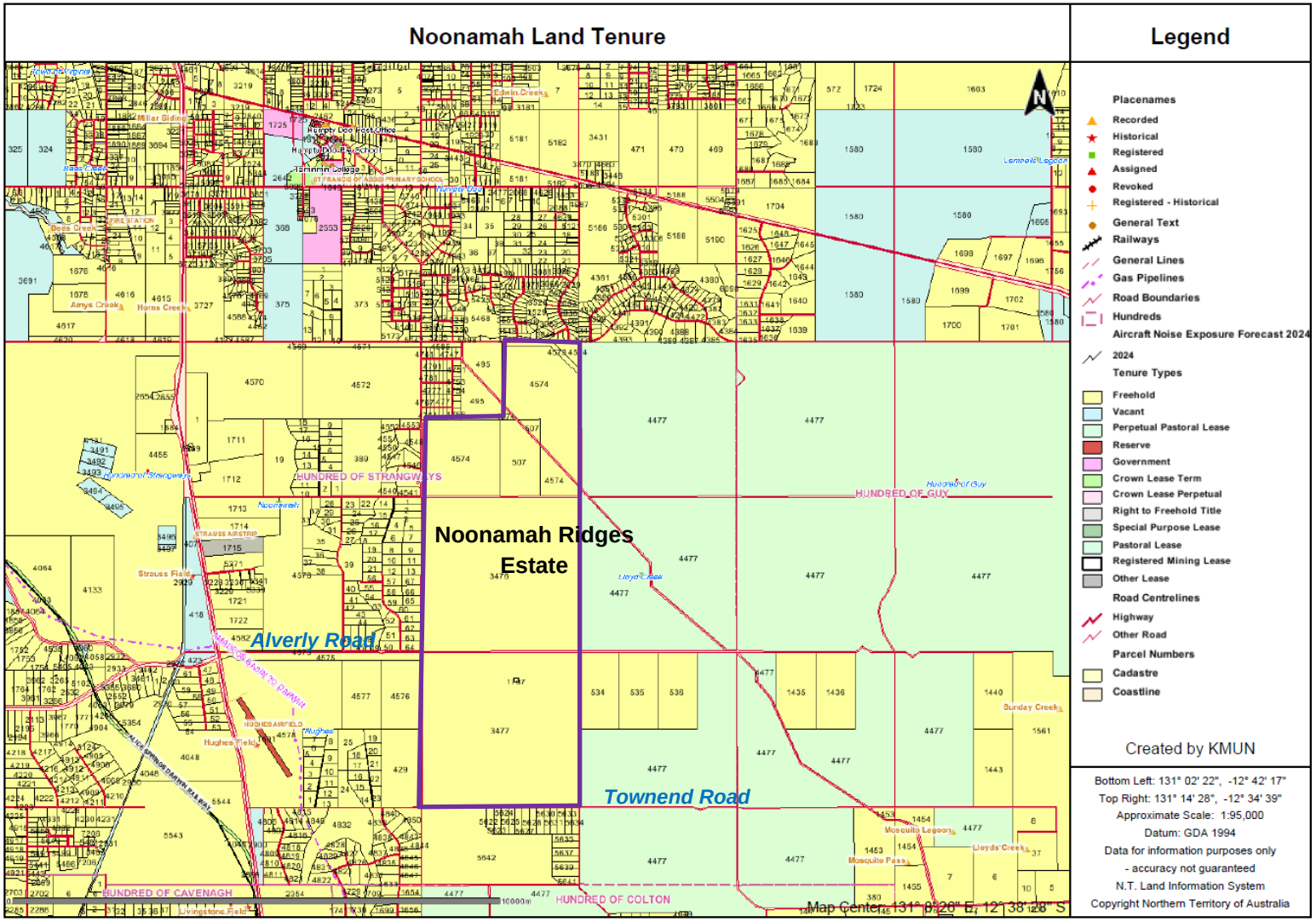


Figure 4-4 Land tenure within the Noonamah area

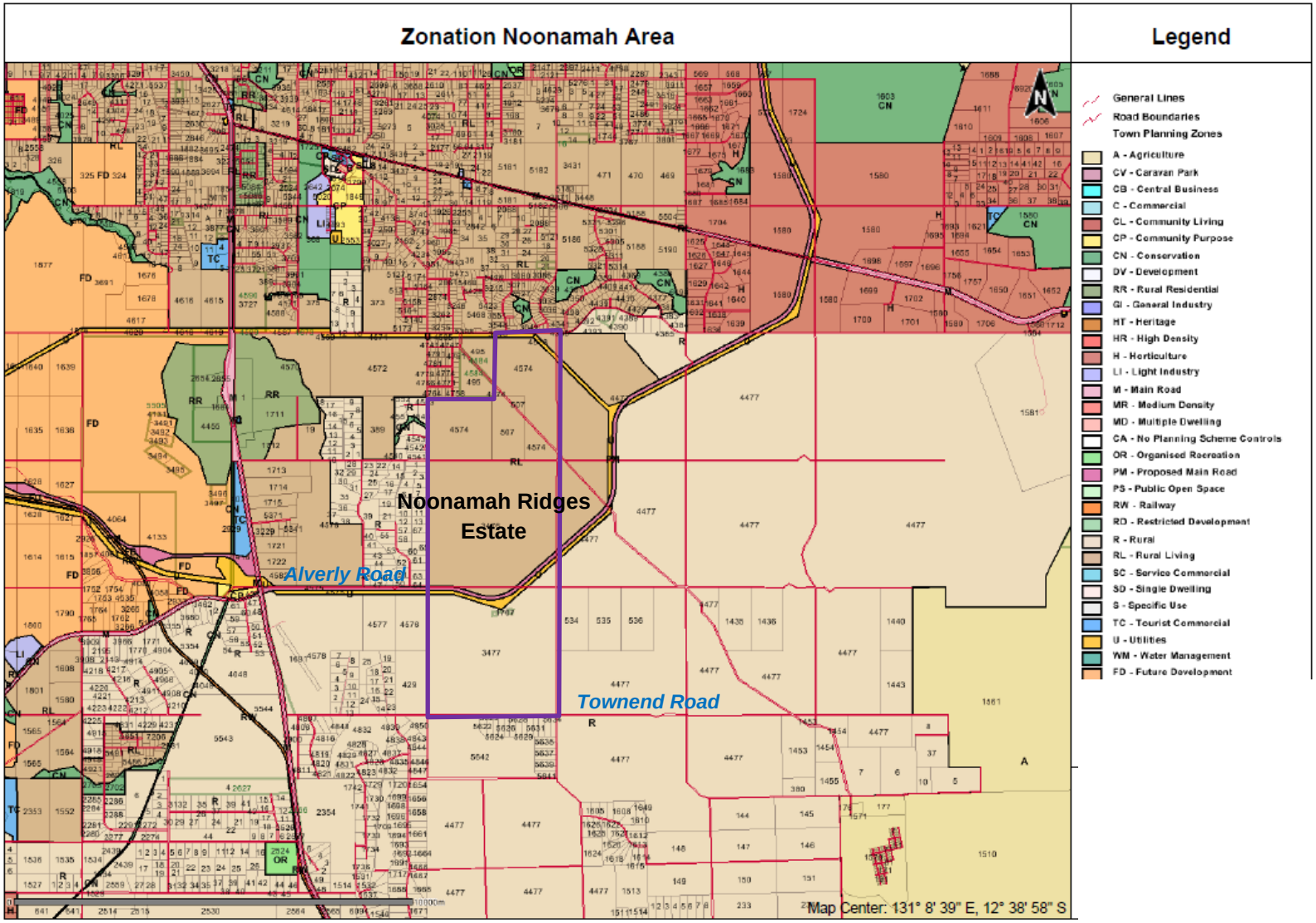
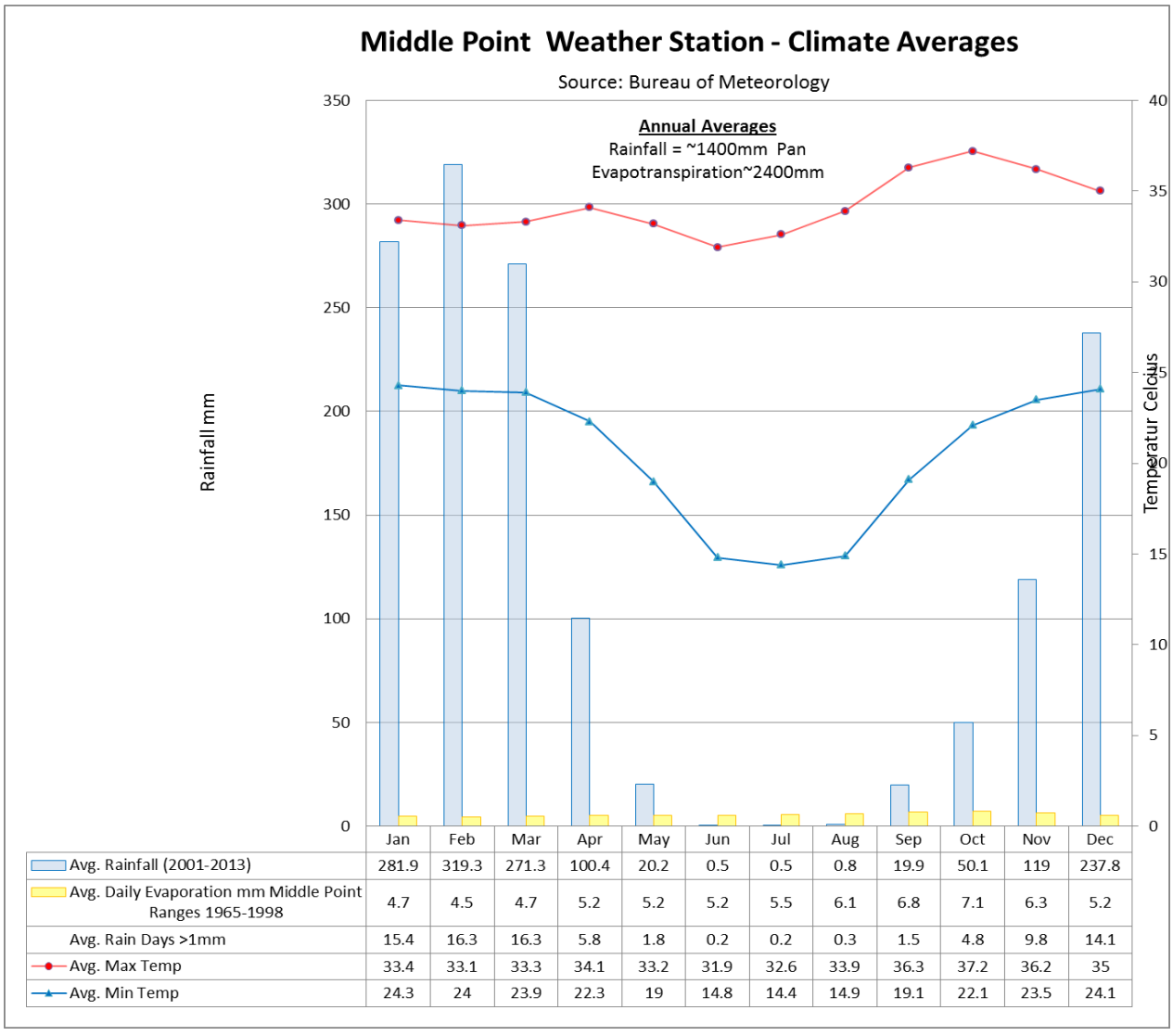


Figure 4-5 Land Use Zoning for the Noonamah Area

4.3 Climate

The climate for Noonamah is typical of the wet dry tropics with a pronounced wet and dry season. Minimum and maximum temperatures being fairly even through the year but with the rainfall and humidity being highly seasonal. The bulk of the annual rainfall (averaging ~1400mm) falls within the summer/wet season (Nov – April).

Figure 4-6 below presents the mean rainfall and daily evaporation as well as the mean maximum and minimum temperature for the Middle Point area, which is the nearest weather station about 20km to the east of the Noonamah estate. The average pan evaporation rate is approximately 2400mm per annum (BOM, 2013).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Rainfall (2001-2013)	281.9	319.3	271.3	100.4	20.2	0.5	0.5	0.8	19.9	50.1	119	237.8
Avg. Daily Evaporation mm Middle Point Ranges 1965-1998	4.7	4.5	4.7	5.2	5.2	5.2	5.5	6.1	6.8	7.1	6.3	5.2
Avg. Rain Days >1mm	15.4	16.3	16.3	5.8	1.8	0.2	0.2	0.3	1.5	4.8	9.8	14.1
Avg. Max Temp	33.4	33.1	33.3	34.1	33.2	31.9	32.6	33.9	36.3	37.2	36.2	35
Avg. Min Temp	24.3	24	23.9	22.3	19	14.8	14.4	14.9	19.1	22.1	23.5	24.1

Figure 4-6 Mean Climate Statistics for Middle Point

4.4 Surface water

The Noonamah Ridges Estate land parcels are located within both the Elizabeth and Adelaide River Catchments. The estate lies at the head of these two catchments. The north-western half of the proposed development area drains into the Elizabeth River with the lower south-eastern portion drains into the Adelaide River (Figure 4-7).

The Elizabeth River flows into the Darwin Harbour. Water quality for rivers and tributaries which flow into the Darwin Harbour inclusive of the Elizabeth River are monitored regularly. The Darwin Harbour Advisory Committee (DHAC) provides the Northern Territory Government with advice on land use, planning, development and the use of natural resources within the Darwin Harbour region. The Darwin Harbour Strategy identifies protection of the Harbour water quality as a high priority.

The National Water Quality Management Strategy (NWQMS) provides nationally agreed processes for the effective management of water quality (DLRM, 2013c). The preparations of action plans under the NWQMS, to improve or protect water quality, are based on the Framework for Marine and Estuarine Water Quality Protection (DLRM 2013c). The action plan being developed to protect water quality in the Darwin region is called the Darwin Harbour Water Quality Protection Plan (WQPP). The overall aim of the WQPP is to ensure that water quality objectives (local guidelines) are maintained and that community's values for waterways are protected (DLRM 2013c). During phase one of the Darwin Harbour Water Management Plan (2011) Darwin harbour was categorised as in good health; even though the evidence of storm water runoff and waste discharge are evident (Report card 2011).

The rivers which flow into the Harbour (including the Darwin, Blackmore and Elizabeth Rivers and Berry Creek) have small catchments (Harrison et al. 2009). Drewry et al. (2010a & c) identifies the main driving factors affecting water quality as treated sewage points and discharge, ground water extraction, development and erosion, diffuse storm water discharge and or fire in the catchment or riparian zones. Pollutants are more pronounced during the wet season flows (Drewry et al. 2010a & c).

In Darwin, urban development doubles the volume of runoff compared to undisturbed areas and total pollutant loads increase with this increased runoff across all catchment land-uses (Skinner et al. 2009). Continued growth of the city and rural areas is destined to place the Harbour under increasing pressure. Increased monitoring is identified as essential to ensure the values of Darwin Harbour are protected (DLRM 2013c).

Urban and commercial developments have large areas of hard impervious surfaces such as roads and roofs that limit infiltration to the ground. This results in a greater volume of runoff. Existing developments have used efficient stormwater drainage designs to convey the runoff from these areas as quickly as possible to minimise the risk of flooding and inundation. This reduces the time it takes for water to leave the catchment and enter rivers and creeks and can lead to higher flow but shorter duration peaks in the stream flows. The increased flow velocities associated with this runoff can result in higher rates of erosion if urban drains and streams are not adequately stabilised

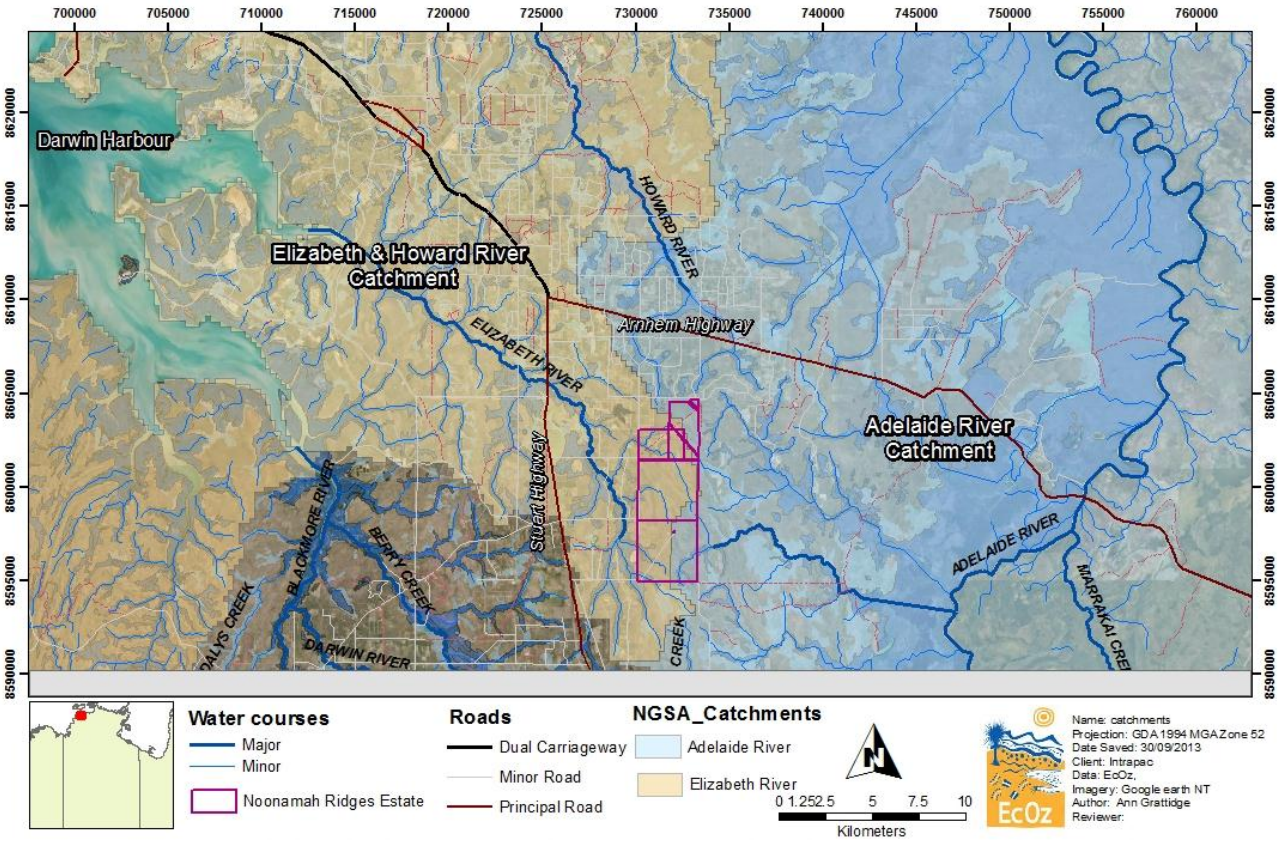
Estimated diffuse pollutant loads from urban land-use are higher than rural and undeveloped catchments when expressed as an export coefficient (mass/area/wet season) and standardised for rainfall. Nitrogen and phosphorus export coefficients are, respectively, 3 and 12 fold higher from urban areas than for rural or undisturbed areas. Sediment coefficients are 8 fold higher, while urban metal loads were more than 10 fold higher for lead, zinc and copper, and 3 – 7 fold higher for the other metals when compared to non-urban values.

Riparian vegetation, the prevalence of lagoons and the general low relief of the rural area most probably act to retain a significant proportion of sediment bound pollutants, mitigating the impact potential of the more intensive rural land-uses from otherwise higher pollutant loads. (Skinner et al. 2009).

4.4.1 Existing monitoring for the Elizabeth River

The Elizabeth River is regularly monitored for water quality as a part of the Darwin Harbour Water Quality Protection Plan, with most monitoring sites located within the estuarine sections of the River. Generally water quality objectives for the Elizabeth are being met with the upper reaches being of higher quality than the estuarine areas, possibly because these areas are downstream of a greater degree of urban and commercial development (Drewry et al. 2010a and b).

According to 2011 reporting carding for the Elizabeth River, one monitoring site has changed from an AUSRIVAS A rating in 2009 and 2010 to a B rating in 2011. Analysis of monitoring data for the 2009 dry season indicated several areas within the mid to lower estuary of the Elizabeth did not comply with upper water quality objectives for chlorophyll a, which is an indicator of nutrients leading to increased algae growth (Drewry, at al. 2010c).



