Figure 26 Brush-tailed Phascogale at Site 35-1 (Map 17)

Figure 27 Brush-tailed Phascogale at Site 25-3 (Map 14)

Figure 28 Brush-tailed Phascogale (on left) at Site 12-2 (Map 9)

Figure 29 Brush-tailed Phascogale at Site 18-1 (Map 12)

6.6.8 Pale Field-rat

6.6.8.1 Observations

Pale Field-rats (*Rattus tunneyi*) were detected by seven cameras, in map areas 2, 4, 6, 9 and 17. Four were within (or very close to) seasonally saturated or inundated grassland or *Melaleuca* dominated communities (of which one was in an apparently previously cleared grassland), and three were in adjacent eucalypt communities. None were captured in pitfall traps.

6.6.8.2 Habitat

Pale Field-rats once occurred across much of continental Australia, including arid and semi-arid areas (Cole & Woinarski, 2002). The species is now restricted to higher rainfall areas across northern Australia (Young & Hill, 2012). Within this range, its distribution is very patchy, and the species is mostly recorded in tall grasslands or dense vegetation along creeks (Braithwaite & Baverstock, in Strahan, 1995; Young & Hill, 2012; McKay, 2017). However, it is also known from, though apparently less frequently (at least on the NT mainland), adjacent eucalypt open forests and woodlands (Bradley *et al*., 1987; Short *et al*., 2017). Its abundance and utilisation of different habitats is thought to increase during the wet season (Bradley *et al*., 1987; Braithwaite & Baverstock, in Strahan, 1995).

During these surveys, the species was recorded in lower-lying (seasonally inundated) grasslands as well as adjacent eucalypt woodlands. Based on the reported preferred habitat types and observed patterns of retraction and reduced abundance during the dry season, the habitats quantified for this project have been categorised as either 'primary' (i.e., riparian and seasonally saturated habitats) and 'secondary' (eucalypt woodlands). However, it is important to note that:

- Other variables such as the density of vegetation, cats, and impacts of large grazing herbivores will influence ability of the species to occupy such habitats.
- The locations of detections and non-detections during these surveys still should be factored into any conclusions made regarding potential impacts as a result of the proposed works for this project.

Figure 30 Pale Field-rat at Site 46-1 (Map 2)

Figure 31 Pale Field-rat at Site 44-1 (Map 6)

6.6.9 Butler's Dunnart

6.6.9.1 Observations

Butler's Dunnart (*Sminthopsis butleri*) was not confirmed within the survey area during the pitfall trapping survey (20 pitfall sites each comprising twenty 60 cm deep pits). Five pits captured dunnarts however none were determined to be a Butler's Dunnart. The soles of the hind feet of each individual were checked and all had separated interdigital pads (as per Cole & Woinarski, 2002; Ward & Woinarski, 2012).

However, photos of dunnarts at five camera sites appeared to be Butler's Dunnart based largely on the lack of rufous facial colouring. This feature is obvious in most photos (see photos in **Figure 32** to **Figure 35**), though size may also assist in identification (Red-cheeked Dunnarts are usually larger). Ward (2009) states that the two species can co-occur in tall open *Eucalyptus miniata*, *E. tetrodonta* and or *Corymbia nesophila* forests with sandy flats (as opposed to those forests with lateritic rocky slopes where only Butler's Dunnarts can occur). Habitats within maps 1 and 2 consisted of sandy flats as shown in the photos below (sandy substrates) and the topographic mapping (flats; **Appendix A**).

Given these factors, it is suspected that the individuals detected on the five cameras are Butler's Dunnarts.

6.6.9.2 Habitat

Butler's Dunnarts mostly occur in eucalypt open forest and woodland dominated by *Eucalyptus tetrodonta*, *E. miniata* and *Corymbia nesophila* with either sandy or rocky (outcropping) surfaces, though occasionally in *Melaleuca* woodlands and low scrubs (Ward, 2009; Ward & Woinarski, 2012). Cole and Woinarski (2002) report that Red-cheeked Dunnarts prefer forest margins, grasslands, swamps and soaks, with Ward (2009) suggesting they can co-occur with Butler's Dunnarts in tall eucalypt forests with sandy flats.

Generally, if the suspected Butler's Dunnart detections are true, their locations, along with those of the Red-cheeked Dunnarts, seem to generally fit the habitat descriptions described here.

Figure 32 Dunnart captured on camera at Site 47-8 (map 1), suspected of being a Butler's Dunnart (photos taken one second apart of same individual)

Figure 33 Dunnart captured on camera at Site 46-3 (map 2), suspected of being a Butler's Dunnart

Figure 34 Dunnart captured on camera at Site 46-5 (map 2), suspected of being a Butler's Dunnart

Figure 35 Dunnart captured on camera at Site 37-3 (map 19), suspected of being a Butler's Dunnart

Figure 36 Red-cheeked Dunnart at camera site 46-1 (map 2)

Figure 37 Red-cheeked Dunnart at camera site 44-2 (map 6)

Figure 38 Red-cheeked Dunnart at camera site 44-1 (map 6)

6.6.10 Northern Brushtail Possum

6.6.10.1 Observations

The Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) was detected on 72 occasions, all of which were on the cameras. It was the most detected species on camera, and the second most overall (behind the Partridge Pigeon).

6.6.10.2 Habitat

Northern Brushtail Possums predominantly occur in tall eucalypt open forests, though are also known from mangroves, rainforests, and semi-urban areas (TSSC, 2021). Within the survey area, the species was recorded in all but one of the 17 map areas where cameras were deployed. It was not captured by any of the three cameras deployed in the seasonally inundated grasslands and *Melaleuca* woodlands in the Maxwell Creek area (map 6). However, whilst the species was generally detected in eucalypt forests and woodlands, it was also detected in adjacent *Melaleuca* woodlands.

