4.11 Threatened fauna species

Table 4.4 provides a summary of the survey results for EPBC Act listed threatened fauna species previously recorded within a 5 km radius or considered to potentially occur based on habitat mapping or listed on the EPBC Act Protected Matters Report.

Appendix A depicts all records of EPBC Act listed threatened fauna species collated from the Natural Values Atlas and observations from the survey. The nature of these records varies from site specific habitats such as known nest sites to evidence of the species including scats and prints.

Further information in relation to abundance, distribution, ecology, habitat preferences, known threats and detailed survey results is discussed below.

Table 4.4 - Summary of the survey results for EPBC Act listed threatened fauna species previously recorded within a 5 km radius or considered to potentially occur based on habitat mapping or listed on the EPBC Act Protected Matters Report

To be *likely*, it is not necessary for an impact to have a greater than 50% chance of happening; it is sufficient if an impact on the environment is a real or not remote chance or possibility.[15]
In this table *impact* is without safeguards and mitigation measures and may include direct, indirect, facilitated or cumulative impacts.

Section 5 of the PER specifies type and significance of impact.

PER Reference	Matter of NES	Results of surveys and assessment of likelihood of occurrence/habitat suitability	Applicable segment along the Tarkine Forest Drive	Is the proposed action *likely* to have an *impact* on the matter of NES and why?	Section 5 reference where *impact* is further assessed
4.11.1	Eastern-barred bandicoot (*Perameles gunnii gunnii*) EPBC Act status: Vulnerable	Potentially suitable habitat occurs south of Arthur River township in proximity of segments A and B. A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest (Segments A-J)[16]. This investigation included headlight surveys to attempt to inform hot spots of activity (Northbarker 2011). 2453 observations of vertebrate fauna were made including 14 observation of the brown bandicoot. However, no observations of eastern barred bandicoots were made in that study (Symbolix 2012). A three year study of the section of road north of the study area from Marrawah to Arthur River never recorded roadkill evidence of the eastern barred bandicoot.	Not applicable	The proposed action is **unlikely** to have any impact on this matter of NES. Justification: The Tarkine Rd is outside the known range of this species. Facilitated impacts leading to increased rates of roadkill on Bass Highway are considered very remote.	No further analysis in the PER
4.11.2	Spotted-tail quoll (*Dasyurus maculatus* subsp. *maculatus*) EPBC Act status: Vulnerable	A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest (Segments A-J)[17]. This investigation included headlight surveys to attempt to inform hot spots of activity (Northbarker 2011). The results of this investigation and other data demonstrates that the spotted-tailed quoll occurs widely but infrequently throughout the study area with localised concentrations at specific locations where the road intersects with the route of a home range.	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.1
4.11.3	Tasmanian devil (*Sarcophilus harrisii*) EPBC Act status: Endangered	A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest. (Segments A-J)[18].This investigation included headlight surveys to attempt to inform hot spots of activity (Northbarker 2011). The results of this investigation and other data demonstrates that the Tasmanian devil occurs widely throughout the study area with greatest concentrations along the western seaboard from Couta Rocks to Arthur River where the habitat in this area is considered to be more be more suitable (Northbarker 2011).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.2
No further analysis in PER	Australasian bittern (*Botaurus poiciloptilus*) EPBC Act status: Endangered	A resident of densely vegetated freshwater wetland habitats. In Tasmania the species is "confined to the coastal regions of the northeast" (Species Profile and Threats Database SEWPaC database). There are no observation records from the vicinity of the study area.	Not applicable.	The proposed action is **unlikely** to have any impact on this matter of NES. Justification: The Tarkine Rd is outside the known range of this species.	No further analysis in the PER
4.11.4	Orange-bellied parrot (*Neophema chrysogaster*) EPBC Act status: Critically Endangered	This species migrates along the west coast of Tasmania to its breeding areas in south western Tasmania. Buttongrass moorland habitat within the study area may be occasionally used for foraging by migrating birds. There are no observation records from the vicinity of the study area.	A B C D E F G H I J K L M N Foraging only habitat by migrating birds.	The proposed action is **unlikely** to have any impact on this matter of NES.	No further analysis in the PER

[15] Australian Government (2009)
[16] This was undertaken by Wildspot Consulting (Sept 2009-2010)
[17] This was undertaken by Wildspot Consulting (Sept 2009-2010).
[18] This was undertaken by Wildspot Consulting (Sept 2009-2010).

PER Reference	Matter of NES	Results of surveys and assessment of likelihood of occurrence/habitat suitability	Applicable segment along the Tarkine Forest Drive	Is the proposed action *likely* to have an *impact* on the matter of NES and why?	Section 5 reference where *impact* is further assessed
				Justification: There is no buttongrass habitat in the immediate vicinity of the Road within the coastal migrating range of the species.	
4.11.5	Swift parrot (*Lathamus discolor*) EPBC Act status: Endangered	This migratory species is occasionally recorded on the west coast and is regularly recorded in the northwest (e.g. Smithton) during the breeding season and post breeding foraging on flowers of planted *Eucalyptus globulus*. There are no observation records from the vicinity of the study area.	A B C D E F G H I J K L M N Post breeding potential foraging habitat in flowering eucalypts	The proposed action is **unlikely** to have any impact on this matter of NES. Justification: The Tarkine Rd is outside the known breeding range of this species. No impact to suboptimal foraging habitat is anticipated and	No further analysis in the PER
4.11.6	Tasmanian azure kingfisher (*Ceyx azureus diemenensis*) EPBC Act status: Endangered	The Arthur River is well documented as supporting the Tasmanian azure kingfisher along its lower reaches (covered by regular sightseeing river boats) (Wapstra et al. (unpublished) cited in Northbarker 2011). The Tasmanian Bird Atlas 1979 (cited in Wapstra et al. (unpublished) as cited Northbarker 2011) identifies a record of the azure kingfisher further up the catchment of the Arthur River near the confluence with the Lyons River. The bridge crossing over the Rapid River may contain potential nesting habitat (in the river banks) in the immediate vicinity of this site (Northbarker 2011).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.3
4.11.7	Tasmanian masked owl (*Tyto novaehollandiae* subsp. *castanops*) EPBC Act status: Vulnerable	There is one observation record of the species along Rapid River Road (Segment E). The wet vegetation types through which the Tarkine Forest Drive traverses are suboptimal habitat although there are large trees with hollows occurring across much of the study area (Northbarker 2011). A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest (Segments A-J)[19]. No Tasmanian masked owls were recorded during these surveys (S Plowright 2012, pers. comm., 9 May).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.4
4.11.8	Wedge-tailed eagle (*Aquila audax* subsp. *Fleayi*) EPBC Act status: Endangered	Two nests that were known from locations close to the existing Blackwater and Sumac Roads have long since disappeared (B. Brown pers. com. cited in Northbarker 2011). There are several other known nests within the vicinity of the study area that indicate there are other territories present (Northbarker 2011). The existing road and traffic is likely to preclude future nesting in the vicinity of the Tarkine Drive. An aerial survey of select sites undertaken by Forestry Tasmania in autumn 2009 failed to locate any new nests. This assessment used PI Inventory mapping to identify tall forest classes within 500m of the road. Consultation with DPIPWE (B. Brown from the Threatened Species Section) and vegetation mapping (50m wide corridor) carried out during ground surveys along the Tarkine Forest Drive have identified additional areas of potential nesting habitat in tall eucalypt forest. Further survey was undertaken in 2010 to inspect these additional areas. No evidence of nests was located during this survey (Northbarker 2011).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.5

[19] This was undertaken by Wildspot Consulting (Sept 2009-2010)

PER Reference	Matter of NES	Results of surveys and assessment of likelihood of occurrence/habitat suitability	Applicable segment along the Tarkine Forest Drive	Is the proposed action *likely* to have an *impact* on the matter of NES and why?	Section 5 reference where *impact* is further assessed
		The entire study area would be utilised for foraging habitat as it overlaps potential territories. This is especially applicable to scavenging for roadkill along the Tarkine Forest Drive.			
4.11.9	White-bellied sea eagle (*Haliaeetus leucogaster*) EPBC Act status: Migratory	There is potential nesting habitat along the coast within the study area and there are known nests along the Arthur River. The nearest potential nesting habitat to the Tarkine Drive is on the Arthur River near Kannunah Bridge although the level of existing activity here is likely to exclude nesting preference within proximity of the bridge and the road.(Northbarker 2011). A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest (Segments A-J)[1]. No white-bellied sea eagles were recorded during these surveys (S Plowright 2012, pers. comm., 9 May).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.6
4.11.10	Green and gold frog (*Litoria raniformis*) EPBC Act status: Vulnerable	All potential habitats were surveyed for green and gold frog between 7 January and 12 March 2010. The suitable habitat along the Tarkine Forest Drive was visited on eight occasions. There were six visits during the day when the conditions were considered ideal and twice at night. No green and gold frogs were observed or heard in any of the areas surveyed and there have been no records of this species occurring in the past decade. A series of other potentially suitable sites were identified from aerial images of the area. Sites were chosen for either being near the proposed road development or on the downstream side of the development. Fourteen locations were identified. This included the Rebecca Lagoon which although well south of the development, and out of the disturbance zone, was considered a good example of permanent water which would be most likely contain green and gold frog if they existed in the area. Several visits to the lagoon failed to show any evidence of the species (Wildspot Consulting 2010).	A B C D E F G H I J K L M N	The proposed action is **unlikely** to have any impact on this matter of NES.	No further analysis in the PER
4.11.11	Australian grayling (*Prototroctes maraena*) EPBC Act status: Vulnerable	The Australian grayling has been recorded near the mouth of the Arthur River. It is also likely to utilise lower and middle reaches of other rivers and creeks which are not obstructed by barriers affecting fish passage (Northbarker 2011). Most of the smaller creeks which are crossed by the Tarkine Forest Drive are unsuitable as they are too small and are obstructed by natural barriers (Northbarker 2011). Habitat for the Australian Grayling potentially occurs in the Frankland River and Rapid River. Nelson Bay River is unsuitable due to a hydraulic barrier 50m downstream of the Temma Road crossing (Northbarker 2011).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.7
4.11.12	Giant freshwater crayfish (*Astacopsis gouldi*) EPBC Act status: Vulnerable	The Frankland and Rapid Rivers have been identified as providing good quality habitat with strong giant freshwater crayfish that are worthy of conservation (Walsh 2003, cited in Threatened Species Section 2006c). These rivers are both crossed by the Tarkine Forest Drive (Northbarker 2011). There are observation records from several other creeks crossed by the Tarkine Forest Drive. In addition many other creeks provide potentially suitable habitat. Assessment has been made of the suitability for crayfish passage of all creeks and rivers considered suitable as habitat for giant freshwater crayfish. Larger rivers and creeks are crossed by bridges and large box culverts. Both these structures present no impediment to crayfish passage.	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.8

[1] This was undertaken by Wildspot Consulting (Sept 2009-2010)

PER Reference	Matter of NES	Results of surveys and assessment of likelihood of occurrence/habitat suitability	Applicable segment along the Tarkine Forest Drive	Is the proposed action *likely* to have an *impact* on the matter of NES and why?	Section 5 reference where *impact* is further assessed
		Some of the smaller creeks include a range of culvert types. Many are single or dual pipe culverts varying in diameter from 1-2m. Most would be accessible to crayfish passage. However, some are hanging culverts where the pipe outlet is above the creek bed. In these circumstances, dispersing crayfish would be forced up and onto the road to access the upper catchment.			
4.11.13	Marrawah skipper (*Oreisplanus munionga* subsp. *larana*) EPBC Act status: Vulnerable	There are several observation records from suitable habitat close to the coast adjacent to Temma Road (Segment B). Potentially suitable habitat is to be found at several of the creek crossings along this section of road. A targeted survey of potentially suitable habitat was undertaken along this section in 2008. No observations were made in the immediate vicinity of the road along segments A, B and C which fall within the range of the species. The flora survey of these segments did not identify any plants of *Carex appressa* suggesting no habitat in the immediate vicinity of the Tarkine Forest Drive (Northbarker 2011).	A B C D E F G H I J K L M N	The proposed action is **likely** to have an impact on this matter of NES.	5.6.9

4.11.1 Eastern-barred Bandicoot (*Perameles gunnii gunnii*)

Abundance

No population census data for the Tasmanian eastern barred bandicoot have been published but population density estimates for the subspecies are available from a limited number of studies. In a study of a north-western population (undertaken in 1960s), densities averaged 0.85 per ha (range 0.45–1.46 per ha) (Heinsohn 1966 cited in SPRAT Profile 2012a). In the Huon Valley, numbers on two 20 ha grids ranged from about 10 to about 45 over a four year period indicating fairly similar densities (i.e. 0.35– 2.35 per ha) (Mallick et al. 1998a cited in SPRAT Profile 2012a).

The eastern-barred bandicoot is not currently listed in Tasmania under the *Threatened Species Protection Act 1995*. The EPBC conservation advice for the Tasmanian subspecies incorrectly asserts that it is listed under Tasmanian legislation. The mainland subspecies of *Perameles gunnii* is listed as endangered because it now only persists as a few small captive colonies in south eastern Victoria. Its decline on the mainland is thought to be linked to the predatory impacts of the European fox. Establishment of the fox in Tasmania probably presents the greatest potential threat to the species (NBES 2011).

Distribution, ecology and habitat preference

Prior to European settlement, the range of the eastern barred bandicoot in Tasmania has been suggested to have been mostly within the Midlands region (Mallick et al. 1997 cited in NBES 2011). The Midlands region falls within the Northern Midlands and south east bioregions. A recent assessment of the distribution of the eastern barred bandicoot has found that the species has declined in the Northern Midlands, is present in the South East, Central Highlands and Northern Slopes bioregions and has naturally expanded into the Ben Lomond, King and Tasmanian Southern Ranges bioregions (Sattler and Creighton 2002 cited in NBES 2011).

This range expansion is believed to have occurred as a result of clearing of forested land for agriculture which has opened up areas within the northern and southern bioregions that were previously unsuitable because they were heavily forested. The preferred habitat of the eastern barred bandicoot is highly productive agricultural land with deep soils and high rainfall where there are open pasture areas for foraging and ground cover for nesting and shelter (Driessen et al. 1996 cited in NBES 2011).

Preferred habitat includes open grassy areas for foraging in close association with dense ground cover for nesting and shelter. Natural habitat includes grasslands and grassy woodland with abundant tussocks, rushes and other forms of cover. However, they also frequently use garden lawns, pasture and sports fields where there is an adjacent cover of dense shrubs including weedy species such as gorse (NBES 2011).

The Tarkine Drive project area appears to be outside the known range of the species (Figure 4.13). The nearest observed observations are derived from roadkill records on Bass Highway at Bond Tier, 18 km to the northeast of Arthur River township.

Known threats

The main known threats to eastern barred bandicoot include clearing of habitat and predation by feral cats and dogs (Driessen et al. 1996, Hocking 1990, Tas PWS 2008 cited in SPRAT Profile 2012a). Cats are also the primary host of *Toxoplasma gondii* which can cause death in the species (Obendorf & Munday 1990, Obendorf et al. 1996 cited in SPRAT Profile 2012a).

Security is considered poor, given that few reserves are known to contain the species (Hocking 1990 cited in SPRAT Profile 2012a) and most of the available habitat is on productive agricultural or other private land (Driessen et al. 1996 cited in SPRAT Profile 2012a).

Overgrazing and urban development also represent pressure on the species habitat and the presence of European foxes in Tasmania also represents a new predation threat (TSSC 2008z cited in SPRAT Profile 2012a).

None of the known threats will be affected by this action. No habitat clearance will occur, feral predators will not be introduced and no changes to grazing in the known habitat will be caused.

Changes in traffic may affect rates of roadkill in suitable habitat. Although there does not appear to be any within the immediate vicinity of the works any facilitated changes to traffic on the Tarkine Forest Drive could affect mortality rates. However, changes to traffic resulting from this project are unlikely to occur between dawn and dusk and so roadkill is unlikely to be modified by this project.

Survey

Figure 4.13 depicts the eastern barred bandicoot records in northwest Tasmania and potential habitat in the study area. Although there are records for the eastern barred bandicoot from northwest Tasmania, there are none from the study area. There are small localised patches of coastal grasslands on the sand plains between sand dune systems along Temma Road (Segments A and B) which may be suitable habitat. However, it is considered that these grasslands have a low potential to support eastern barred bandicoots because they are on sandy soils with low fertility, which is not the preferred habitat of this species (NBES 2011).

A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River/Sumac Road junction where traffic volumes are highest (Segments A-J)[20]. This investigation included headlight surveys to attempt to inform hot spots of activity (NBES 2011). The methodology is detailed in section 4.9.3.

2453 observations of vertebrate fauna were made, including 14 observation of the brown bandicoot. However, no observations of eastern barred bandicoots were made in that study (Symbolix 2012).

Generally, the Tarkine Forest Drive project passes through vegetation characterised by a mosaic of moorland, scrub, heathland, dry *Eucalyptus nitida* forest, wet *Eucalyptus nitida / obliqua* forest types, or rainforest communities; none of which are ideal habitat for eastern barred bandicoots (NBES 2011).

[20] This was undertaken by Wildspot Consulting (Sept 2009-2010)

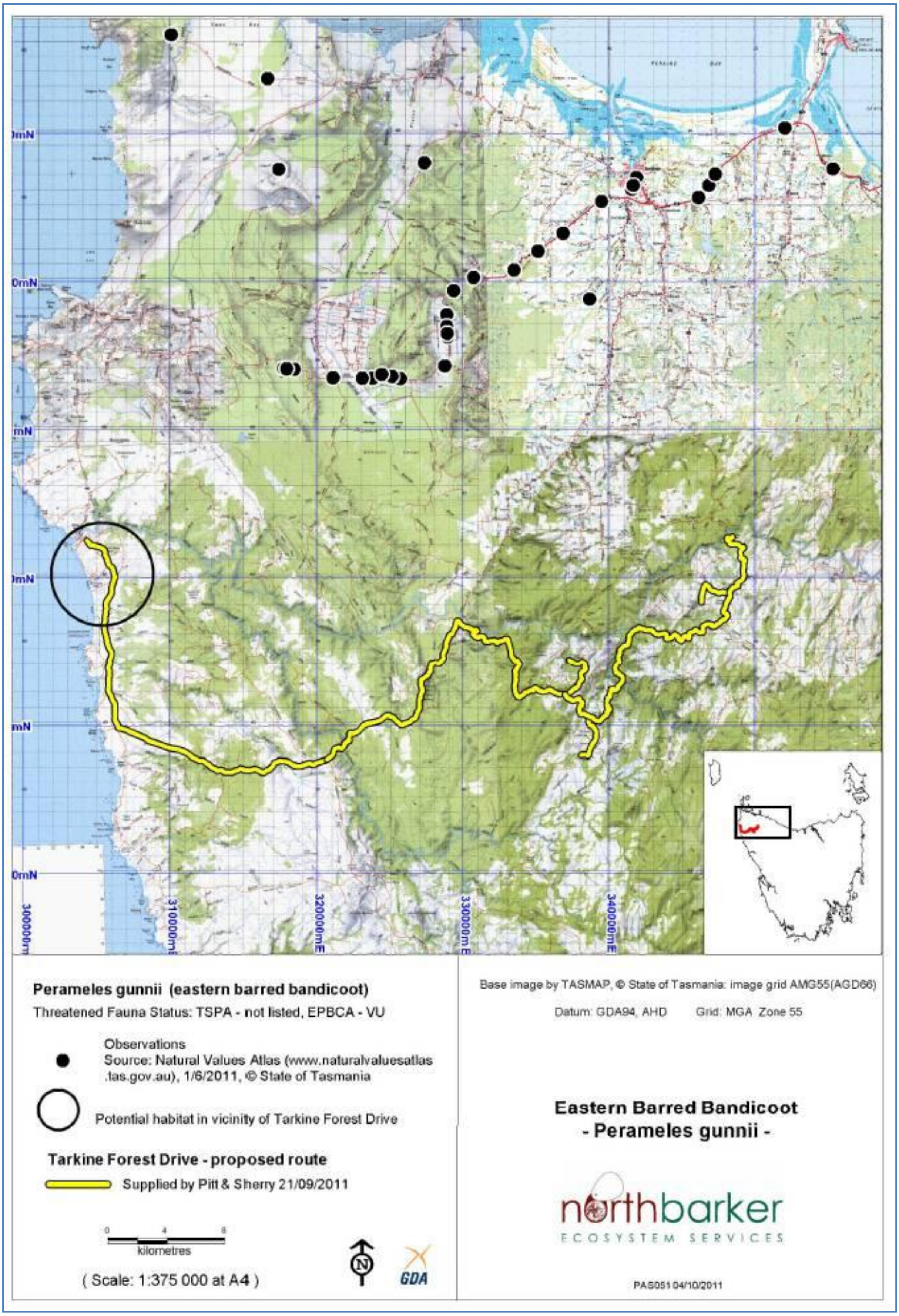

Figure 4.13 - Eastern barred bandicoot records in northwest Tasmania and potential habitat in the study area (Source: NBES 2011)

4.11.2 Spotted-tail Quoll (*Dasyurus maculatus* subsp. *maculatus*)

Abundance

There are currently estimated to be 3000 to 4000 Spotted-tailed quoll remaining in Tasmania based on a density of about 1 per 300 ha (Jones and Rose 1996 cited in NBES 2011). The density can be higher in the core habitat area in northern Tasmania and in other limited 'hot spots', in the incised river valleys of the Gordon and Huon River catchments in southern Tasmania, and along a narrow strip of the west coast.

The species appears to be declining in abundance, and may be vulnerable to further declines through continued habitat removal and fragmentation (Bryant and Jackson 1996 cited in NBES 2011).

Distribution, ecology and habitat preference

Spotted-tailed quoll are distributed across the state with the exceptions of King Island and Flinders Island where it is locally extinct. Important populations have been located from the following locations (SPRAT Profile 2012b):

- Freycinet National Park
- Central-north Tasmania (including Great Western Tiers to Narawntapu)
- Cradle Mountain National Park
- Far north-western Tasmania (including the Smithton and Marrawah regions)
- Eastern Tiers/northern Midlands (including Nugent and Ross regions)
- Southern forests/south coast (including the Hastings region)
- Gordon River system
- South West Cape.

The species is found in a large range of habitats, including rainforests, wet and dry sclerophyll forest, coastal heathland, scrub and dunes, woodland, heathy woodland, swamp forest, on beaches and sometimes in grassland or pastoral areas adjacent to forests. The species is solitary and occupies large home ranges (SPRAT Profile 2012b).

Home ranges extend to more than 1,500 ha of continuous suitable habitat for a male and a little less for a female spotted-tailed quoll. Population densities are likely to be in the order of one individual per 4 km^2, with female ranges largely exclusive and male ranges overlapping. Continuous habitat patches (denning and hunting) totalling more than 15,000 ha may be required to sustain a minimum viable population of 50 spotted-tailed quoll based on an exclusive home range of 300 ha (PLUC 1996 cited in NBES 2011).

Priority habitat for the species is generally described as lowland, high-rainfall forest across the north of Tasmania. The species requires forested areas with suitable shelter sites such as hollow logs or rocky caverns as denning habitat. This is distinguished from foraging habitat which can include non-forest and regenerating forest areas adjacent to suitable denning habitat (Mallick 2003 cited in NBES 2011). The best foraging habitat is characterised by an abundance of mammalian prey species which tends to be on fertile land and is often associated with riparian or alluvial sites as well as lower slopes in wet gullies (NBES 2011).

Habitat occurs in the vicinity of all Segments. Observation records are shown in Figure 4.14.

Known threats

In summary, the threats to spotted-tailed quoll include the following (SPRAT Profile 2012b):

- **Habitat loss and modification:** Considered the greatest threat to the species. In the Tasmania 50% of the species core habitat has been removed by logging or agriculture. Of the remaining 50% half has been subject to logging in the past 20 years – particularly in the north and northwest regions of the state for plantations in the 1980s
- **Fragmentation:** In many areas the current habitats are fragmented resulting in isolated populations. This leads to breeding complications, including difficulty in locating breeding partners and a lack of genetic diversity. The species naturally occurs in low population densities (breeds only once a year) meaning isolated populations have inherent breeding difficulties. Isolated populations are subject to stochastic events
- **Timber harvesting:** Research suggests that forestry practices that remove or reduce prey or critical habitat (including trees with hollows, hollow logs and complex vegetation structure) may render habitat unsuitable
- **Poison baiting:** In particular, 1080 to control red fox, wild dogs and rabbit. However, recent research indicates that 1080 baiting is in fact not a threat[21]
- **Competition and predation** from introduced carnivores
- **Deliberate killing and dog attacks**
- **Road mortality:** Road mortality is believed to be a significant factor in the decline of some populations. It is estimated that 1-2 individuals are killed daily on the main road between Hobart and the north west of the state. Juvenile males are most at risk due to extensive range. The full impacts of road mortality on the species are not well known. However, other carnivorous marsupials have been significantly impacted locally
- **Wildfire and prescription burning:** The impacts of wildfire and prescription burning are not well known but it may reduce prey and habitat. However, recent research found that fire may be beneficial as it can increase the formation of tree hollows used by the species and its prey.