*Note the NGSA catchment boundaries contain some errors

Figure 4-7 Surface catchments for the Elizabeth and Adelaide River

4.5 Groundwater

The proposed development site occurs within the Elizabeth and Howard Rivers Region Groundwater Beneficial Uses Region. Aquifers which exist within the vicinity of the estate are presented in

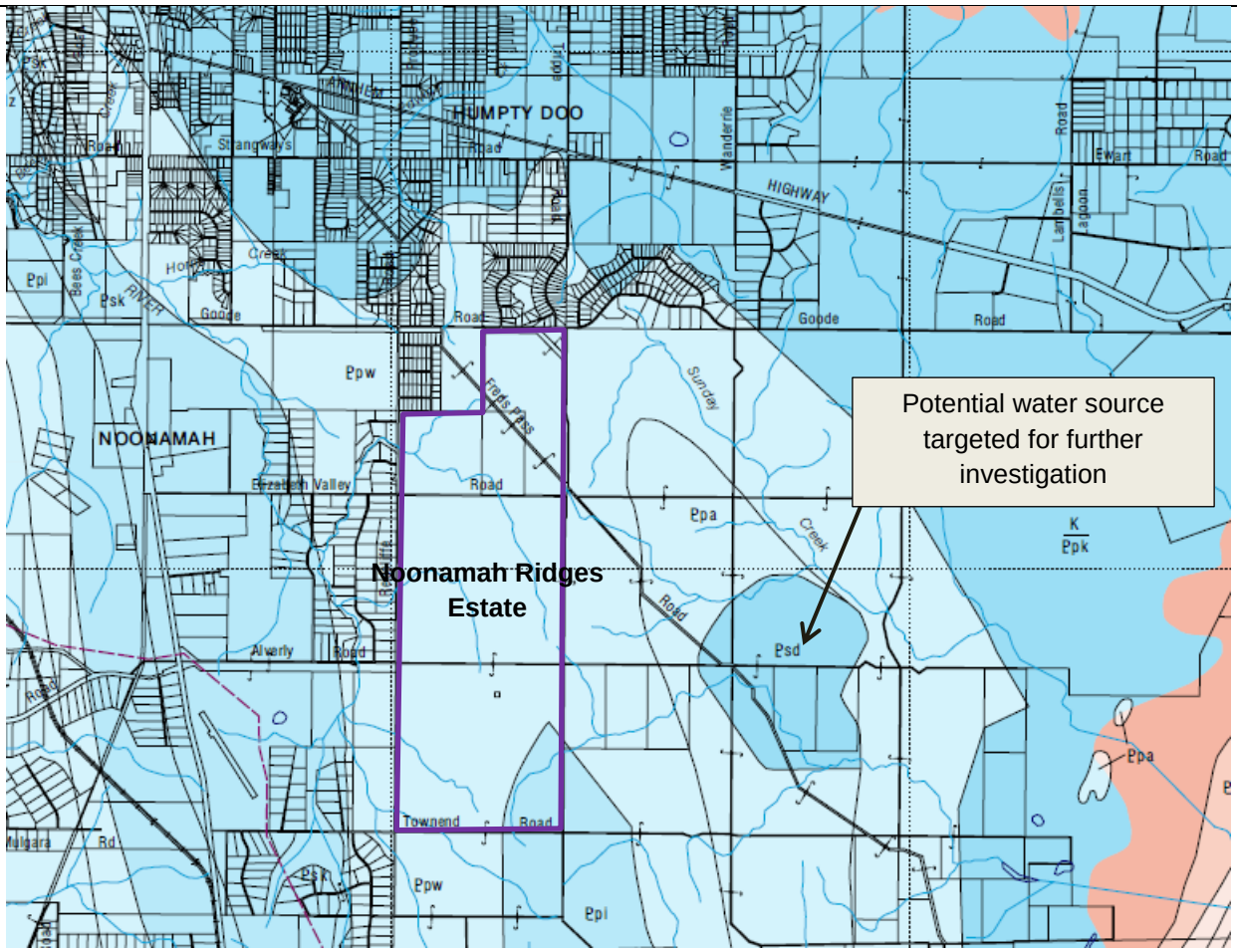
Figure 4-8.

The hydrogeology of the proposed development site comprises fractured and weathered rocks with minor groundwater resources with yields less than 0.5 L/s (Acacia Gap Quartzite Member and Wildman Siltstone).

The south east portion of the development site features fractured rock aquifers (Whites formation) of dolomitic shale yielding 0.5 – 5.0 L/s (Verma, 2002).

The Koolpinyah property, adjacent to the east of the proposed development site, overlies an area of Carbonate Fractured Rock with potential yields >5.0L/s and potential water quality suitable for human consumption. No bores are evident within this geological formation through Natural Resource Maps NT.

No bores exist within the proposed development site, however numerous bores are located on adjacent properties (Figure 4-9) for domestic and stock supply with yields generally ranging from 0.0 – 5.0 L/s. A number of irrigation and production bores, some exhibiting yields in excess of 15.0 L/s, exist on properties adjacent to the proposed development.



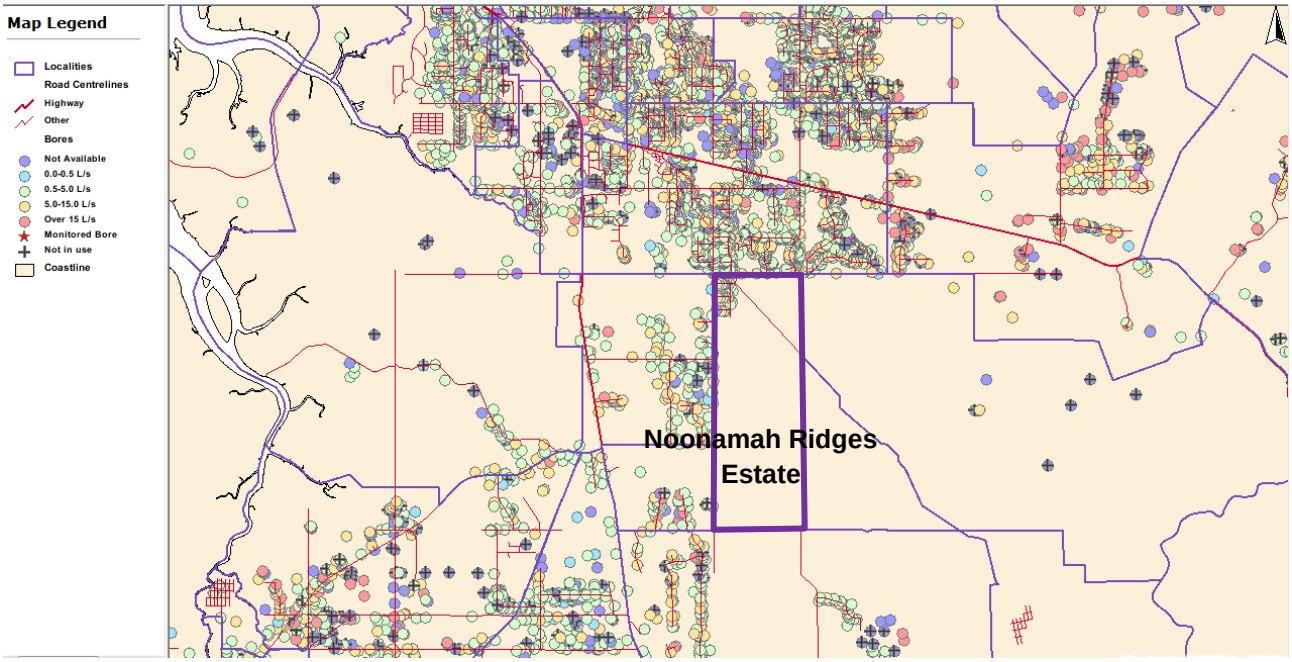
*extracted from the Ground water and hydrology prospects for the Litchfield Shire (NRETAS, 2008).

Psd: >0.5 L/sec Carbonate Layer Formation

Ppw: <0.5L/sec Wildman Siltstone Formation

Ppl: 0.5-5 L/sec Whites Formation (fractured weathered rock)

Figure 4-8 Aquifers in the vicinity of the Noonamah Ridges Estate



*sourced from NR Maps 2013

Figure 4-9 Existing bores in the vicinity of the Noonamah Ridges Estate

4.6 Topography and land resources

4.6.1 Topography

The Noonamah Ridges Estate features a substantial series of quartzite to sandstone hilly ridges running diagonally through the land parcels on a north-west to south east alignment, occupying over 50% of the land parcels (combined), which grade into low rises to flat gently undulating upland. The highest points within the land parcels are approximately 80m above sea level situated in the southern area in the vicinity of the Telstra tower. The lower areas, largely on the boundaries of the land parcels, are about 32m above sea level (Figure 4-10).

Within the hilly areas some of the steepest slopes are approximately 18-20% with these areas being localised hill slopes up to 110m in width and 400m or more in length. The hill areas feature some broad areas of hill crest (over 350m in width) with a slope of around 5-6%. Generally the rugged hills exhibit a pattern of undulating rises separated by open drainage depressions often with a moderate slope of 20%.

Within the lowlands the drainage areas are generally broad depressions with occasional incised or gully like systems.

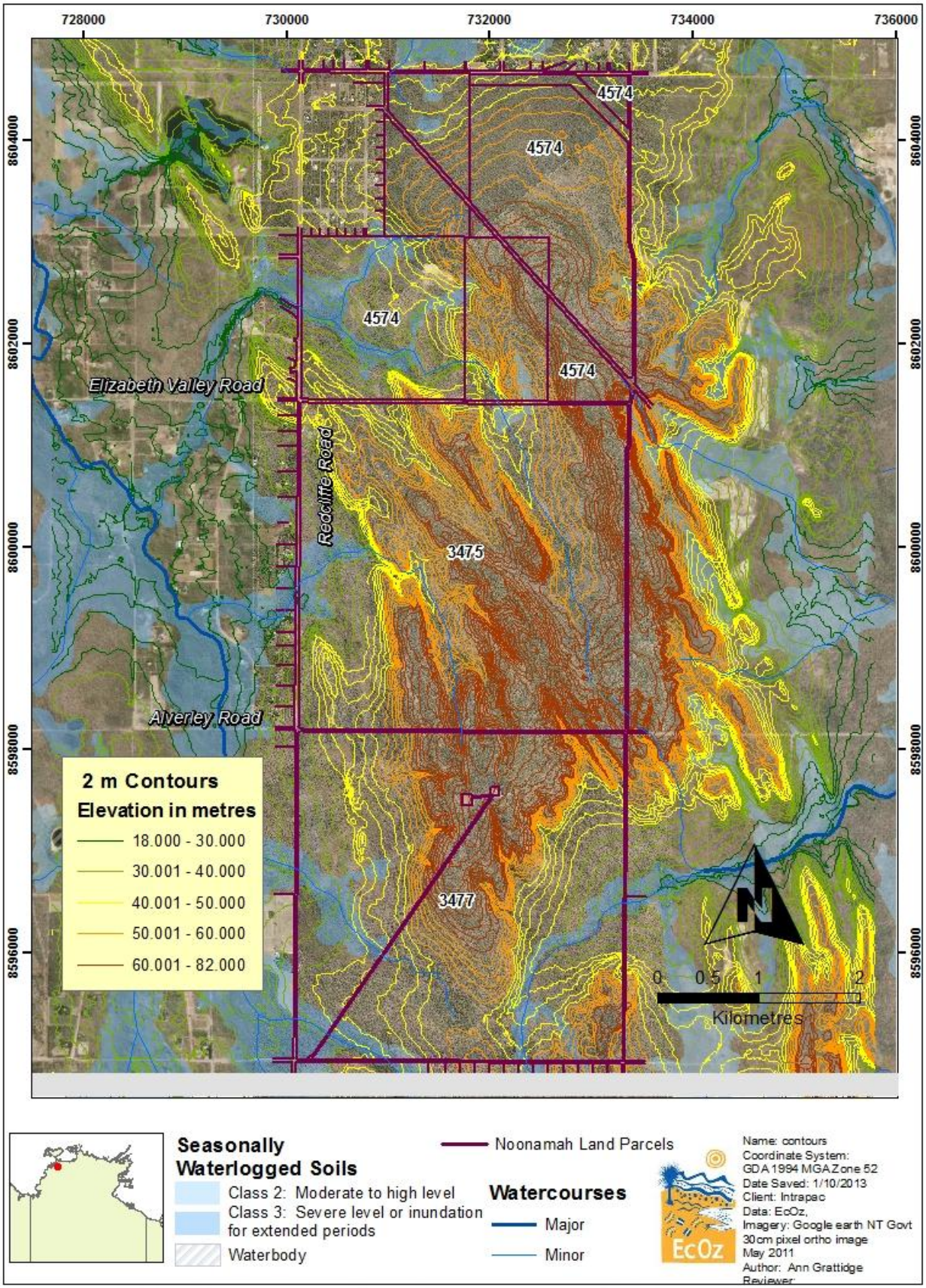


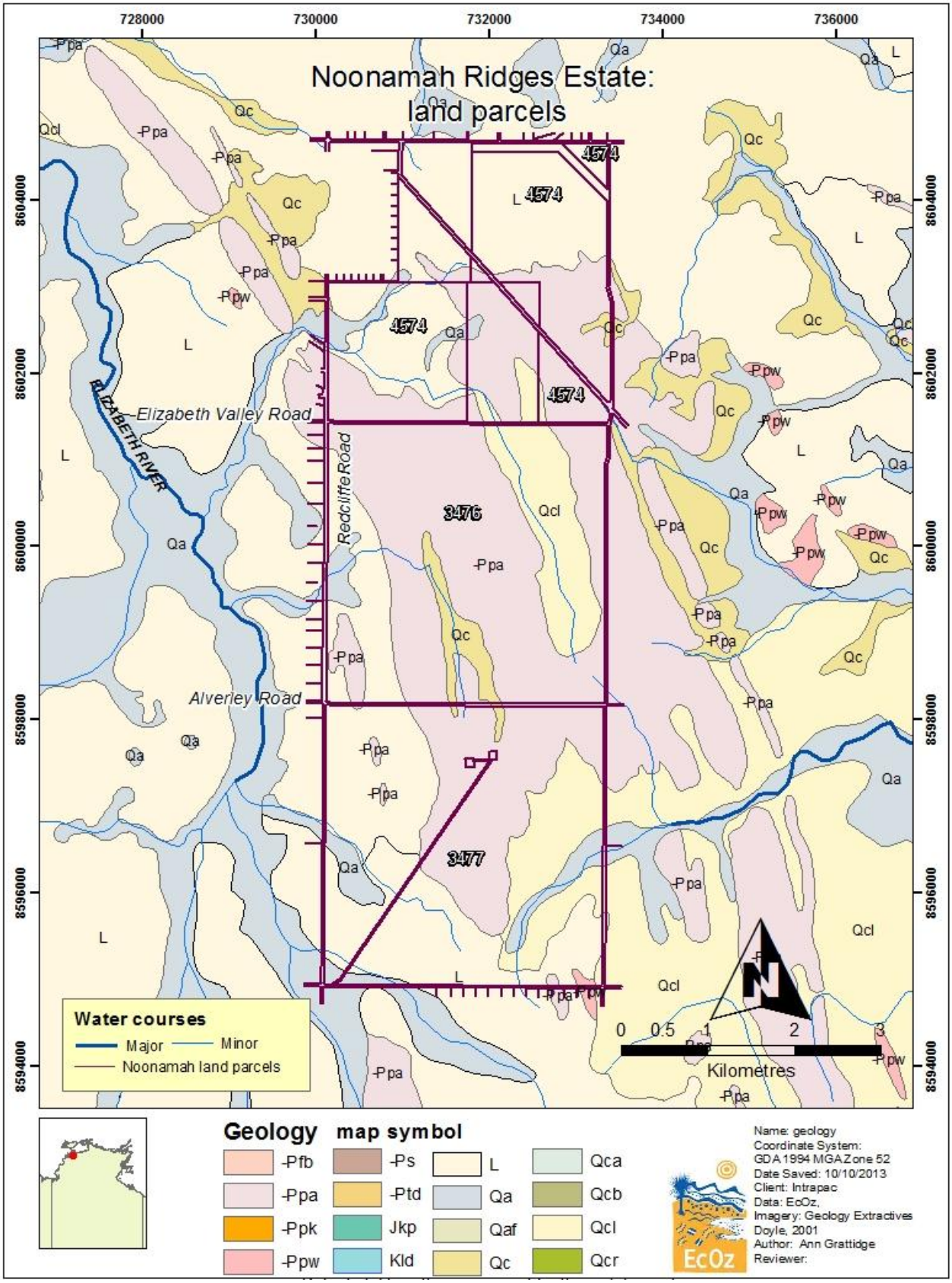
Figure 4-10 Contours for the Noonamah Ridges Estate project area

4.6.2 Geology

Geological mapping by Pietsch and Stuart-Smith, 1987 for Darwin at 1: 250,000 scale has been slightly modified by Doyle, 2001 for the extractive industry and is presented in Figure 4-11. The main geological units for the estate, according to the most recent geological mapping by Doyle, 2001 include: Ppa, Qcl (Sand, silt, transported laterite gravel and intact duricrust) and Qc (Slope wash, sandy flood plains, gravel, sand silt, colluvium) for the Hills and slopes, unit L (Laterite gravel (pisolitic and nodular) diricrust/ferricrete) largely for the low plains and Ppw (siltstone, siltstone and shale) and Qa (River and creek alluvium - gravel, sand, silt) in the drainage areas. Characteristics of the geological units for the Noonamah estate are detailed in Table 4-1 below.

Table 4-1 Geological units and corresponding descriptions for the Noonamah Ridges Estate

Geological units (according to mapping by Doyle, 2001)	Landform association within the Noonamah Estate
Ppa: Quartzite, commonly pyritic, sandstone interbedded shale Qcl: Sand, silt, transported laterite gravel and intact duricrust Qc: Slope wash, sandy flood plains, gravel , sand silt, colluvium	Hills and ridges
L: Laterite gravel (pisolitic and nodular) diricrust/ferricrete Ppw: Wildman siltstone, siltstone and shale	Low plains
Qa: River and creek alluvium - gravel, sand, silt.	Drainage areas



*refer to Table 4-1 for explanations of the geological units

Figure 4-11 Geology of the project area (Doyle, 2004)

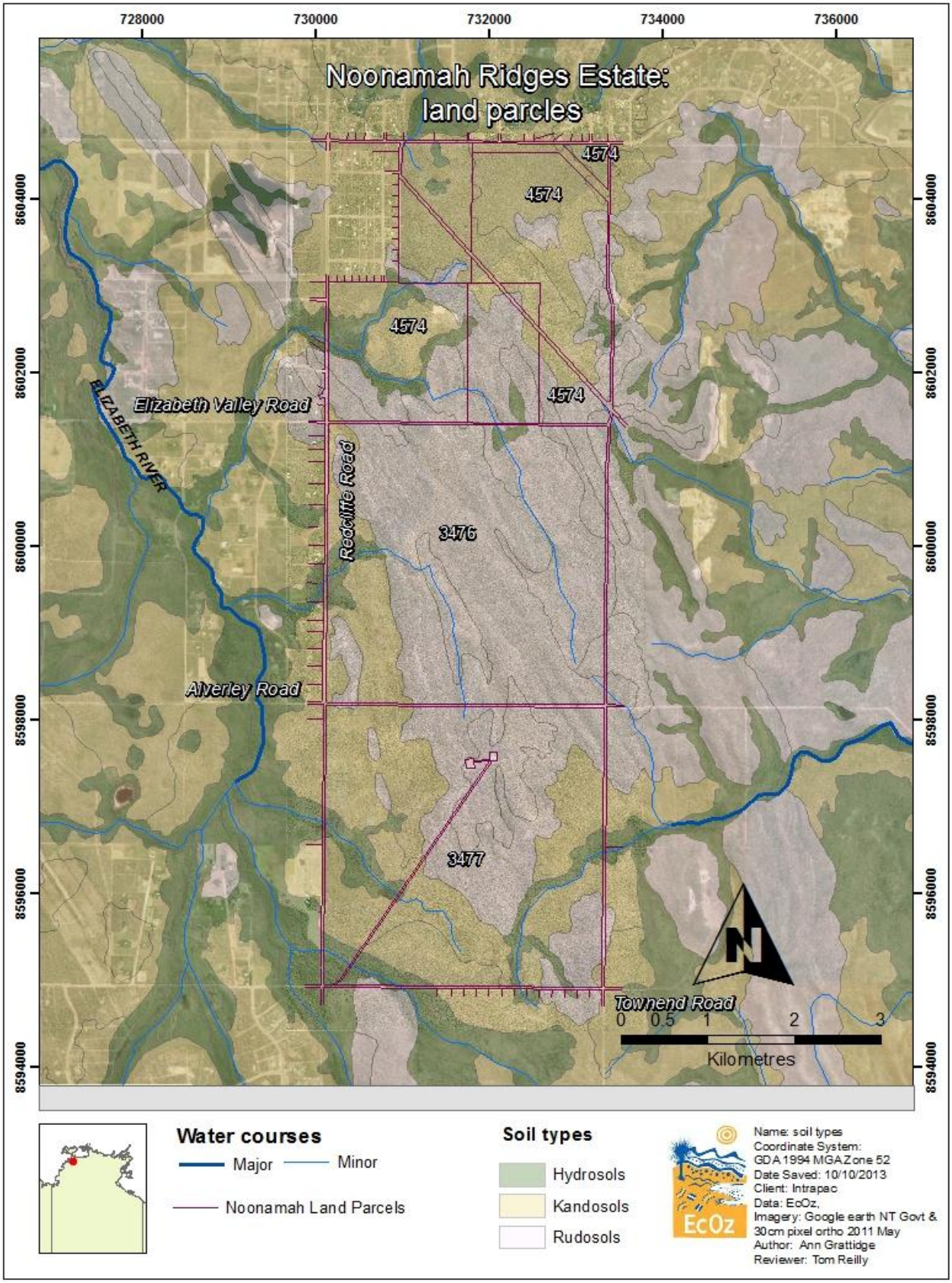
4.6.3 Broad Soil types

Noonamah soil types comprise of a combination of Hydrosols, Kandosols and Rudosols (Figure 4-12). The general characteristics for these soils types (particularly relevant to Northern Australia) are described in (Table 4-2). Parcel 3476 is dominated by Rudosols. The Land parcels 4574 and 3477 feature a combination of all three soil types. Soils of the Hydrosol types are predominately associated with the drainage areas in the lower lands.

Table 4-2 General characteristics of the main soil orders occurring with the Noonamah Ridges Estate

Soil Order	General Characteristics	Association with Landform
Hydrosols	Defined on the basis of seasonal or permanent wetness. The greater part of the profile is saturated for prolonged periods (2-3 months) in most years. Site drainage patterns are key factor in defining the extent. Most acid sulphate soils are hydrosols. These soil types can pose engineering and environmental problems.	Located in the low lands associated with drainage
Kandosols	Lack a clear textural B horizon. Not calcareous throughout and the clay content of the massive to weakly structured B2 horizon exceeds 15% equivalent to heavy sandy loam. Soils can be quite deep up to 3m or more in depth. The clay content can increase to 35-50% by a depth of 0.5-1m. Clay content is dominated by kaolinite. Common on extensive to level plains. Red and brown sub orders are generally permeable and well drained.	Located on the level plains and lower slopes
Rudosols	Consists of material not greatly affected by pedological processes. Soils feature little of pedological development apart from a minimal A1 horizon or presence of a minor B horizon in the fissures of the parent rock. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present. In Northern Australia these soils types can be shallow gravelly sands formed on siliceous rocks of quartzite or sandstone.	Located on the hills and rugged slopes

*Descriptions taken from Mckenzie (1958-2004 CSIRO)



*Refer to Table 4-2 for explanation of the soil orders

Figure 4-12 Broad Soil types within the Noonamah Ridges Estate project area

The broad soil orders which are present within the Noonamah Ridges Estate can be broken down further into sub order types as per the land unit mapping at 1:25,000 scale by Forgarty et al, 1984 (Figure 4-13). The sub order and sub group types are described in Table 4-3 below.

The following defines some of the sub group terminology according to the CSIRO Australian Soil Classification (2013):

Ternosolic soils - apart from wetness, fulfil the requirements for Tenosols which have a weak pedologic organisation apart from the A horizons. Tenosols may be considered and intermediate between Rudosols and a variety of other soil types

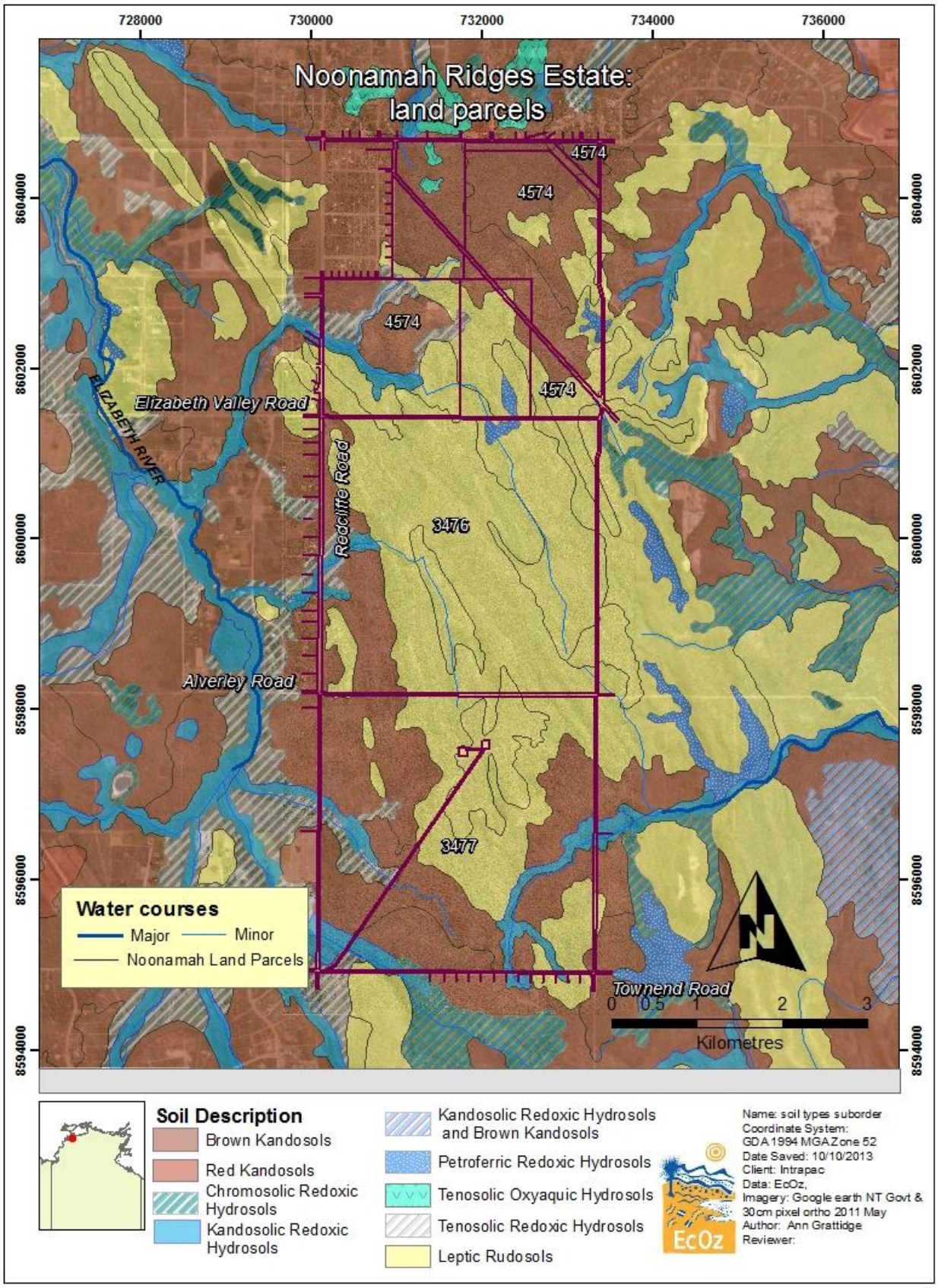
Kandosolic - soils with B2 horizons and which apart from wetness fulfil the requirements for Kandosols.

Chromoosolic – soils with a clear or abrupt textural B horizon and the pH in the major part of the upper 0.2 m of the B2 horizon is not strongly acid.

Petroferric – Soils with a petroferric horizon within the solum. A petroferric horizon consists of ferruginous, ferromanganiferous or aluminous nodules or concretions cemented in place into indurated blocks or large irregular fragments.

Table 4-3 Characteristics of the sub order soil types occurring with the Noonamah Ridges Estate

Soil Order	Sub order	Characteristics	Subgroup
Hydrosols	Redoxic	Soils with a seasonal or permanent water table and in which the major part of the solum (or the subsoil if the profile is stratified) is mottled.	Ternosolic.
			Kandosolic
			Chromoosolic
			Petroferric
	Oxyaquic	Soils with a seasonal or permanent water table and in which the major part of the solum (or the subsoil if the profile is stratified) is whole coloured.	Ternosolic.
Kandosols	Brown	The dominant colour class is brown.	na
	Red	The dominant colour class in the major part of the upper 0.5 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.5 m thick) is red.	na
Rudosols	Leptic	Soils that are underlain within 0.5m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite.	na



*Refer to Table 4-3 for explanation of the soil sub orders

Figure 4-13 Soil types by sub order and subgroup within the Noonamah Ridges Estate project area based on Fogarty et al, 1984

4.6.4 Land Units

The Noonamah Ridges Estate is within an area covered by Land Resource Mapping by Fogarty, Lynch and Wood, 1984 for the Elizabeth, Darwin and Blackmore Rivers.

The majority of the Estate (14km^2 of a total of 26.9km^2 approximately 50%) features land units 1a, 1b and 1c which are rugged hills and slopes dissecting the land parcels obliquely running north-west to south-east. While these areas are well drained they can feature some very steep slopes (ranging at from 5-40% but more generally the maximum is 20%) and a significant proportion (20-40%) of extensive rock outcrop or surface rock of up to 90% surface cover in localised areas.

A large portion of the proposed development area features low rises to flat gently undulating upland surface which are well to moderately drained with some drainage areas which may experience periodic inundation (mainly land units 5b2, 5b1 and 6b) and also some areas which feature soils prone to water logging (e.g. land unit 4a).

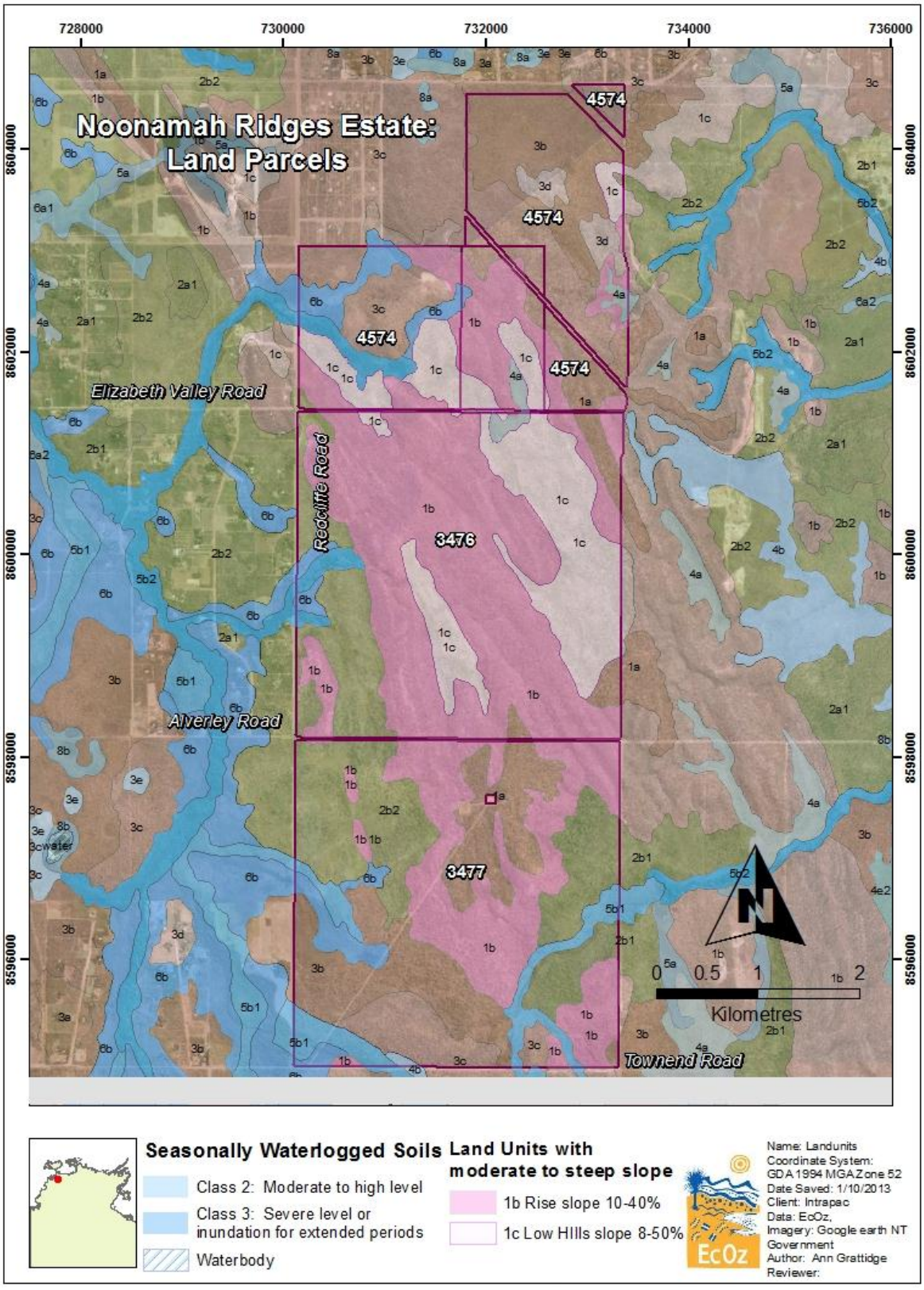
Table 4-4 Land units for Noonamah Ridges Estate according to Fogarty et al, 1984

Land unit	Landform	Vegetation type	Drainage Capacity	Development Limitations	Area ha	Percentage Area %
1a	Rugged hills and slopes	Open Woodland to Forest	Very rapid	Stony shallow soils, common outcrop. Rock outcrop and surface stone (20-40%)	170.4	5.33
1b		Woodland		Steep slopes, stony shallow soils, extensive stone surface Side slopes commonly 10-40% Relief between 10 and 40 m	1106.4	34.60
1c		Woodland		Steep slopes (scape gradients: 20-50% and side slopes: 8-20%), common surface stone and outcrop (30-60%), shallow soils. Relief between 5 and 20 m	356.9	11.16
2b1	Low rises and gravelly side slopes	Open Woodland to Woodland	Rapid	Very gravelly soils	120.8	3.78
2b2		Low Open Woodland		Shallow gravely soils, outcrop	288.7	9.03
3a	Flat to gently undulating upland surface	Open Forest		nil	0.7	0.02
3b		Woodland	Moderately rapid	nil	318.9	9.97
3c		Woodland		Shallow gravely soils	562.5	17.59
3d		Open Woodland	Rapid	Very gravelly shallow soils	30	0.94

Land unit	Landform	Vegetation type	Drainage Capacity	Development Limitations	Area ha	Percentage Area %
3e	Flat to gently undulating upland surface	Woodland	Slow drainage: subject to run on and wet season waterlogging	Site drainage	0.1	0.00
4a	Gentle lower slopes	Open Woodland	Slow: waterlogged in wet season	Site drainage, soil drainage.	17.8	0.56
4b		Open Woodland	nil	Site drainage, soil drainage.	1.9	0.06
5b1	Upland drainage lines	Woodland to Open Forest	Slow: wet season waterlogging and inundation	Site drainage	82.2	2.57
5b2		Open Shrubland to Open Woodland	Slow: can carry water in wet season	Site drainage, soil drainage.	38.9	1.22
6b	Broad lowlands plains	Tall Shrubland to Low Open Woodland	Slow; wet season inundation	Site drainage	94.7	2.96
8a	Depressions and Billabongs	Grassland	Very slow: wet season inundation.	Site drainage, outcrop	6.6	0.21

Unit 4a (between unit 1c and 1b) Water logged soils scattered within unit 1c

Figure 4-14 land units featuring water logged soils either within or between units 1c and 1b



* Refer to Table 4-4 above for translation of land unit codes (e.g. 1a, 1b etc)

Figure 4-15 Land units within the Noonamah Ridges Estate project area as defined by Fogarty et al, 1984

Figure 4-16 Hill slope typical of unit 1c and 1b

Figure 4-17 Hills with extensive rock surface cover occuring in patches within unit 1b

4.6.5 Erosion potential

Water flow is a major driver of erosion in the Tropical Savannas due to the concentration of exceptional rainfall events (Lynch & Hill 2007). The tropical Savannas typically feature non-cohesive sandy soils which are highly erodible (Isbell 1986; Weston 1991 cited in Russell-Smith et al. 2006). The climate is strongly seasonal with a long dry period, resulting in reduced soil vegetation cover (Russell-Smith et al. 2006) followed by intense storm events from November through to April. Most of the annual rainfall (90%) occurs in the wet season during high energy rainfall events (Dilshad et al. 1996). This combination of natural factors means that the Northern Landscape is inherently highly vulnerable to degradation in terms of decline in productivity and also water quality through soil erosion. For development, any area with a gradient slope greater than 5% can be considered to be at high risk of erosion. However, erosion can be common on slopes less and 0.5% depending on the soil type and exposure to surface flows.

Intensity of rainfall events or heaviness can give an accurate indication of severity of erosion and flooding potential. Rainfall intensity is calculated by dividing the depth by the rainfall duration for example one hour (BOM 2013). An average rainfall per wet day in the wet season is 38.7mm (based on 2010 Weather Bureau data for Acacia Hills). However, the intensity of rainfall events can be extreme with a 50% chance of 50mm and 1% chance of 100mm falling within a span of an hour (BOM 2013).

Landuse and built infrastructure largely influences erosion potential through alterations to vegetation cover, micro-relief, surface flow characteristics and soil structure. Key attributes which influence the erosion potential and how these relate to the Noonamah estate are detailed in Table 4-5.

Table 4-5 Key attributes which influencing the erosion potential

Attribute	Parameter	Relationship with Erosion potential	Relationship to Noonamah estate
Geology & Soil type	-Soil depth	Skeletal and sandy soils (Rudosols) are the greater proportion of the land parcels.	Land units 1a,b and c in particular are skeletal in nature and vulnerable to erosion
	- Graveliness or Rockiness	Surface roughness can influence the velocity of overland flow and hence processes of soil detachment (Dilshad et al. 1996).	Land units 1a, b and c in particular exhibit a high degree of rock cover which is contributing the bulk of the resistance of erosion, opposed to vegetation cover
	- Soil Physical Structure such as Permeability and Water holding capacity	Hydraulic characteristics of the soil surface and water holding capacity strongly influence infiltration and runoff processes and therefore, soil water storage and sediment movement (Dilshad 1996).	Most land units feature at least some areas which are stable during the dry season but have a high water holding capacity and therefore vulnerable to water logging in the wet season.
	- Soil organic matter and chemistry	Organic content plays a key role in forming and maintaining a sound surface structure (Mott et al. 1979).	Frequent burning can reduce organic matter in the soil and increase erosion potential. This is likely to be concern in land units 1a, b and c.

Attribute	Parameter	Relationship with Erosion potential	Relationship to Noonamah estate
Landform or Relief	-Slope (influencing velocity and concentration of surface flows)	Hill slope together with obstructions such as rock and vegetation cover influence the velocity and concentration of surface run-off.	Land units 1a,b and c in particular feature some moderate to steep slopes with rock surface playing a key role in soil stability.
Drainage Characteristics	-Surface flow (velocity and concentration)	A vegetation cover threshold of above 40% in October results in negligible runoff losses. However, rainfall intensity and duration, soil moisture and litter also need to be taken into account (Dilshad et al. 1994 and Owen 2009).	Surface flow and velocity are likely to be a concern for erosion potential in the land units prone to water logging and also the hilly units 1a, b and c.
	- Subsurface flow	Flood plains prone to Inundation can experience multiple water sources. The saturated soils are vulnerable to basal seepage, flood water scouring and soil dispersion (Brooks et al. 2009).	Land units 5b1 and 6b in the lowlands are most prone the impacts of flood waters and erosion.
	- Degree of Inundation	water ponding increases erosion risk.	Land units 5b1 and 6b and 4a are prone to water logging and ponding for extended periods in the wet season.

4.6.6 Potential for Soil Contamination

There does not appear to be any history such as agriculture, illegal dumping, nor ties to the World War II activities or bombing of Darwin suggesting that contaminated soil might be of concern. An ex-quarry site of 5.7ha within parcel 4574 may feature minor areas where hazardous materials or pollutants (e.g. hydrocarbons) may have been spilt or disposed of. This quarry is intended to be rehabilitated for a potential public use area.

4.6.7 Soil salinity potential

According to broad assessment of dry land salinity potential for the Northern Territory by Tickell (1994) the overall hazard for dry land salinity is relatively low. The low risk of clearing leading to dry salinity in the north is largely due to the low levels of ground water salinity. Rising water tables in lowland areas (e.g. water input from irrigation) can have the potential to mobilise salts stores within soils. Salt stores in the northern half of the Northern Territory are low compared to Southern Australia.

4.6.8 Acid Sulphate soil potential

An assessment of Acid sulphate soils for the Darwin region by Hill and Edmeade (2008) has mainly focused on coastal areas and areas where such soils might be expected to occur. The Noonamah area does not trigger concern and therefore no current studies into the acid sulphate potential for the Noonamah area have been undertaken.

4.7 Biodiversity

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into units of broadly similar landform, geology and biodiversity (Baker et al. 2005).

The land parcels associated with Noonamah Ridges Estate are located within the Darwin Coastal Bioregion.

The Darwin Coastal Bioregion includes significant portions (almost 30%) of the bioregion is reserved with several major conservation reserves, most notably including Litchfield National Park, Mary River National Park and Kakadu National Park, which together (along with other smaller reserves) provide a reasonably good representation of the region's environmental variation (DLRM 2013a). However, the existing park reserves and extensive areas of intact vegetation have experienced significant declines in small to medium sized mammals (Woinarski et al. 2010) which translates into a high priority on protecting and managing areas which can contribute to conserving this range of species. A study of regional patterns of mammal abundance and their relationship to landscape variables for Eucalypt woodland near Darwin by Price et al. 2005 indicated that some of that the diversity of small to medium sized mammal species is higher within Southern Litchfield shire than other regions of Darwin.

Most of the bioregion is in reasonably good condition. However, there has been extensive clearing (about 200 km^2) associated with urban development and horticulture in the coastal plains near Darwin (DLRM 2013a). There is a need to retain more bushland fragments and corridors within the growing horticultural and rural lands around and to the east of Darwin (DLRM 2013a). There is a current local government regulation to maintain 50% of native vegetation in Litchfield Shire, which encompasses most of this horticultural area (DLRM 2013a).