The impacts of the proposed action are discussed in Section 5. No breeding habitat will be lost or modified. This road project will not increase any already existing fragmentation. No timber harvesting, 1080 baiting or increased feral species will not occur and there will be no increased threat from dog attacks. This project does not include any changes to prescription burning and a roadkill monitoring program has been undertaken, as discussed below.

There are no pest species or diseases that are likely to be introduced that would impact on this species.

Survey

A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River/Sumac Road junction where traffic volumes are highest (Segments A-J). The methodology is detailed in section 4.9.3 and further discussed in Section 6.6.

[21] RSPCA (2005) cited in http://www.dpiw.tas.gov.au/inter,nsf/WebPages/JBRN-6VR882?open

This investigation included headlight surveys to attempt to inform hot spots of activity The results of this investigation and other data demonstrate that the spotted-tailed quoll occurs widely but infrequently throughout the study area, with localised concentrations at specific locations where the road intersects with the route of a home range.

Analysing headlight surveys, roadkill data and spotted-tailed quoll sightings indicate that there is a correlation between roadkill of all vertebrate animals combined and roadkill of spotted-tailed quolls. It was also evident that roadkill rates increased with increases in vehicle speed.

By extrapolation it was shown that increases in roadkill resulting from increases in traffic volume and speed could lead to increases in roadkill rates including spotted-tailed quolls. More importantly, these results were able to inform a predictive model for identifying sections of road with a high risk of roadkill.

In March 2012 a carnivore scat survey of the entire route was undertaken by bicycle. This method ensured a high level of inspection, being more efficient than a foot survey and more effective than a vehicle survey. This was particularly informative for the eastern half of the road where the absence of traffic precluded the value in roadkill and headlight surveys of this section. This work confirmed evidence of dispersed distribution of spotted-tailed quolls across the area. Figure 4.14 depicts the observation records (including live sightings and roadkill) of spotted-tailed quolls from the study area.

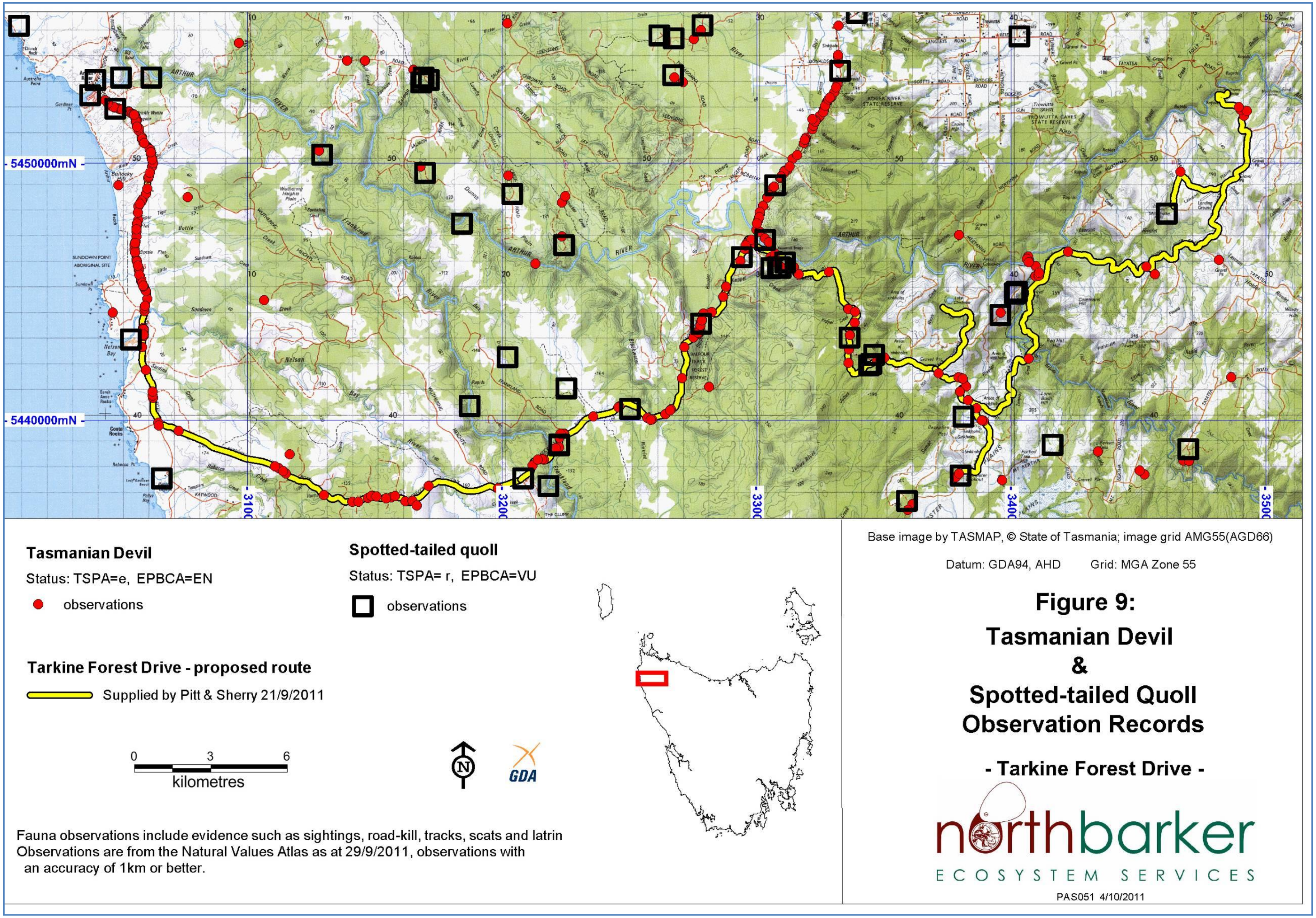

Figure 4.14 - Observation records (including live sightings and roadkill) of Tasmanian devils and spotted-tailed quolls from the study area (Source: NBES 2011)

4.11.3 Tasmanian Devil (*Sarcophilus harrisii*)

Life history

The Tasmanian devil is Australia's largest surviving marsupial carnivore and only specialist scavenger. Although variable in size, adult males can weigh up to 12 kg and be 30 cm high at the shoulder. They are covered in coarse thick black fur with variable white markings. They have a proportionately stronger upper body and large jaws strong enough to crush the bones of carrion which includes dead animals of any type and some live food also (Jones and Rose 1996, MacCallum et al. 2007 cited in NBES 2011).

Tasmanian devils are usually solitary animals but they are known to come into contact with other devils around prey carcasses and during the mating season (Hamede et al. 2009 cited in NBES 2011). They mate once a year giving birth in April through to July, and can produce up to four young which develop for up to 20 weeks in the pouch. The young are fully weaned at 10 months of age (NBES 2011).

Tasmanian devils roam familiar routes using their sense of smell to locate food. Animals typically travel with a characteristic loping gait around 8 km a night, although individuals have been recorded covering more than 50 km in a single night (Tarkine Devil Forum 2009 cited in NBES 2011). They have home ranges of 8 to 20 square kilometres, although more recent studies suggest smaller ranges.[22] These overlap with other individuals as they are not wholly territorial (NBES 2011).

The devil is largely nocturnal and is well known for its screaming calls and growls. In daytime they hole up in shelter, including underground dens, wombat burrows, hollows and caves (NBES 2011).

Persecuted along with the Tasmanian tiger, the species was in threat of extinction by the early 20th century. However, changes in policy allowed the species to recover so that it reached historically high levels by 1990s. Some estimates suggest the population may have exceeded 150,000 individuals at this time (N. Mooney cited in Mc Glashan et al. 2006 cited in NBES 2011).

Abundance

From pre-Devil Facial Tumour Disease (DFTD) (1992) to 2009 there has been an 80% decline in Tasmanian devil sightings across the state. So far this decline has not slowed or ceased (DPIPWE 2010).

Accurate estimates of the current population size are not available. However, considering an average decline of sightings in the annual spotlighting surveys of 16% since 2007, the best estimate of the total maximum state wide population is no more than between 17,000 and 42,000 individuals (DPIPWE 2010).

Two management units have been identified for the species. Tasmanian devils in northwest Tasmania are genetically distinct from those found across the rest of the state (SPRAT Profile 2012c). However, there is still a small amount of movement of the species between the two groups, therefore making all of the species part of a single population (DPIPWE 2010).

The Tarkine Forest Drive is within the northwest population, which has been identified as a genetically distinct management unit in northwest Tasmania across approximately 13,400 $km^{2,}$ west of the Forth River and south to Macquarie Heads. The region encompasses four sites that have been intensively surveyed by DPIPWE since 2004, and one surveyed by Hawkins (unpubl. data) in 2003.

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[22] 2.5 km^2 for females and 10km^2 for males (S. Troy pers. com. cited in NBES 2011)

One of the sites surveyed, Woolnorth, holds the highest population density found in any of the Team's surveys, more than double that at the other sites. Extrapolating from these density estimates the northwest population may currently consist of between 3,000 and 12,500 individuals (SPRAT Profile 2012c).

Distribution, ecology and habitat preference

Tasmanian devils occur throughout mainland Tasmania and on two islands: Robbins Island (which is virtually joined to mainland Tasmania at very low tides) and remnants of an introduced population are thought to remain on Badger Island (DPIPWE 2010).

Observation records in NW Tasmania are shown in Figure 4.14.

The species inhabits all terrestrial habitats within their geographic range with an extent and area of occupancy of 64,030 km^2 (Jones and Rose 1996 cited in DPIPWE 2010). There has not been a significant change in recorded distribution in the last 10 years. It is not currently known whether DFTD will result in the contraction of the area occupied by the species via localised extinctions (DPIPWE 2010).

The average pre-DFTD density of the species in unmodified habitat across the state was 0.3–0.7 per km^2 (M. Jones unpublished cited in DPIPWE 2010). The species was more abundant in the north, which may have been due to the reliability of seasonal rainfall in the north or cooler temperatures in the south and the resultant influence of these factors on vegetation and/or prey species (Jones and Rose 1996 cited in DPIPWE 2010).

The core habitat of the species comprises the low to moderate annual rainfall zone of the east and northwest of the state, including the eastern half of the state, the northern coastal region and a narrow strip down the west coast (see Figure 4.15) (DPIPWE 2010).

For marsupial carnivores, good quality habitat encompasses a combination of year round food supply, enough den sites for breeding and daily movements, and structural features for refuge and foraging (Jones et al. 2003 cited in DPIPWE 2010). Habitat requirements for Tasmanian devils include the following (DPIPWE 2010):

- Places to hide and shelter during the day (such as dense vegetation, hollow logs, burrows or caves)
- Areas with an open understorey mixed with dense patches of vegetation which allow hunting
- Soil suitable for burrowing for the purpose of maternal dens (although devils usually use ready-made dens).

For Tasmanian devils the combination of these features within a habitat is more important than a particular vegetation community or habitat type (DPIPWE 2010).

The preferred habitat of the species includes sclerophyll forest and coastal scrub (Guiler 1970 cited in DPIPWE 2010). Predicted high densities of the species occur in mixed patches of grazing land and open forest or woodland and in coastal heathland (Jones and Rose 1996 cited in DPIPWE 2010). Low densities of the species occur in dense wet eucalypt and rainforest, alpine areas, dense wet heath and open grassland (Jones et al. 2004 cited in DPIPWE 2010).

Critical habitat for the species includes the following (DPIPWE 2010):

- All DFTD free areas within mainland Tasmania with suitable habitat
- All areas of pre DFTD core habitat
- Areas required under the recovery program for the future introduction of the species.

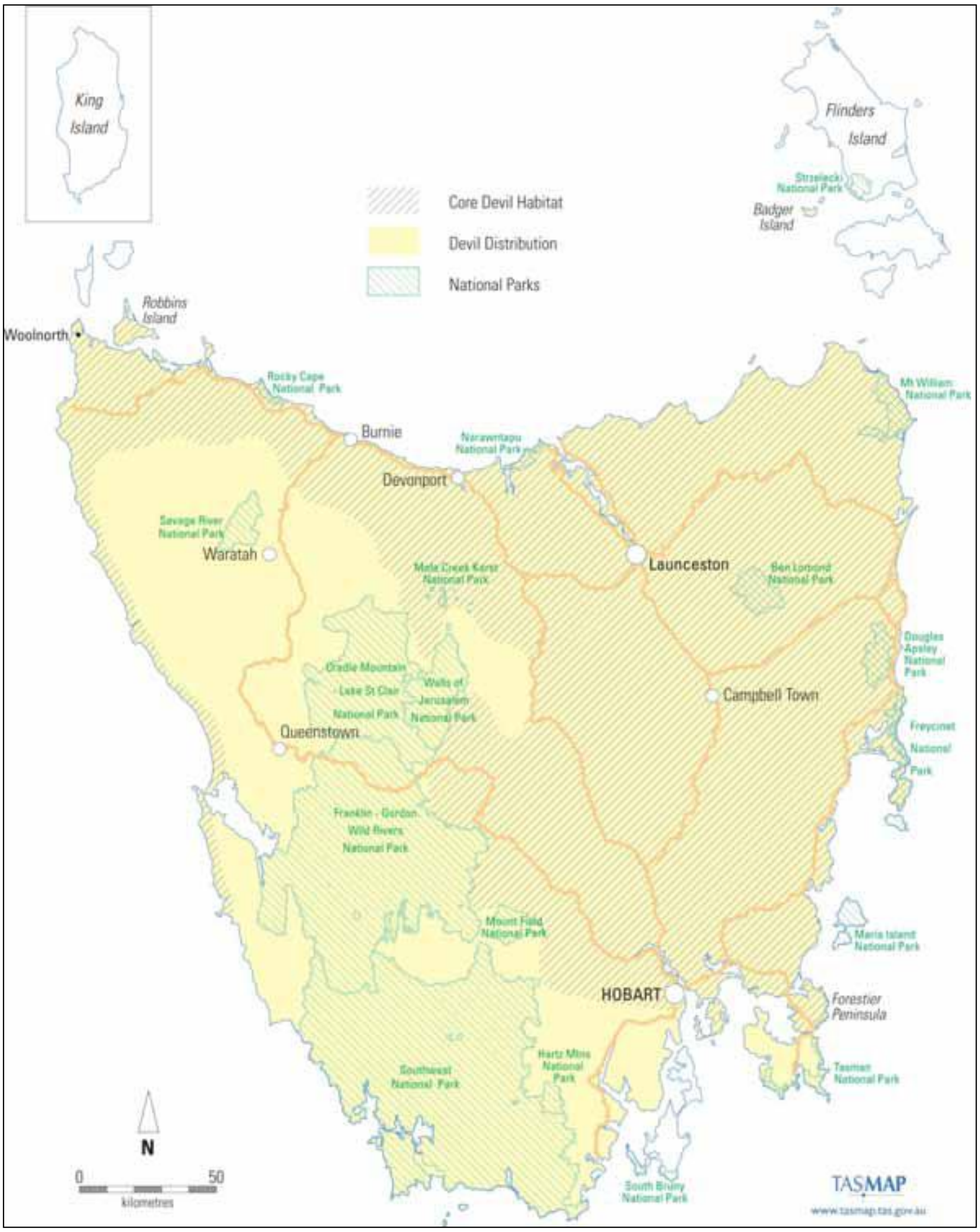

Figure 4.15 - Tasmanian devil distribution and approximate core habitat (Source DPIPWE 2010)

Known threats

Devil Facial Tumour Disease

In 1996 debilitating facial lesions where observed on animals in the north east of Tasmania. This was the first signs of what is now described as Devil Facial Tumour Disease (DFTD), a rare contagious cancer which is 100% fatal to animals that contracts it, usually killing within 8 months of the initial signs (NBES 2011).

Information on population densities gleaned from a mark and recapture study (MacCallum et al. 2007 cited in NBES 2011) indicates 0.8 to 2.9 individuals per km^2 in disease-free areas (three sites), and 0.3 to 1.4 individuals per km^2 in the confirmed diseased region (four sites).

It is the impacts of DFTD which have resulted in the listing of the Tasmanian devil as endangered under both state and commonwealth legislation. It is estimated that the species may be extinct in the wild within 25 to 30 years (CBSG 2008 cited in NBES 2011).

In 2003, the Tasmanian Government with Australian Government support established the Save the Tasmanian Devil Program which is directed by the following objectives[23]:

- Maintain the genetic diversity of the Tasmanian devil population
- Maintain the Tasmanian devil population in the wild
- Manage the ecological impacts of a reduced Tasmanian devil population over its natural range.

Studies of DFTD have shown that it has spread across more than 60% of Tasmania with population declines averaging 84% with up to 96% in the northeast of the state[24]. The last remaining stronghold for the Tasmanian devil is in the northwest with the west and southwest areas supporting much lower densities. A reduced population such as that affected by DFTD is considered highly vulnerable to other causes of mortality such as roadkill (NBES 2011).

Particular interest has been taken in the western front of the disease in northwest Tasmania, which approximates to the Murchison Highway. Intensive sampling undertaken in 2009 and repeated in 2010[25] indicates the DFTD continued to progress westwards at about 7 km per year. This is markedly slower than the rate of spread elsewhere in Tasmania (NBES 2011).

The DFTD is the single most significant cause of mortality and therefore threat to the conservation of the Tasmanian devil. The retention of naturally occurring disease free populations is a key factor in ensuring the long term survival of the species in the wild. Any activity that may increase the risk of accelerating the spread of DFTD into areas currently disease free may be considered as having a significant impact to the species (NBES 2011).

There have been no local extinctions as a result of the disease, although in the northeast of Tasmania the devil population is at a very low level. It has declined by 97% and the age structure of the population has changed with no animals over two years old persisting in the region (MacCallum et al. 2007, Hawkins et al. 2006 cited in NBES 2011). It is when populations are at such low levels that they become sensitive to other causes of mortality such as roadkill (NBES 2011).

[23] http://www.dpiw.tas.gov.au/inter.nsf/Attachments/PWOD-7XB7D8/$FILE/STTD_StrategicPlan.pdf
[24] Based on sightings: Save The Tasmanian Devil website (www.tassiedevil.com.au), DPIWE threatened species website(4 Oct 2011) cited in NBES 2011
[25] Reported on the Save The Tasmanian Devil website (**www.tassiedevil.com.au)** (4 October 2011) cited in NBES 2011

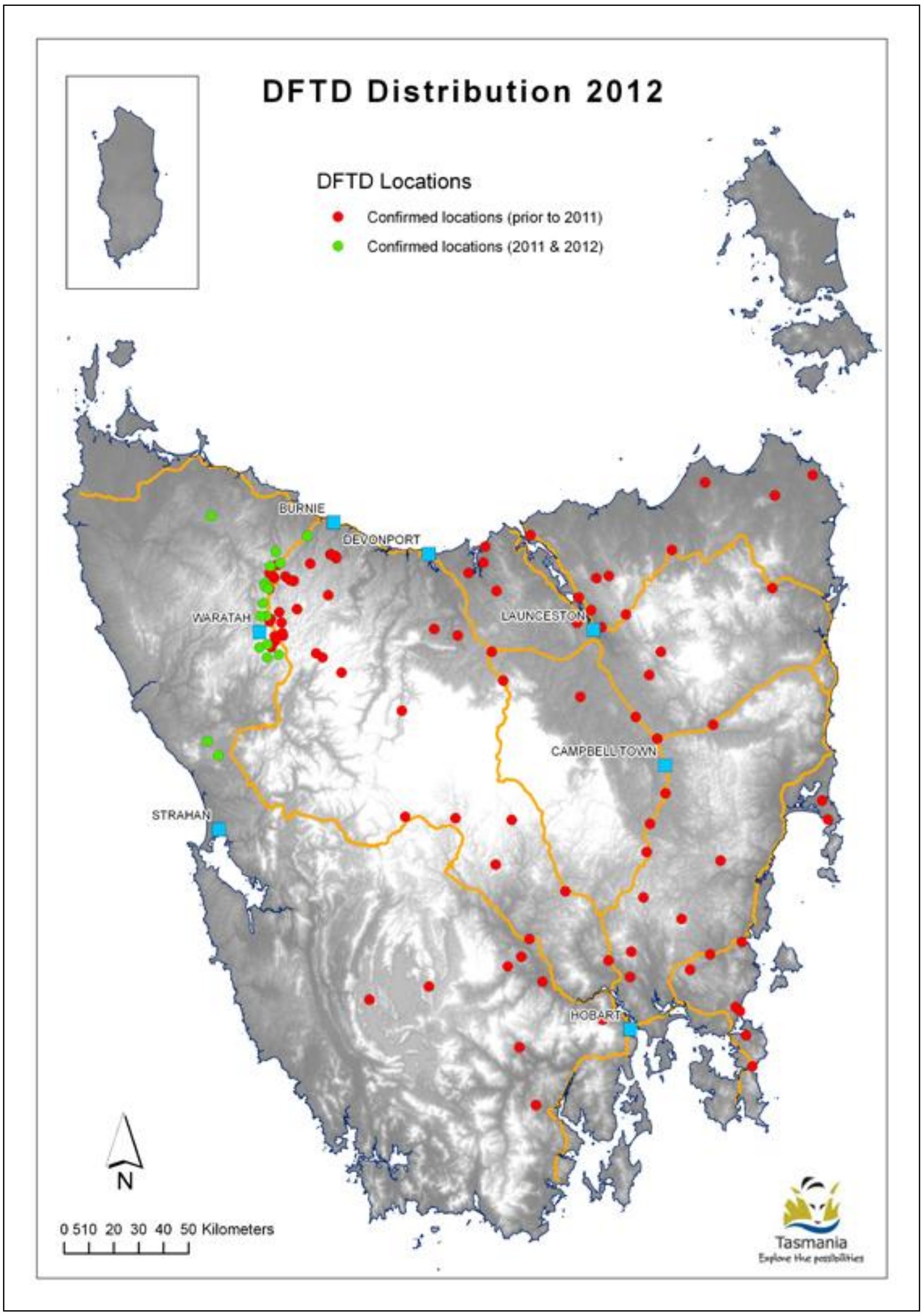

Figure 4.16 - Distribution of Devil Facial Tumour Disease (Source: Save the Tasmanian Devil website (www.tassiedevil.com.au) (2 August 2012))

The DFTD is an extremely unusual but lethal disease, being a contagious cancer which forms grotesque lesions around the face. It is able to be transferred from animal to animal by a process known as allograft where infectious cells are passed through biting (Pearse et al., Fox, Bender et al. (Save the Tasmanian Devil 2007) cited in NBES 2011).

The management of disease transfer therefore requires management of animal movements and their social behaviours (NBES 2011).

The northwest population of Tasmanian devils is disease free. The western most occurrence of DFTD is at Takone and the Murchison Highway; however, this data is 12 months old (Save the Tasmanian Devil Program unpublished data cited in NBES 2011).

Current modelling indicates a rate of disease spread between 10 and 20 km per year (Marveneck (Save the Tasmanian Devil 2007) cited in NBES 2011) although it has moved 50 km per year on at least one occasion. This has lead to a consensus view amongst scientists that the DFTD may have spread throughout mainland Tasmania in as little as 5 to 6 years and that the species may become extinct in the wild within 15 years (MacCallum – Overview (Save The Tasmanian Devil 2007) cited in NBES 2011). Other estimates suggest 25 to 30 years (CBSG 2008 cited in NBES 2011). Elsewhere the disease 'front' has been estimated to be spreading at an average rate of 7 km per year (McCallum et al. 2007 cited in NBES 2011).

The Save the Tasmanian Devil Program undertook targeted investigation of the western front of DFTD in the spring of 2009, which was repeated in 2010 and 2011. These investigations suggest a slow but continuous spread of approximately 7km per year (NBES 2011).

Trapping studies indicate that devils are regularly trapped at distances of 5 to 7 kilometres apart on consecutive nights (Hamede pers. com. cited in NBES 2011). An adult male has been radio-tracked covering a distance of 50 km in a single night, albeit within its home range (Jones pers. com. cited in NBES 2011). Young adults are known to disperse from their home territory and may potentially travel significant distances.

Studies into dispersal rates are ongoing and will further inform this issue (Hamede pers. com. cited in NBES 2011). However, the current knowledge indicates that it is possible that a diseased animal could spread the DFTD a significant distance. Most dispersal is undertaken by young animals post weaning (at 9-18 months of age), which are less likely to be carriers of the DFTD than mature individuals. However, DFTD has been found in animals as young as 13 months of age, although this is rare. DFTD in sub-adults is reportedly low (Hawkins et al. 2006 cited in NBES 2011), although this relies on the assumption that the incubation period is brief (NBES 2011).

The identification of DFTD relies on gross pathology and disease front monitoring is based on clinical testing. There is no pre-clinical test available yet. A pre-clinical test is currently under trial (STDP newsletter cited in NBES 2011) but it is not certain whether this will prove to be viable (NBES 2011).

The disease 'front' is not a solid line - the typical pattern is localised outbreaks ahead of a more generalised infected population. A recently published study on Tasmanian devil social networks has found that, despite being solitary, animals devils are highly connected socially, which has implications for the spread of DFTD. Certain individuals have a large number of social connections and present a heightened risk of translocating the disease through a population (Hamede et al. 2009 cited in NBES 2011).

There is evidence that the northwest devil population is of a distinct genetic provenance, showing greater allelleic variation than the eastern population (Jones and Barmuta 2000 cited in NBES 2011). This has been further corroborated by research of major histocompatability complex (MHC) genes which demonstrated greater variability in western populations than eastern devils which may result in improved levels of disease resistance (Siddle et al. 2010 cited in NBES 2011). This may result in the possibility that DFTD will have a different impact to northwest populations. Early evidence suggests mortality rates may be lower.

The pinch point for the genetic separation is thought to be at Mawbanna. The devil genetic provenance starts to change at about Devonport. There is a grey zone in the genetic provenance from Devonport to Stanley (M. Jones pers. com. cited in NBES 2011). Wet forest and higher altitude are thought to be the partial barrier to devil movements in this area (NBES 2011).

Preliminary results from observations of disease spread within an infected population west of Cradle Mountain (Hamede (Save The Tasmanian Devil 2007) cited in NBES 2011) support the hypothesis that some level of disease resistance occurs in the western population. Similarly, a 12 month monitoring study of Tasmanian devils in the Cradle Mountain area using remote cameras (Coupland and Anthony 2007 cited in NBES 2011) in 2006/07 recorded 77 individuals of which the presence of DFTD was observed in a small proportion. There was no evidence of an increase in the prevalence of the disease in the population during the period of monitoring. This differs from observations of the rates of spread of DFTD in eastern Tasmania. Given that the disease was first observed in the area in 2004, these results indicate DTFD incidence is around 10% and suggests that the local population may have a level of resistance to the disease (NBES 2011).

The slowed rate of transmission may be due to a higher degree of resistance as a result of the greater genetic diversity in the northwest Tasmanian devil population.

Alternatively, there may be other explanations, such as a reduced basal population having lower transmission due to reduced contact between individuals in a population with a naturally low density (Obendorf and McGlashan 2008 cited in NBES 2011) or slower rates of transmission through dense forests than across agricultural land (Marveneck (Save The Tasmanian Devil 2007) cited in NBES 2011).

Healthy populations of Tasmanian devils are able to withstand what may appear to be devastating mortality rates. Roadkill rates peak in summer, impacting on young animals just out of the den and migrating males which may have been driven out by dominant adults. Roadkill, however, has been shown to have a significant impact on small isolated populations (e.g. Cradle Valley) and on depleted populations such as those affected by DFTD (Jones 2000 cited in NBES 2011).

While the northwest of Tasmania continues to have a healthy population of Tasmanian devils roadkill is not likely to have a significant impact on the population (NBES 2011).

The Save the Tasmanian Devil Programme is planning for the expected spread of the DFTD into the northwest of Tasmania (A. Sharman pers. com. cited in NBES 2011). Roadkill could have a significant impact in the area if the disease arrives (NBES 2011).

The rate of the spread of DFTD will affect the nature of the response from the Devil Task Force. If there is an opportunity for DFTD to penetrate into new areas this would have a major impact on the Save the Tasmanian Devil Programme. The Devil Task Force is planning to set up disease free populations in the northwest which will be fenced to prevent access by diseased individuals (CBSG 2008 cited in NBES 2001). If the disease arrives in the northwest before these refuge populations are established this will have major implications for this program (NBES 2011).

Many wide ranging carnivores have been shown to use roads with low traffic volumes to move through the landscape. These include red fox, dingo, wolf, cheetah and lion (Coffin 2007 cites in NBES 2011). There is evidence that devils will use a road as part of their home range and some anecdotal evidence of devils following tracks for longer periods[26]. Most typically the road is acting as a corridor for a few hundreds of metres at a time[27].

[26] D. Pemberton *pers. com.* (cited in NBES 2011) – observation on West Coast near Sandy Cape devils followed track for several kilometres
[27] A. Sharman, M. Jones *pers. com.* (cited in NBES 2011)

Devils with overlapping ranges are attracted to tracks and roads due to ease of movement and the openness of the terrain for the establishment of latrines. Devils are attracted to open areas for latrines[28] and disused tracks in dense forest provide suitable areas for their establishment. However, this does not necessarily mean that tracks and roads increase the dispersal of devils.

For the Tarkine Drive to be a factor in affecting the rate of spread of DFTD it would need to introduce an increased opportunity for the movement of animals, either by the road providing a corridor for migration or by allowing access across existing landscape barriers. Alternatively, if the upgrade of the road were to modify devil behaviour resulting in an increase in social interactions over roadkill, this may increase the rate of disease spread.

There are no obvious barriers to devil movements along the northwest coast from Devonport through to Woolnorth. Indeed, the mosaic of agricultural land and bushland represents favourable habitat and the population density would be anticipated to be concentrated along the northern seaboard thus providing the most likely route for the spread of DFTD into the far northwest.

Although evidence is limited, the rate of socialisation of animals may enhance the passing of DFTD between individuals, which could influence the rate of spread of the disease. Where animals are fighting over carcases the interactions include biting, which is the means by which the disease is transmitted. If increased numbers of roadkill, and thus available food, attracts elevated numbers of animals to the road there is the risk that opportunities for disease spread are enhanced.

Other threats

The other known threats to Tasmanian devil include the following (DPIPWE 2010):

- **Lack of genetic diversity:** Low genetic diversity can reduce the species resistance to DFTD. There is a small chance that the populations in the northwest may be genetically resistant to DFTD; however, to date all individuals tested during research have contracted the disease.
- **Competition and predation by foxes:** Habitat preferences of European red fox overlap heavily with the Tasmanian devil. If foxes become established they will replace most of the medium and large carnivores. This presents an enormous risk to the species' recovery as foxes could prevent devils' populations from becoming re-established.
- **Collision with vehicles:** Most of the core habitat for the species has roads and the species has relatively large home ranges and movements. The species use roads for long distance travel and as a source for carcasses, to which they are attracted for food. Most collisions are fatal for the species. Estimations during 2001-2004 revealed approximately 3392 devils killed on roads each year. A previous estimate for 1998 was 5000 individuals per year. In local areas where roadkill has been measured, the impact on the species has been high (for example a 50% increase in sightings of roadkill when the existing Arthur River Road was sealed). Collision with vehicles is generally considered a low level threat to the species across the state. However, in locations where the species numbers are already reduced, a loss of individuals due to collisions with vehicles could contribute to a population decline.
- **Habitat loss, degradation and fragmentation:** Since European settlement suitable habitat has been lost through clearing for agriculture, forest plantations, extractive industries and residential development, especially in the east of the state.

[28] M. Jones *pers. com.* (cites in NBES 2011)

- **Illegal culling and dog attacks:** Current illegal culling is considered to be less than in the past but can still be locally intense. Many devils are killed each year by poorly controlled dogs and this could contribute to a population decline in locations where the species numbers are already reduced (Nick Mooney pers. com.).
- **Climate change:** Climate change might occur faster than the rate of adaption by species.
- **Ecosystem changes due to low species numbers:** Removal of a top-order predator can have significant direct and indirect effects on an ecosystem.

The impacts of the proposed action are discussed in Section 5. Devils are free to move within the region and the road upgrade will not alter the movement of disease infected devils. No breeding habitat will be lost or modified. This road project will not increase any already existing habitat fragmentation. The nature of this road, size and traffic volumes will have no bearing on fragmentation as it does not present any form of barrier to animal movements. No effect on feral species such as foxes will occur. Illegal culling or dog attacks are not going to be affected. A roadkill monitoring program has been undertaken as discussed below.

Survey

A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River/Sumac Road junction where traffic volumes are highest (Segments A-J). The methodology is detailed in section 4.9.3 and further discussed in Section 6.6. This investigation included headlight surveys to attempt to inform hot spots of activity.

Figure 4.14 depicts the observation records (including live sightings and roadkill) of Tasmanian devil from the study area.

The results of this investigation and other data demonstrate that the Tasmanian devil occurs widely throughout the study area, with greatest concentrations along the western seaboard from Arthur River to Couta Rocks (Segments A & B) where the habitat in this area is considered to be more be more suitable. Other segments with the most evidence of activity included D, E & G (Section 6.6).

Hot spots of activity and roadkill were identified within these segments. Analysis of headlight surveys, roadkill data and devil sightings suggests that there is a close correlation between roadkill of all vertebrate animals combined and roadkill of Tasmanian devils. This is logical as devils will concentrate activities where there is a ready supply of animal carcases. It was also evident that roadkill rates increased with increases in vehicle speed. By extrapolation it was shown that that increases in roadkill resulting from increases in traffic volume and speed could lead to increases in roadkill rates, including Tasmanian devils. More importantly, these results were able to inform a predictive model for identifying sections of road with a high risk of roadkill.

In March 2012 a vertebrate carnivore scat survey of the entire route was undertaken by bicycle. This method ensured a high level of inspection, being more efficient than a foot survey and more effective than a vehicle survey. This work identified hot spots of devil activity which again is useful in identifying sections of road with a high risk of roadkill. This was particularly informative for the eastern half of the road where the absence of traffic precluded the value in roadkill and headlight surveys of this section.

4.11.4 Orange-bellied Parrot (*Neophema chrysogaster*)

Abundance

Recent population estimates of orange-bellied parrot in southwest Tasmania (Melaleuca) for the period 1994 – 2004 indicate an average minimum population of 92 individuals (range 71 – 116). Other recent surveys have not found large congregations of breeding birds such as those at Melaleuca. It is therefore unlikely that the adult population exceeds 150 individuals (DPIW 2006).

Distribution, ecology and habitat preference

Orange-bellied parrot are endemic to south east Australia including Tasmania. In Tasmania the species range extends along the west and south coast and east to Bruny Island. The species breeding range encompasses a narrow coastal strip of south west Tasmania between Louisa Bay on the south coast and Birches Inlet in Macquarie Harbour. Most of the breeding activity occurs (in what is considered as one breeding population) within 20 km of Melaleuca (DPIW 2006).

The species occurs in diverse habitats within 10 km of the coast, including eucalypt forest (within the breeding range) salt marshes, coastal dunes, pastures, shrublands, estuaries, islands, beaches and moorlands. Breeding habitat within the Tasmanian Wilderness World Heritage Area includes a mosaic of eucalypt forest, rainforest and extensive fire dependent moorland and sedgeland plains, intersected by wooded creeks, rivers and estuaries. Nesting is focused within 20 km of Melaleuca and 5 km of Birches Inlet, mainly in the hollows of live *Eucalyptus nitida.* The breeding population of the species is entirely contained within the Tasmanian World Heritage Area (in particular the Southwest National Park) and Southwest Conservation Area (DPIW 2006).

Observation records from the vicinity of the study area are shown in Figure 4.18.

Known threats

The threats to orange-bellied parrot include the following (DPIW 2006):

- **Biology and ecology relevant to threatening processes:** Orange-bellied parrot survives as a small single population. Stochastic factors have the potential to reduce the species long term survival
- **Degradation and loss of habitat:** The majority of this impact has occurred within the non-breeding range (migratory corridors and wintering areas) and includes drainage of wetlands for grazing, alteration and destruction of saltmarsh for industrial and urban development, grazing of native vegetation, vegetation clearance for agriculture, changes to land use regimes, inappropriate fire regimes and recreational activities
- **Invasive weeds:** Specifically, in foraging habitats throughout the species' non-breeding range
- **Introduced predators and competitors:** Mainly anecdotal observations at some locations concerning predation by European fox and feral cat. In breeding grounds, common starlings, honey bee, and sugar glider compete for nest hollows and kill incubating females at nest (impact is not yet quantified)
- **Wind energy developments:** Particularly throughout the migratory and winter range of the species
- **Disease within captive colonies**
- **Illuminated boats and structures:** Lit strictures such as lighthouses and ships pose a threat to migrating birds
- **Illegal trapping** (some potential)

- **Inadequate knowledge of population trends:** Estimating the total size of the species is extremely difficult due to the wide distribution and dispersal of the species
- **Areas under threat:** An unknown proportion of the breeding population may be subject to development pressures (recreational activities and mineral exploration) within the Cape Sorell to Low Rocky Point region. Habitats and migratory corridors throughout the non-breeding range are under land use and development pressures.

No breeding habitat will be lost or modified. No stochastic events affecting the species are anticipated. No habitat alteration in the migratory corridor is anticipated. No invasive weeds will be introduced into non-breeding foraging habitat. No predators or competitors will be introduced. The project will have no bearing on wind energy projects. Captive colonies will not be affected. There will be no lighting affecting migration. No developments in breeding or on breeding territory are anticipated to result from this project.

No known diseases will be introduced. Summer foraging habitat (buttongrass moorland) is maintained by fire and is subject to management burns. Likewise, habitat is managed by fire in the Arthur-Pieman area. Wildfire could take place in summer but this would be outside the likely period when migrating birds would be passing.

Survey

This species migrates along the west coast of Tasmania to its breeding areas in south western Tasmania. Buttongrass moorland habitat within the study area may be occasionally used for foraging by migrating birds.

There are no observation records from the vicinity of the study area. Potential habitat occurs in buttongrass along the coast near but not immediately adjoining segments B and C. Buttongrass further to the east is outside the coastal migration route.

During the construction phase of the Tarkine Forest Drive no clearance of buttongrass moorland will occur within 10 km of the coast (see Table 4.5). As a result, it is unlikely that any impact on orange-bellied parrots will occur during the construction phase.

There is no conceivable means by which the project could have a significant impact on orange-bellied parrots during the operational phase of the project.

4.11.5 Swift Parrot (*Lathamus discolor*)

Abundance

Historical breeding survey data estimates the total population of swift parrot at no more than 1000 breeding which may be continuing to decline because of continued habitat loss (DPIWE 2001).

Distribution, ecology and habitat preference

Swift parrot breed in Tasmania and migrate to the mainland of Australia in autumn. In Tasmania, the breeding range of the species is largely restricted to the south east coast within the range of *Eucalyptus globulus* where the species occupies an area of less than 500 km^2. In addition, there is a smaller breeding population in the north of the state between Launceston and Smithton (DPIWE 2001).

During the breeding season swift parrot occur mainly in grassy *Eucalyptus globulus* forest in the east of the state where they feed on the nectar from the flowers of these eucalypts. Shrubby *Eucalyptus ovata* forest is an important food source early in the breeding season and in the years when *Eucalyptus globulus* flowering is poor (DPIWE 2001).

Swift parrot nest in hollows of old growth eucalypt species and prefer *Eucalyptus obliqua, Eucalyptus pulchella* and *Eucalyptus globulus* with a diameter at breast height over bark greater than 0.8 metres. In the south east of the state all of the recorded nest sites are located within 8 km of the coast, away from foraging areas, and often occur in shrubby dry *Eucalyptus obliqua* forest, grassy/shrubby dry *Eucalyptus pulchella* or grassy dry *Eucalyptus globulus* on upper slopes and ridge tops. There are known nesting areas in the north of the state in shrubby dry *Eucalyptus obliqua* forest of the Gog Range and Badgers Hills (DPIWE 2001).
Post breeding habitat is mainly in the wetter forests of the west and northwest of the state where summer and autumn flowering eucalypts are abundant including (DPIWE 2001):

- *Eucalyptus obliqua*
- *Eucalyptus delegatensis*
- *Eucalyptus viminalis*
- *Eucalyptus dalrympleana*
- *Eucalyptus pauciflora.*

There are some areas of wet *Eucalyptus obliqua* forest within the study area.

Observation records from the vicinity are shown in Figure 4.19.

Known threats

In summary, the threats to the swift parrot include the following (DPIWE 2001):

- **Habitat loss:** *Eucalyptus globulus* forest within the species' restricted breeding distribution continues to be lost and fragmented due to agriculture, development of plantations and urban and coastal subdivision. Forestry and firewood collection have altered the age structure of forests across the species range resulting in the loss of older trees which provide food sources and hollows for nesting
- **Adult mortality:** Collisions with chain-link fences, windows and cars contribute to a significant cause of mortality during the breeding season. Most of the collisions occur in the urban areas before young are fledged and adults are highly mobile in search for flowering eucalypts. This problem is exacerbated in years of poor Eucalyptus globulus flowering.

No breeding habitat will be lost or modified. The project present no risk of impacting on bird mortality during the breeding season as the study area is outside the breeding range and does not support habitat for the breeding population.

No known diseases will be introduced. Wildfire will not affect breeding habitat as it is not present.

Survey

This migratory species is occasionally recorded on the west coast and is regularly recorded in the northwest (e.g. Smithton) during the breeding season and post breeding foraging on flowers of planted *Eucalyptus globulus*.

The combined potential area of impact on these eucalypt communities due to the project construction works is 3.06 ha (Table 4.5).

There are no observation records from the vicinity of the study area and no core foraging or breeding habitat within any of the segments.

4.11.6 Tasmanian Azure Kingfisher (*Ceyx azureus diemenensis*)

Abundance

The Tasmanian population is an endemic subspecies and is currently only known from the western half of the island in moderate to high rainfall areas. Although the population size of the Tasmanian azure kingfisher is not conclusively known, the population is assumed to be very small and probably does not exceed 1000 mature individuals (Azure Kingfisher listing statement). Other estimates suggest no more than 250 mature individuals although this estimate has a low reliability factor (TSSC 2010a).

Distribution, ecology and habitat preference

The Tasmanian azure kingfisher is endemic to Tasmania and occurs along several river systems in the west, south and northwest coast with the potential to occur in isolated sites in the centre and the northeast. The subspecies has been historically recorded from locations throughout the state although it is not considered common in the east and north. The extent of occurrence has been reported as 2000 km^2 (with a medium reliability factor) and an area of occupancy of 500 km^2 (with a low reliability factor) (TSSC 2010a).

The species' stronghold is the western and far north-western river systems (e.g. Arthur, Pieman, Henty, Gordon, Montagu, Duck, Emu, Cam, Blythe, Leven, Mersey, etc.) but it also may occur in some other river systems with sightings from the south-east (e.g. Lune, D'Entrecasteaux, Cockle Creek, Huon, Derwent, Jordan, etc.), east (e.g. Maria Island), northeast (e.g. Derby, Ansons River, Bridport, etc.) and the central regions (e.g. Lake River, highland lakes, Maydena). The species has been reported from both Flinders and King Islands but whether it is a breeding resident is not known (FPA 2011).

Resident birds are typically associated with heavily vegetated riparian areas along major rivers, favouring sites with overhanging trees touching or close to the water level (NBES 2011).

The subspecies feeds on small fish, freshwater crayfish, aquatic insects and occasionally amphibians and catches prey by shallow plunging from perches 1-10 m high that overhang rivers and streams. Nests are made in burrows excavated into stream banks with an entrance near the top of the stream bank, with a tunnel extending 20-40 cm to a widened nest chamber. The fledging period is approximately 4-5 weeks. The subspecies generation length is unknown but is estimated to be 3 years (TSSC 2010a).

Habitat intersecting with the Tarkine Drive occurs in the vicinity of Segments E, G and K at major river crossings. Observation records are shown in Figure 4.17.

Known threats

The threats to the subspecies include the following (TSSC 2010a):

- **Habitat clearing including forestry activities:** Habitat clearing along stream banks and logging which could affect stream health may have contributed to a decline in the subspecies including some localised extinctions
- **Acid mine drainage from tailings dams:** Acidic runoff from tailings dams may adversely affect local populations. The worst affected river systems within the range of the subspecies are not inhabited, suggesting that acid mine drainage may make some sections of river systems unsuitable for the species

- **Fluctuating water levels caused by dams and weirs:** Fluctuating levels have the potential to flood nest tunnels
- **Bridge construction:** Disturbance events such as clearing and grading for bridge construction works
- **Flooding of nesting burrows from boat wash**
- **Competition with brown trout (*Salmo trutta*):** Identified as the most likely reason for the decline in range of the subspecies. Brown trout reduce the availability of galaxiids and other small fish which are presumed to be the bird's natural prey.)
- **Loss of habitat due to the inappropriate removal of willows** (anecdotal evidence)
- **Illegal removal of whitebait by recreational fishers:** Poaching of whitebait from western rivers may be a reason for decline of the bird.

Whether these threats are affecting the species has not been fully confirmed or quantified (TSSC 2010a).

The impacts of the proposed action are discussed in Section 5. No breeding habitat will be lost or modified. The project has no bearing on acid mine drainage, and no effect on water levels. Bridge construction at the crossing of the Rapid River (Segment K) could potentially impact on any breeding through noise disturbance. No direct impact to a nest site is likely, however, as the bridge work is to replace an existing structure. The project has no direct influence on boat activity although a substantial boost in tourism may increase boating activity which could affect boat wash. No changes anticipated to brown trout populations, there is no willow in the vicinity, and no impact on whitebaiting is expected.

No known diseases will be introduced. Wildfire is unlikely to affect breeding habitat as riparian vegetation is not readily susceptible to burns.

Survey

The Arthur River is well documented as supporting the Tasmanian azure kingfisher along its lower reaches (covered by regular sightseeing river boats) (Wapstra et al. (unpublished) cited in NBES 2011). The Tasmanian Bird Atlas 1979 (cited in Wapstra et al. (unpublished) as cited NBES 2011) identifies a record of the azure kingfisher further up the catchment of the Arthur River near the confluence with the Lyons River. The bridge crossing over the Rapid River may contain potential nesting habitat (in the river banks) in the immediate vicinity of this site (NBES 2011). See Figure 4.17 for known records and creek habitat. The Frankland River bridge is already in place and so no works, or disturbance to habitat, is anticipated in the vicinity.