Frequent late dry season fires, feral animals, livestock, and weeds have led to broad scale but diffuse as well concentrated, habitat degradation throughout the bioregion (DLRM 2013a).

4.7.1 Sites of Conservation Significance

A study by scientists from the Department of Land Resource Management identifies 67 of the most important sites for biodiversity conservation for the Northern Territory. The Noonamah Ridges Estate is bordered by three of these sites of Conservation Significance to the north, west and east which include: Howard Sand Plains, Darwin Harbour and the Adelaide Flood Plains (Figure 4-18). All three of these areas are recognised as being of international conservation significance; however, none of these sites are afforded any official or legislated level of protection.

The western portions of the Noonamah land parcels drains into the Elizabeth River which flows into the Darwin Harbour the site of international conservation significance.

The south eastern tributaries of the Noonamah Ridges Estate land parcels drain into the Adelaide River which feeds the Adelaide River Coastal Flood plains site of international conservation significance.

The Howard Sand Plains, which is a site of International Conservation Significance, is situated largely around the Howard River to the north of the Noonamah Ridges Estate land parcels with its southern boundary crossing the top of the northern parcels.

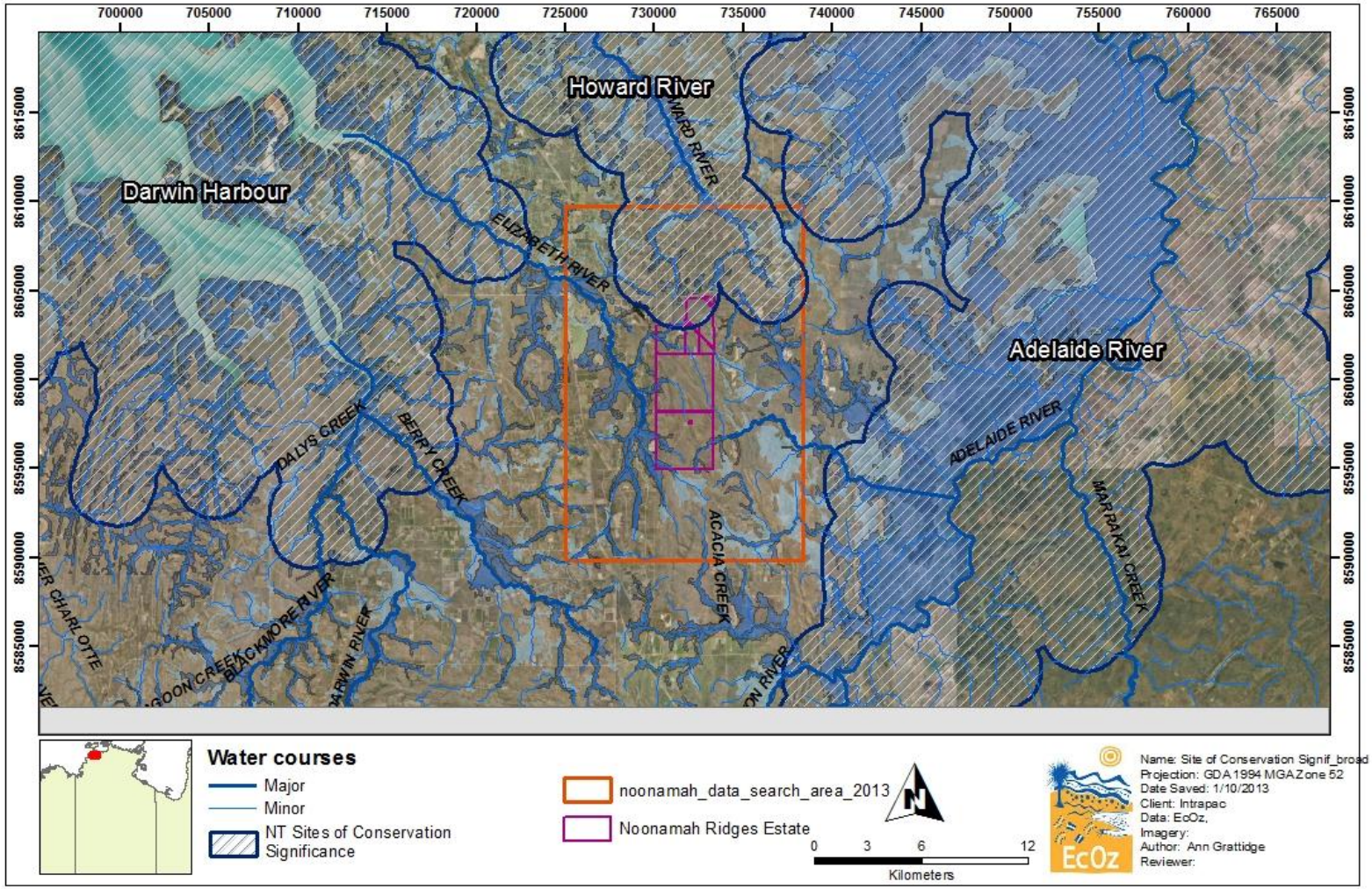


Figure 4-18 Sites of Conservation Significance in relation to the Noonamah Ridges Estate

The Howard Sand Plains

The Howard Sand Plain area features a significant proportion of the Sandsheet land type also alternatively identified as a Sandsheet Heath Vegetation type (Harrison et al. 2009). Although fine sand deposits exist beyond the Greater Darwin area, the Howard Springs area exhibits some particularly unusual diversity in flora and fauna compared to other regions in the near surrounds and also compared to sandy habitats in other parts of the Northern Territory such as Kakadu. The Howard Sandsheet is considered a rare vegetation type covering approximately 56km^2 within the Greater Darwin area and it features a number of threatened species (DLRM 2013b).

The Howard River Sandsheet feature at least 26 Bladderwort species (Harrison, et al, 2009) of which several are rare or restricted to this land type within the Greater Darwin area alone. In addition the Howard River Toadlet (a small native frog of the *Uperoleia* genus) is only found within Sandsheet habitat within the Greater Darwin area. The Howard River Toadlet is the only frog species in the Territory listed as vulnerable and it is considered threatened due to its restricted occurrence and the impacts of clearing of the Sandsheet habitat. A number of the *Utricularia* species and herb *Typhonium taylori (EBPC listed as endangered)* are also listed as threatened or near threatened under the NT legislation (DLRM 2013b).

The Darwin Harbour

Darwin Harbour has one of the richest coastal environments anywhere in the Asia Pacific region, and occurs within one of the world's least impacted marine regions (Harrison et al. 2009). Protection of the Harbour water quality is identified as a high priority. Frameworks and concerns for managing for surface water quality are detailed in section 4.4.

The Adelaide River Coastal Flood Plains

The Adelaide River floodplain regularly supports large numbers of waterbirds including internationally significant numbers of many species such as Magpie Goose and Whistling-Ducks (Harrison, et al, 2009). The upper and middle parts of the floodplain provide core nesting habitat for Magpie Geese, and the largest waterbird breeding colony in the Northern Territory is found in mangroves in the lower reaches of the Adelaide River (Harrison et al. 2009).

This site has not been formally assessed against Ramsar criteria but is likely to satisfy at least waterbird based criteria (Harrison et al 2009). Parts of this site are listed as a wetland of national significance in the Directory of Important Wetlands in Australia (Harrison et al. 2009).

4.7.2 Vegetation types

Vegetation mapping which presently exists for the Noonamah Ridges Estate land parcels are listed in Table 4-6 below.

Mapping at 1:1 Million scale by Wilson et al, 1990 for the Noonamah estate is indicated in Figure 4-22. Remnant vegetation mapping for the Litchfield shire is presented for the Noonamah estate in Figure 4-23.

Fogarty et al, 1984 provides the more comprehensive vegetation mapping for the area (Figure 4-24).

According to Fogarty et al, 1984 the Noonamah land parcels features sixteen vegetation types which are detailed in Table 4-7 Vegetation types along with their proportional presence.

Table 4-6. Vegetation mapping available for the Noonamah Ridges Estate

Scale & Coverage	Vegetation Mapping	**Figures** *in this report*
1:Million Whole of the NT	Wilson, B, Brocklehurst, P, Clark, M and Dickinson, K 1990, *Vegetation Survey of the Northern Territory - Technical Report No. 49*, Conservation Commission of the Northern Territory, Darwin.	Figure 4-22
1:25,000 Greater Darwin	Department of Planning Infrastructure & Environment (DPI&E), 2002, Litchfield Shire remnant vegetation mapping at 1:25,000 scale Department of Planning Infrastructure & Environment, Northern Territory Government, Darwin.	Figure 4-23
1:25,000 Greater Darwin	Fogarty, PJ, Lynch, B, & Wood, B. 1984, The land resources of the Elizabeth, Darwin and Blackmore Rivers. Conservation Commission of the Northern Territory, Darwin	Figure 4-24

Table 4-7 Vegetation types within the Noonamah Ridges Estate according to Forgarty et al 1984

Land unit	Landform	Vegetation Structure	Vegetation Description	Water logging concerns	Area ha	Percentage Area %
1a	Rugged hills and slopes	Open Woodland to Forest	*Eucalyptus tetrodonta*, *Eucalyptus miniata* over Sorghum species & *Heteropogon triticeus*	nil	170.4	5.33
1b		Woodland	*E. tetrodonta*, *E. tectifica*, *Corymbia foelscheana*, over *Sorghum plumosum*	nil	1106.4	34.60
1c		Woodland	*E. miniata*, *E. tetrodonta* over Sorghum species.	nil	356.9	11.16
2b1	Low rises and gravelly side slopes	Open Woodland to Woodland	*E. tetrodonta*, *C. foelscheana*, *E. tectifica* over *Sorghum spp.*	nil	120.8	3.78
2b2		Low Open Woodland	Mixed species over mixed grasses	nil	288.7	9.03
3a	Flat to gently undulating upland surface	Open Forest	E. *tetrodonta*, *E. miniata* over mixed grasses	nil	0.7	0.02
3b		Woodland	*E. miniata*, *E. tetrodonta*, over *Sorghum sp*.	nil	318.9	9.97
3c		Woodland	*E. miniata*, Euc. tetrodonta, over Sorghum species	nil	562.5	17.59
3d		Open Woodland	*E. miniata*, over Sorghum sp	nil	30	0.94

Land unit	Landform	Vegetation Structure	Vegetation Description	Water logging concerns	Area ha	Percentage Area %
3e	Flat to gently undulating upland surface	Woodland	*Corymbia polycarpa*, *Erythrophleum chlorostachys* over mixed grasses: wet season watertables	Slow drainage: subject to run on and wet season waterlogging	0.1	0.00
4a	Gentle lower slopes	Open Woodland	*Corymbia polycarpa*, *Lophostemon lactifluus* over *Themeda triandra*, *Eriachne burkittii*; wet season water table	Slow: waterlogged in wet season	17.8	0.56
4b		Open Woodland	*Corymbia polycarpa,* over mixed grasses; wet season water table	nil	1.9	0.06
5b1	Upland drainage lines	Woodland to Open Forest	*Lophostemon lactifluus*, *Corymbia Bella*, *Melaleuca viridiflora* over mixed grasses	Slow: wet season waterlogging and inundation	82.2	2.57
5b2		Open Shrubland to Open Woodland	Corymbia. polycarpa, Melaleuca spp, *Euc. alba* over *Eriachne spp*, *Sorghum* spp.	Slow: can carry water in wet season	38.9	1.22
6b	Broad lowlands plains	Tall Shrubland to Low Open Woodland	*E. miniata*, *E. tetrodonta*, *C. foelscheana*, *E. tectifica* over *Sorghum* sp.	Slow; wet season inundation	94.7	2.96
8a		Grassland	*Eriachne* species, annual *Sorghum* sp. with scattered trees or shrubs	Very slow: wet season inundation.	6.6	0.21

The dominant vegetation types within the hilly areas (comprising 51% of the total area) are associated with land units 1b, 1c and 1a which feature Eucalypt woodland with potentially some elements of forest or open forest within land unit 1a. The lower areas of the estate are dominated by land units 3b and 3c (comprising 28% of the total area) featuring Woodland dominated by *E. miniata*, *E. tetrodonta*, over Sorghum species. Land unit 2b2 (9% of the area) is also quite extensive in the low lands which features mixed canopy species over mixed grasses.

Drainage areas, particularly land units (6b, 5b1 and 5b2) in the low land areas occupy approximately 7% of the total area. Some of these low lying drainage areas are quite diffuse and the boundary for these land and vegetation types are not clear cut.

Significant vegetation types

Vegetation types for the Greater Darwin area which are those considered to be significant under the Northern Territory Vegetation Clearing Guidelines (2009) include areas of: rainforest, vine thicket, riparian vegetation, mangrove Sandsheet heaths and wetlands.

Some areas riparian vegetation, forest and possibly Sandsheet heath may be present within the Noonamah Ridges Estate land parcels. The following details the potential for these vegetation types to be present within the project boundaries and also within a buffer area which may be prone to off-site impacts.

Riparian

Vegetation types typical of temporarily flowing drainage areas are likely to be present within the hilly landforms.

Low lying drainage areas on the perimeter of the land parcels, particularly on the western, southern and south-eastern boundary, flow into tributaries of the Elizabeth and hence exhibit characteristics of riparian vegetation.

Forest – Open Forest

Some elements of open forest may be present within land unit 5b1 in the southern extent of the land parcels and possibly associated with some of the drainage areas within the hilly land units, such as *Lophostemon* open forest identified in the mapping of remnant vegetation for Litchfield Shire (Figure 4-23).

Sandsheet heath

The Howard Sandsheet is considered a rare vegetation type covering approximately 56km^2 within the Greater Darwin area and it features a number of threatened species (DLRM 2013b).

The Sandsheet Heath vegetation associated with the Sandsheet land type is characterised by having acidic infertile sandy soils overlaying an impermeable deposit of clay of laterite. This seasonally saturated land type typically features a specific suite of common plant species which are adapted to the rapid drainage pattern. The upper canopy species of the Sandsheet heath includes: *Grevillea pteridifolia*, *Banksia dentata*, *Melaleuca nervosa*, *Lophostemon lactifluus,* and *Verticordia cunninghamii* while the ground species can typically include: *Dapsilanthus spathaceus*, *Xyris complanata* and a variety of sedges. The actual suite of species occurring within the Sandsheet vegetation type can vary enough to warrant classification into a number of subtypes (Liddle et al. 2012).

Mapping for Sandsheet habitat within the greater Darwin area by Hempel, 2003 (Figure 4-25) does suggest Sandsheet habitat to be present but not in a large quantity. According to Hempel's data an area of sand sheet is present within a drainage area on the western boundary of parcel 3477. On ground survey to date indicate Sandsheet to be present in the drainage area on the north-western corner of parcel 4574. Areas of significant Sandsheet are located off site, particularly located within drainage areas to the north and west of the land parcels. Further surveys are required to confirm presence or absence of this vegetation type within the lowland areas of the estate.

Although the Howard Springs area is recognised as a site of international significance; the Sandsheet habitat in this area is considered rare and at risk (DLRM 2013b). A number of threatened species under the Northern Territory Parks and Conservation Wildlife Act and one under the EPBC Act) feature within this habitat type, the Howard Sandsheet is not listed as a threatened community nor afforded any official or legislated level of protection (Harrison et al. 2009 and DLRM 2013b). This habitat type if present, along with surrounding land types, which sustain the shallow flow of surface water to these land types, should be afforded protection where possible.

Ground water dependent ecosystems

Systems which are dependent upon ground water such as springs can be considered high value habitats. At least two areas which are possibly springs or expressions of ground water are present within the drainage areas within the hilly areas of parcel 3476 (Refer to Figure 4-24).

4.7.3 Priority Environmental Management Areas

Priority Environmental Management Areas for the Litchfield Shire are identified as drainage areas which are prone to waterlogging. These areas those with seasonal water logging as indicated in Figure 4-15. They require assessing to delimit and avoiding for development.

Figure 4-19 SandSheet (north eastern parcel 4574)

Figure 4-20 Lophostemon Open Forest (land unit1c Parcel 3476, vegetation type 19 Figure 4-23)

Figure 4-21 Spring or Expression of Groundwater (refer to Figure 4-24)

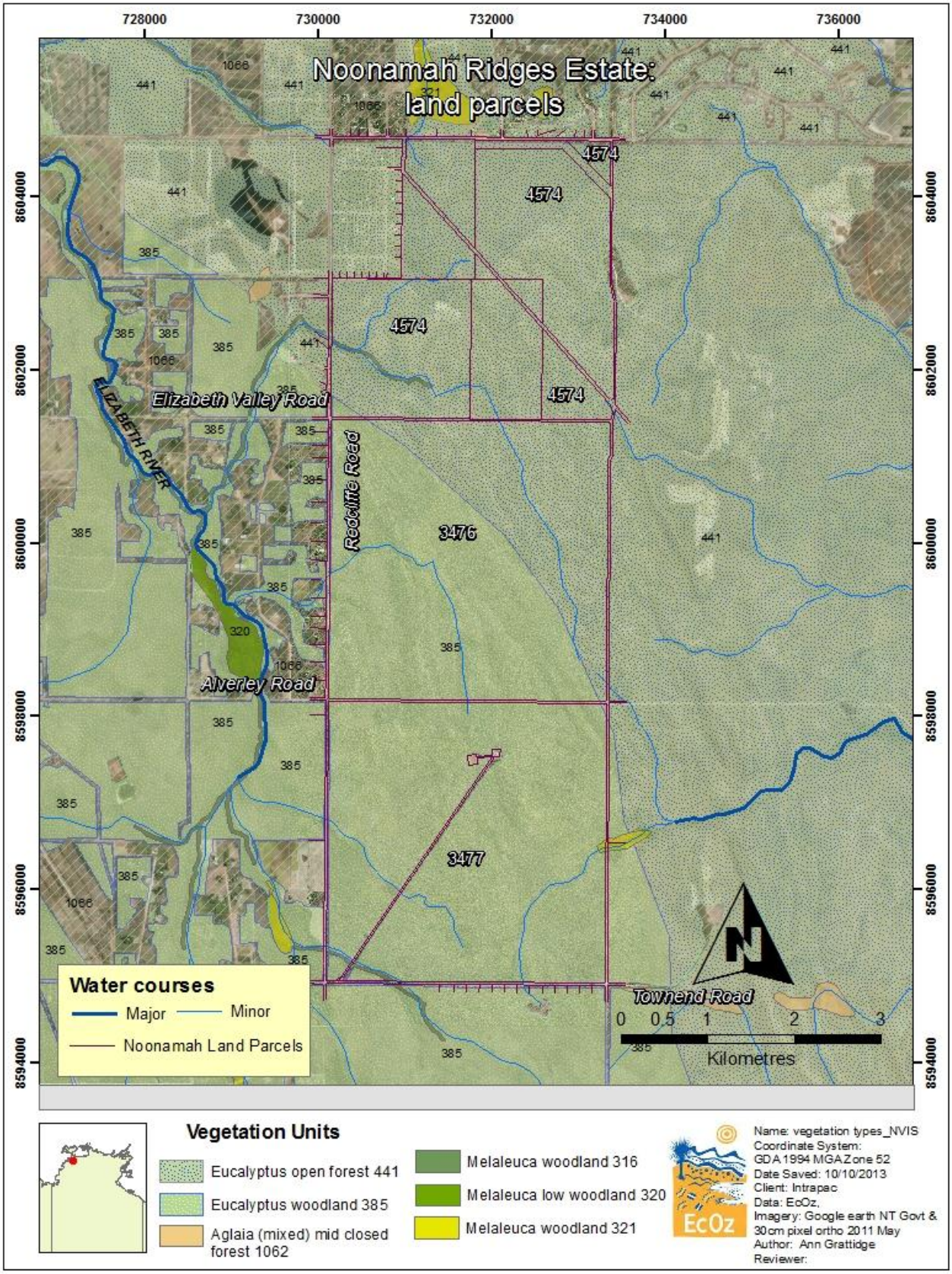


Figure 4-22 Vegetation types for Noonamah Ridges Estate according to Wilson et al, 1990