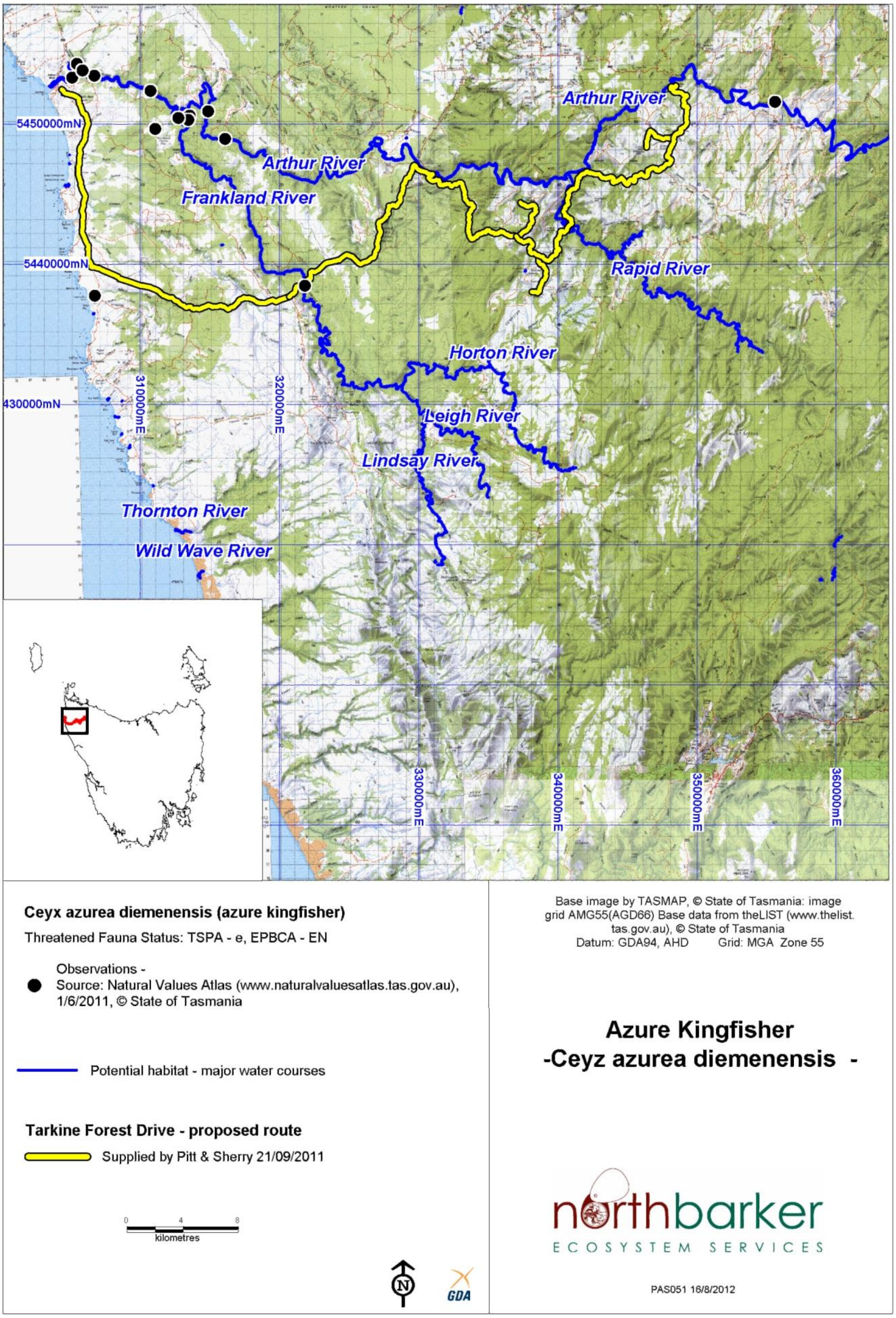

Figure 4.17 – Azure Kingfisher records and known creek habitat

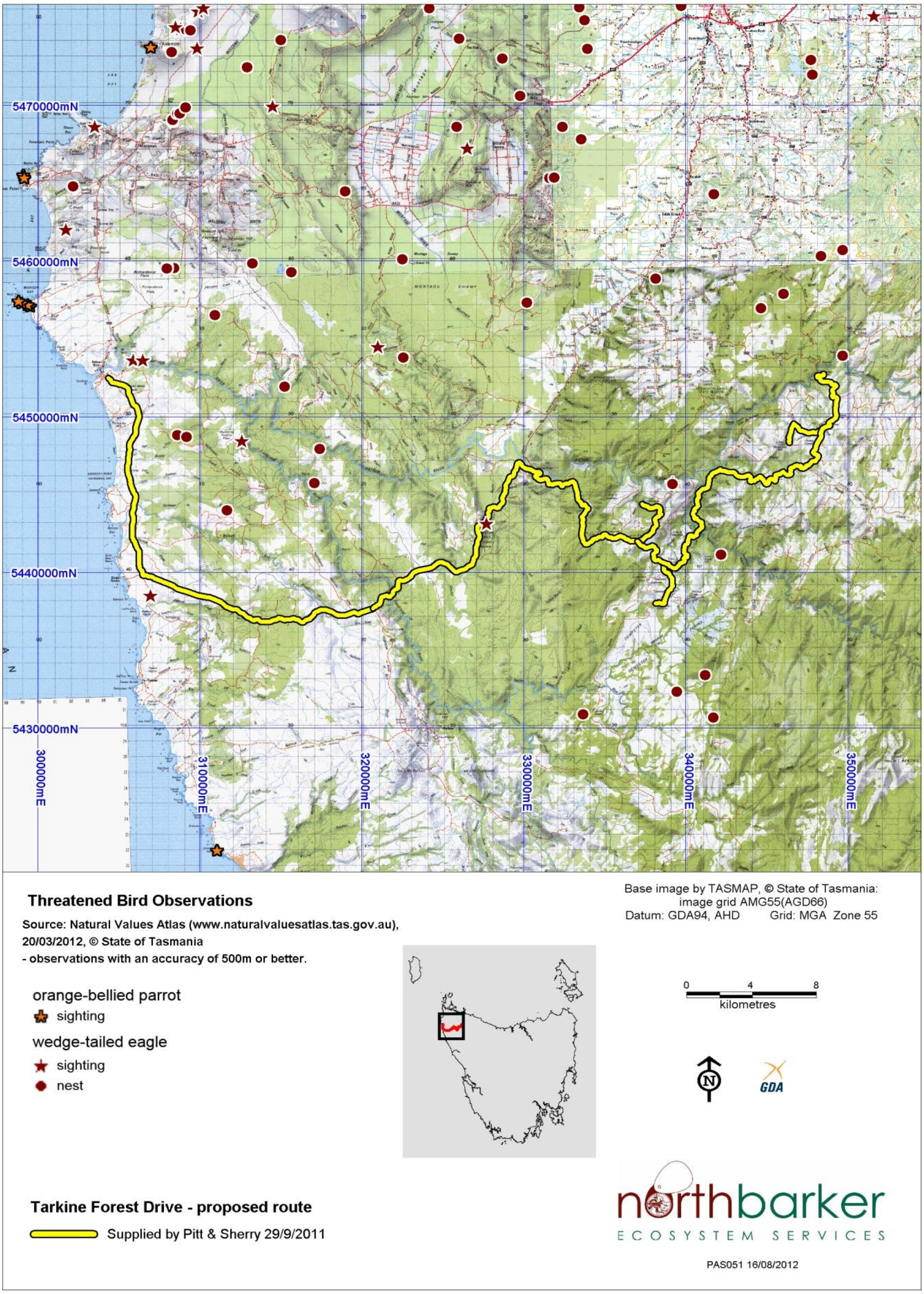

Figure 4.18 – Orange bellied parrot and Wedge-tailed eagle records

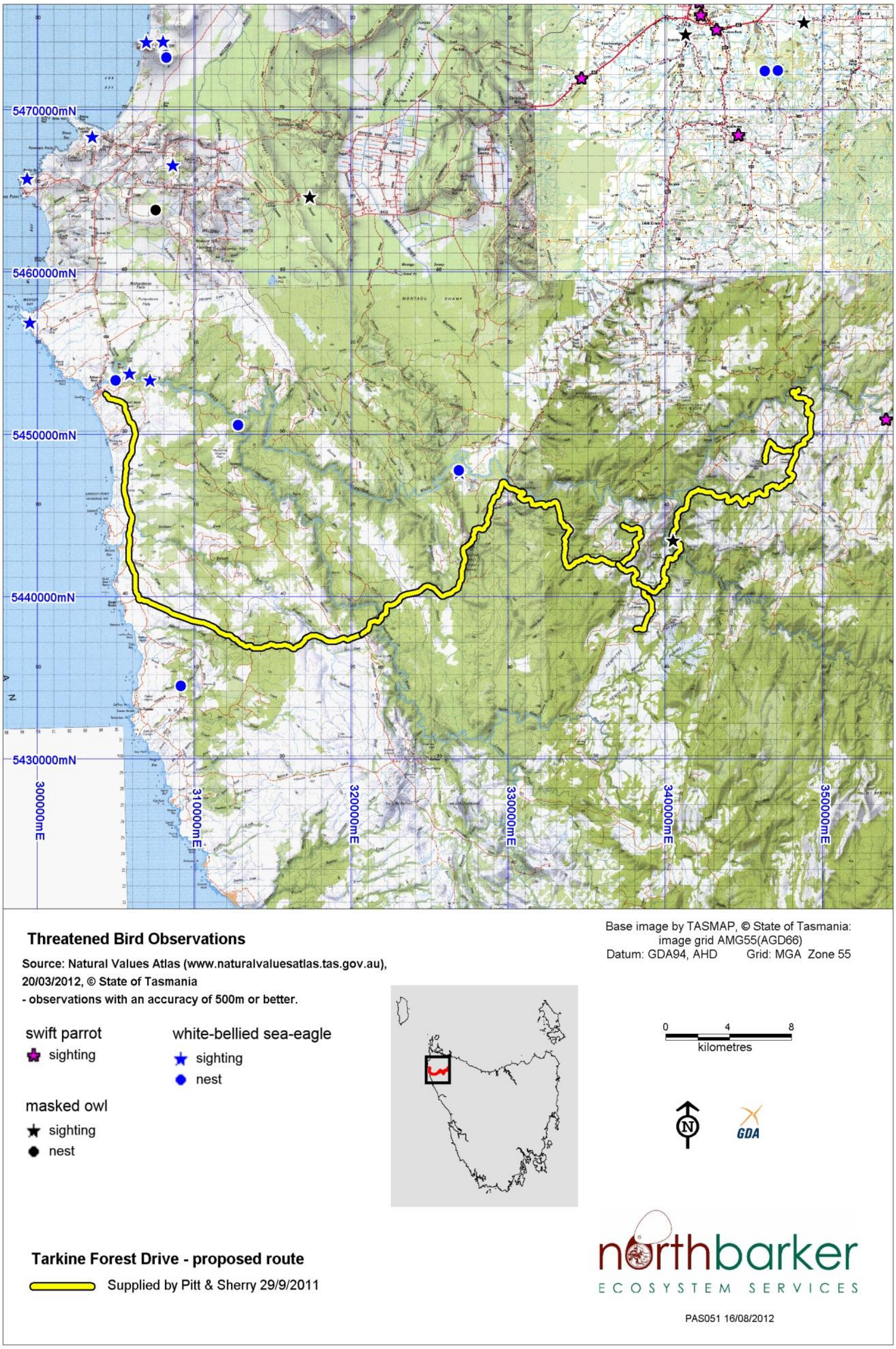

Figure 4.19 – Swift parrot, Masked owl and White-bellied sea-eagle records

4.11.7 Tasmanian Masked Owl (*Tyto novaehollandiae* subsp. *castanops*)

Abundance

A number of population estimates of Tasmanian masked owl have been made ranging from 520 to 1330 breeding individuals (TSSC 2010b).

Distribution, ecology and habitat preference

The Tasmanian masked owl is endemic to Tasmania, including several near shore islands. The densities of the sub-species vary across the state, with the highest densities occurring in the east and north and the lowest densities at elevations more than 600 m in the western half of the state (this could be due to the lack of survey effort) (TSSC 2010b).

The nocturnal species inhabits a diverse range of forests and woodlands, including agricultural and forest mosaics. Particularly favoured are forests with relatively open under stories, especially when this habitat adjoins areas of open or cleared land. Nesting of the sub species occurs in large tree hollows of living or dead trees but sometimes in vertical spouts or limbs (TSSC 2010b).

The sub species is sometimes seen on the edge of roads where it may utilise the open spaces to prey on animals (for example bandicoots and rabbits) grazing on roadside regrowth grasses (S Plowright 2012, pers. comm., 9 May).

Observation records are shown in Figure 4.19.

Known threats

In summary, the threats to Tasmanian masked owl include the following (TSSC 2010b):

- **Habitat clearing and fragmentation, including forestry activities:** Conversion of native forest to monoculture plantation or agriculture has resulted in the loss of nesting habitat and foraging habitat
- **Rural tree decline:** Tree loss from dieback is causing a continuing loss of nesting habitat
- **Secondary poisoning:** From consumption of flesh from another animal that has ingested a poison, for example 1080
- **Collision mortality:** For example power lines and vehicles
- **Competition for tree hollows:** Loss of nesting habitat results in increasing competition for large tree hollows.

The impacts of the proposed action are discussed in Section 5. No habitat will be cleared. The project has no bearing on rural tree decline, poisoning, or competition with other species for tree hollows. The risk of collision is unlikely to be affected by this project as no structures likely to present any risk of collision will be constructed. Increases in night time traffic volumes or speed may increase the very marginal risk of roadkill.

No known diseases will be introduced. Wildfire may affect breeding habitat - mature trees in forest and woodland.

Survey

There is one observation record of the species along Rapid River Road (Segment E). There are no segments where preferred habitat is present.

The wet vegetation types through which the Tarkine Forest Drive traverses are suboptimal habitat, although there are large trees with hollows occurring across much of the study area (NBES 2011).

A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River/Sumac Road junction where traffic volumes are highest (Segments A-J)[29]. No Tasmanian masked owls were recorded during these surveys (S Plowright 2012, pers. comm., 9 May).

4.11.8 Wedge-tailed Eagle (*Aquila audax* subsp. *fleayi*)

Abundance

The total population of Tasmanian wedge-tailed eagles is estimated at less than 1000 individuals. This includes an adult population which is estimated at less than 440 individuals. The population is likely to be decreasing in size (SPRAT Profile 2012d).

The breeding success has decreased to a point where it is now considered that fewer than 100 pairs are successful at breeding each year (B. Brown pers. com. cited in NBES 2011).

Distribution, ecology and habitat preference

Tasmanian wedge-tailed eagles are endemic to Tasmania and nearby islands. The subspecies is widespread on the mainland of Tasmania where it is known from coastal and inland regions, including the Central Highlands. It also occurs on the larger offshore islands. Breeding of the subspecies occurs throughout most of this range. Distribution is naturally fragmented because of the large home ranges and territories that are very widely dispersed (SPRAT Profile 2012d).

The subspecies mainly inhabits coastal, lowland and highland regions and has been recorded in a wide variety of habitats including dry sclerophyll forest, temperate rainforest, sub-alpine forest, dry woodland coastal heathland, small wetlands, riparian vegetation, sedgeland, grassland and farmland. Breeding is restricted to old growth dominated eucalypt species (SPRAT Profile 2012d).

Wedge-tailed eagles nest in a range of old growth native forests and are dependent on forest for nesting. They nest almost exclusively in mature eucalypts capable of supporting their nests, which can develop after many years of use into massive structures over 2 m in diameter. They choose old growth trees in relatively sheltered sites for locating their nests. Territories can contain multiple nests and up to five alternate nests have been located. Nests within a territory are usually close to each other but may be up to 1 km apart where habitat is locally restricted (NBES 2011).

Wedge-tailed eagles prey and scavenge on a wide variety of fauna including fish, reptiles, birds and mammals. The species forages in open areas and has been recorded hunting over most types of terrestrial habitat in the state (SPRAT Profile 2012d).

Observation records are shown in Figure 4.18.

Known threats

The threats to wedge-tailed eagles include the following (Threatened Species Section 2006b):

- Loss of habitat (specifically nesting habitat)
- Nest disturbance

[29] This was undertaken by Wildspot Consulting (Sept 2009-2010)

- Unnatural mortality (persecution including shooting, poisoning and trapping; collision with power lines, vehicles, fences and wind turbines)
- Electrocution
- Decline in mean age of the population
- Decline in recruitment.

The impacts of the proposed action are discussed in Section 5. No habitat will be lost or modified. No nest disturbance is anticipated. Roadkill hazard is low for a road with the traffic volumes. However, any increase in daytime traffic volume or speed will increase this risk proportionately. The project has no bearing on electrocution hazards or population age.

No known diseases will be introduced. Wildfire may affect breeding habitat - mature trees in forest and woodland.

Survey

Two nests that were known from locations close to the existing Blackwater and Sumac Roads have long since disappeared (B. Brown pers. com. cited in NBES 2011). There are several other known nests within the vicinity of the study area that indicate there are other territories present (NBES 2011).

An aerial survey of select sites undertaken by Forestry Tasmania in autumn 2009 failed to locate any new nests. This assessment used PI Inventory mapping to identify tall forest classes within 500 m of the road.

Consultation with DPIPWE (B. Brown from the Threatened Species Section) and vegetation mapping (50 m wide corridor) carried out during ground surveys along the Tarkine Forest Drive have identified additional areas of potential nesting habitat in tall eucalypt forest (see Figure 4.20). Further survey was undertaken in 2010 to inspect these additional areas. No evidence of nests was located during this survey (NBES 2011).

The entire study area would be utilised for foraging habitat as it overlaps potential territories. This is especially applicable to scavenging for roadkill along the Tarkine Forest Drive.

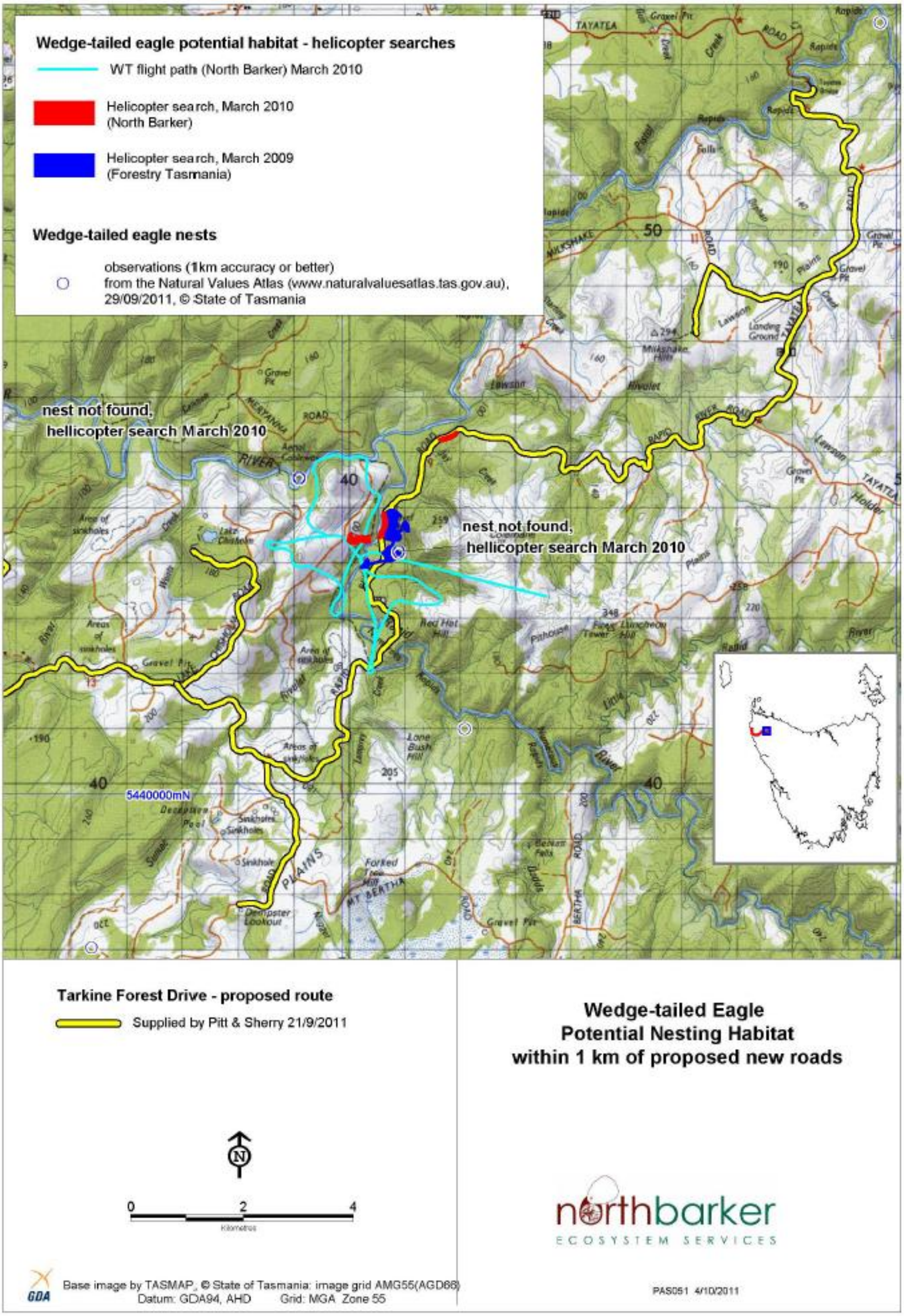

Figure 4.20 - Wedge-tailed eagle potential nesting habitat within 1 km of the study area (Source: NBES 2011)

4.11.9 White-bellied Sea Eagle (*Haliaeetus leucogaster*)

Abundance

The total population of the white-bellied sea eagle in Tasmania is estimated to be less than 1000 individuals (Threatened Species Section 2006b).

Distribution, ecology and habitat preference

The white-bellied sea eagle is distributed around the coastline of mainland Australia and Tasmania. More than 80% of the total white-bellied sea eagle population is found in south-eastern Australia (SPRAT Profile 2012g). The species is found in coastal habitats, particularly those close to the coast. Although it is recorded mostly in coastal lowlands, it can occur up to 800 m above sea level in Tasmania. The species generally breeds within 5 km of open water and prime nesting habitat is found along estuaries (Threatened Species Section 2006b).

The species nest in large sheltered trees, usually eucalypts, generally within 5 km of open water. They are sensitive to disturbance during the breeding season, which occurs between August and January. They perch in a prominent place to hunt fish, eels or birds from the water, or small vertebrates or carrion on land. Their nesting requirements are similar to that of wedge-tailed eagle, although white-bellied sea eagles appear to be less susceptible than wedge-tailed eagles to disturbance that may cause abandonment of the nest during breeding (Threatened Species Section 2006b).

Observation records are shown in Figure 4.19.

Known threats

The threats to white-bellied sea eagle are similar to those to the wedge-tailed eagle, and include the following (Threatened Species Section 2006b):

- Loss of habitat (specifically nesting habitat)
- Nest disturbance
- Unnatural mortality (persecution including shooting, poisoning and trapping, collision with power lines, vehicles, fences and wind turbines)
- Electrocution
- Decline in mean age of the population
- Decline in recruitment.

An additional threat to the sea eagle arises from recreational use of the coastal zone, from marine pollution and debris, which can cause entanglement.

The impacts of the proposed action are discussed in Section 5. No habitat will be lost or modified. No nest disturbance is anticipated. Roadkill hazard is low for a road with the traffic volumes. However any increase in daytime traffic volume or speed will increase this risk proportionately. The project has no bearing on electrocution hazards, population age or recruitment. No impacts on marine pollution will result from this action.

No known diseases will be introduced. Wildfire may affect breeding habitat - mature trees in forest and woodland.

Survey

There is potential nesting habitat along the coast within the study area and there are known nests along the Arthur river. However, there is no known potential nesting habitat within 1 km of the Tarkine Forest Drive (NBES 2011).

A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River /Sumac Road junction where traffic volumes are highest (Segments A-J)[1]. No white-bellied sea eagles were recorded during these surveys (S Plowright 2012, pers. comm., 9 May).

4.11.10 Green and Gold Frog (*Litoria raniformis*)

Abundance

The green and gold frog is most abundant north between Launceston and Devonport and south to the Longford and Hagley area (NBES 2011). Population estimates are difficult as frog populations fluctuate wildly between seasons. In 2001 the population was estimated to include between 5000 and 10000 adults (Threatened Species Unit 2001).

Distribution, ecology and habitat preference

The green and gold frog is distributed across eastern and northern Tasmania including the north east and north west. There is a break in the distribution to the west of Devonport with no records until Smithton. There is a scattering of records in the far northwest from Smithton to Woolnorth and some older records in 1988 on the west coast at Temma south of the study area (see Figure 4.21). The range of the green and gold frog does not extend to the button grass moorlands of western Tasmania (NBES 2011).

Immature frogs will disperse some distance from breeding waterbodies and can be found in a range of wetlands including ephemeral ponds. However, adult frogs require permanent still or slow flowing water with abundant floating or emergent vegetation for breeding. Breeding habitat includes swamps, dams and lagoons (NBES 2011).

Known threats

The major threats to the species are (SPRAT Profile 2012e):

- Habitat loss and fragmentation
- Habitat degradation
- Altered flood regimes
- Chytrid fungus disease
- Predation by introduced fish
- Drought
- Chemical pollution of water bodies
- Biocides
- Salinisation
- Roadkill
- UV radiation.

The impacts of the proposed action are discussed in Section 5. No known pest species will be introduced. Wildfire will not impact on wetland frog habitats.

[1] This was undertaken by Wildspot Consulting (Sept 2009-2010)

No habitat will be lost or modified. Suboptimal habitat identified in seasonal wetlands close to Temma Road is potentially vulnerable to habitat degradation, altered flood regimes and chytrid fungus. Increases in traffic volumes could increase the risk to frogs that stray onto the road in the vicinity of these wetlands. The project will not affect other threats listed. These risks are entirely theoretical with no evidence of there being any green and gold frogs present in the vicinity of the Tarkine Drive.

Targeted surveys failed to find any presence of green and gold frog in the study area. In addition, it is unlikely that the Tarkine Forest Drive will contribute to the live contact between frogs as the area is already opened up and accessible. It has been postulated that the use of water in maintaining gravel roads may facilitate the spreading of infected water from one location to another (Pauza and Driessen 2008 cited in NBES 2011). The sealing of the gravel segments along the Tarkine Forest Drive will reduce the use of water used in ongoing maintenance of the existing gravel roads.