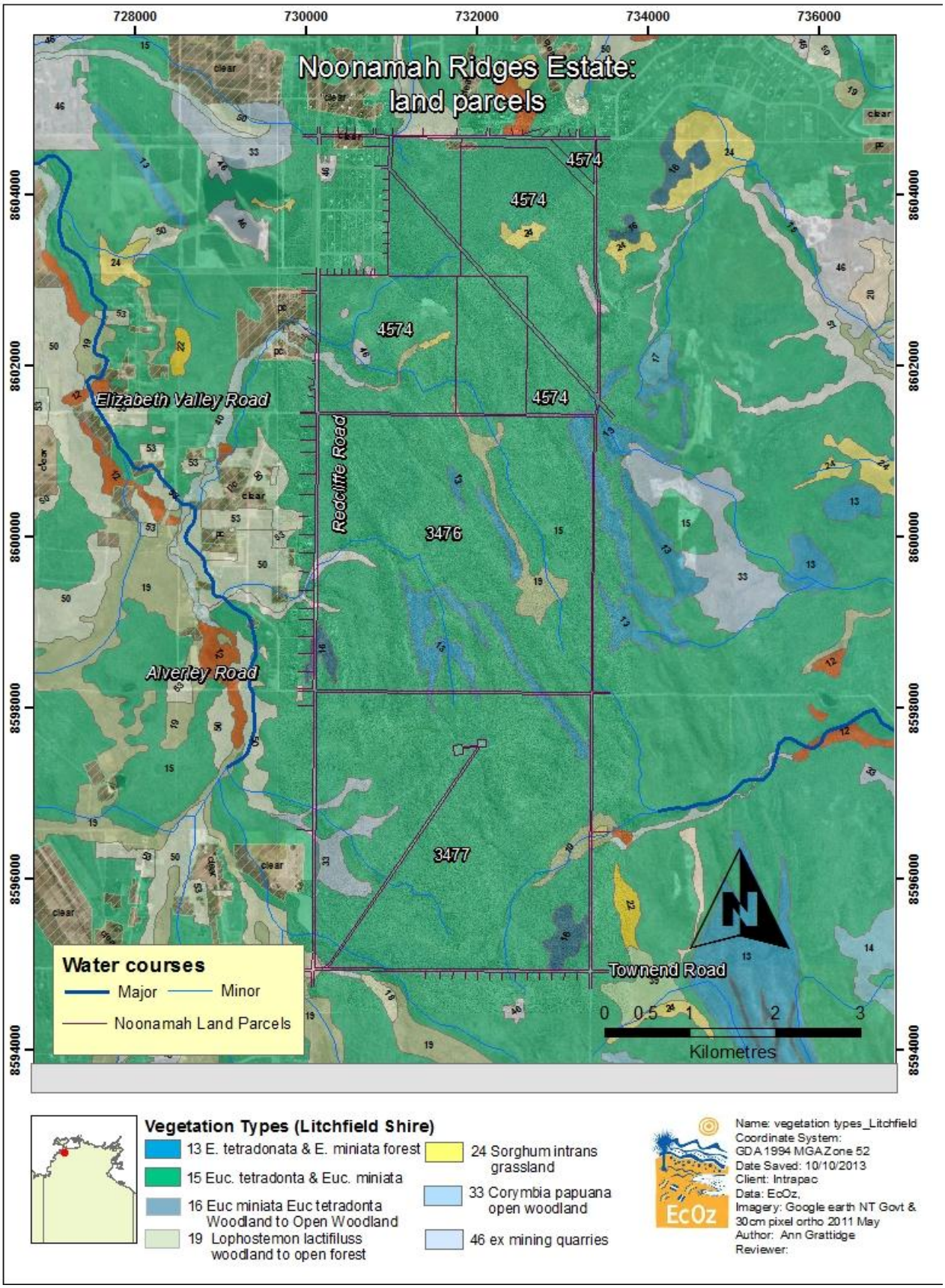
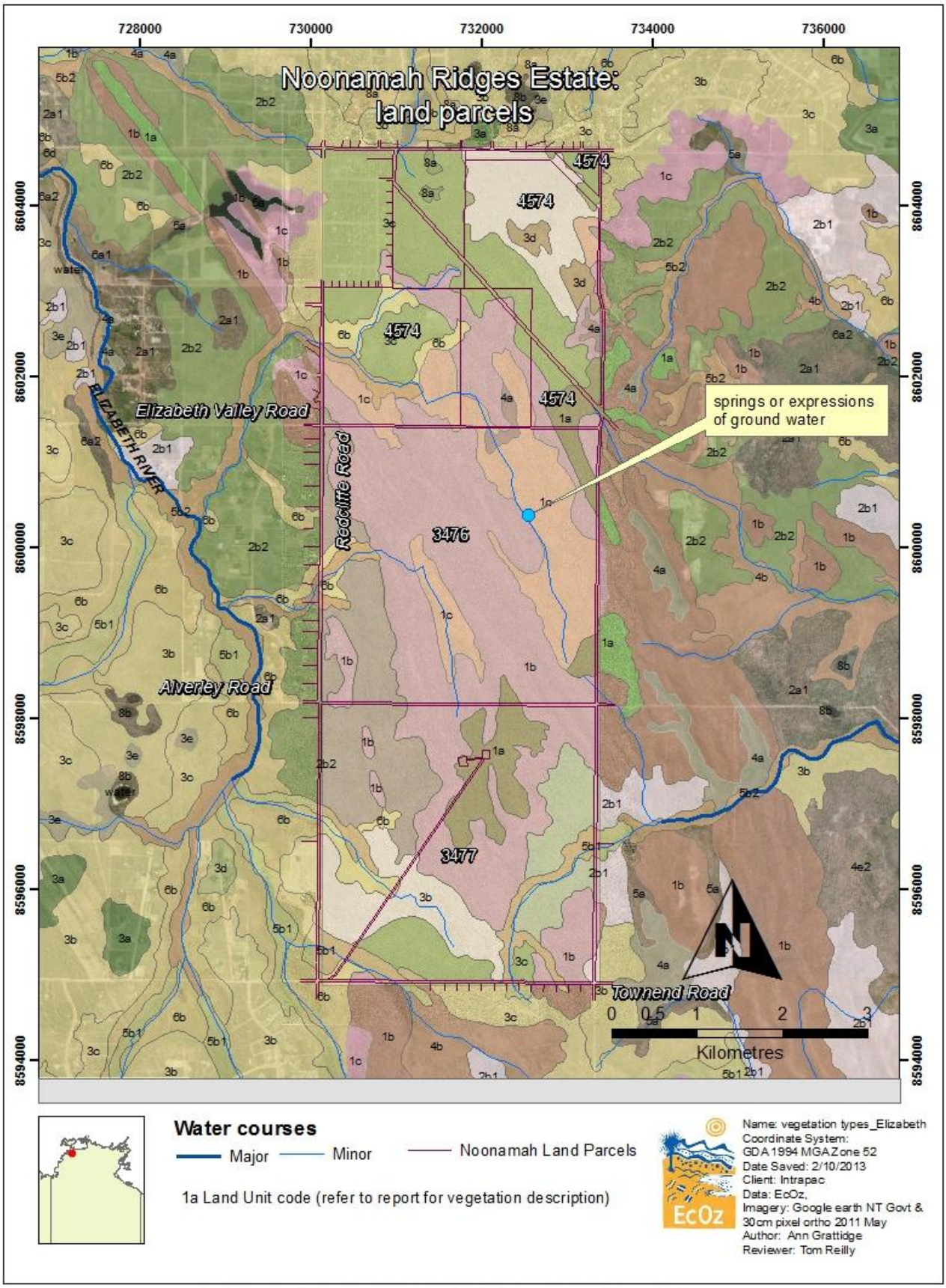


Figure 4-23 Vegetation types for Noonamah Ridges Estate according to the remnant vegetation mapping for Litchfield Shire, 2002



*Refer to Table 4-7 for interpretation of vegetation type with the land unit code (e.g. 1a, 1b etc).

Figure 4-24 Vegetation types for Noonamah Ridges Estate according to Forgarty et al. 1984

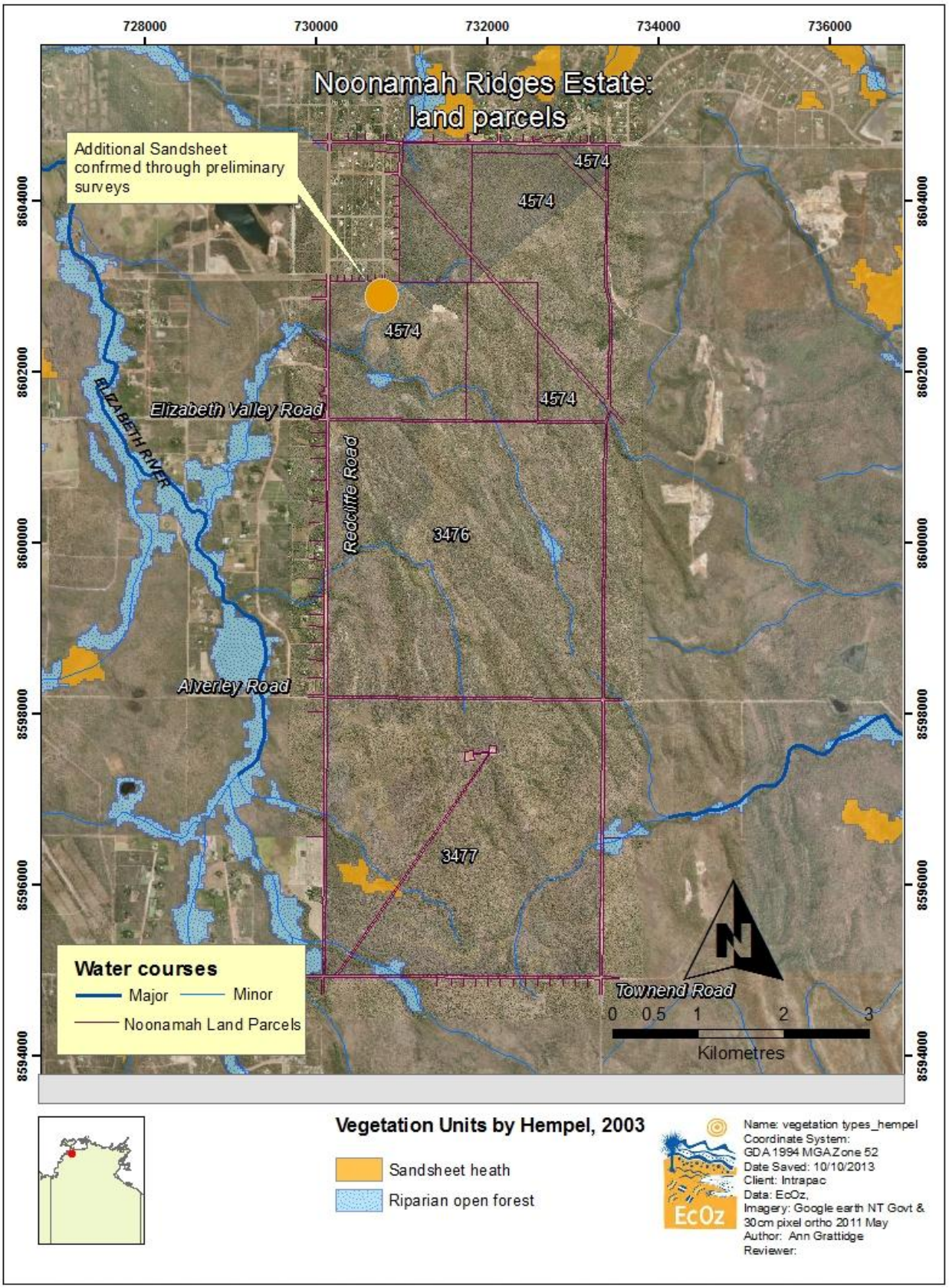


Figure 4-25 Mapping for Sandsheet habitat

4.7.4 Flora and Fauna

The International Union for the Conservation of Nature (IUCN) nominates a set of criteria used to identify species at risk to extinction used to define categories of risk (Figure 4-26). These criteria and categories are used by both the NT Government to identify threatened species and habitat which are listed under the TPWC Act and the Commonwealth Government to identify national threatened species under the EPBC Act. The focus of this report is flora and fauna species that are listed as threatened under either the TPWC Act or the EPBC Act (or both).

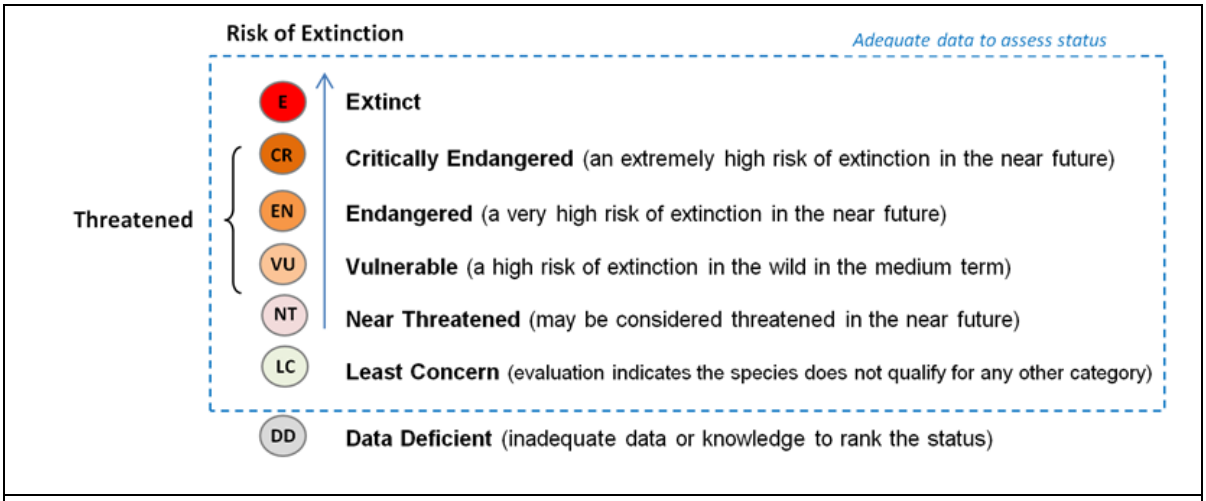


Figure 4-26 IUCN categories of risk of extinction

Based on profilers for threatened species (e.g. the EBPC matter search tool) existing records and a review of the biology of the state and federally listed threatened species, approximately 34 threatened species could potentially occur within the boundaries of the Noonamah Parcels. The likelihood of occurrence has been assessed for two key zones the Noonamah Parcels and within a 5km buffer of the boundaries of the parcel bounds.

Likelihood that any of the potential species of concern (threatened or EPBC listed as Migratory) is located within two key zones of interest (within the estate and off site within a 5km buffer) has been based on the criteria listed below and determined from available existing records and ecological knowledge of the area.

Likelihood of presence is indicated in line with four categories of possibility defined as follows:

- **Unlikely** – The range of distribution and suitable habitat is not located within the project area and/or its zone of impact; and there are either no records within the catchment; or the species has experienced a considerable range reduction and is considered either locally or regionally extinct.
- **Possible/May** –The range of distribution and potential suitable habitat occurs within the project area or the zone of impact; there are no records which are post 1970 in the near vicinity (e.g. within 5km) but there are records within a similar habitat type within the bioregion or catchment, or; there are historic records predating 1970 but none since, the species range may have contracted or its nature results in sporadic presence or sightings.
- **Likely** – the range of distribution and suitable habitat is known to occur in the project area and the zone of impact; there may be no records within the project area (or they are historic, pre 1970) but there are relatively recent records (post 1970) within 5km.
- **Known** – the range of distribution and suitable habitat is known to occur in the project area and individuals of this species have been recorded within the project area or the zone of impact post 1970.

The assessments of likelihood of presence for threatened species are presented in Table 4-9 for fauna and Table 4-10 for flora. The assessment examines 10 bird species, 8 mammal species 3 reptiles, 1 amphibian, 1 shark, 1 invertebrate and 10 plant species which are listed as threatened and may potentially be present within the estate or near surrounds (which could be affected by development of the estate).

The results of this assessment indicate that of the 34 species examined 5 are known to be present 4 are judged as likely to be present 16 may/possibly be present and 9 are unlikely to be present based on existing knowledge of the species and habitat available.

The species known and likely to be present are listed below (Table 4-8). This list includes three species which are EPBC listed and all bar the Bare-rumped Sheath-tailed Bat are listed under Northern Territory Legislation.

Table 4-8 Listed Threatened Species Know or Likely to be Present within the Noonamah Ridges Estate

Threatened species	EPBC Listing	TPWC Listing
Known to be present		
Partridge Pigeon *(Geophaps smithii)*	Vulnerable	Vulnerable
Northern Quoll (*Dasyurus hallucatus)*	Endangered	Critically Endangered
Pale Field-rat (*Rattus tunneyi)*		Vulnerable
Armstrong's Cycad (*Cycas armstrongii)*		Vulnerable
Howard Springs Toadlet (*Uperoleia daviesae)*		Vulnerable
Likely to be present		
Fawn Antechinus (*Antechinus bellus)*		Endangered
Black-footed Tree-rat (*Mesembriomys gouldii*)		Vulnerable
Bare-rumped Sheath-tailed Bat (*Saccolaimus saccolaimus nudicluniatus)*	Critically Endangered	
Yellow-spotted Monitor (*Varanus panoptes)*		Vulnerable

Note the taxonomic uncertainty associated with the Bare-rumped Sheath-tailed Bat outlined in Table 4-9. The status of this species is unlikely to be a concern for the Northern Territory.

Table 4-9 Assessment of Likelihood of presence for threatened fauna

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Birds					
Bar-tailed Godwit *Limosa lapponica*	Migratory	Vulnerable	**Habitat:** Coastal and estuarine with tidal mudflats. May roost during high tide on nearby beaches. May also be found at near-coastal swamps and lakes (DEWHA 2013a). **Distribution:** In the NT they have been reported all along the coastline, including all major islands (Ward 2012a). **Existing Records:** Within the data search area a single record within a drainage area in the vicinity of the junction between the Stuart and Arnhem Highways.	Habitat loss, pollution and human disturbance at migratory stop-over grounds (Ward 2012a)	**Land Parcels:** POSSIBLE/MAY As a the occasional vagrant **5km Buffer** KNOWN **Habitat Distribution:** Shore birds can be found inland occasionally although this is not their core habitat.
Partridge Pigeon *Geophaps smithii*	Vulnerable	Vulnerable	**Habitat:** This species occurs in open forests and woodlands with an associated grassy understorey usually in areas with a fire regime that promotes a mosaic of fire ages (Woinarski, 2007a). **Distribution:** The partridge pigeon occurs throughout the top end of the Northern Territory and the Kimberley region of Western Australia (Woinarski 2007a). **Existing Records:** Within the data search area one record is located on the corner of Redcliffe and Alvery Road dated from 2001. There are several post 1970 records between Scrutton and Kentish Roads to the west of the Stuart Highway.	Clearing of Tall Open forests and Woodlands and the inter-related changes in grass composition and fire regimes (Woinarski 2007a). This species is also quite susceptible to predation by feral cats, due to its ground dwelling habits (Woinarski 2007a).	**Land Parcels:** KNOWN **5km Buffer** KNOWN **Habitat Distribution:** Potential habitat is common within the land parcels and surrounds.
Masked Owl (northern Mainland) *Tyto novaehollandiae kimberli*	Vulnerable	Vulnerable	**Habitat:** Occurs mainly in eucalypt tall open forests (especially those dominated by *Eucalyptus miniata* and *E. tetrodonta*), but also roosts in monsoon rainforests, and forages in more open vegetation types, including grasslands (Woinarski & Ward 2012a). **Distribution:** Very imperfectly known, with remarkably few records across its broad range in	No reliable information on threats to this subspecies. It is possible that food resources may be diminishing, through broad-scale decline of small and medium-sized native mammals, possibly due to changed fire regimes (Woinarski et al. 2001; Pardon et al. 2003). The greatly increased cover and height of invasive	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat is located at least in patches within the region.

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			northern Australia. In the NT records known from the Top End, Kakadu, Coburg Peninsula (majority of records) and south-west Gulf country (Atlas of Living Australia 2013). **Existing Records:** There are no existing records within the data search area.	exotic grasses (Rossiter et al. 2003) may cause a reduction in foraging efficiency for this owl.	
Curlew Sandpiper *Calidris ferruginea* **Eastern Curlew** *Numenius madagascariensis* **Greater Sand Plover** *Charadrius leschenaultii* **Lesser Sand Plover** *Charadrius mongolus*	Migratory	Vulnerable	**Habitat:** Coastal and estuarine with tidal mudflats. May roost during high tide on nearby beaches. May also be found at near-coastal swamps and lakes **Distribution:** Mostly widespread around the northern Australian coast, less common in the south, with few inland records. Eastern Curlew is uncommon across most of Australia. Every year these species breed in the northern hemisphere in the summer, and migrate to Australia for the southern hemisphere summer. Some birds remain in Australia during the winter. **Existing Records:** There are no existing records within the data search area.	Habitat loss, pollution and human disturbance at migratory stop-over grounds.	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Shore birds can be found inland occasionally although this is not their core habitat.
Australian Painted Snipe *Rostratula australis*	Vulnerable	Vulnerable	**Habitat:** Inhabits fringes of permanent and temporary wetlands, swamps and inundated grasslands (Taylor et al. 2007). The species could occur on any shallow ephemeral wetlands in central or southern Northern Territory. **Distribution:** This species is nomadic and scattered across Australia with no predictable occurrence (Rogers, 2001). In the Northern Territory it is known from a range of localities with no known resident sites (Taylor et al. 2007). In the Northern Territory the species is unlikely to have a population that is separate to that inhabiting other areas of Australia. **Existing Records:** There are no existing records within the data search area.	The main threat to this species is the loss of wetlands from degradation by cattle; however within the Northern Territory there is no substantial data to assess this (Jaensch 2003).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat is located at least in patches within the region.

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Red Goshawk *Erythrotriorchis radiatus*	Vulnerable		**Habitat:** Solitary and very thinly dispersed. Tall open eucalypt forest and riparian areas. Nests in large trees, frequently the tallest and most massive in a tall stand, and nest trees are invariably within one km of permanent water (Debus & Czechura 1988; Aumann & Baker-Gabb 1991). **Distribution: Existing Records:** Occurs across much of northern Australia, from the Kimberley to south-eastern Queensland. **Existing Records:** There are no existing records within the data search area.	Habitat loss. The effect fragmentation of habitat has on the Red Goshawk is yet to be determined. It has been suggested that there may be a threshold above which habitat alterations within a breeding pair's home range will not be tolerated (Debus & Czechura 1988).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat is located at least in patches within the region.
Gouldian Finch *Erythrura gouldiae*	Endangered		**Habitat:** The critical components of suitable core habitat for the Gouldian Finch appear to be the presence of favoured annual and perennial grasses (especially Sorghum), a nearby source of surface water and, in the breeding season, unburnt hollow-bearing Eucalyptus trees (*especially E. tintinnans, E. brevifolia* and *E. leucophloia*) (Tidemann 1996; *et al.* 1999; Higgins *et al.* 2006). **Distribution:** Sparsely distributed across northern Australia from the Kimberley to north-central Queensland (Dostine 1998; Franklin 1999; Barrett *et al.* 2003). It is currently known to occur in significant numbers (> 50 adult birds) at only 10 locations, including five in the Northern Territory (O'Malley 2006). **Existing Records:** There are no existing records within the data search area.	The main causes of the past declines, and the main threats to the species at present, are thought to be grazing pressure, establishment of pastoral, agricultural and mining operations, and fire (Dostine 1998; O'Malley 2006).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Habitat with a sorghum understory in the vicinity of water is present.
Mammals					
Fawn Antechinus *Antechinus bellus*		Endangered	**Habitat:** This species occurs in tall open forest dominated by eucalypts where it was historically quite common (Young 2012). It shelters in tree hollows and fallen logs. **Distribution:** The habitat range is centred Predominantly in Kakadu, Coburg Peninsula and the greater Darwin region (Young 2012).	The fawn antechinus is one of a suite of mammal species exhibiting declines across the Top End over the past ten years, with no clear explanation (Young 2012).	**Land Parcels:** LIKELY **5km Buffer:** KNOWN **Habitat Distribution:** Rocky habitat is common within the estate. Existing

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			Existing Records: Several 2002 records are located on Goode Road nearly 2km to the west of Redcliffe Road		records occur within land unit 1b which is common within the land parcels. However this habitat is frequently burnt.
Northern Quoll *Dasyurus hallucatus*	Endangered	Critically Endangered	**Habitat:** Originally a wide range of habitats, now mostly restricted to rocky areas. **Distribution:** Across northern Australia in five regional populations. In the NT, most records from central and western Top End. **Existing Records:** There are several records for the greater Darwin area with at least two records near the perimeter of the northern land parcels.	Primarily Cane toad ingestion (Van Dam *et al.* 2002), but also inappropriate fire regimes, and removal, degradation and fragmentation of habitat.	**Land Parcels:** KNOWN **5km Buffer:** KNOWN **Habitat Distribution:** Within the project area and greater Darwin region preferred habitat is common and widespread.
Black-footed Tree-rat *Mesembriomys gouldii*	-	Vulnerable	**Habitat:** tropical woodlands and open forests in coastal areas **Distribution:** Found in the Top End of the Northern Territory (NT) in tropical woodlands and open forests in coastal areas. Also occurs in the Kimberley in Western Australia, and the east and west coastal areas of Cape York Peninsula south to Townsville (Hill 2012). **Existing Records:** There are several records located on Goode Road nearly 2km to the west of Redcliffe Road. There is one record 1km to the south east of the southern parcel boundary	The main driver of the decline of this species is throughout most of its range not easily defined. Studies have shown that it is disadvantaged by frequent fire, probably because of its requirement for tree hollows, and its habitat preference for a shrubby understory (Friend 1987). This species may have remained relatively abundant (or become more abundant) in the Darwin rural area, perhaps because of fire regimes (Price et al. 2005).	**Land Parcels:** LIKELY **5km Buffer:** KNOWN **Habitat Distribution:** Within the land parcels and greater Darwin region preferred habitat is common but constrained to drainage areas.
Pale Field-rat *Rattus tunneyi*	-	Vulnerable	**Habitat:** Historically occurred in a wide range of habitats, but is now primarily found in dense vegetation along creeks (Aplin et al. 2008). **Distribution:** Kimberley, Western Australia, coastal Northern Territory, coastal Queensland and northern New South Wales (Aplin et al. 2008). **Existing Records:** Several 2002 records are located on Goode Road nearly 2km to the west of Redcliffe Road. There are four records in the southern half of the land parcels dated 2001.	The exact factor is unknown but it is presumed that loss of its preferred creek line habitats to degradation by introduced mammals (Aplin et al. 2008).	**Land Parcels:** KNOWN **5km Buffer:** KNOWN **Habitat Distribution:** Preferred creek line habitat occurs within localised areas on the edges of the land parcels

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Northern Brush-tailed Phascogale *Phascogale pirata*	Vulnerable	Endangered	**Habitat:** There are no detailed studies, but its ecology is probably similar to that reported for its temperate relatives (Rhind et al. 2008). Most records are from tall open forests dominated by *Eucalyptus miniata* and *E. tetrodonta* **Distribution:** Restricted to eucalypts forests in the Top End of the Northern Territory. Most records are from Kakadu National Park (Woinarski & Ward, 2012b). **Existing Records:** The occurrence of this species is described as rare and scattered (Rhind et al. 2008). There are no existing records within the data search area.	There is no clear explanation for the species decline but is speculated to be due to habitat degradation through fire, grazing and possibly disease (Rhind et al. 2008 and Woinarski & Ward 2012b). Feral cats, Cane Toads and localised clearing in areas where remnant populations remain are also contributing factors.	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat may be present in localised areas only.
Bare-rumped Sheath-tailed Bat *Saccolaimus saccolaimus nudicluniatus*	Critically endangered		**Habitat:** This species has been found in open pandanus woodland and also tall eucalypt forests in the Northern Territory (Milne & Woinarski 2006). **Distribution:** This species has a wide distribution from southeast Asia to North Queensland and the Northern Territory (Milne & Woinarski 2006). **Existing Records:** There are no existing records within the data search area. However there are few records for this species in general due to challenges in detecting them	There is taxonomic uncertainty about the species, including known distribution for two subspecies. Subspecies *nudicluniatus* occurs in eastern Australia. The Northern Territory populations which are geographically disjunct and morphologically different have not been taxonomically assessed (Milne & Woinarski 2006). Currently the EPBC Act listing follows the currently accepted taxonomy of this species, recognises one subspecies, *S. s. nudicluniatus* as occurring in Australia (incorporating both north-eastern Queensland and Northern Territory populations). The main threatening process appears to be targeted to Subspecies *nudicluniatus* through land clearing in Queensland and the loss of hollow trees due (Milne & Woinarski 2006).	**Land Parcels:** LIKELY **5km Buffer:** LIKELY **Habitat Distribution:** Potential habitat is located at least in patches within the region.

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Brush-tailed Rabbit-rat *Conilurus penicillatus*	Vulnerable		**Habitat:** Appears to have quite specific habitat requirements. Largely restricted to mixed eucalypt open forest and woodland, or on dunes with Casuarina, seeming to prefer habitats that are not burnt annually, that have an understorey of predominantly perennial grasses and a sparse-to-moderate middle storey (Firth et al. 2006; Firth 2007; Kemper & Firth 2008). **Distribution:** Currently it is only known from Cobourg Peninsula, Tiwi Islands, Groote Eylandt, and a small area within Kakadu National Park (Woinarski & Hill 2012). **Existing Records:** There are no existing records within the data search area.	At the present time no single factor is known to have caused the decline in this species (Woinarski & Hill 2012). It is however though that habitat alteration due to inappropriate fire regimes and grazing by introduced herbivores, habitat destruction resulting from forestry and mining operations and predation by Feral Cats are the causes (Woinarski & Hill 2012).	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** Potential habitat according to its historic range is present.
Water Mouse *Xeromys myoides*	Vulnerable		**Habitat:** Mangrove forests, freshwater swamps and floodplain saline grasslands (Woinarski et al. 2000) **Distribution:** In the NT it is known only from ten records at six sites, including one in East Arnhem land (Woinarski 2007b). **Existing Records:** There are no existing records within the data search area.	At the present time there is insufficient information to assess the threatening processes for this species. It is presumed that removal and degradation of habitat as a result of development actions is one cause (Woinarski et al. 2000).	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** Known habitat types are not present within the project area.
Reptiles					
Merten's Water Monitor *Varanus mertensi*		Vulnerable	**Habitat:** Edges of watercourses and lagoons – seldom seen far from water but may explore during the wet season in search of new watercourses (Christian 2004a). **Distribution:** This species is found across northern Australia from Cape York Peninsula to the Kimberley (Christian 2004a). **Existing Records:** There are no existing records within the data search area.	This species experiences significant declines due to cane toad poisoning (Griffiths & McKay 2005; Doody et al. 2009).	**Land Parcels:** POSSIBLE/MAY **5km Buffer:** KNOWN **Habitat Distribution:** Potential habitat is extremely limited existing in localised areas associated with the drainage in the low lands and springs in the mid uplands.

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Yellow-spotted Monitor *Varanus panoptes*		Vulnerable	**Habitat:** Broad range of habitats from riparian to savannah woodlands (Christian 2004). **Distribution:** This species is found across northern Australia with a disjunct population in Western Australia (Christian 2004b). **Existing Records:** There some records with in the 5km buffer surrounding the Noonamah estate.	This species experiences significant declines due to cane toad poisoning (Doody et al. 2009).	**Land Parcels:** LIKELY **5km Buffer:** KNOWN **Habitat Distribution:** Potential habitat is widespread and common
Plains Death Adder *Acanthophis hawkei*	Vulnerable		**Habitat:** This species is known to inhabit floodplains in the Northern Territory (Webb et al. 2002). **Distribution:** The current distribution of this species if unknown due to taxonomic uncertainties but is presumed to be widespread across Northern Australia. **Existing Records:** There are no existing records within the data search area.	It is a major predator on frogs. A threatening process is primarily Cane Toad ingestion (Phillips et al. 2010).	**Land Parcels:** UNLIKELY **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Suitable habitat exists off site at Fogg dam, 16km north east and east in the Adelaide River catchment.
Frogs					
Howard Springs Toadlet *Uperoleia daviesae*		Vulnerable	**Habitat:** Confined to sand sheet and drainage areas with a shallow surface flow in the wet season (Reynolds & Grattidge 2013). **Distribution:** confined to Its preferred habitat type within the Howard and Elizabeth River catchments (Reynolds & Grattidge 2013). This species maybe more widespread than currently known. **Existing Records:** There are records on the boundary of parcel 4574 within Lloyd creek crossing of Redcliffe Road.	Sand mining, vegetation clearing and altered surface flows (including nutrient levels) associated with various urban, rural and extractive developments.	**Land Parcels:** KNOWN **5km Buffer:** KNOWN **Habitat Distribution:** Preferred habitat is potentially present on localised areas in the lower lying areas As well as off-site off site.
Fish/Sharks					
Freshwater Sawfish *Pristis microdon*	Vulnerable		**Habitat:** Juveniles and sub-adults predominantly occur in rivers and estuaries, while large mature animals tend to occur more often in coastal and offshore waters up to 25 m depth (Giles et al. 2006; Stevens et al. 2005). **Distribution:** Known from at least eight catchments	Highly vulnerable to gillnet fishing. Populations may be threatened in streams where poaching for barramundi is a common practice (Last & Stevens 1994).	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** Downstream locations at

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			in the Northern Territory, this species has the potential to occur in more. Currently it is known from the Adelaide, Alligator (East and South), Daly, Darwin, Goomadeer, McArthur, Robinson & Victoria Rivers (Larson et al. 2007). **Existing Records:** There are no existing records within the data search area.		least 7km from the site provides potential habitat
Invertebrates					
Dodd's Azure Butterfly *Ogyris iphis doddi*		Endangered	**Habitat:** The species is highly localised to habitat with mistletoe and associated with the presence of attendant ants (Braby, Woinarski, 2006). **Distribution:** restricted to the Top End of the NT. It is known only from two sites: Darwin (Braby, Woinarski, 2006). **Existing Records:** There are no existing records within the data search area.	It is not clear if rarity is due to insufficient survey effort or that the subspecies is in decline. Clearing and altered fire regimes are suggested to be plausible reasons for the species decline (Braby, Woinarski, 2006).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Suitable habitat may be present

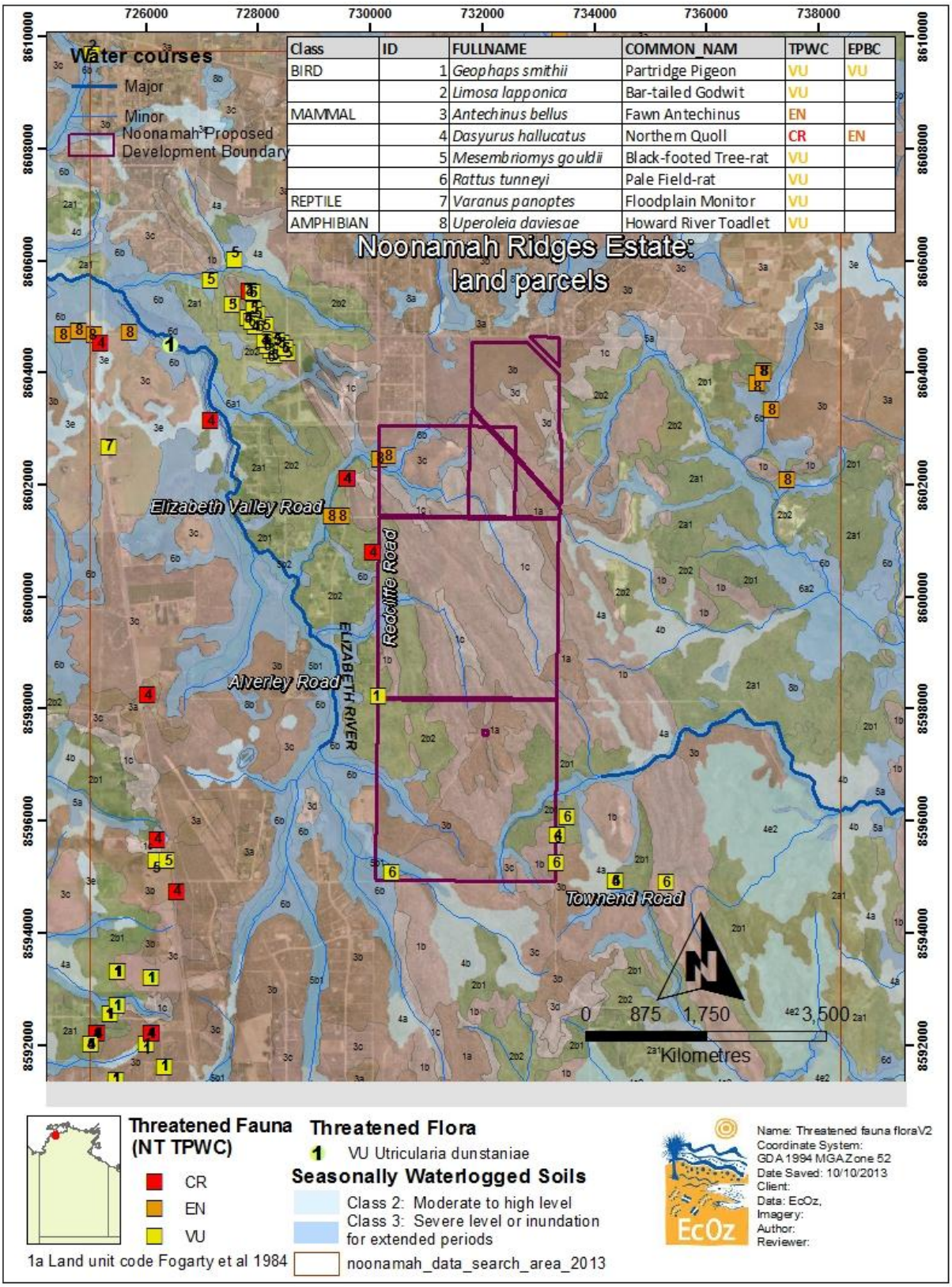
Table 4-10 Assessment of likelihood of presence for threatened flora

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
Flora					
Armstrong's Cycad *Cycas armstrongii*		Vulnerable	**Habitat:** This species occurs in open grassy woodland where adequate drainage appears to be a limiting factor (Kerrigan et al. 2006) **Distribution:** Endemic to the Top End of the Northern Territory with populations on the Tiwi Islands and Cobourg Peninsula (Kerrigan et al. 2006) **Existing Records:** There are no existing records within the data search area.	The main threat associated with this species is land clearing for urban Darwin development. Additionally a changed fire regime also appears to be of concern (Kerrigan et al. 2006).	**Land Parcels:** KNOWN **5km Buffer:** KNOWN **Habitat Distribution:** Suitable habitat is common
Armstrong's Cycad *Cycas armstrongii x conferta*		Vulnerable	**Habitat**: A somewhat restricted species, usually occurring on sandy soils over granites or coarse sandstone. **Distribution:** This species has been noted north	*Cycas conferta* has been confused with *Cycas armstrongii* (Royal Botanic Gardens Sydney 2013)	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			of the Arnhem Highway into Mary River national Park, another east of Adelaide river and the third south (Atlas of Living Australia 2013) . **Existing Records:** There are no existing records within the data search area.		**Habitat Distribution:**
Typhonium *Typhonium praetermissum*		Vulnerable	**Habitat**: Species has been found in open woodland situation including relatively unshaded areas in soils types ranging from red brown clay soil and shallow or gravelly lateritic soil (Cowie & Westaway 2012a). **Distribution:** Endemic to the Northern Territory (NT). It has been recorded at six locations in the Darwin/ Litchfield area (Cowie & Westaway 2012a). Previously listed as Data deficient. Thought to be short range endemic. **Existing Records:** There are no existing records within the data search area.	Habitat loss through clearing processes and population fragmentation. Invasive weed species out competing post fire regeneration and altered fire regimes. One population is known to suffer from soil disturbance by feral pigs (Cowie & Westaway 2012a).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat is associated with Sandsheet and drainage areas which occur in localised areas in the lowlands.
Typhonium *Typhonium taylori*	Endangered	Endangered	**Habitat**: The species occurs in seasonally saturated sandy soil in nutrient poor grass/sedgeland with occasional Melaleuca viridiflora (Kerrigan and Cowie 2006a). **Distribution:** This species is endemic to the Northern Territory, and positively known only from the type locality on the edge of the Howard River floodplain. A second collection of sterile material nearby is also likely to be T. taylori (Kerrigan and Cowie 2006a). **Existing Records:** There are no existing records within the data search area.	Threats to this species are potential disturbance of habitat from sand mining, clearing for subdivision and changes to hydrology (Kerrigan and Cowie 2006a).	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** The only known population is associated with Sandsheet in the Howard River area.
Ground Orchid *Habenaria rumphii* Previously known as H. holtzei.	Endangered		**Habitat**: This species occurs in open forest and woodland growing amongst grass. It is reported to be prominent in low-lying sites that are partially inundated during the wet season. In the NT, this species has been collected from a sand-plain adjacent to a	Threats to the species include sand mining, land clearing and hydrology impacts. Invasive weed species out competing and altering fire regimes as well as feral animals including pig soil	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** Only known from Humpty Doo and Howard River

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			spring-fed rainforest (Kerrigan and Cowie 2006b) **Distribution:** In the NT, it has been recorded only from the upper Howard River, Humpty Doo. Known fin the Northern parts of Queensland and overseas (Kerrigan and Cowie 2006b). **Existing Records:** There are no existing records within the data search area.	disturbance are also of concern.	
Luisia Orchid *Luisia corrugata* Until recently confused with *Luisia teretifolia,* which is from Guam		Vulnerable	**Habitat**: Occurs in coastal forests and rainforests. Highly localised. In the Northern Territory this species has been from the margins of monsoon forest (Kerrigan and Cowie 2006c). **Distribution:** It is known from 11 records in the NT with 9 from Melville Island and two on the mainland in Black Jungle Conservation Reserve (Kerrigan and Cowie 2006c). **Existing Records:** There are no existing records within the data search area.	Specific threats have not been identified. It may be prone to collectors, cyclones and fire.	**Land Parcels:** UNLIKELY **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** The preferred forest habitat does not seem to be present. It is known from a limited number of populations.
Darwin Palm *Ptychosperma macarthurii*	Endangered	Endangered	**Habitat:** This species occurs in in dense rainforests that are fed from lowland springs at the edges of tropical floodplains (Liddle et al. 2006). **Distribution:** Within the Northern Territory this species is known from eight locations on the western margin of the Adelaide River Floodplain (Liddle et al. 2006). **Existing Records:** There are no existing records within the data search area.	This species was formerly considered as an NT endemic, *Ptychosperma bleeseri*. *P. bleeseri* is treated as a synonym and isolated population of *P. macarthurii*, a species more widespread in Queensland The main threats associated with this species is a changed fire regime and overgrazing by feral animals and stock (Liddle et al. 2006)	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** The species is known from 8 populations which are located outside of the project area and the 5km buffer.
Helicteres *Helicteres macrothrix*	Endangered	Endangered	**Habitat**: Helicteres sp. Glenluckie Creek occurs in woodland dominated by Eucalyptus tectifica, E. tetrodonta and E. miniata on sandy loam on rocky siltstone slopes or granitic rocks (Cowie et al. 2012). **Distribution:** Endemic to the NT. The species is recorded from three populations. This species	Threats to the population include development pressures, out competing weed species including altered fire regimes (Cowie et al. 2012).	**Land Parcels:** UNLIKELY **5km Buffer:** UNLIKELY **Habitat Distribution:** There is a high degree of confidence that the

Threatened Species	EPBC Status	TPWC Status	Habitat & Distribution	Threatening Processes	Likelihood of presence
			occurs on have a limited geographic distribution in the north-west NT (Cowie et al. 2012). **Existing Records:** There are no existing records within the data search area.		species is restricted to its current general area which does not include the project area and the 5km buffer.
Bladderwort *Utricularia dunstaniae*	Vulnerable		**Habitat**: The species grows in wet sand, often in shallow water, in Melaleuca nervosa woodland or Verticordia shrubland. It occurs in slightly wetter micro-habitats than other sympatric Utricularia species, frequently where water is percolating from the ground (Kerrigan and Cowie 2012). **Distribution:** This species is an Australian endemic, known from WA and the NT. In the NT, it is known from seven collections. New subpopulations have recently been recorded from Cobourg Peninsula, near Murgenella and near Finniss River (Kerrigan and Cowie 2012a). **Existing Records:** One record is located within drainage areas associated with the Elizabeth River about 4km from the estate boundary north-west.	Three of the seven known localities are susceptible to disturbance from sandmining, quadbike and motorbike activity, subdivision and potential changes to hydrology (Kerrigan and Cowie 2012a).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** KNOWN **Habitat Distribution:** A small patch of sand sheet is present on parcel 3477 otherwise this habitat type is more likely situated off site in the vicinity of drainage areas which may or may not be impacted.
Trigger Plant *Stylidium ensatum*	Endangered		**Habitat**: The habitat appears to be margins of drainage areas in damp heavy clay or peaty soil (Cowie and Westaway 2012b). **Distribution:** known form three localities in Darwin with other historical collections with location unknown. Has not been collected since 1974 (Cowie and Westaway 2012b) **Existing Records:** There are no existing records within the data search area.	Invasion of habitat by weeds, encroaching urban development and changed fire regimes resulting in unsuccessful regeneration (Cowie and Westaway 2012b).	**Land Parcels:** MAY/POSSIBLE **5km Buffer:** MAY/POSSIBLE **Habitat Distribution:** Potential habitat is present within the low drainage areas.