It is unlikely that the Tarkine Forest Drive will have a significant impact on this species.

Survey

Potential habitat for the green and gold frog within and adjacent to the study area has been identified using existing geological mapping and is depicted in Figure 4.22. All low lying soaks, creeks and pools extending up to 500 m beyond the geological boundary of Mesoproterozoic quartzites and metamorphosed sediments are shown in Figure 4.22. These include some small vegetated pools on the immediate margin of the Temma Road on Segment B which appear potentially suitable as habitat.

All potential habitats were surveyed for green and gold frog between 7 January and 12 March 2010. The suitable habitat was visited on eight occasions. There were six visits during the day when the conditions were considered ideal and twice at night. No green and gold frogs were observed or heard in any of the areas surveyed and there have been no records of this species occurring in the past decade. A series of other potentially suitable sites were identified from aerial images of the area. Sites were chosen for either being near the proposed road development or on the downstream side of the development. Fourteen locations were identified. This included the Rebecca Lagoon which although well south of the development, and out of the disturbance zone, was considered a good example of permanent water which would be most likely contain green and gold frog if they existed in the area. Several visits to the lagoon failed to show any evidence of the species (Wildspot Consulting 2010 – Included in Appendix B pg 160 Appendix 10).

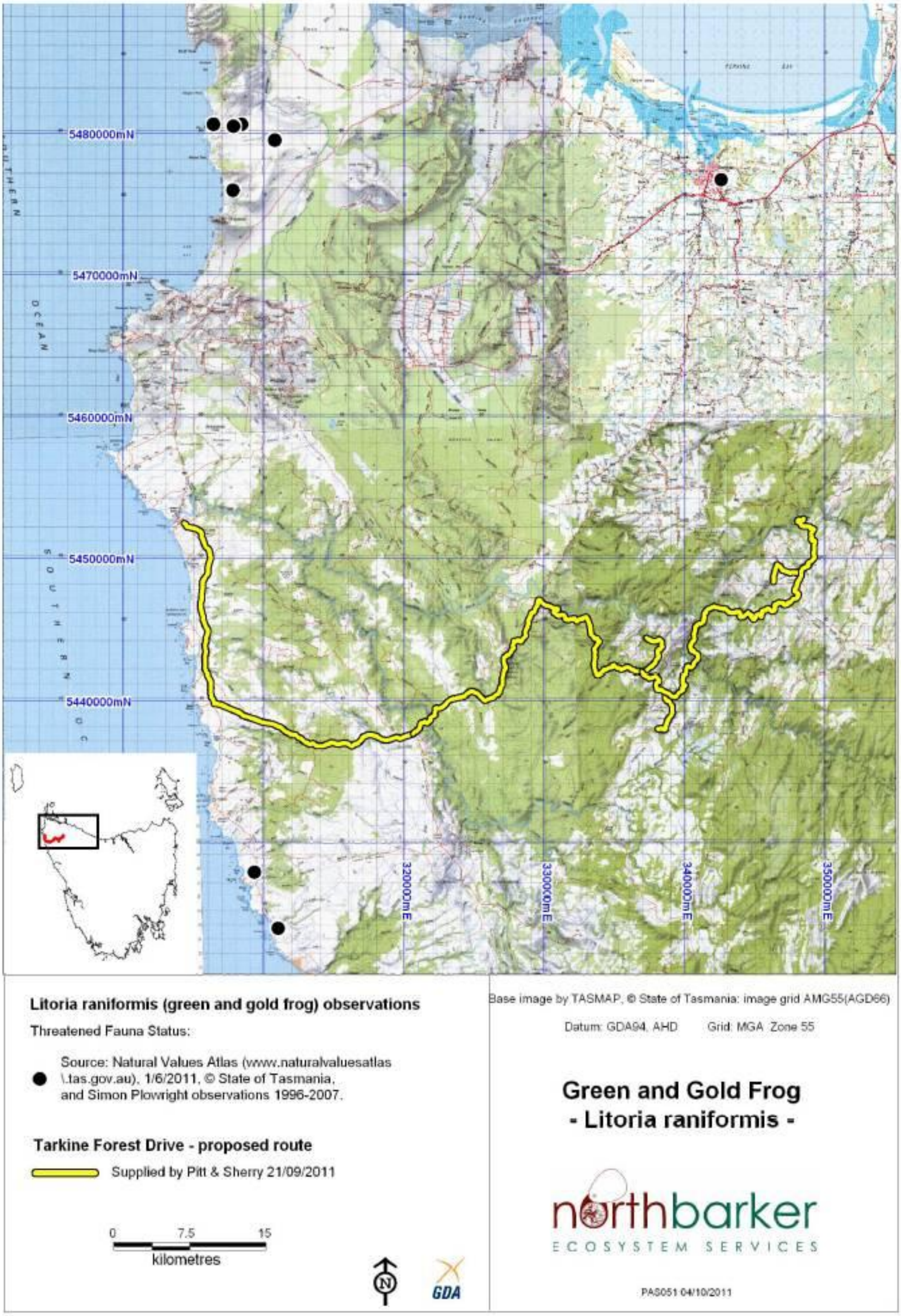

Figure 4.21 - Green and gold frog records from northwest Tasmania (Source: NBES 2011)

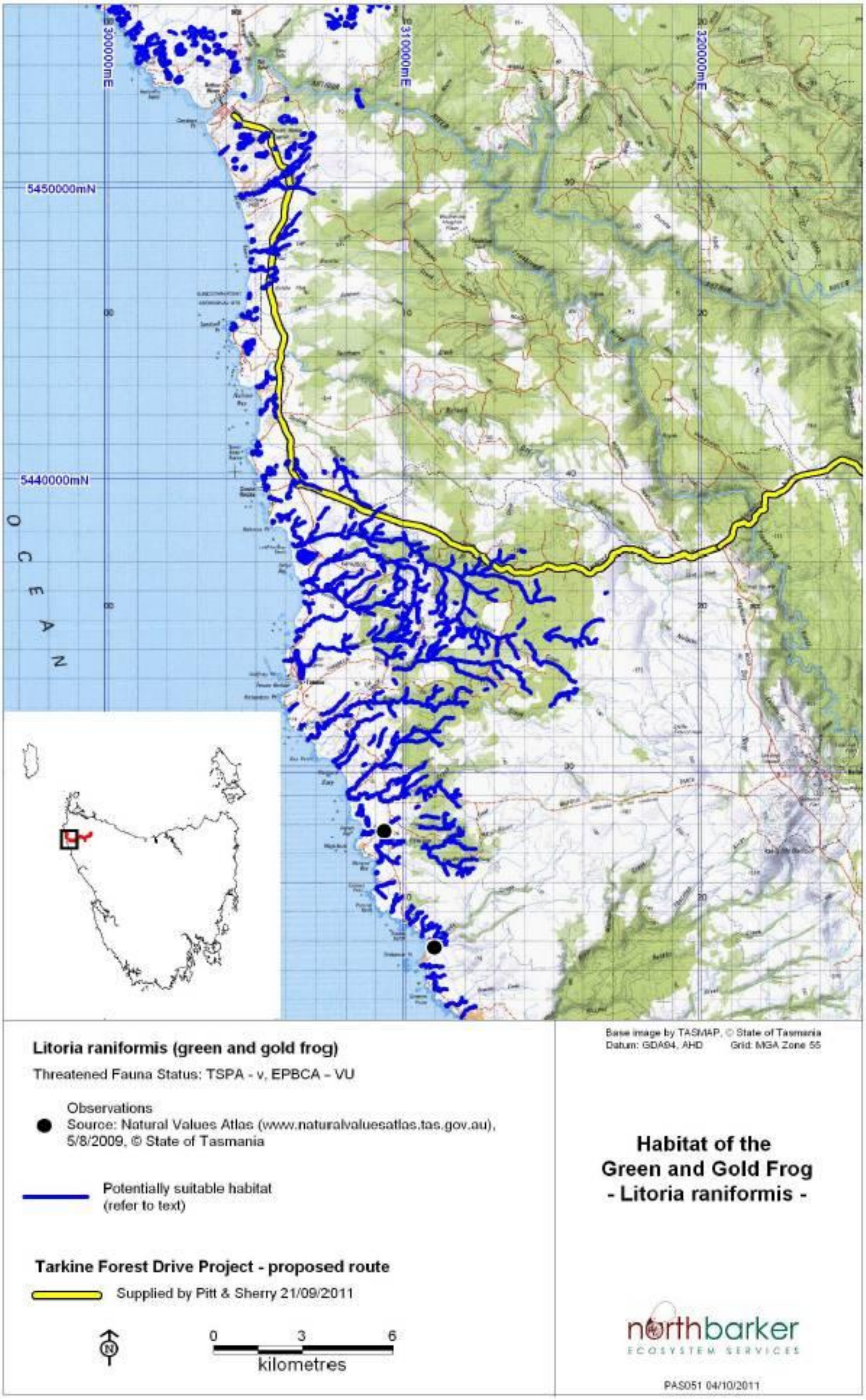

Figure 4.22 - Potential green and gold frog habitat (Source: NBES 2011)

4.11.11 Australian grayling (*Prototroctes maraena*)

Abundance

Australian Grayling were once reported as common to abundant throughout much of their range but in recent decades the species was thought to be extremely rare and perhaps in danger of extinction, especially since the closely related New Zealand Grayling had become extinct. Surveys in Victoria and New South Wales since then indicate that, while the species appears to have declined throughout much of its range, it is still widely but patchily distributed, and can be locally common in some areas (Backhouse et al. 2008).

Distribution, ecology and habitat preference

The Australian Grayling occurs in south-eastern Australia, in coastal rivers and streams in New South Wales, Victoria and Tasmania. In Tasmania, it occurs on King Island in Bass Strait, and around much of the coast but has not been recorded from the south-west, although this is probably due to lack of surveys in the region (Backhouse et al. 2008).

The species inhabits the middle and lower reaches of rivers and streams that open to the sea. It needs to move between rivers and coastal seas to complete its life cycle - barriers block upstream migration, and can interfere with downstream migration, and can cause local extinction in the section of river upstream from the barrier (Backhouse et al. 2008).

Known threats

The major threats to the species are (Backhouse et al. 2008):

- Barriers to upstream movements, including river regulation through weirs and dams
- Reduction in stream water quality
- Stream siltation
- Predation, competition and disease from introduced fish species
- Fishing.

The impacts of the proposed action are discussed in section 5. No barriers will be imposed on any river crossings. Potential risks of affecting water quality and siltation are most notable at the Rapid River where a new bridge is proposed for construction. The project has no bearing on introduced fish. Increases in visitation resulting from a boost in tourism into the area may increase fishing in the rivers which could impact on this species.

No known diseases will be introduced.

Survey

The Australian grayling has been recorded near the mouth of the Arthur River. It is also likely to utilise lower and middle reaches of other rivers and creeks which are not obstructed by barriers affecting fish passage (NBES 2011).

Most of the smaller creeks which are crossed by the Tarkine Forest Drive are unsuitable as they are too small and are obstructed by natural barriers. Figure 4.23 shows the major water courses that are potential habitat (NBES 2011).

Habitat for the Australian Grayling potentially occurs in the Frankland River and Rapid River. Nelson Bay River is unsuitable due to a hydraulic barrier 50 m downstream of the Temma Road crossing (see Figure 4.24) (NBES 2011).

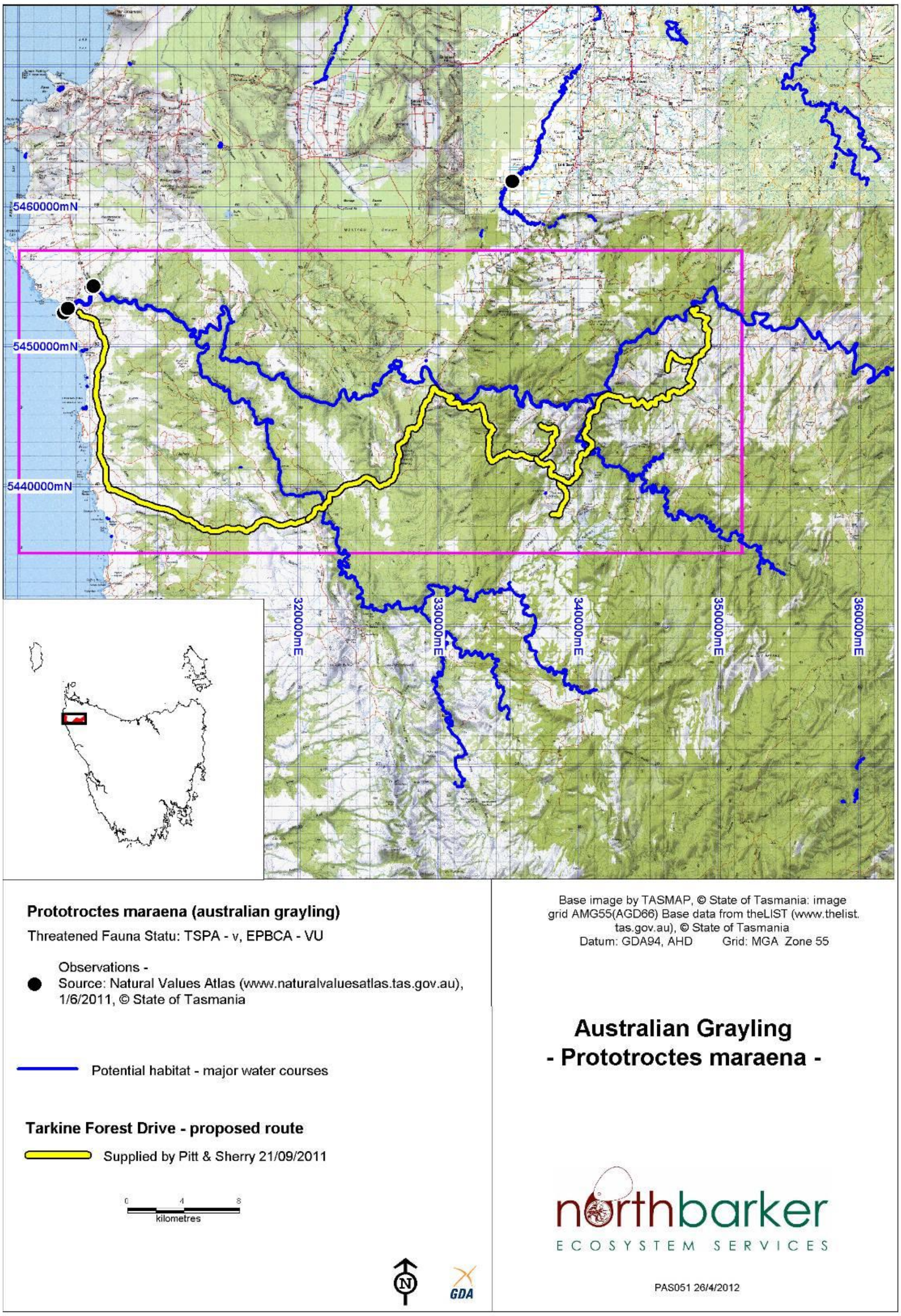

Figure 4.23 - Potential Australian grayling habitat (Source: NBES 2011)

Figure 4.24 - Waterfall which presents a natural barrier to the Australian grayling (note Temma Road Bridge in background) (Source: pitt&sherry)

4.11.12 Giant freshwater crayfish (*Astacopsis gouldi*)

Abundance

No data on population numbers are available (SPRAT 2012f).

Distribution, ecology and habitat preference

The distribution of the giant freshwater crayfish is confined to the Arthur River catchment and northern rivers that flow into Bass Strait, excluding the Tamar catchment (Threatened Species Section 2006c).

Preferred habitat is associated with river systems that have significant sections with vegetated river banks. Slow flowing creeks in the upper catchment with pools and snags are also important habitat. Adults shelter in deep pools beneath submerged logs and overhangs while juveniles tolerate slightly faster flowing creeks but also require submerged logs for shelter (Threatened Species Section 2006a cited in NBES 2011). Individuals can show dispersal behaviour, even leaving the water to walk across land, but tend to return to a home site (NBES 2011).

To maintain healthy populations, giant freshwater crayfish require water bodies with good water quality, a stable thermal regime of relatively low water temperature, snags, pools, undercut banks, and ample canopy cover. Riparian vegetation needs to be predominantly intact and extensive to provide the shading, nutrient, energy and structural inputs required for the species' in-stream habitat (Threatened Species Section 2006c).

Known threats

The two major threats to the species are (Threatened Species Section 2006c):

- The cumulative effects of past and current (illegal) fishing pressure
- Large-scale habitat disturbance for agricultural, urban and forestry land use.

The project will have no impact on illegal fishing as all areas are already accessible to potential poachers.

Habitat disturbance includes the removal or destruction of riparian vegetation, bank erosion, desnagging, channelisation, siltation, nutrification, toxic chemical inputs, in-stream barriers to lobster movement such as culverts and farm dams, and alterations to stream flow and thermal regime (Threatened Species Section 2006c).

The impacts of the proposed action are discussed in Section 5. No significant habitat disturbance is anticipated.

Stream barriers such as large weirs, dams and poor culvert design can lead to isolation and fragmentation. Concrete structures such as raised road culverts may act as a barrier to the giant freshwater crayfish (Bryant and Jackson 1999 cited in NBES 2011). However, this is likely to be dependent on culvert design and its impact on water flow (NBES 2011).

Some culverts may be replaced as part of the proposed works. Where practicable, crayfish passage will be catered for in the alignment and depth of new culverts. The designs to the new bridge structures at Nelson Bay River and Rapid River will ensure that they create no impedance to crayfish passage.

Survey

The Frankland and Rapid Rivers have been identified as providing good quality habitat with strong giant freshwater crayfish that are worthy of conservation (Walsh 2003, cited in Threatened Species Section 2006c). These rivers are both crossed by the Tarkine Forest Drive (see Figure 4.25).

There are observation records from several other creeks crossed by the Tarkine Forest Drive. In addition many other creeks provide potentially suitable habitat (NBES 2011). Habitat is present in the vicinity of Segments E-N.

Assessment has been made of the suitability for crayfish passage of all creeks and rivers considered suitable as habitat for giant freshwater crayfish. Larger rivers and creeks are crossed by bridges and large box culverts. Both these structures present no impediment to crayfish passage. Some of the smaller creeks include a range of culvert types. Many are single or dual pipe culverts varying in diameter from 1-2 m. Most would be accessible to crayfish passage. However, some are hanging culverts where the pipe outlet is above the creek bed. In these circumstances, dispersing crayfish would be forced up and onto the road to access the upper catchment (NBES 2011).

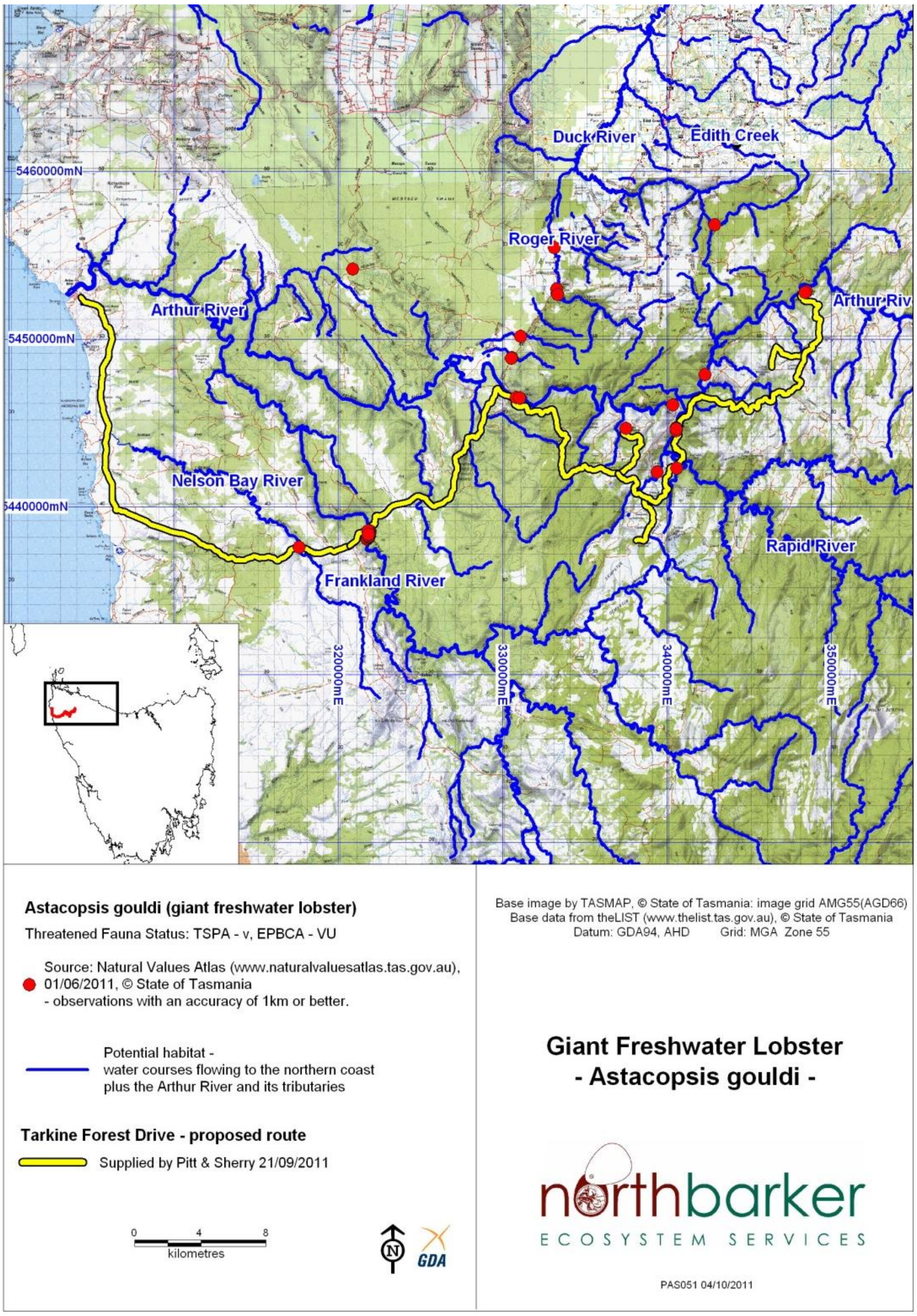

Figure 4.25 - Giant freshwater crayfish records from the study area (Source: NBES 2011)

4.11.13 Marrawah Skipper (*Oreisplanus munionga larana*)

Abundance

There are 14 subpopulations at 11 locations. Population size was estimated to be less than 10000 individuals in 1994 but is considered to be substantially lower (TSSC 2011).

The extent of occurrence is 3710 km^2 with substantial areas of unsuitable habitat. The area of occupancy of all colonies is 2000 ha (TSSC 2011).

Distribution, ecology and habitat preference

This endemic subspecies is confined to northwest Tasmania between Marrawah and Temma with an outlying population at Penguin. It is associated with habitats that include the larval food plant *Carex tasmanica/appressa*, typically in association with sedgeland or swamp forest and scrub dominated by *Melaleuca ericifolia* or *Eucalyptus brookeriana* (Bell and Miller 2005 cited in NBES 2011).

Habitat occurs in the vicinity of Segments A & B. Observation records are shown in Figure 4.26 along with potential habitat based on vegetation types considered likely to support the foodplant.

Known threats

The Conservation Advice (TSSC 2011) considers the main threat to be cattle grazing and clearance of habitat. The following threats are identified in the Listing Advice (TSSC 2011):

- Inappropriate fire regimes
- Cattle grazing and trampling
- Land clearing
- Forestry operations
- Weed invasion
- Slashing of vegetation.

The impacts of the proposed action are discussed in Section 5. The will be no change to cattle grazing practices. Land clearing is limited to the widening of the road verge with minimal impact on habitat. No changes to forestry practises will occur. Weed invasion affecting larval habitat is unlikely to be exacerbated by the project, especially if weed minimisation protocols are followed during construction. Habitat will not be subject to vegetation slashing as it is not located in close proximity to the Tarkine Drive.

There are no known predators or diseases that would be introduced as a result of the project. Changes to wildfire incidences could impact on larval food habitat.

Survey

There are several observation records from suitable habitat close to the coast adjacent to Temma Road (Segment B). Potentially suitable habitat is to be found at several of the creek crossings along this section of road. A targeted survey of potentially suitable habitat was undertaken along this section by DPIPWE in 2008[30]. No observations were made in the immediate vicinity of the road along segments A, B and C which fall within the range of the species. The flora survey of these segments did not identify any plants of *Carex appressa*, indicating that there is no habitat in the immediate vicinity of the Tarkine Forest Drive (NBES 2011).

[30] No report was produced but all records were added to the Natural Values Atlas

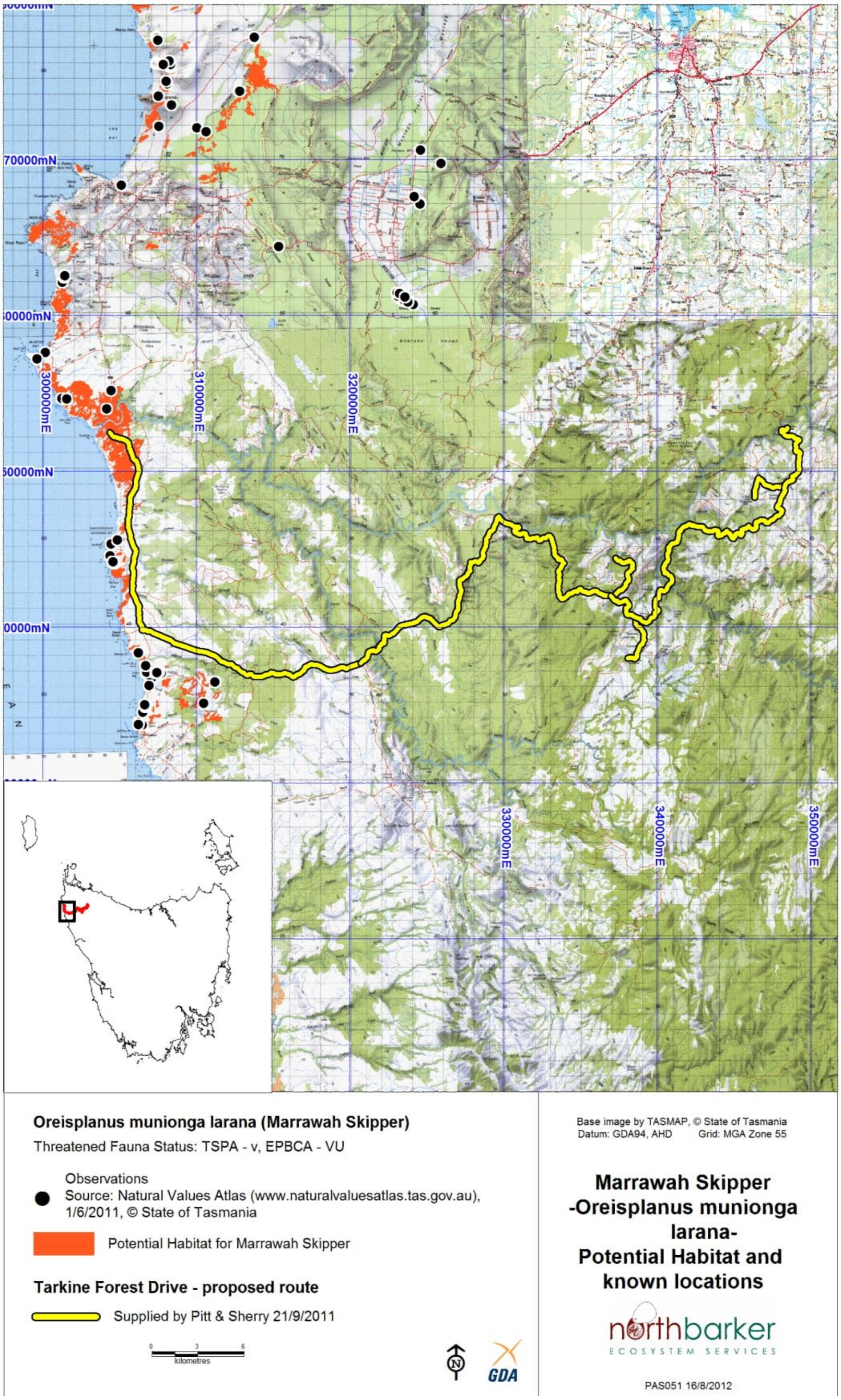

Figure 4.26 - Marrawah skipper records and potential habitat from the study area (Source: NBES 2011)

4.12 Vegetation

The EPBC Act Protected Matters Report identifies Lowland Native Grasslands of Tasmania as being likely to occur in the area. Lowland Native Grasslands of Tasmania are listed as a nationally threatened ecological community under the EPBC Act.

There are localised occurrences of grassland on the coast adjacent to Segments A and B that occur in stable calcareous dunes in the near coastal zone in the Arthur-Pieman area. These include tussock grassland dominated by velvet tussock grass (*Poa rodwayi*) with kangaroo grass (*Themeda triandra*) as a minor element. They extend up to 700 m from the coast with an estimated overall area of less than 20 ha (Harris & Kitchener 2005). Some of these would qualify as Lowland Native Grasslands of Tasmania and have been identified and mapped in the policy statement for this community (Commonwealth of Australia 2009). This vegetation community has not been identified by the survey for the Tarkine Forest Drive.

There are also small localised patches of coastal grass and herbfield (TASVEG mapping unit GHC (Harris & Kitchener 2005)). These do not qualify as Lowland Native Grasslands of Tasmania due to the paucity of kangaroo grass velvet tussock grass and silver tussockgrass (*Poa labillardierei*) (NBES 2011).

The vegetation communities identified by the survey along the Tarkine Forest Drive are identified in Table 4.5. None of these accords to any EPBC listed threatened ecological communities.

Table 4.5 - Vegetation communities identified along the Tarkine Forest Drive

TASVEG Community (Harris and Kitchener 2005)	**Length of Road (km)**	**Applicable Segment along the Tarkine Forest Drive[31]**														**Estimate of Native Vegetation Clearance (hectares)**
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	
Eucalyptus nitida dry forest and woodland (DNI)	8.0	0.17										1.06	0.09			1.31
Eucalyptus obliqua dry forest and woodland (DOB)	2.7											0.13				0.13
Eucalyptus viminalis coastal forest and woodland (DVC)	0.4		0.24													0.24
Eucalyptus brookeriana wet forest (WBR)	1.8															0.00
Eucalyptus nitida forest over *Leptospermum* (WNL)	6.9											0.68	0.06			0.74
Eucalyptus nitida forest over rainforest (WNR)	3.3															0.00
Eucalyptus obliqua forest with broadleaf shrubs (WOB)	4.9				0.08				0.04							0.12
Eucalyptus obliqua forest over *Leptospermum* (WOL)	9.6				0.06							0.66	0.11			0.83
Eucalyptus obliqua forest over rainforest (WOR)	13.4								0.02			0.63				0.66
Eucalyptus obliqua undifferentiated (WOU)	9.0											1.08				1.08
Acacia melanoxylon swamp forest (NAF)	0.3															0.00
Melaleuca ericifolia swamp forest (NME)	0.1															0.00

[31] Also defined in the table is the actual quantum in hectares of vegetation community to be cleared in each segment

5. Relevant potential impacts

The PER must include a description of all of the relevant impacts during the construction and operational phases of the action. The following information must be provided:

- *A detailed assessment of the nature and extent of the likely short-term and long term relevant impacts*
- *A statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible*
- *Analysis of the significance of the relevant impacts*
- *Any technical data and other information used or needed to make a detailed assessment of the relevant impacts.*

Consideration of impacts must not be confined to the immediate areas surrounding the upgraded road corridor but must also consider the potential of the proposed action to impact on areas of the broader Tarkine region and adjoining areas that are likely to contain matters of NES.

Consideration of potential impacts must encompass direct and indirect, facilitated and cumulative impacts.

Indirect impacts are impacts that are not a direct result of the project but to which the proposed action contributes. They may include offsite or downstream impacts such as impacts on downstream hydrology and water quality, spread of pests and diseases or changes in species foraging, breeding and movement patterns.

Facilitated impacts are impacts resulting from the actions of third parties that are facilitated by the proposed action, such as increased road traffic or tourist and recreational activities facilitated through the upgrading of road infrastructure.

Cumulative impacts are impacts of the proposed action in combination with other past, present and reasonably foreseeable future actions (both related and unrelated), such as the increased threat of roadkill and habitat disturbance generated from additional development and activities in the surrounding area.

In relation to direct impacts of the proposed action, the discussion must include (but not be limited to) assessment of:

(a) The direct loss of vegetation and terrestrial habitat from construction activities such as road work, bridge work, development of supporting infrastructure such as car parks, toilets and picnic areas

(b) The changes to aquatic habitat in the vicinity of the road corridor and at water crossings from construction activities, including changes to water quality, hydrology, in-stream habitat and movement corridors for aquatic species

(c) Noise, lighting and other disturbance effects during construction activities, including potential disruption to foraging, breeding and hunting activities.

In relation to indirect or facilitated impacts by the proposed action, the discussion must include (but not be limited to) assessment of:

(a) Potential for the proposed road upgrade to act as vector for the spread of the Devil Facial Tumour Disease (DFTD), including characteristics of local Tasmanian Devil populations, the extent and rate of spread of DFTD, means of DFTD transfer, risks of DFTD spread posed by construction activities and ongoing use of the road route, likely higher risk points along the road route for DFTD incursion and the

basis for calculating risks of DFTD spread. The analysis must investigate the level of certainty in the information provided

a. *Wildlife road mortality threats, including details of expected changes in traffic conditions, areas of likely impact, temporal impacts (daily and seasonal), species most at risk, basis for calculating impacts (including reference to studies on-site and other areas), disruption to wildlife foraging and movement patterns*

b. *Changes in human activity in the area due to use of the upgraded road route including details of projected tourist numbers (and methods for calculating numbers), changes in the types of traffic and road use in the area, likely future developments in the vicinity of the road route, expected impacts on vegetation communities and native species habitats, increased risk of poaching of listed species, increased risk of environmental damage from increased off-road activities*

c. *Risks of the introduction and spread of pathogens such as Phytophthora cinnamomi and Myrtle wilt caused by fungus Chalara australis*

d. *Risks of the introduction and spread of exotic predators and non-native competitors such as the European Fox;*

e. *Risks of the introduction and spread of weed species*

f. *Risks of the increased incidence of fire.*

Direct and *indirect* impacts are associated with the construction phase of the project. *Facilitated* impacts relate to the operational phase of the project once works are completed and the nature of human activity in the area is changed or increased. *Cumulative* impacts consider reasonable foreseeable actions that contribute further to any impacts associated with this project.

The ecological impact of roads on ecosystems has been thoroughly documented to the point of being a specific scientific discipline, often referred to as 'road ecology' (Coffin 2007 cited in NBES 2011).

Roads cause direct impacts across the landscape through the removal of vegetation and the destruction of wildlife by vehicle collision or the creation of barriers to movement. They can also cause indirect change through the impacts of disturbance driving some animals away or conversely through modification to the local environment attracting some species, e.g. roadside grazing habitat or scavenging opportunities resulting in increased levels of mortality.

Roads may form corridors along which wildlife, weeds and disease may be spread. The increased levels of associated human activity created by opening up the landscape to access bring with them a potential range of facilitated impacts.

5.1 Direct impacts

Direct impacts are defined by the footprint of the development resulting from ground works required to provide the necessary infrastructure.

The action being proposed is detailed in Section 2 of this report. The Tarkine Forest Drive project extends along 92.77 km consisting of road works, bridge works, tourism infrastructure works and roadkill mitigation works.

The roadworks are essentially the upgrading of an existing road with most works limited to the existing corridor, however, there are some minor realignments.

Bridge works involves the replacement of two existing bridge structures.

Tourism infrastructure includes the provision of car parks and associated infrastructure including toilet and barbecue facilities.

Roadkill mitigation works involve the provision of constructed features with the specific purpose of reducing the risk of roadkill to native fauna.

In total, the works will require the clearance of 6.92 ha of vegetation.

Direct impact to Matters of NES includes the removal of two plants of an endangered orchid on the edge of a colony.

Potential direct impacts can occur from contractors straying outside the construction corridor to lay up machinery, store materials and locate site offices and other temporary structures. Traffic changes during the construction period can include contractors and works crew driving at above average speeds and during dawn and dusk when the threat of roadkill is greatest.

Potential direct impacts in this project are the possibility of inadvertent damage to the habitat of threatened orchids (three species) and potential increases in rates of roadkill of two listed vertebrate species during the construction period.

5.2 Indirect impacts

The construction activity associated with this project brings with it a range of indirect impacts. With road construction these include the potential for runoff from earthworks, especially in heavy rain. This can lead to sedimentation and pollution affecting adjoining environments, in particular wetlands and rivers.

Earth working machinery can also introduce or spread existing infestations of soil pathogens (notably *Phytophthora cinnamomi*) and weeds.

Impacts to aquatic habitat are dependent on the standards of the construction activities. There will be some localised sedimentation during the construction of the bridges but these can be maintained to acceptable levels with minimal impacts to water quality.

The bridge crossing includes design features (refer section 2.3) to ensure that they minimally affect water flow and so will not restrict fauna passage. They also allow terrestrial fauna to follow the riverbanks, limiting their need to come up onto the road where they would be exposed to the risk of being run over.

The replacement bridge at Rapid River will be a considerable improvement on the current structure in this regard. The two bridge structures have been designed to ensure they have no impact on the movement of aquatic fauna and allow for passage of terrestrial fauna on the riverbanks.

Noise, lighting and vibration associated with construction works may disturb vertebrate fauna in the immediate vicinity, temporarily dislodging animals from shelter sites and potentially dens sites. However, the likelihood of a denning site being impacted in this way is considered remote, as the extent of these disturbances will be short term and not significantly greater than existing heavy vehicle usage of the road.

5.3 Facilitated impacts

Facilitated impacts are associated with the operational phase of the road on completion of the construction activities.

5.3.1 Spread of Devil Facial Tumour Disease (DFTD)

The construction works will not conceivably affect the movement of infected individual animals. However, the project could have implications for the movement of DFTD if the disease were to become established in the area. This would be through roadkill rates increasing to such an extent that they attract increasing numbers of Tasmanian devils from the surrounding area. The rate of socialisation, especially biting which is the means of transmitting DFTD, will then rise. This could accelerate the rate of spread of the disease through the population.

Analysis of the state of DFTD and consideration of any association with facilitated spread resulting from the Tarkine Drive has been considered in detail in section 4.11.3.

5.3.2 Wildlife road mortality threats

A potential facilitated impact on wildlife could occur during the operational phase of the project. Increased traffic may result in a higher incidence of roadkill or injury to individual animals. This is considered the most significant issue associated with the Tarkine Forest Drive project.

Wildlife biologists began publishing research on the effects of roads on wildlife populations in the 1970s (e.g. Coffin 2007). The effects of roads on wildlife can be significant (Forman et al 2002, Hobday and Minstrell 2008, Hobday 2010, Litvaitis & Tash 2008, Magnus 2006, Ramp et al 2005).

Roads can disrupt wildlife populations directly through vehicles hitting animals and indirectly through habitat fragmentation and behavioural changes. Roads can form barriers to movement, which can fragment populations and isolate animals from resources, and they can cause avoidance behaviour by animals which can alter the structure of populations adjacent to roads (Coffin 2007, Forman et al 2002, Hobday and Minstrell 2008, Malo et al 2004, Ramp et al, Taylor & Goldingay 2010).

The impact of habitat fragmentation is determined by the characteristics and behaviour of wildlife species, the physical qualities of the road, road traffic volumes and the spatial configuration of the road relative to adjacent landscapes (Coffin 2007, Forman et al 2002).

Many researchers consider habitat fragmentation and the isolation of populations to be a greater impact than road-kill itself (e.g. Coffin 2007, Forman et al 2002). However, this might depend on the rarity and behaviour of a species – some are very prone to roadkill. Roadkill can be a significant source of wildlife mortality because:

- Home ranges or territories might be bisected by roads
- Animals intermingle with traffic as they move along open road corridors
- New food resources are available in road corridors and
- Some roadside environments are attractive and serve as habitat for some species (Coffin 2007)
- There has been no long evolutionary pressure for animals to adapt to vehicles as 'predators' and normal escape behaviour can be inappropriate, e.g. jumping as a vehicle passed over (N. Mooney 2012, pers comm., 21 May). Thus, roadkill could provide different selection pressures than natural mortalities, including by killing individuals not particularly prone to predation.

Roadkill also presents an animal welfare problem in that many animals are not killed immediately, some even lingering for days before death (N. Mooney 2012, pers comm., 21 May).

For small animals, roads can also be barriers to dispersal and if dispersal across them does occur predation can be intense because of their break in ground cover (N. Mooney 2012, pers comm., 21 May).

Roadkill can be highly visible on Tasmanian roads due to our high density of wildlife relative to most areas of other states, their medium size (meaning they are rarely dangerous or damaging to cars if hit), their usual escape behaviours (only flushing with several sets of stimuli and then a sudden rush in almost random directions) and because parts of many of our roads pass through areas with good wildlife habitat (the case for the Tarkine Forest Drive) or areas that wildlife crosses, such as a bush edge with pasture where wallabies are going from bush refuge to pasture to feed and back again double-crossing roads (N. Mooney 2012, pers comm., 21 May).

An understanding of roadkill causes and patterns is necessary for successful management intervention. Because of the complexities of habitat distribution and the dynamics of wildlife populations and behaviour and the inevitable variety of vehicles and driver motivations and experience (some careful, some not, some capable, some not), there can be no single, fixed mitigation solution. Management and mitigation measures should adapt to the findings of ongoing monitoring that measures their effectiveness over time, with the aim of steady and progressive improvement, using an adaptive management approach.

Adaptive management is a systematic process for continually improving management by learning from outcomes. The concept of adaptive management was developed in the 1970's. Its goal is to develop optimum management while avoiding major crisis (Allan 2002). Adaptive environmental management recognizes the complex and interrelated character of ecosystems, with flexibility stressed within the process to account for any changes in conditions or the emergence of new evidence (Briassoulis 1989, Lawrence 2000). It provides a means to continue to manage and benefit in the face of uncertainty (Allan 2002, Briassoulis 1989). Because of the complexities of natural systems, predicting their response over the long term to up-front management measures is difficult. The best way to optimise those measures is to allow them to evolve in response to observations, to learn from experience.

Importantly, adaptive management is not a random trial and error process, but involves systematically monitoring outcomes to test assumptions. Broadly, it involves an evaluation of the issue, the development of a concept of what is occurring and what appears to be needed, followed by the implementation of initial management measures and then the monitoring of their outcomes. Importantly, the next stage involves comparing the results with the predictions and developing an understanding of what works and why, and also what does not work and why (Salafsky et al 2001).

By monitoring before, during and after the disturbance, we are able to learn how the natural system responds to the changes, so that the process can be fine-tuned through subsequent interventions. Adaptive management addresses criticisms of conventional environmental management practices which often do not allow for the uncertainty of outcomes from policy implementation (Allan 2002, Ladson and Argent 2002, Salafsky et al 2001).

One problem with adaptive management is that it often does not follow a formal experimental design (e.g. with replicates and control) and decisions can therefore suffer from small, inherently unreliable samples.
Adaptive management provides a means to gain a better understanding of a system while that system is being actively managed. The steps in adaptive management are (Ladson and Argent 2002, Salafsky et al 2001):

- Define clearly what the problem is and what you are trying to achieve
- Develop a model that understands the system based on all the available information; this provides a framework for comparing management alternatives

- From the model develop a management plan that includes the factors you want to affect and what actions need to be done to achieve this
- Develop a monitoring plan to test assumptions; this helps to establish what is working and what is not
- Implementation of the plans (management and monitoring)
- Analyse the information and communicate outcomes
- Use the results to gain a better understanding of the system - the most crucial step in the process involves returning to the original model to see if the assumptions tested turned out as predicted, and then using the results to modify the model if and as necessary.

This process has merit with the unpredictable nature of environmental management, including roadkill, and has therefore formed the basis for the roadkill background investigations, analysis and management plan design for this project.

Factors Influencing Roadkill

How animals perceive, use and cross roads can vary significantly from road to road and also between different sections of the same road (Havlick 2004). Not surprisingly, there are temporal and spatial patterns to roadkill, with the majority of research indicating localised high-density roadkill areas, or 'hotspots' (Coffin 2007, Clevenger et al 2003, Hobday and Minstrell 2008, Litvaitis & Tash 2008, Malo et al 2004, Ramp et al 2005, Roger & Ramp 2009). The occurrence of roadkill in seasonal hotspots has important implications for mitigating roadkill, allowing local and seasonal mitigation strategies (Hobday & Minstrell 2008).

The identification of features associated with roadkill hotspots is an important step toward implementing mitigating strategies and lessening road mortalities (Ramp et al 2005, Magnus 2006, Litvaitis & Tash 2008).

The features are generally associated with both wildlife and human factors. For example, the roadside environment, varying natural resources (such as standing water), species life history, their foraging patterns and their dispersal are recognised as key wildlife or environmental determinants (Clevenger et al 2003, Coffin 2007, Hobday and Minstrell 2008, Ramp et al 2005, Taylor & Goldingay 2004). Factors such as traffic volumes and speed, road width, visibility and roadside barriers are key human determinants of roadkill (Hobday and Minstrell 2008, Jones 2000, Shaw et al 2003). Traffic type and driver attitude can also have major influences.

In Australia, the majority of species are killed at night because many are nocturnal animals and do not frequent the road during the day (Hobday and Minstrell 2008) and visibility at night is compromised, notable exceptions being most reptiles, birds and echidnas. Visibility is associated both with drivers seeing animals and also animals being able to detect approaching vehicles. Driver vision is restricted during the night as a result of limited headlight range and because many native species are dark in colour and have poor contrast against road surfaces that typically are dark (Hobday 2010, Jones 2000, Magnus et al 2004). Animal vision is compromised due to the sharp contrast between on-coming headlights and the surrounding dark (Magnus et al 2004, Jones 2000, Ramp et al 2005 and Shaw et al 2003).

The frequency of road corners and undulations also affects visibility (Shaw et al 2003). For example, Mooney (in Magnus et al 2004) reports that on a particular regularly driven route in Tasmania, 78% of roadkills are on corners and 86% of those kills occur on the inside of the corner. During the Tarkine Drive Vertebrate Carnivore Assessment Forum it was noted that a higher incidence of roadkill was observed on the inside of corners, particularly when associated with grassy habitats that attract herbivores.

A likely explanation for this is a combination of poor visibility for the driver, initial behavioural security for the animal (it appears initially that the vehicle is not coming towards it), the camber directing water to the inside (helping grasses grow) and that animals on the inside of a curve escaping *directly away* from an oncoming vehicle go *onto* the road (N. Mooney 2012, pers comm., 21 May).

The night-time driver detection distances for Tasmanian fauna have recently been studied by Hobday in an attempt to inform speed limits to reduce roadkill (Hobday 2010). The study used mounts of nine nocturnal Tasmanian mammal species to determine night-time driver detection distances and then converted the data into stopping distances on the basis of reaction time and braking distance. The study recommended a night-time driving speed of slower than 80 km/h to minimise roadkill (Hobday 2010). However, in real situations a driver may slow down to allow an animal to escape, or swerve to avoid the animal, increasing the effective detection distance.

The spatial distribution of natural resources is the main reason why animals venture onto roads, where they may be killed. Animals are struck by vehicles while trying to reach food, water, den sites etc (Coffin 2007). Wildlife movements (and their interaction with roads) tend to be linked to specific habitats, adjacent land use types and topography, with roadside vegetation being one of the most commonly identified attributes associated with roadkill (Taylor & Goldingay 2010).

Topographic features, such as ridges and riparian corridors, can funnel animal movements towards particular sections of roads, resulting in roadkill peaks where wildlife corridors intersect roads (Clevenger et al 2003, Havlick 2004, Litvaitis & Tash 2008, Malo et al 2004). Additional natural contributing factors include animal densities and foraging behaviours that attract animals to roads (Hobday & Minstrell 2008). For example, mammals tend to be killed on roads close to cover (Clevenger et al 2003). Animals are attracted by grass (Case 1978 in Magnus et al 2004), water in roadside table drains (Mooney in Magnus et al 2004) and existing roadkill (Forman & Alexander 1998 in Magnus et al 2004).

Vehicle speed and traffic volumes are recognised as probably the most important human factors explaining wildlife collisions (Clevenger et al 2003, Hobday & Minstrell 2008, Hobday 2010, Jones 2000, Taylor & Goldingay 2010).