Class	ID	FULLNAME	COMMON_NAM	TPWC	EPBC
BIRD	1	*Geophaps smithii*	Partridge Pigeon	VU	VU
	2	*Limosa lapponica*	Bar-tailed Godwit	VU	
MAMMAL	3	*Antechinus bellus*	Fawn Antechinus	EN	
	4	*Dasyurus hallucatus*	Northern Quoll	CR	EN
	5	*Mesembriomys gouldii*	Black-footed Tree-rat	VU	
	6	*Rattus tunneyi*	Pale Field-rat	VU	
REPTILE	7	*Varanus panoptes*	Floodplain Monitor	VU	
AMPHIBIAN	8	*Uperoleia daviesae*	Howard River Toadlet	VU	

*Refer to Figure 4-15 for interpretation of land unit codes (e.g. 1a, 1b etc.)

Figure 4-27 Existing data for Threatened Species in the near vicinity of the Noonamah Ridges Estate

4.7.5 Weeds & Feral Animals

Weeds

The Northern Territory Weeds Management Act 2001 Classifies declared weeds into three categories which are defined as follows:

- **A** - To be eradicated reasonable effort must be made to eradicate the plant within the NT
- **B** - Growth and spread to be controlled Reasonable attempts must be made to contain the growth and prevent the movement of the plant
- **C** – Not to be introduced to the Territory All Class A and Class B weeds are also considered to be Class C weeds. Not to be introduced.

For some species (e.g. Mimosa and Belly Ache Bush) the category can vary according a nominated location within the NT.

Declared weeds species within the region, based on data from the Department of Land Resource Management (as of 2013), are presented in Table 4-1. Some of the weed species known to occur within the area are also recognised as Weeds of National Significance (WoNs) and their management therefore aligns with a national strategy. A selection of species from existing weed presence data for the Hundred of Stangways areas is presented in Figure 4-28.

Gamba grass is common and widespread in the region and anticipated to be concern for fire management for the Noonamah Ridges Estate. Weeds which promote extreme fires such as Mission and Gamba grass are of greatest concern in the rural areas. Gamba Grass poses a significant fire hazard with landscape changing impacts such as reducing the density of woodland trees. The Noonamah Ridges Estate is within a zone categorised for management (opposed to eradication) according to the NT Gamba management plan, 2010 (currently being reviewed).

Declared weed species which are of particular concern for areas which may be drainage and seasonally inundated area and targeted for public use areas include: Mimosa, Belly Ache Bush, Rubber Vine and Grader Grass as well as the exotic grasses promoting fire and several other environmental weeds which are not listed under the Weeds Management Act such as Coffee Bush, Tully Grass and Para Grass.

Pond apple, a WoNS species and new to the Territory, has recently been detected in the Howard River Catchment, North of the Estate. Pond apple is targeted for eradication. However due to the high degree of concern to prevent this weed from establishing land owners are encourage by the Department of Land Resource Management not to embark on controlling this weed species without their assistance.

Weed management is the responsibility of the land owner. Successful weed management can require significant investment over an extended period of time, for at least the longevity of the seed bank.

Exotic fauna

Exotic fauna which are generally associated with and generally increase with urban and rural developments include Cats, Cane toads, Rats, exotic Pigeon, a variety of introduced ants (such as the African Big-headed Ant) and exotic fish such as Mosquito fish (*Gambusia*). All of these species can reduce the quality of remaining native habitat and place pressure on resident native fauna.

Table 4-11 Declared weeds species known to occur within the Hundred Strangways area

Scientific name	Weeds species common name	Declaration under the NT Weeds Act	WoNS
Andropogon gayanus	Gamba Grass	B/C	Yes
Annona glabra	Pond Apple	A/C	Yes
Barleria prionitis	Baleria	A/C	
Cabomba spp.	Cabomba	A/C	Yes
Cryptostegia spp.	Rubber Vine	A/C	
Hyptis suaveolens	Hyptis	B/C	
Jatropha gossypiifolia	Bellyache bush	A/C	Yes
Lantana camara	Common lantana	B/C	Yes
Lantana montevidensis	Creeping lantana	B/C	
Mimosa pigra	Mimosa, giant sensitive plant	B/C	Yes
Pennisetum polystachion	Mission grass	B/C	
Salvinia molesta	Salvinia	B/C	Yes
Senna obtusifolia	Sicklepod	B/C	
Senna occidentalis	Coffee senna	B/C	
Sida acuta	Spinyhead sida	B/C	
Sida cordifolia	Flannel weed	B/C	
Stachytarpheta spp.	Snake weeds	B/C	
Themeda quadrivalvis	Grader grass	B/C	

4.7.6 Fire

Frequency of fire events for the Noonamah Ridges Estate between 2000 and 2012 are indicated in Figure 4-29.

As study of a 9 year fire history for the Darwin area (an extensive areas inclusive of the Litchfield Shire to Coomalie) indicates that 43% of the region burns every year and one quarter of these fires occur in the late dry season (Price, et al, 2007). This frequency of fire is less than that for significant National Parks such as Litchfield NP with 56% of the area burnt every year. However, the overall fire frequency in the Darwin areas is judged to be too high and probably having a negative impact on wildlife despite a lack of direct evidence (Price et al. 2007).

The Armstrong's Cycad (Cycas armstrongii) is listed as vulnerable due to the threat of fire. Many birds, and some mammals show a negative response to too frequent fires. Fire regimes with frequent late season burns are implicated as a possible cause for the declining of many small to medium size mammals across the tropical savannahs (Price et al. 2007).

The frequency of fires and frequency of late dry season fires is generally less in more developed areas compared to other part of the tropical savannas (Price, et al, 2007). Privately owned land can tend to be managed for fire suppression. Fire suppression can also have a deleterious impact on native vegetation

quality, as many species require fire for recruitment (Cook 2012). In addition fire suppression can and also lead to substantial increase risk to extreme fires (Cook 2012).

Roads and fence lines can provide as fire breaks and can lead to more desirable fire regimes. However, public land in developed areas can tend to be heavily and frequently burnt (Price, et al, 2007).

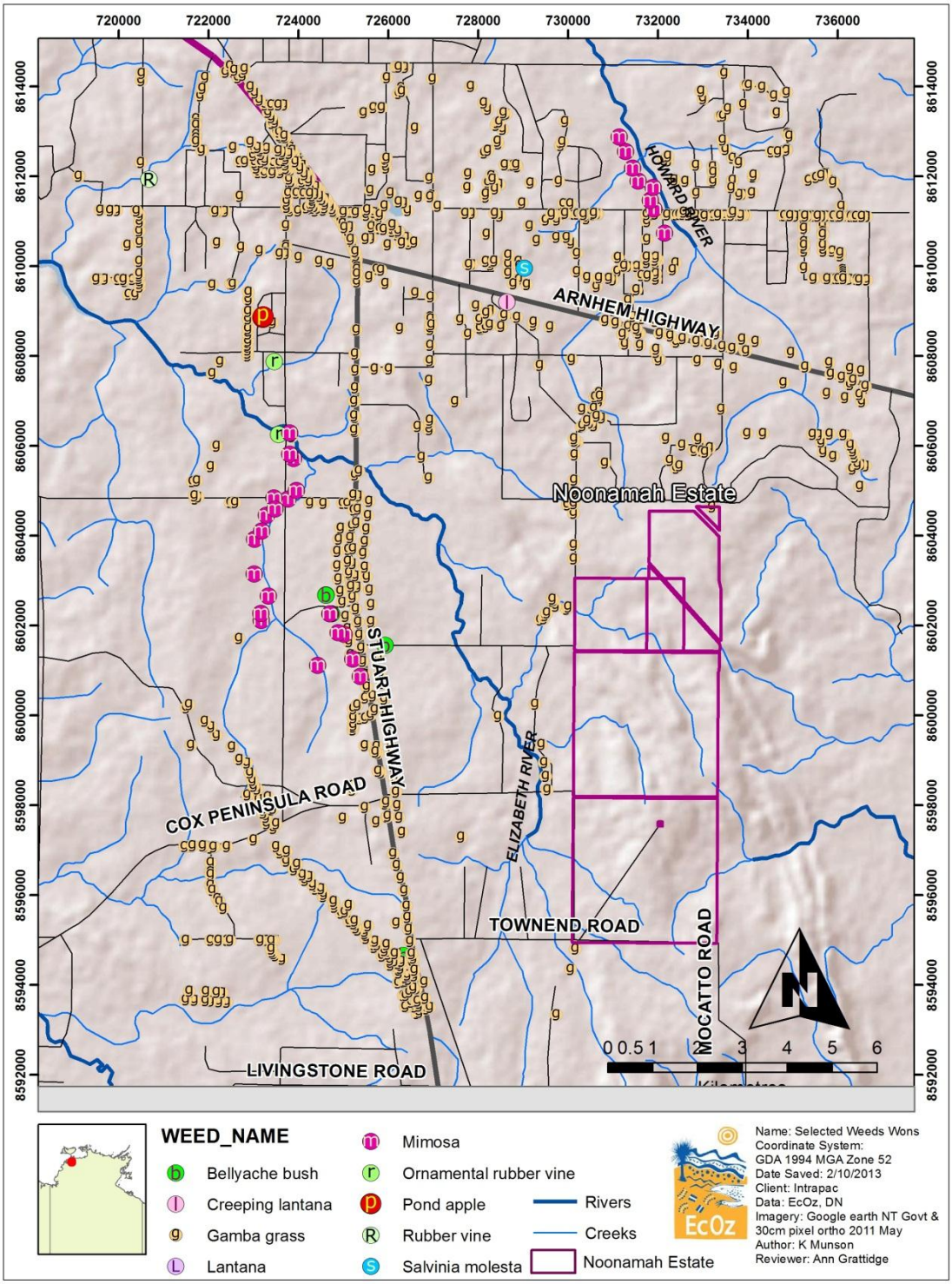


Figure 4-28 Weed presence in the Hundred of Strangways area for a selection of significant weeds

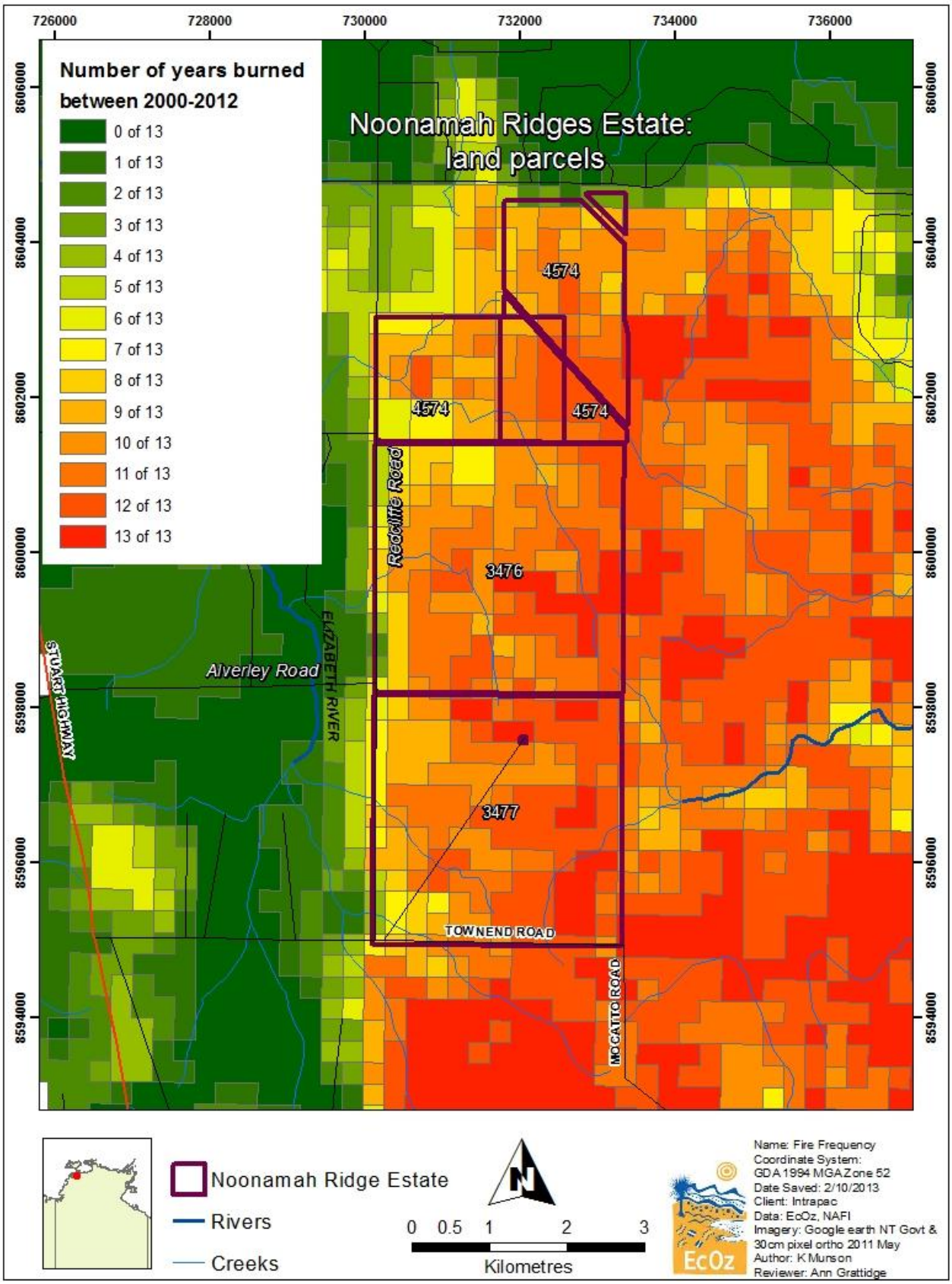


Figure 4-29 Fire frequency for the project area

4.8 Culture and heritage Sites

A search of existing records and authority certificates issued by the Aboriginal Areas Protection Authority under the Scared Sites Act indicates presence of a recorded site a restricted works area (and associated conditions) within a drainage zone on the eastern boundary of parcel 3477 as indicated in Figure 4-32.

A search of the NT Heritage Register and the Archaeological Sites Database by the Heritage branch of Department of Lands, Planning and the Environment indicated that there are no nominated, proposed or declared heritage places located within the project area. Nor are there any previously recorded Aboriginal archaeological sites located within the estate.

On-site Inspection by Fyfe surveyors found the remains of a plane crash, possibly associated with the World War II bombing of Darwin, located at coordinates 732 015 E MGA and 8595 137 N MGA. Figure 4-30 and Figure 4-31 present photographs of the wreckage as well as a plaque including a heritage site number as HC2268.

There may be potential for archaeological artefacts (e.g. stone implements and chards from blades) to be scattered throughout the estate. On-ground assessment by an archaeologist is necessary to ascertain this potential.

Figure 4-30 The remains of a plane wreckage from a test flight during World War II

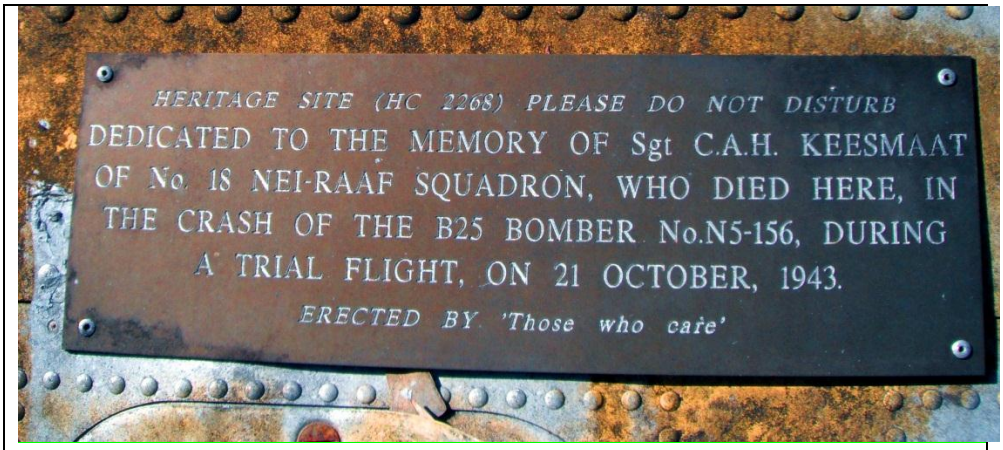


Figure 4-31 A plague attached to the plane wreckage located on the southern edge of parcel 3477.

4.9 Socio-economic environment

Character of the Noonamah area

The majority of development within the region of Noonamah is rural and rural residential featuring a mixture of residential and agricultural land uses. Population and hence services within the shire is projected to grow. In 2010 population growth for Litchfield Shire was slightly greater than that of Palmerston.

Medical & Emergency Services

Royal Darwin Hospital is the closest hospital to deal with emergencies. Existing medical and services within vicinity of the proposed Noonamah Estate include a medical centre at Palmerston, however this centre does not cover emergencies.

The Northern Territory Government and previous federal coalition government announced the site for the new Regional Hospital. A new $150 million hospital is planned to be built in Holtze in the Litchfield Shire.

Ambulance services are based at the Saint John Litchfield Rural Response Division based at Livingstone Reserve.

The nearest fire brigade is located at Humpty Doo with the second closest fire station being Palmerston. The nearest volunteer fire brigade is located at Elizabeth Valley and also numerous volunteer fire and bushfire brigade groups in the Litchfield shire inclusive of: Acacia Hills, Berry Springs, Darwin River, Lambells Lagoons, Livingstone, Manton, Virginia/Bees Creek, Howard Springs, Humpty Doo and Koolpinyah-Herbert.

Schools

The closest Primary Schools are Berry Springs Primary School located at 1150 Cox Peninsula Rd, Berry Springs, and Humpty Doo Primary School located at 50 Freds Pass Rd, Humpty Doo. Taminmin College is the closest middle school. A senior school located at Challoner Circuit Humpty Doo is a private school. Other Middle and Senior schools are located in nearby Palmerston and also Darwin.

Shops and Post

The nearest shopping centre with access to Australia Post and banking facilities is at Humpty Doo Village approximately 6km from the proposed Ridges Estate. The nearest services station for fuel supplies is at Noonamah approximately 4km from the proposed Ridges Estate.

Waste Management

The Litchfield Shire council does not provide waste bins or pick up services, only a managed rubbish tip. There are transfer stations at Humpty Doo and Berry Springs. Most properties within the Litchfield Municipality have a septic tank to treat waste water.

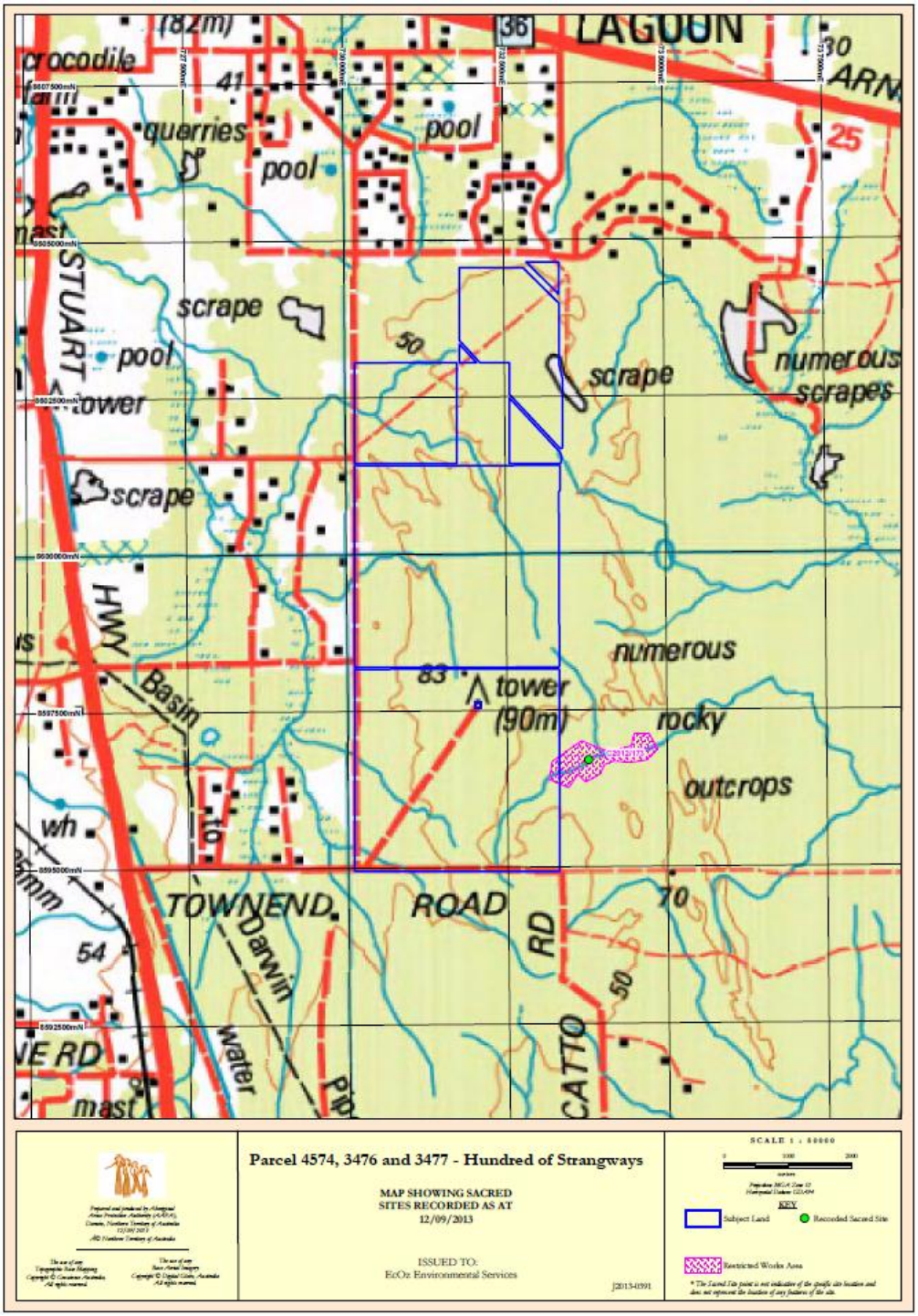


Figure 4-32 Results of a database search for recorded sites and issued certificates (Sections 19A-22) under the NT Sacred Sites Act for the Noonamah Ridges Estate

5 Environmental Risks and Mitigations

The following key regional assets or areas of interest based on developing the existing lots into the Noonamah ridges estate rural village, consisting of a mixture of allotment sizes (1ha to 5ha or greater):

- surface water integrity and quality
- ground water supply and quality
- landscape and soils
- biodiversity
- historic and cultural significance
- health safety and amenity
- socio-economic environment
- maintenance of infrastructure

Key concerns for each of these areas of risk are summarised below, potential mitigations are proposed and further studies intended to support the staged development are outlined.

5.1 Risks to surface water integrity and quality

Key concerns

Key concerns for maintaining the integrity of surface water and quality include:

- Altered surface flows (increased coefficient in proportion to the density of development and potentially altered directions)
- Increased nutrient levels and sediment for surface water flows (particularly in areas with allotments averaging <5ha)
- Potential for septic systems to fail (due to inappropriate use) or overflow during intense rainfall events

Mitigations

- A storm water design and management blue print will be developed for the entire estate in a staged manner
- Water Sensitive Urban Design principles will be applied including potential design of bio-retention services within the existing drainage systems and grassed swales to entrap and process nutrients
- Design specifications of septic/sewerage systems, roads and storm water will accommodate intense rainfall events
- Water discharge licenses shall be sought should overflow of septic/sewerage systems in the wet season be anticipated

Proposed studies

- Appropriate stormwater management systems will be developed based on existing local waterways and varied in design according the intensity of development. Issues such as amenity, mosquitos and fire management will be considered in their design.
- Scoping appropriate design measures to accommodate flood mitigation and entrapment and processing of nutrients on site.

5.2 Risks to ground water supply and quality

Key concerns

Key concerns for maintaining the integrity of ground water supply and quality include:

- Potential for significant draw down on existing ground water supplies through either communal water supplies and/or individual bores on rural allotments.
- Potential for contamination of ground water from septic systems

Mitigations

- Land titles will include conditions for water meters and covenants for domestic bores on individual lots 5ha or greater
- Communal bore fields to accommodate utilisation caps to constrain water use and also land use buffers around bores/potential bore fields to reduce the opportunity for potential contamination and excessive draw down.

Proposed Studies

- Desktop modelling of ground water availability for feasibility of supply (both at a property level and communal supply level)
- Desktop assessment and modelling of potential contamination sources for ground water

5.3 Risks to landscape and soils

Key concerns:

Over 50% of the estate features a moderate to high degree of erosion vulnerability, featuring steep slopes and areas with skeletal soils and little vegetation cover due to a high degree of rock cover. The lowland areas feature localised areas prone to periodic inundation.

Key concerns are:

- Built infrastructure requires appropriate placement, design and maintenance to avoid or contain erosion and sediment movement
- Development within individual allotments will require careful consideration of erosion potential and implications of altered surface flow especially within land types with a raised profile and high degree of rock cover

Mitigations

- Zonation of the estate for land capability to support smaller (<5ha) rural allotments and varying intensity of service provision and storm water design
- Lowlands shall be targeted for smaller allotments (<5ha) whereas the hill and rises shall be targeted for larger allotments (~5ha or greater)
- Development of an erosion and sediment control plan (inclusive of a storm water plan for the estate, refer to section 5.1) for each stage of development
- Land parcels will accommodate an appropriately placed development envelope and the remaining land will have a covenant to protect integrity of the landscape and native vegetation
- Development of an overarching storm water plan (refer also to surface water quality risks)

Proposed studies

- Land capability assessment by zoned areas according to the intensity of development (e.g. Areas zoned Rural Living to be zoned under the Specific Use category and incorporating lots ranging from 1ha – 5ha will require more detailed land capability studies). Refer to Appendix B
- Specific land capability studies for suitable placement of septic systems and other infrastructure
- Assessment of constrained/unconstrained land for individual allotments >5ha

5.4 Risks to biodiversity

Key concerns:

There is the potential for threatened or rare species and high value habitat to be present:

- Threatened or rare species - at the least the following species are likely to be present: Partridge Pigeon (*Geophaps smithii*), Pale Field-rat (*Rattus tunneyi*), Howard Springs Toadlet (*Uperoleia daviesae*), Armstrong's Cycad (*Cycas armstrongii*) and Yellow-spotted Monitor (*Varanus panoptes)*
- High value habitat - at least two localised areas of Sandsheet are present. Open forest may also be present in the drainage of the hilly areas. Two springs or expressions of ground water are also located within the hilly land form.
- Litchifield Priority Environmental Management Areas (PEMs) are located within the drainage areas largely along the edges of the estate (mapped as water logged soils Figure 4-15)

Few flora and fauna surveys have been conducted within the region there is potential for other biodiversity values to be identified.

Key concerns for conserving local and regional biodiversity values include alterations of key ecological processes such as:

- Altered surface flow – either direction of water away from the natural flow or increasing water shed to existing drainage areas
- Increased sediment and nutrient input to surface flows - particularly increasing nutrients to Sandsheet habitats as these are low nutrient environments
- Fire – public space may be prone to frequent burning as in other parts of Darwin, weeds such as Gamba Grass will need a high degree of coordinated effort to manage with multiple land owners, private land tends to manage fire for fire suppression which can be deleterious to habitat quality over the long term. Also refer to safety section 5.6

Introduction and increase of pest species are also a concern:

- Weeds – increased opportunity for the introduction and spread of weeds during construction and long term. There may be a need for increased coordination and reliance on voluntary action to manage significant weed infestations particularly those fuelling extreme fires (such as Gamba Grass)
- Pest animals – increased opportunity for toads, cats and exotic fish and ants to be either introduced, establish and increase within the area due to increased availability of conditions favouring their populations

Mitigations

- Avoid development within the areas prone to water logging (particularly those demarked as PEM's) utilising these areas to accommodate wildlife corridors on private land tenure or feature as public lands with multiple purposes (e.g. wildlife corridors, storm water services and parklands)
- Recognition of the NT Clearing Guidelines to identified high value habitat where possible

- Allotments will incorporate designated development envelopes and remaining areas shall be covenanted for wildlife corridors
- Development envelopes will aim to avoid high value habitat for threatened or rare species with an appropriate buffer where possible
- Allotments 5ha and greater shall incorporate covenants where possible to retain wildlife corridors
- Storm water and drainage design sensitive to the natural drainage patterns and incorporating grasses swales and retarding basins where required for the areas targeted for allotments ranging from 1-5ha (refer to sections 5.1 and 5.3)
- Incorporation of local to regional scale wildlife corridors (largely aligning to drainage patterns) within private allotments through the application of covenants
- Fire management for wildlife corridors to be incorporated into the developments fire management plan as well as road and allotment design
- Individual allotments 5ha or greater shall incorporate 4m perimeter fire breaks
- Recommended hygiene protocols to be compiled for subcontractors for invasive species (inclusive of ants) for the construction phase
- Develop an extraction/recovery plan for Armstrong's Cycad **(***Cycas armstrongii)* for their removal and use in amenity plantings/landscaping

Proposed studies

- Increased knowledge of on-site conditions so as to better inform the subdivision design may include:
  - Survey for vegetation types likely to be targeted for development – particularly in drainage areas
  - General fauna surveys – with a particular emphasis in on threatened species known and likely to be present – targeted at least initially to the build up
  - Targeted surveys for Sandsheet habitat and associated threatened plant species in the lowland area
  - Targeted survey for the Howard River Toadlet within Sandsheet and riparian habitat
  - Survey for existing weed presence for each stage of development

5.5 Risks to historic and cultural significance

Key concerns

At this stage the main concerns for culture and heritage are a recorded heritage site (a crashed war plane) and a recorded sacred site.

Mitigations

- Identified sites of cultural and heritage significance will be avoided with an appropriate buffer
- The development design will make a feature of the plane wreckage (HC2268) if possible
- An AAPA certificate shall be sought for each stage of development

Proposed studies

Further studies will include:

- Archaeological assessment for each stage of development

5.6 Risks to health, safety & amenity

Key concerns

Key concerns to health and safety associated with the proposed Noonamah Ridges Estate development include:

- Existing radio towers may require buffering from radiation (refer to appendix A)
- Wildfire - the threat and management of wildfire for life and property
- Biting insects - the potential for increased contact with biting insects, and associated mosquito borne diseases either through increased water flow to existing drainage areas, retention of water in potential bio-reticulation and storm water structures or increased residential areas situated near to temporary standing water
- Emergency services - access to and capacity of emergency services
- Accessibility during extreme weather events – e.g. flood proneness and access during cyclonic rain events

Mitigations

- The development design shall accommodate appropriate buffers for existing radio towers
- Road design, fence placement and design of storm water infrastructure shall accommodate the functionality for managing wildfire
- Development of a fire management plan
- Development of water stores for fire fighting

Proposed studies

- Investigation of reticulate sewerage and storage and reuse of treated water for fire fighting
- Investigate areas of Koolpinyah which may be managed as a broad fire break to the east of the development
- Investigation of artificial wetlands (e.g small lakes) associated with storm water management which can reduce the opportunity for mosquitos through native fish species

5.7 Risks to local socio-economic environment

Key concerns

Key areas of concern to the socio-economic environment include:

- Pressure on existing road infrastructure and services & service providers (particularly schools and emergency and medical services)
- Potential impact of the proposed Arterial Links to Glyde and Gunn Point
- Altered character to the existing rural developments
- Increased pressure on services for general council services: e.g. management of public space for weeds & fire, waste management etc.

Mitigations

- Development of a traffic management plan

- Development design to accommodate the proposed Arterial Links to Glyde and Gunn Point with appropriate traffic management and buffers for noise and dust associated with the volume and size of future traffic
- Project communication plan
- Establishment of a rural shopping centre and local school

Proposed studies

- Community consultations

5.8 Maintenance of infrastructure integrity

Key concerns

Key concerns include:

- Communal sewerage systems
- New roads networks
- Storm water infrastructure
- Management of public lands
- Uncontrolled impact of rural land use and infrastructure within private allotments to the regional environment (e.g. disturbance of natural surface flows and erosion)
- Potential increased pressure on NT government services for ground and surface water monitoring and also responding to soil erosion concerns

Mitigations

- Service agreements

Proposed studies

- Consultations with lead agencies and local government for on-going service provision
- Further mitigations will be investigated

5.9 Conclusions

This report concludes the major desktop assessment of existing environment and risks and supports scoping the next steps for investigating feasibility, assessment requirements for the project and further studies.

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Appendix A – Telstra Communications Tower Compliance Certificate for Radio Frequency Exposure

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SITE COMPLIANCE CERTIFICATE

NSA SITE NO 0837004 HUGHES

RF Human Exposure Limits

The Australian Radiation Protection And Nuclear Safety Agency (ARPANSA) has produced a standard for exposure to RF transmissions - ARPANSA Radiation Protection Standard 2002 Maximum Exposure Levels to Radio Frequency Fields - 3 kHz to 300 GHz (RPS3)

The Australian Communications and Media Authority (ACMA) has a Licence Condition Determination (LCD) that requires that the general public is not exposed to RF transmission levels exceeding the general public limits specified in the ARPANSA Standard (RPS3)

State and Commonwealth Occupational Health & Safety Acts require compliance with the limits and requirements of the ARPANSA standard (RPS3)

Compliance Statement

This site has been assessed and found to comply with the RF Human Exposure Limits as specified by the ACMA Licence Condition Determination (LCD) and requirements of the ARPANSA Standard (RPS3)

NATA Endorsed Inspection Report **Accreditation No 15092** This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17020.	**Qualified NATA EME Signatory** Name: Dominic Edwards Signature: Designation: RF Technical Officer Company: Corearth Australia Pty Ltd Date: 8 Feb 12 RCSMB Issue No: 8 Job Number: BNE-ATS0073 SAR Issue No: 8 Job Number: BNE-ATS0073 SCC Issue No: 8 Job Number: BNE-ATS0073

Access Control, RF warning signs (if required) and Safe Working Procedures are in place as detailed in the accompanying Radio Communications Site Management Book (RCSMB).

Summary of Estimated RF EME Levels around the Mobile Phone Base Station at Telstra RT "Hughes", LLOYD CREEK NT 0837

Introduction:

Date 3/3/2011

NSA Site No (0837004)

This report summarises the estimated maximum cumulative radiofrequency (RF) electromagnetic energy (EME) levels at ground level emitted from the existing Mobile Phone Base Station antennas at Telstra RT "Hughes" LLOYD CREEK NT 0837 . Maximum EME levels are estimated in 360° circular bands out to 500m from the base station. The procedures for making the estimates have been developed by the Australian Radiation Protection And Nuclear Safety Agency (ARPANSA)[1]. These are documented in the ARPANSA Technical Report; "Radio Frequency EME Exposure Levels - Prediction Methodologies" which is available at http://www.arpansa.gov.au

EME Health Standard

ARPANSA, an Australian Government agency in the Health and Ageing portfolio has established a Radiation Protection Standard[2] specifying limits for continuous exposure of the general public to RF transmissions at frequencies used by mobile phone base stations. Further information can be gained from the ARPANSA web site.

The Australian Communications and Media Authority (ACMA)[3] mandates exposure limits for continuous exposure of the general public to RF EME from mobile phone base stations. Further information can be found at the ACMA website http://emr.acma.gov.au

Existing Site Radio Systems

Telstra / WCDMA850	Telstra / GSM900		

Table of Predicted EME Levels – Existing

Distance from the antennas at Telstra RT "Hughes" in 360° circular bands	Maximum Cumulative EME Level – All carriers at this site (% of ARPANSA exposure limits[2]) Public exposure limit = 100%
0m to 50m	0.0059%
50m to 100m	0.0037%
100m to 200m	0.0059%
200m to 300m	0.0034%
300m to 400m	0.003%
400m to 500m	0.0049%
Maximum EME level 45.53 m, from the antennas at Telstra RT "Hughes"	0.0059%

Note: Estimation for the maximum level of RF EME at 1.5m above the ground from the existing antennas assuming level ground. The estimated levels have been calculated on the maximum mobile phone call capacity anticipated for this site. This estimation does not include possible radio signal attenuation due to buildings and the general environment. The actual EME levels will generally be significantly less than predicted due to path losses and the base station automatically minimising transmitter power to only serve established phone calls[5]. Where applicable, particular locations of interest in the area surrounding the base station, including topographical variations, are assessed in Appendix A " Other areas of Interest" table on the last page.

Summary – Existing Radio Systems

RF EME levels have been estimated from the existing antennas at Telstra RT "Hughes" LLOYD CREEK NT 0837 . The maximum cumulative EME level at 1.5 m above ground level is estimated to be 0.0059 % of the ARPANSA public exposure limits.

Existing and Proposed Site Radio Systems

Telstra / GSM900	Telstra / WCDMA850		

Table of Predicted EME Levels – Existing and Proposed

Distance from the antennas at Telstra RT "Hughes" in 360° circular bands	Maximum Cumulative EME Level – All carriers at this site (% of ARPANSA exposure limits[2]) Public exposure limit = 100%
0m to 50m	0.0077%
50m to 100m	0.008%
100m to 200m	0.054%
200m to 300m	0.072%
300m to 400m	0.061%
400m to 500m	0.037%
Maximum EME level 251.73 m, from the antennas at Telstra RT "Hughes"	0.072%

Note: Estimation for the maximum level of RF EME at 1.5m above the ground from the existing and proposed antennas assuming level ground. The estimated levels have been calculated on the maximum mobile phone call capacity anticipated for this site. This estimation does not include possible radio signal attenuation due to buildings and the general environment. The actual EME levels will generally be significantly less than predicted due to path losses and the base station automatically minimising transmitter power to only serve established phone calls[5]. Where applicable, particular locations of interest in the area surrounding the base station, including topographical variations, are assessed in Appendix A "Other areas of Interest" table on the last page.

Summary – Existing and Proposed Radio Systems

RF EME levels have been estimated from the existing and proposed antennas at **Telstra RT "Hughes"** LLOYD CREEK NT 0837 . The maximum cumulative EME level at 1.5 m above ground level is estimated to be **0.072** % of the ARPANSA public exposure limits.

Reference Notes:

1. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government agency incorporated under the Health and Ageing portfolio. ARPANSA is charged with responsibility for protecting the health and safety of people, and the environment, from the harmful effects of radiation (ionising and non-ionising).

2. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2002, 'Radiation Protection Standard: Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz', Radiation Protection Series Publication No. 3, ARPANSA, Yallambie Australia. [Printed version: ISBN 0-642-79400-6 ISSN 1445-9760] [Web version: ISBN 0-642-79402-2 ISSN 1445-9760]

3. The Australian Communications and Media Authority (ACMA) is responsible for the regulation of broadcasting, radiocommunications, telecommunications and online content. Information on EME is available at http://emr.acma.gov.au/

4. The EME predictions in this report assume a near worst-case scenario including:
   - base station transmitters operating at maximum power (no automatic power reduction)
   - simultaneous telephone calls on all channels
   - an unobstructed line of sight view to the antennas.

   In practice a worst-case scenario is rarely the case. There are often trees and buildings in the immediate vicinity, and cellular networks automatically adjust transmit power to suit the actual telephone traffic. The level of EME may also be affected where significant landscape features are present and predicted EME levels might not be the absolute maximum at all locations.

5. Further explanation of this report may be found in "Understanding the ARPANSA Environmental EME Report" and other documents on the ARPANSA web site, http://www.arpansa.gov.au

Appendix A

Table of Other Areas of Interest

Additional Locations	Height / Scan relative to location ground level	Maximum Cumulative EME Level All Carriers at this site (% of ARPANSA exposure limits[2]) Public exposure limit = 100%
ACIF Code Section 5.5 - community consultation plan new sites	n/a	Existing Site Update - No additional locations identified. Refer to previous table for the environmental EME assessment
Topography/Buildings	n/a	No locations identified
Other (e.g. significant previous community concern)	n/a	No locations identified

Note: Estimation for the maximum EME levels at selected areas of interest over a height range relative to the specific ground level at the area of interest. This table includes any existing and proposed radio systems.

Estimation Notes / Assumptions – Other Areas of Interest
Variable ground topography has been included in the assessment of the "Other Areas of Interest" as per ARPANSA methodology.