Overall, relatively more roadkill occurs at higher vehicle speeds. For example, in a three year study across five major transport routes in Tasmania, 50% of the roadkill was detected when the survey vehicle speed was greater than 80 km/h (Hobday & Minstrell 2008). The study involved 154 separate trips, over 15,000 km of road and recorded 5691 roadkill individuals. This study is one of the most extensive conducted in Australia, and possibly worldwide, in terms of time-span (>3 years), geographic range (>200 km), species coverage (>50) and survey effort (>15 000 km). At low speeds relatively few roadkills were observed (Hobday and Minstrell 2008).

Roadside barriers and escape routes have been highlighted as important predictors of the probability of finding wildlife roadkill (Magnus et al 2004, Shaw et al 2003). Roadside table drains, metal barriers and steep batters can impede animals from escaping from the path of vehicles (Magnus et al 2004, Shaw et al 2003).

Road width and roadside clearance width have also been demonstrated as key determinants of aversion (Shaw et al 2003, Taylor & Goldingay 2010). Wide roads tend to have low kill rates compared with other roads, suggesting that wide clearance zones have an inhibitory effect on wildlife crossing. Mammalian carnivores have been shown to cross low to medium volume two lane roads but avoid high volume two and three lane roads (Taylor & Goldingay 2010).

Roadkill tends to be highest during summer as a result of changes to both human and animal behaviours (Clevenger et al 2003, Hobday and Minstrell 2008). Vehicle traffic may increase during summer, particularly associated with summer school holidays, and animal movements may increase during breeding, juvenile dispersal and changing resource availability (Hobday and Minstrell 2008).

Driver motivation and inclination (to hit or miss animals is very important). During tests of ultra-sonic deterrent devices on light trucks routinely travelling along several long Tasmanian road routes, it was noted that drivers made no attempt to avoid hitting animals either by slowing, horn tooting to flush them early or taking even very minor evasive action, the explanation being to the effect that “if I did that I’d never get there”. Consequently, on some nights, dozens of animals were struck by each truck; on one night 7 Tasmanian devils by one truck (N. Mooney 2012, pers comm., 21 May).

An often politely overlooked issue is deliberate running over of animals – drivers speeding up and/or moving around the road and its verges away from the normal driving track to hit animals. This is quite common, indeed habitual, by some drivers despite it being an offence under Wildlife Regulations if the species is protected or the place is in a State Reserve (the driver is ‘taking’ or attempting to do so because they demonstrate intent) and perhaps an offence under animal welfare legislation (a vehicle not being an approved method of take). Such behaviour of course defeats most amelioration. Policing, education and peer pressure are needed to change it.

5.3.3 Changes in human activity

This factor has bearing on the two facilitated impacts described above and some of those that follow, for example modelling for tourism suggests an increase in visitation of ~ 44,000 visitors per year by 2025.

5.3.4 Pathogens

Phytophthora cinnamomi

Commonly known as dieback or root rot fungus, *Phytophthora cinnamomi* is a soil borne fungal pathogen that invades the roots of plants and starves them of nutrients and water. Heath communities are the most susceptible to infection with a consequent serious loss of species diversity. It is generally spread by the transportation of soil on vehicles, construction machinery and walking boots. The establishment and spread of *Phytophthora cinnamomi* is favoured in areas that receive above 600 mm of rainfall per annum, are below 800 m altitude and have a predominantly heathy shrub layer (NBES 2011).

The entire route (except for segment N - Lake Chisholm Rd) was resurveyed on bicycle. This allowed for a more thorough coverage than achievable from a vehicle. All observations of symptomatic evidence of *Phytophthora cinnamomi* were recorded and mapped. These along with previous records from the Natural Values Atlas plus additional data supplied by Forestry Tasmania are collated and depicted in Appendix A.

Symptomatic signs of *Phytophthora cinnamomi* were observed to be widespread throughout the study area, in areas of open heath. Widespread death was observed in *Sprengelia incarnata*, with occasional observations in other species including *Banksia marginata* and *Epacris curtisiae*. *Phytophthora cinnamomi* symptoms were observed on roadsides, in an old rehabilitated gravel store and work site on the Blackwater Road just east of the junction with the Western Explorer Tourist Drive and also in and around old quarry sites.

The study area is considered to be of moderate to high susceptibility to *Phytophthora cinnamomi* infection in the heathland and moorland environments and low susceptibility in the eucalypt and rainforest environments (NBES 2011).

Phytophthora cinnamomi has no direct impact on matters of NES but can alter species composition of habitat. This is particularly relevant to heathland orchids where infected heath can support a greater proportion of resistant graminoids such as sedges and twine rushes at the expense of woody plants such as heaths and peas. This may affect habitat suitability for the orchid species.

Myrtle Wilt

Myrtle wilt (*Chalara australis*) is a naturally occurring fungus that causes a disease in older myrtle beech (*Nothofagus cunninghamii*) regeneration (40-60 years) and mature myrtle, which results in death of the trees (NBES 2011).

Symptoms are wilting, followed by leaf death with the dead leaves being retained on the tree for some time. Myrtle wilt is the main cause of disease in undisturbed stands of rainforest and mixed forest. Disturbance within the stand exacerbates the effect of myrtle wilt. Disease incidence has been shown to be higher in callidendrous than in thamnic or implicate rainforests; higher in mixed forests the greater the myrtle densities; higher at lower altitudes; higher with increased diameter of tree; and higher where there is stem and crown damage (Parkham 1991 cited in NBES 2011).

Road construction and any other disturbance which causes damage to older myrtles has the potential to trigger local epidemics of myrtle wilt killing a high proportion of the mature trees and spreading into adjacent undisturbed areas of myrtle forest. Tree damage, producing infection sites typically 50 m from the edge of a road, results in rapid initial disease spread with incidences of 150 m in three years with later infections occurring much slower to adjacent forest with examples of 20 m in five years. There is evidence from research that elevated mortality rate eventually drops to normal levels after an average of nine years (NBES 2011). Symptomatic evidence of myrtle wilt is depicted in Appendix A.

The impacts of myrtle wilt are limited to rainforest and mixed forest communities. These impacts are localised and cannot conceivably have any bearing on any matter of NES.

Chytrid Fungus

Chytrid fungi include numerous species, most of which are free-living saprophytes, with a few species capable of infecting invertebrates and vascular plants. In 1999 a new species - *Batrachochytrium dendrobatidis* - was described. This fungus infects amphibians and causes the often fatal disease, chytridiomycosis. It has since been found to have infected populations of amphibians throughout the world. There has been a global decline in many species of amphibians which is thought to be linked to the spread of this disease. Chytridiomycosis has been a greater causal factor in loss of biodiversity than any other single known disease (Skerratt et al. cited in NBES 2011). Half of documented declines and extinctions in frog species throughout the world cannot be attributed to habitat loss (the most common threatening process). The case for chytridiomycosis being the cause is compelling (Skerratt et al. cited in NBES 2011).

Retrospective studies have shown that chytrid fungus has been infecting Australian frogs since as early as the 1970s (Johnson & Spear 2003 cited in Obendorf and Dalton 2006 cited in NBES 2011) and it is postulated to be a major causal factor in the decline of the green and gold frog throughout Australia (Threatened Species Unit 2001 cited in NBES 2011). It has been shown to be widespread across northern and eastern Tasmania, associated with townships but also found in more remote sites in central and western areas (Obendorf 2005 cited in NBES 2011).

Chytrid fungus has been shown to be highly toxic to the green and gold frog and to Burrows tree frog (*Litoria burrowsae*), endemic to western Tasmania, and is considered to present a 'high' risk to the decline of both species (Obendorf 2005 cited in NBES 2011). The core distribution of Burrows tree frog is further to the south of the study area, although the absence of records within the Tarkine area may be more a reflection of the absence of searching in the region.

Obendorf (2005 cited in NBES 2011) suggests that live contact between frogs may be the means by which disease transmission occurs (Obendorf 2005 cited in NBES 2011). A survey for chytrid fungus across the Tasmanian Wilderness World Heritage Area suggests that the disease is associated with wetlands accessed by gravel roads. The authors of that study (Pauza and Driessen 2008 cited in NBES 2011) conclude that 'human facilitated movement' is the likely cause of its spread.

It is inconclusive as to whether this has been brought about by the deliberate introduction of frogs (probably inadvertently infected) or by some other means such as water or soil. However, it is postulated that the use of water in maintaining gravel roads may facilitate the spreading of infected water from one location to another (Pauza and Driessen 2008 cited in NBES 2011). There is also a possibility that wildfire suppression could result in the spread of infected water from one location to another due to the activities of water trucks (NBES 2011).

No comprehensive study has been undertaken for chytrid fungus in the area so it is unknown what the extent of infection is. There is Natural Values Atlas records of chytrid fungus from two locations near Couta Rocks (see Appendix A).

The proposed Tarkine Forest Drive will not present any increased hazard other than during the construction phase when construction works may present a risk of introducing chytrid fungus into wetland systems. The impact to matters of NES is discounted as there is no evidence of any nationally listed species occurring in the immediate vicinity of the Tarkine Drive.

5.3.5 Exotic predators and non-native competitors

The EPBC Act Protected Matters Report identifies invasive feral animals that occur or invasive species habitat that is likely to occur. Feral goats, cats and rabbits are recorded as occurring or likely to occur due to suitable habitat being present (NBES 2011).

Rabbits were recorded during headlight surveys in road Segments A and B which are both relatively grassy habitats. Outside of these two road sections habitat suitability is low. Currently rabbit numbers are relatively low but as the areas in which they were recorded correspond with hotspots for threatened orchids, the rabbit could represent a threatening process if the population were to increase suddenly. The population of the feral rabbit is very variable and would be expected to boom and bust over time. If the population is limited by predation then any impact to predators through increases in roadkill or disease may trigger a rise in the rabbit population (NBES 2011). Rabbits are unsuited to most of the vegetation types outside of their current range on the west coast.

No sightings of domestic cats were made during the course of field survey within the study area although they were sighted north of Kanunnah Bridge on the Roger River Road and also south of Dempster Plain on Sumac Rd suggesting they are likely to be present. There is mounting opinion and concern that the decline of the Tasmanian devil provides an opportunity for the feral cat population to expand to exploit any niche gap created by the loss of native carnivores which may result from impacts of roadkill or the arrival of DFTD[32] (NBES 2011).

[32] Nick Mooney in DFTD Senior Scientists Forum 2007 Consultation of Ranger at Arthur River

Habitats on the western coastal plain appear the most suitable to goats, although there is no knowledge of goats being feral there [33](NBES 2011). Observations of feral animals from the study area are depicted in Appendix A.

Mainland Australia's biodiversity has been severely impacted by red foxes, which were deliberately introduced in the 19th century from Europe. Tasmania's wildlife has benefited from a fox free existence. However, in recent years there has been mounting evidence of fox presence in Tasmania, resulting from a likely combination of deliberate and accidental introductions. As of March 2012 four fox carcases, 61 fox scats (DNA tested), one fox skull and over 2900 reported sightings have been reported over a 10 year period (DPIPWE 2012).

Considerable State and Commonwealth Government resources have been directed towards the Fox Eradication Program to prevent a fox population establishing in Tasmania. This has involved establishing a fox reporting hotline, a rapid response team and strategic baiting programs. There is no reliable evidence of fox activity west of Boat Harbour, 35 km northeast of Tayatea Bridge and 130 km along the core habitat coastal strip to Arthur River. The coastal grasslands adjoining Segments A & B are considered likely core habitat. The densely vegetated wet forests and heathlands are that characterise the remainder of the Tarkine Drive environment are not.

Foxes will prey on many native fauna and may compete with spotted-tailed quolls and Tasmanian devils, and are likely to prey on their young. Competition and predation involving foxes and feral cats are suspected to suppress quoll populations (Edgar and Belcher 1995, Maxwell et al. 1996). Fox establishment may cause both direct and indirect effects on Tasmanian devils. Direct effects include killing by foxes of juvenile devils at dens while the female forages (Jones et al. 2007). Fox establishment may also cause ecosystem disruptions through changes in other species (Jones et al. 2007)

The Tarkine Forest Drive will not conceivably facilitate the spread of the fox. If the fox were to reach the area then an enhanced concentration of roadkill may facilitate the colonisation of the road corridor by foxes. Feral cats are likely to already be present across the area and may also benefit from any increases in availability of roadkill.

5.3.6 Weeds

Table 5.1 identifies introduced plants recorded (or could occur due to suitable habitat as identified in the EPBC Act Protected Matters Report) from the study area:

Table 5.1 - Introduced plants from the study area

Introduced plant	Weed of National Significance	Declared under the *Weed Management Act 1999*	Recorded from the study area
Blackberry (*Rubus fruticosus* agg.)	Y	Y	Y
Gorse (*Ulex europaeus*)	Y	Y	Y
Spanish heath (*Erica lusitanica*)	N	Y	Y
Creeping thistle (*Cirsium arvense*)	N	Y	Y
Bridal creeper (*Asparagus asparagoides*)	Y	Y	N
Boneseed (*Chrysanthemoides monilifera*)	Y	Y	N
Serrated tussock (*Nassella trichotoma*)	Y	Y	N
Willows (*Salix* spp.)	Y	Y	N

[33] Consultation with PWS Ranger at Arthur River

Of the Weeds of National Significance (WONs) two species were recorded from the study area (blackberry and gorse). It is unlikely that boneseed or serrated tussock occur on the route of the Tarkine Forest Drive as the vegetation is generally of low suitability to invasion by these species and the locations of these species elsewhere in Tasmania is well removed from the far northwest of Tasmania. Willows, although not recorded, have some probability of occurring in the study area, particularly in the vicinity of Arthur River, although it is unlikely that they were overlooked. Bridal creeper, although not recorded, would have the potential to establish in much of the scrub and forest habitats. There are currently no records from the vicinity (NBES 2011).

Current distributions of WONS are:

- Blackberry (*Rubus fruticosus* agg.) – present at a few culvert and bridge crossings
- Gorse (*Ulex europaeus*) – one site just south of Arthur River.

Other declared weeds recorded include (NBES 2011):

- Spanish heath (*Erica lusitanica*) – localised but dense roadside infestations along Blackwater Road extending for several hundred metres
- Creeping thistle (*Cirsium arvense*) – localised roadside patches along Blackwater Road.

Other environmental weeds recorded include (NBES 2011):

- Foxglove (*Digitalis purpurea*) – Blackwater Road, Rebecca Rd and Sumac Road verge
- Cotoneaster (*Cotoneaster* sp.) – one site on Temma Road.

Numerous other herbaceous weed species were present in native vegetation on the coastal section, particularly where cattle graze, but their effect is not thought to be significant. One of particular note is milkwort (*Polygala vulgaris*). Rarely seen in Tasmania, this is naturalised amongst the grassy vegetation at Tiger Flat. Its effect is unknown but it may be competitive with native herbs, including orchids (NBES 2011).

The entire route (except for segment N - Lake Chisholm Rd) was surveyed on bicycle, a survey method that is efficient and effective. All observations of weeds were recorded and mapped.

Appendix A depicts records of significant weed species from the vicinity. These include the species recorded from the study area which have been accurately mapped for this project.

Currently weed infestations are localised. Roads are conduits for the spread of generalist species capable of utilising the modified and disturbed environments of roadsides. Vehicles can spread seed along roads. Earthworks associated with road construction period will bring increased risk of weed species being introduced along its length. Subsequent elevated use of the road brings a proportionately much smaller risk of spreading environmental weeds.

Long term, a sealed road requires less frequent grading along its shoulders. Consequently, standard maintenance practices are less likely to cause the spread of weeds along a sealed road than an unsealed road.

The threat of the existing weeds and other known weeds to Matters of NES is considered low. The greatest threat is to habitat for orchids along Segment B. Grasslands are susceptible to a wide range of introduced weeds. Heathlands, being less fertile, are susceptible to smaller range of weeds although these do include at least one of WONS (Spanish heath) which has been recorded elsewhere along Tarkine Drive.

5.3.7 Fire

The threat of wildfire is an ever present concern during drier summer periods and especially in drought. In 1995 there was a devastating wildfire centred on Rebecca Creek which impacted large areas of heathland and also affected regenerating native forest and some mature native mixed forest as at Rebecca Creek Forest Reserve. Several other more extensive fires occurred in the 1980s affecting much of the eastern part of the project area. Some of these fires were started by anthropogenic sources including one where a chainsaw spark is known to be its ignition source. Much of the Norfolk Range south of the Tarkine Drive was burnt in 2008. This fire was started by a tourist seeking attention when their car rolled on a side track 400 m from the Western Explorer Road.

Other fires occur from natural sources such as lightning strikes and these are likely to occasionally ignite some of the heathy and more flammable vegetation in dry periods.

The increase in visitation could arguably increase the likelihood of accidentally lit wildfires. However, in the case of the tourist the fire was lit after he had become distressed after losing patience waiting for assistance. More frequent traffic passing by is likely to discourage malicious fire lighting and reduce misplaced signal fires.

Wildfires can impact on habitat for threatened orchids and in some instances affect vertebrate fauna.

The habitats that are occupied by the orchids in the Arthur Pieman Protected Area are subject to periodic management burns. Orchids are adapted to fire and require some form of biomass reduction such as fire to maintain habitat suitability. Most orchids are spring flowering and so are not likely to be directly affected by fire as the habitat would rarely be highly flammable at that time. Management burns ensure that fuel loads are controlled, which limits the impact of devastatingly hot wildfires that could damage the underground tubers.

Forest fires could disturb nesting birds including eagles and owls, as well as impact on listed marsupial fauna.

The impact of the project to the risk of wildfire cannot be quantified and is theoretical.

5.4 Cumulative impacts

This PER also considers the cumulative impacts of the proposed action: Nelson Bay River Magnetite Mine (EPBC 2011/5846) located east of Couta Rocks and approximately 7 km northeast of Temma.
The Minister for Sustainability, Environment, Water, Population and Communities, the Hon. Tony Burke, has determined that Shree Minerals' proposed Nelson Bay River magnetite and hematite mine is a controlled action under the EPBC Act.

The Minister considered that the project was likely to have a significant impact on the following matters of NES:

- Listed threatened species and ecological communities
- Listed migratory species.

The specific matters were:

- Tasmanian devil (*Sarchophilus harrisii*)
- Tasmanian wedge-tailed eagle (*Aquila audax fleayi*)
- Spotted-tailed quoll (*Dasyurus maculatus maculatus*)

- Pretty leek-orchid (*Prasophyllum pulchellum*) (Critically Endangered)
- Western leek-orchid (*Prasophyllum favonium*) (Critically Endangered)
- White-bellied sea-eagle (*Haliaeetus leucogaster*) (Migratory)
- Satin flycatcher (*Myiagra cyanoleuca*) (Migratory).

The Minister also determined that the project would be assessed using an EIS. The Final EIS is currently still being assessed by the Commonwealth.

In summary, the EIS has determined that the Nelson Bay River Magnetite Mine will not have a significant impact on the threatened flora species that are the subject of this PER.

Potential impacts are confined to threatened fauna species including the Tasmanian wedge-tailed eagle, Tasmanian masked owl, spotted-tail quoll and Tasmanian devil. The assessment of these impacts was determined to be negligible.

The transport of product from the Nelson Bay River Magnetite Mine will utilise Rebecca Road, Blackwater Road and Sumac Road.

Cumulative impacts could potentially occur as a result of the increase of traffic volume utilising Segments D – G of the Tarkine Forest Drive and could potentially elevate the risk of roadkill or injury to Tasmanian wedge-tailed eagle, Tasmanian masked owl, spotted-tail quoll and Tasmanian devil.

5.5 Threatened Flora

Four flora species have been identified in section 4 as being impacted or having potential to be impacted. These are further described in Table 5.2.

A sealed road requires less maintenance with less gravel being pushed out each side of the road. This will reduce the impact of road maintenance works and the potential impacts of those works on individual plants and habitat. It will also reduce the risk of spreading weeds and *Phytophthora*.

5.5.1 Arthur River greenhood (*Pterostylis rubenachii*)

Direct Impacts

There is a population in native grassland that abuts the road near Tiger Creek, on Temma Road. A subpopulation has colonised bare gravelly ground close to the road shoulder 2 plants were observed in 2009 at two locations increasing to 17 at three locations in 2012 (Threatened Plants Tasmania 2012).

Direct impact can be avoided with particular care in construction activity at most of these sites. One site (containing 2 plants) is unlikely to be avoided. The locations are vulnerable and potentially could be affected by periodic shoulder grading undertaken in routine maintenance of the current road. The core population extends well beyond the footprint of the site and can be avoided.

A potential impact is that machinery and other associated materials could be inadvertently driven or stored on the site of the known colony at Tiger Creek adjoining Temma Road.

Indirect Facilitated and Cumulative Impacts

Earthworks could increase the risk of introduced plants becoming established in habitat and especially colonising population at Tiger Creek adjacent to the road.

Higher visitation to the area may increase the likelihood of tourist vehicles parking off road at Tiger Creek and disturbing plants.

Potential increase incidence of wildfire resulting from increased human visitation may affect habitat although the risk is remote. The grasslands require some form of biomass removal and orchids are well adapted to fire. Fire is unlikely to occur during the spring flowering season.

There are no cumulative impacts as no other projects threaten this species.

5.5.2 Shortspike midge orchid (*Corunastylis brachystachya*)

Direct Impacts

All known sites within the vicinity of the Tarkine Drive are beyond the footprint of any works.

A potential impact is that machinery and other associated materials could be inadvertently driven or stored on the site of the known site north of Couta Rocks junction.

Indirect Facilitated and Cumulative Impacts

Earthworks could increase the risk of weeds and *Phytophthora* becoming established in habitat which could alter the floristic composition of the habitat supporting this species, to its detriment.

Higher visitation to the area may increase the likelihood of tourist vehicles parking off road north of Couta Rocks and disturbing plants.

Potential increased incidence of wildfire resulting from increased human visitation may affect habitat although the risk is remote. Heathlands require some form of biomass removal and orchids are well adapted to fire. This species flowers during mid summer and plants could be impacted by a wildfire. However, as with most orchids this is well adapted to fire and typically flowers in greater numbers following a fire event.

There are no cumulative impacts as no other projects threaten this species.

5.5.3 Western leek orchid (*Prasophyllum favonium*)

Direct Impacts

No direct impacts are likely. All known sites within the vicinity of the Tarkine Drive are beyond the footprint of any works.

Indirect Facilitated and Cumulative Impacts

Earthworks could increase the risk of weeds and *Phytophthora* becoming established in habitat which could alter the floristic composition of the habitat supporting this species, to its detriment.

Potential increased incidence of wildfire resulting from increased human visitation may affect habitat although the risk is remote. Heathlands require some form of biomass removal and orchids are well adapted to fire. This species flowers in spring and so flowering is unlikely to be directly impacted by a wildfire. However, as with most orchids this is well adapted to fire and typically flowers in greater numbers following a fire event.

There are no cumulative impacts as no other projects threaten this species.

5.5.4 Windswept spider orchid (*Caladenia dienema*)

Direct Impacts

No direct impacts are likely. All known sites within the vicinity of the Tarkine Drive are beyond the footprint of any works. The species is unlikely to be impacted as known sites can be avoided.

Indirect Facilitated and Cumulative Impacts

Earthworks could increase the risk of weeds and *Phytophthora* becoming established in habitat which could alter the floristic composition of the habitat supporting this species, to its detriment.

Potential increased incidence of wildfire resulting from increased human visitation may affect habitat although the risk is remote. Heathlands require some form of biomass removal and orchids are well adapted to fire. This species flowers in spring and so flowering is unlikely to be directly impacted by a wildfire. However, as with most orchids this is well adapted to fire and typically flowers in greater numbers following a fire event.

There are no cumulative impacts as no other projects threaten this species.

Table 5.2 - Threatened flora potentially impacted

Indirect impacts are impacts that are not a direct result of the project but to which the proposed action contributes. They may include offsite or downstream impacts such as impacts on downstream hydrology and water quality, spread of pests and diseases or changes in species foraging, breeding and movement patterns.
Facilitated impacts are impacts resulting from the actions of third parties that are facilitated by the proposed action, such as increased road traffic or tourist and recreational activities facilitated through the upgrading of road infrastructure.
Cumulative impacts are impacts of the proposed action in combination with other past, present and reasonably foreseeable future actions (both related and unrelated), such as the increased threat of roadkill and habitat disturbance generated from additional development and activities in the surrounding area.
Safeguard and mitigation measures are described in Section 6.

PER Reference	Matter of NES	Applicable segment along the Tarkine Forest Drive	Direct impacts Construction phase	Indirect impacts Construction phase	Facilitated impacts Operational phase	Cumulative impacts	Section 6 reference where safeguard and mitigation measures are discussed
5.5.1	Arthur River greenhood (*Pterostylis rubenachii*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	Direct impact to 2 plants on the gravel shoulder of Temma Rd near Tiger Creek. Potential impact to colony by unmanaged construction activities.	Potential for weed introduction into existing colony.	Increase in visitation increases risk of: • off road parking on known colony • likelihood of wildfire	Unlikely	6.3.1, 6.4.1
5.5.2	Shortspike midge orchid (*Corunastylis brachystachya*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	No direct impacts necessary. Potential impact to plants by unmanaged construction activities north of Couta Rocks junction.	Potential for weed introduction. Potential to spread *Phytophthora cinnamomi*.	Increase in visitation increases risk of: • off road parking near known plants • likelihood of wildfire.	Unlikely	**6.3.1, 6.4.1**
5.5.3	Western leek orchid (*Prasophyllum favonium*) EPBC Act status: Critically Endangered	A B C D E F G H I J K L M N	Unlikely	Potential for weed introduction. Potential to spread *Phytophthora cinnamomi*.	Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.1, 6.4.1**
5.5.4	Windswept spider orchid (*Caladenia dienema*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	No direct impacts necessary. Potential impact to plants by unmanaged construction activities in vicinity of know sites along Temma Rd and Couta Rocks Rd.	Potential for weed introduction. Potential to spread *Phytophthora cinnamomi*.	Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.1, 6.4.1**

5.6 Threatened Fauna

Nine fauna species have been identified in section 4 as being impacted or having potential to be impacted. These are further described in Table 5.3 Cape National Park.

5.6.1 Spotted-tail Quoll (*Dasyurus maculatus* subsp. *maculatus*)

Spotted-tailed quoll occurs widely but infrequently throughout the study area, with localised concentrations at specific locations where the road intersects with the route of a home range.

Direct Impacts

Construction and material transport traffic may result in a higher incidence of roadkill or injury to individual animals. Commuting contractors are likely to be driving at dawn and dusk when there is likely to be greatest risk to spotted tailed quoll. There will also be a tendency for workers to drive fast on what will become a familiar route to them.

Indirect Facilitated and Cumulative Impacts

Construction works will bring a heightened level of disturbance from noise and vibrations. These will tend to disperse sheltering animals greater distances from the road. There is a small possibility that any dens being utilised in close proximity to the road could be abandoned. Given the extensive areas of habitat it is difficult to conceive of dens being located so close to the existing road.

Changes in traffic behaviours are anticipated. These include potentially higher speeds, higher numbers of tourists and changes to route selection for residents of Temma. These all may increase the incidence of roadkill.

Increases in visitation may potentially increase incidence of wildfire which could have an impact. This is considered unlikely.

Table 5.3 - Threatened fauna potentially impacted

Indirect impacts are impacts that are not a direct result of the project but to which the proposed action contributes. They may include offsite or downstream impacts such as impacts on downstream hydrology and water quality, spread of pests and diseases or changes in species foraging, breeding and movement patterns.
Facilitated impacts are impacts resulting from the actions of third parties that are facilitated by the proposed action, such as increased road traffic or tourist and recreational activities facilitated through the upgrading of road infrastructure.
Cumulative impacts are impacts of the proposed action in combination with other past, present and reasonably foreseeable future actions (both related and unrelated), such as the increased threat of roadkill and habitat disturbance generated from additional development and activities in the surrounding area.
Safeguard and mitigation measures are described in Section 6.

PER Reference	Matter of NES	Applicable segment along the Tarkine Forest Drive	Direct impacts Construction phase	Indirect impacts Construction phase	Facilitated impacts Operational phase	Cumulative impacts	Section 6 reference where safeguard and mitigation measures are discussed
5.6.1	Spotted-tail quoll (*Dasyurus maculatus* subsp. *maculatus*) EPBC Act status: Vulnerable	**A B C D E F G H I J K L M N**	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Disturbance to dens in close proximity to the road from noise.	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume. Increase in visitation increases likelihood of wildfire	Unlikely	**6.3.2, 6.4.2**
5.6.2	Tasmanian devil (*Sarcophilus harrisii*) EPBC Act status: Endangered	**A B C D E F G H I J K L M N**	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Disturbance to dens in close proximity to the road from noise.	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume. Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.2, 6.4.2**
5.6.3	Tasmanian azure kingfisher (*Ceyx azureus diemenensis*) EPBC Act status: Endangered	A B C D **E** F **G** H I J **K** L M N	Unlikely	Noise disturbance during construction of Rapid River Bridge if nesting in vicinity which is of low probability.	Higher visitation resulting in increases in recreational boating on Arthur River affecting boat wash.	Unlikely	**6.3.2, 6.4.2**
5.6.4	Tasmanian masked owl (*Tyto novaehollandiae* subsp. *castanops*) EPBC Act status: Vulnerable	**A B C D E F G H I J K L M N**	Potential increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Unlikely	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume. Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.2, 6.4.2**
5.6.5	Wedge-tailed eagle (*Aquila audax* subsp. *Fleayi*) EPBC Act status: Endangered	**A B C D E F G H I J K L M N**	Potential increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Unlikely	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume. Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.2, 6.4.2**
5.6.6	White-bellied sea eagle (*Haliaeetus leucogaster*) EPBC Act status: Migratory	**A B C** D E F **G** H I J K L M N	Potential increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Unlikely	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume. Increase in visitation increases likelihood of wildfire.	Unlikely	**6.3.2, 6.4.2**
5.6.7	Australian grayling (*Prototroctes maraena*) EPBC Act status: Vulnerable	A B C D **E** F **G** H I J **K** L M N	Unlikely	Siltation or pollution affecting water quality during construction of Rapid River bridge.	Higher visitation resulting in increases in recreational fishing.	Unlikely	**6.3.2, 6.4.2**
5.6.8	Giant freshwater crayfish (*Astacopsis gouldi*) EPBC Act status: Vulnerable	A B C D **E F G H I J K L M N**	Potential impact to individuals that may occupy habitats in immediate vicinity of proposed new bridge or culvert replacements.	Siltation or pollution affecting water quality during construction of bridges over Nelson Bay River and Rapid River.	Increases in incidence of roadkill resulting from changed traffic times, speeds and volume.	Unlikely	**6.3.2, 6.4.2**
5.6.9	Marrawah skipper (*Oreisplanus munionga* subsp. *larana*) EPBC Act status: Vulnerable	**A B** C D E F G H I J K L M N	Unlikely	Earthworks could increase the risk of introduced plants becoming established that are invasive into habitat supporting the larval foodplant.	Higher visitation to the area may increase likelihood wildfire which could impact on butterfly colonies.	Unlikely	**6.3.2, 6.4.2**

5.6.2 Tasmanian Devil (*Sarcophilus harrisii*)

The Tasmanian devil occurs widely throughout the study area, with its greatest concentrations along the western seaboard from Couta Rocks to Arthur River where the habitat in this area is considered to be more suitable.

Direct Impacts

Construction and material transport traffic may result in a higher incidence of roadkill or injury to individual animals. Commuting contractors are likely to be driving at dawn and dusk when there is likely to be greatest risk to Tasmanian devils. There will also be a tendency for workers to drive fast on what will become a familiar route to them.

Indirect Facilitated and Cumulative Impacts

Construction works will bring a heightened level of disturbance from noise and vibrations. These will tend to disperse sheltering animals greater distances from the road. There is a small possibility that any dens being utilised in close proximity to the road could be abandoned. Given the extensive areas of habitat it is difficult to conceive of dens being located so close to the existing road.

Changes to traffic usage is anticipated on Tarkine Drive. These include potentially higher speeds, higher numbers of tourists and changes to route selection for residents of Temma. These all may increase the incidence of roadkill.

Increases in visitation may potentially increase incidence of wildfire which could have an impact. Significant changes to wildfire are considered unlikely.

Based on the understanding of DFTD, the construction and operational phases of the Tarkine Forest Drive will not introduce any changes to the environment that would increase the risk of DFTD entering the area, nor would they facilitate the intermixing of devil populations. All rivers and creeks separating eastern and western devil populations already have existing bridges, which provide possible east-west movement and intermixing routes. The Tarkine Forest Drive will not create any new river or stream crossings, only replace existing bridges over the Nelson Bay River and Rapid River.

It is unlikely that the Tarkine Forest Drive could facilitate the risk of introduction of DFTD. The only conceivable way in which this could occur was if diseased or dead individuals, or equipment that has come in contact with diseased individuals, was brought into the site. The likelihood of this occurrence is low.

Increased rates of roadkill could attract larger numbers of Tasmanian devils from the area surrounding the Tarkine Drive to scavenge on the road. If this facilitated more socialising then this could facilitate the rate of spread of DFTD if it were to become established in the area.

5.6.3 Tasmanian Azure Kingfisher (*Ceyx azureus diemenensis*)

The only location where there is a potential for nesting habitat (in the river banks) in the immediate vicinity of the Tarkine Forest Drive is at the site of the Rapid River bridge (NBES 2011).

Direct Impacts

During bridge replacement for the Tarkine Forest Drive there is no potential for direct impacts on nesting birds as an existing bridge is already in place.

Indirect Facilitated and Cumulative Impacts

If nesting does occur on the banks of Rapid River in close proximity to the bridge then nesting birds could be disturbed by construction noise.

Increases in visitation facilitated by the Tarkine Drive could lead to an increase in recreational boats on the Arthur River which may increase levels of disturbance most notably from boat wash entering riverside nest hollows.

5.6.4 Tasmanian Masked Owl (*Tyto novaehollandiae* subsp. *castanops*)

There is one observation record of Tasmanian masked owl along Rapid River Road (Segment E). The wet vegetation types through which the Tarkine Forest Drive traverses are suboptimal habitat, although there are large trees with hollows occurring across much of the study area (NBES 2011).

Direct Impacts

Tasmanian masked owls are sometimes the victim of roadkill through collision on the wing as they hunt along road corridors where they use the open spaces to prey on animals (for example, bandicoots and rabbits) grazing on roadside regrowth grasses.

Construction traffic provides an increase albeit negligible in the likelihood of roadkill through collision due to changes in traffic activity.

Indirect Facilitated and Cumulative Impacts

A potential facilitated impact on this species could occur during the operational phase of the Tarkine Forest Drive through roadkill. An increase in traffic may result in a higher incidence of roadkill or injury to the species, although the likelihood of this is considered very low.

Increases in visitation may potentially increase incidence of wildfire which could have an impact. Significant changes to wildfire are considered unlikely, however.

Cumulative impacts to the masked owl are considered insignificant based on the assessment of the Nelson Bay River magnetite and hematite mine which suggest the impact to this species will be negligible.

5.6.5 Wedge-tailed Eagle (*Aquila audax subsp. fleayi*)

The entire Tarkine Forest Drive lies within potential wedge-tailed eagle foraging habitat and the road itself may provide a food source through roadkill.

Direct Impacts

Construction traffic provides an increase albeit negligible in the likelihood of roadkill through collision due to changes in traffic activity.

Indirect Facilitated and Cumulative Impacts

Wedge-tailed eagles can be the victim of roadkill as they forage on roadside carcases. They are large birds that are delayed in their ability to take off once disturbed.

A potential facilitated impact on this species could occur during the operational phase of the Tarkine Forest Drive due to an increase in traffic leading to a higher incidence of roadkill or injury.

Increases in visitation may potentially increase incidence of wildfire which could have an impact. Significant changes to wildfire are considered unlikely.

Cumulative impacts to the Tasmanian wedge-tailed eagle are considered insignificant based on the assessment of the Nelson Bay River magnetite and hematite mine which suggest that the impact to this species will be negligible.

5.6.6 White-bellied Sea Eagle (*Haliaeetus leucogaster*)

There is potential nesting habitat along the coast within the wider region around the project and there are known nests along the Arthur River. Potential nesting habitat in the vicinity of the Tarkine Forest Drive is limited to the Arthur River in Segment G.

Direct Impacts

Construction traffic provides an increase, albeit very low, in the likelihood of roadkill through collision due to changes in traffic activity.

Indirect Facilitated and Cumulative Impacts

White-bellied sea eagles can be the victim of roadkill as they forage on roadside carcases. They are large birds that are delayed in their ability to take off once disturbed.

A potential facilitated impact on this species could occur during the operational phase of the Tarkine Forest Drive due to an increase in traffic leading to a higher incidence of roadkill or injury.

Increases in human visitation may potentially increase incidence of wildfire which could have an impact. Significant changes to wildfire are considered unlikely.

Cumulative impacts to the white-bellied sea eagle are considered insignificant based on the assessment of the Nelson Bay River magnetite and hematite mine which suggest the impact to this species will be negligible.

5.6.7 Australian Grayling (*Prototroctes maraena*)

Most of the smaller creeks which are crossed by the Tarkine Forest Drive are unsuitable as they are too small and are obstructed by natural barriers (NBES 2011).

Nelson Bay River has a hydraulic barrier 50 m downstream of the Temma Road crossing, which would prevent grayling from moving upstream (NBES 2011).

Habitat for the Australian grayling potentially occurs in the Frankland River and Rapid River (NBES 2011).

Direct Impacts

No construction work on the bridge across the Frankland River is proposed for the Tarkine Forest Drive. A potential indirect impact to Australian grayling may occur as a result of construction adjacent to the Frankland River resulting in sediment entering the river system. However, as the road either side of the Frankland Bridge is already sealed, works will be minimal in this area and the likelihood of this occurrence is therefore extremely remote.

Potential direct and indirect impacts to Australian grayling habitat may occur as a result of bridge replacement across the Rapid River. The river bed and banks may be disturbed by the construction of a coffer dam. This activity may cause temporary stream siltation of the lower reaches of the Rapid River.

The existing deteriorated timber bridge at Rapid River currently restricts some amount of river flow due to the two timber log piers located in the river bed and the new bridge design should improve river flows and enhance upstream movements of Australian grayling.

Indirect Facilitated and Cumulative Impacts

A potential facilitated impact may be an increase in fishing of Australian grayling. However, fishing is considered unlikely to be a major threat to the species or populations (Backhouse et al. 2008). In general the poaching of wildlife takes place in locations which are away from the watchful eye of the public. The Tarkine Forest Drive will increase visitation to the area by tourists and the public, which may result in increased surveillance of the area therefore making it unattractive to poachers.

5.6.8 Giant Freshwater Crayfish (*Astacopsis gouldi*)

The Frankland and Rapid Rivers have been identified as providing good quality habitat with strong giant freshwater crayfish that are worthy of conservation (Walsh 2003, cited in Threatened Species Section 2006c).

Direct Impacts

No construction work on the bridge across the Frankland River is proposed for the Tarkine Forest Drive. A potential indirect impact to giant freshwater crayfish may occur as a result of construction adjacent to the Frankland River causing sediment to enter the river system. However, as the road either side of the Frankland Bridge is already sealed, works will be minimal in this area and the likelihood of this occurrence is therefore low.

The replacement of the Rapid River Bridge along the Tarkine Forest Drive presents a risk of direct disturbance to crayfish that may occupy habitats in the immediate vicinity such as in pools at the base of bridges.

The replacement of culverts along the Tarkine Forest Drive also presents a risk of direct disturbance to crayfish that may be occupying suitable habitat. However, the replacement of culverts also provides an opportunity to install improved designed culverts with a depth and alignment which will not impede crayfish passage.

Indirect Facilitated and Cumulative Impacts

Sedimentation during the construction phase may have a temporary adverse impact on crayfish habitat. The most vulnerable sites are associated with the construction of new bridges across Nelson Bay River and Rapid River.

A potential facilitated impact on this species could occur during the operational phase of the Tarkine Forest Drive. An increase in traffic may result in a higher incidence of roadkill or injury to the species. Increased traffic volumes, especially in the eastern segments, may increase the risk of roadkill to giant freshwater crayfish where culverts are unsuited to passage. However, this risk is considered to be very low (NBES 2011). A 12 month Roadkill Monitoring Project has been undertaken covering the western half of the route between Arthur River and the Rapid River/Sumac Road junction where traffic volumes are highest (Segments A-J)[1]. No evidence of crayfish mortality was found by this study. The Tarkine Forest Drive provides an opportunity to ensure that crayfish passage is catered for in the alignment and depth of the culverts.

A potential facilitated impact may be an increase in poaching of giant freshwater crayfish. The area is currently open and accessible to poachers. It can be said in general that the poaching of wildlife takes place in locations which are away from the watchful eye of the public. The Tarkine Forest Drive will increase visitation to the area by tourists and the public, which may result in increased surveillance of the area therefore making it unattractive to poachers.

[1] This was undertaken by Wildspot Consulting (Sept 2009-2010)

5.6.9 Marrawah Skipper (*Oreisplanus munionga* ssp. *larana*)

Direct Impacts

No colonies are known to occur in the immediate vicinity of the Tarkine Drive. The flora survey of these segments did not identify any plants of *Carex appressa*, suggesting that there is no habitat in the immediate vicinity of the Tarkine Forests Drive (NBES 2011).

No direct impact to the Marrawah skipper will occur.

Indirect Facilitated and Cumulative Impacts

Habitat that supports *Carex tasmanica* is susceptible to some weed infestations, notably blackberry. During the construction period there is a heightened risk that earthmoving machinery could introduce weed species.

Potential increased incidence of wildfire resulting from increased human visitation may affect habitat and larval food plants.

6. Proposed Safeguards and Mitigation Measures

The PER must provide information on proposed safeguards and mitigation measures to deal with the relevant impacts of the action. Specific and detailed descriptions of proposed measures must be provided and substantiated, based on best available practices and must include the following elements:

(a) A consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including

- *A description of proposed safeguards and mitigation measures to deal with relevant impacts of the action, including mitigation measures proposed to be taken by State governments, local governments or the Proponent*
- *Assessment of the expected or predicted effectiveness of the mitigation measures*
- *Any statutory or policy basis for the mitigation measures*
- *The cost of the mitigation and ongoing management measures and the resources available to meet these costs*
- *The name of the agency responsible for endorsing or approving each mitigation measure or monitoring program*

(b) details of the structure and content of management plans proposed for the continuing management of relevant impacts of the action on matters of NES, including indicative construction and operational environmental management plans, flora and fauna management plans, disease and pest management plans, roadkill monitoring and mitigation plans (including specific measures to avoid or minimise wildlife road mortalities) and water quality plans, along with a schedule for the development and approval of these plans

(c) details of ongoing research and monitoring programs to support an adaptive management approach and determine the effectiveness of the proposed mitigation measures (including evaluation of projects in the surrounding area using related mitigation approaches, such as the sealing of the Marrawah to Arthur River Road project)

(d) details of arrangements and resources provided to ensure compliance with measures to mitigate impacts, such as control of traffic speed, prevention of poaching and inappropriate off-road access, restricting fire outbreaks, minimising vehicle and human spread of soil and disease

(e) details of contingency arrangements for events that may impact on matters of NES, particularly in relation to unexpected or uncertain impacts of the spread of DFTD and increased wildlife road mortality.

Any management plans, surveys and monitoring programs (dealing with matters of NES) that have already been completed, along with any supporting documentation on matters of NES determined, suspected or thought to be present, must be attached to the PER as appendices.

Where impacts on matters of NES cannot be avoided or mitigated, the PER must provide a description of any strategies proposed to offset (compensate for) those impacts. The proposed strategies must have regard to any relevant publicly available guidance issued by the department in relation to offsets, and in particular must:

(a) Demonstrate how they will achieve long-term conservation outcomes

(b) Have regard to the nature, scale and intensity of the impacts of the proposed action on the site

(c) Consider the approach of the relevant state or territory.

6.1 Structure of Proposed Safeguards and Mitigation Measures

The proposed safeguards and mitigation measures are discussed in relation to the phases of the proposed action (Figure 6.1).

Pre-construction Phase (Section 6.2)	→	Construction Phase (Section 6.3)	→	Operational Phase (Section 6.4)	→	Monitoring and Research (Section 6.5)

Figure 6.1 - Structure of proposed safeguards and mitigation measures

6.2 Pre-construction Phase

6.2.1 Flora and fauna surveys

Flora and fauna surveys have been undertaken for the proposed action and have been described above in Section 4.9.

6.2.2 Baseline Water Quality Monitoring Program

The aim of this program is to gather baseline information of all waterways where construction works are proposed. This information will be used in monitoring the effectiveness of the mitigation measures identified below for specific Matters of NES.

The objectives of the Baseline Water Quality Monitoring Program are to:

- Establish a database of background water quality which can compare water quality during and post construction
- Ensure that an appropriate appreciation of the surface water values in the project area are known and considered in developing project tender documents, project task instructions and project management prescriptions prior to construction
- Demonstrate compliance with the *Environmental Management and Pollution Control Act 1994* and the *State Policy on Water Quality Management 1997*.

All surface water samples have been and will be analysed during the Construction Phase for the following parameters:

- pH
- Electrical Conductivity
- Dissolved Oxygen
- Temperature
- Turbidity
- Suspended Solids
- Alkalinity
- Total metals.

6.2.3 Baseline Roadkill Monitoring Program

Please refer to Section 6.6.

6.3 Construction phase

Table 6.1 provides a description of the safeguards and mitigation measures for the Construction Phase of the Tarkine Forest Drive. In addition, the Table provides a summary of the expected or predicted effectiveness of measures and the identification of residual impacts.

The safeguards and mitigation measures specified in Table 6.1 will be incorporated into a Construction Environmental Management Plan (CEMP).

The CEMP will describe the minimum construction management measures that will be required to be implemented by construction contractors as a condition of contract with DIER.

The construction controls of the CEMP will comprise three parts:

Part A - Environment Protection Guidelines

Part A will describe Environment Protection Guidelines (EPGs). These guidelines are provided in Appendix C and referenced in Table 6.1 where they relate to a matter of NES.

Part B - Site Specific Controls

Part B will describe the Site Specific Controls (SSCs) relating to specific environmental and heritage protection requirements. For example, construction exclusion zones.

Part C - Construction Environmental Plans

Part A and B will be supported by Construction Environmental Plans (CEPs), which will show the location of important construction controls.

Table 6.1 - Proposed safeguards and mitigation measures for the Construction Phase

Part of Section 6 of PER	Matter of NES	Applicable segment along the Tarkine Forest Drive	Objective of safeguard and mitigation measures	Safeguard and mitigation measures	Assessment of the expected or predicted effectiveness of safeguard and mitigation measures (see Section 6.3.3 for further analysis)	Significant residual impact after safeguards and mitigation measures.
6.3.1	Arthur River greenhood (*Pterostylis rubenachii*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	Minimise direct impacts to near Tiger Creek. Protect all other known sites of which may potentially be directly impacted by construction activities Minimise the risk of introduced plants becoming established in habitat	Construction exclusion zones Inductions and toolbox meetings EPG to manage introduced plants	Likely to be effective	The residual impact is 2 plants which have colonised the gravel shoulder of Temma Rd near Tiger Creek. This impact is not considered to be a significant impact in the context of the EPBC Act.
6.3.1	Shortspike midge orchid (*Corunastylis brachystachya*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	Protect all known sites which may potentially be directly impacted by construction activities Minimise the risk of introduced plants and *Phytophthora cinnamomi* becoming established in habitat	Construction exclusion zones Inductions and toolbox meetings EPGs to manage introduced plants and *Phytophthora cinnamomi*	Likely to be effective	Unlikely
6.3.1	Western leek orchid (*Prasophyllum favonium*) EPBC Act status: Critically Endangered	A B C D E F G H I J K L M N	Minimise the risk of introduced plants and *Phytophthora cinnamomi* becoming established in habitat	EPGs to manage introduced plants and *Phytophthora cinnamomi*	Likely to be effective	Unlikely
6.3.1	Windswept spider orchid (*Caladenia dienema*) EPBC Act status: Endangered	A B C D E F G H I J K L M N	Protect all known sites which may potentially be directly impacted by construction activities Minimise the risk of introduced plants and *Phytophthora cinnamomi* becoming established in windswept spider orchid habitat	Construction exclusion zones Inductions and toolbox meetings EPGs to manage introduced plants and *Phytophthora cinnamomi*	Likely to be effective	Unlikely
6.3.2	Spotted-tail quoll (*Dasyurus maculatus* subsp. maculatus) EPBC Act status: Vulnerable	A B C D E F G H I J K L M N	Minimise the incidence of roadkill Monitor the incidence of roadkill Minimise noise disturbance to dens in close proximity to construction activities	Inductions and toolbox meetings Daylight hours only operation 60 kph speed limit between dusk and dawn Identification of high risk roadkill locations Move roadkill away from the road corridor Report injured or dead roadkill EPG to manage noise	Likely to be effective	Unlikely