6.6.11 Merten's Water Monitor

6.6.11.1 Observations

Merten's Water Monitor (*Varanus mertensi*) was detected only once during the survey, despite the deployment of cameras at 100 sites (noting that no cameras were deployed along creeks). The single detection was on the road in Map 6, observed incidentally.

6.6.11.2 Habitat

Suitable habitat for the species consists of drainage lines that contain enough surface water to support fish and frogs (Ward *et al*., 2006). No such incised creek lines were observed in the survey area, however several areas

(e.g., Maps 6, 9, 12, 13, 16, 17, 18) contained small drainage lines or seasonally inundated wetlands that the species is likely to utilise in the wet season. These areas contained shallow (<10 cm) areas of standing water during February and March when rainfall was high, with some having defined drainage channels but were either narrow, sparely vegetated, or not deeply incised. Individuals of Merten's Water Monitor are known to travel substantial distances in search of temporary waters during the wet season (McKay, 2017). In this regard, Merten's Water Monitors may be found in these areas during the wet season. Such areas are referred to as 'seasonal' habitat for the purposes of this report. An example of this 'seasonal' habitat is shown in **Figure 39**, which was in the vicinity of the single observation of the species.

Figure 39 Seasonally inundated Melaleuca woodland in Map 6

6.7 Incidental Fauna Observations

Incidental fauna species observed during the surveys are shown in **Table 31**. These were not necessarily seen within the survey areas, though rather in the vicinity (e.g., when travelling between sites).

Table 31 Incidental fauna observations

Scientific name	**Common name**
Birds	
Aegotheles cristatus	Australian Owlet-nightjar

Scientific name	**Common name**
Aprosmictus erythropterus	Red-winged Parrot
Aquila audax	Wedge-tailed Eagle
Burhinus grallarius	Bushstone Curlew
Cacatua galerita	Sulphur-crested Cockatoo
Centropus phasianinus	Pheasant Coucal
Cisticola exilis	Golden-headed Cisticola
Climacteris melanurus	Black-tailed Treecreeper
Coluricincla harmonica	Grey Shrike-thrush
Coracina papuensis	White-bellied Cuckoo-shrike
Corvis orru	Torresian Crow
Coturnix ypsilphora	Brown Quail
Cracticus nigrogularis	Pied Butcherbird
Dacelo leachii	Blue-winged Kookaburra
Daphoenositta chrysoptera	Varied Sitella
Dicaeum hirundinaceum	Mistletoe Bird
Dicrurus bracteatus	Spangled Drongo
Edolisoma tenuirostre	Cicadabird
Entomyzon cyanotis	Blue-faced Honeyeater
Erythrotriorchis radiatus	Red Goshawk
Falco berigora	Brown Falcon
Gallinago sp. (likely megala)	Snipe
Geopelia humeralis	Bar-shouldered Dove
Geopelia striata	Peaceful Dove
Geophaps smithii	Partridge Pigeon
Haliastur sphenurus	Whistling Kite
Lalage sueurii	White-winged Triller
Lichenostomus flavescens	Yellow-tinted Honeyeater
Lichenostomus unicolor	White-gaped Honeyeater
Lichenostomus virescens	Singing Honeyeater
Lichmera indistincta	Brown Honeyeater
Malurus melanocephalus	Red-backed Fairy-wren
Manorina flavigula	Yellow-throated Miner
Megapodius reinwardt	Orange-footed Scrubfowl
Melithreptus albogularis	White-throated Honeyeater
Merops ornatus	Rainbow Bee-eater
Ninox boobook	Australian Boobook
Pachecephala rufiventris	Rufous Whistler

Scientific name	**Common name**
Pachecephala simplex	Grey Whistler
Pardalotus striatus	Striated Pardalote
Phaps chalcoptera	Common Bronzewing
Philemon argenticeps	Silver-crowned Friarbird
Philemon buceroides	Helmeted Friarbird
Platycercus venustus	Northern Rosella
Podargus strigoides	Tawny Frogmouth
Pomatostomus temporalis	Grey-crowned Babbler
Psitteuteles versicolor	Varied Lorikeet
Rhipidura rufiventris	Northern Fantail
Smicrornis brevirostris	Weebill
Todiraphus macleayii	Forest Kingfisher
Trichoglossus haemadotus	Red-collared Lorikeet
Turnix sp. (likely maculosis)	Button-quail (species not confirmed)
Tyto novaehollandiae, melvillensis race	Masked Owl
Vanellus miles	Masked Lapwing
Mammals	
Bubalus bubalis	Buffalo
Canis familiaris	Wild Dog / Dingo
Conilurus penicillatus	Brush-tailed Rabbit-rat
Equus caballus	Horse
Isoodon macrourus	Northern Brown Bandicoot
Mesembriomys gouldii	Black-footed Tree-rat
Notamacropus agilis	Agile Wallaby
Reptiles	
Antaresia childreni	Children's Python
Morelia spilota variegata	Carpet Python

6.8 Feral Animals

Three feral animal species were detected on the cameras:

- Cats were detected in map areas 9 (one camera) and 11 (four cameras)
- Wild Dogs / Dingoes were detected by 11 cameras (maps 1, 4, 16, 17, 18, 19, 21, 22) and seen frequently between sites while driving though not all observations were recorded.
- A horse was detected by one camera (map 22)

Buffaloes and horses were also frequently observed while driving between sites. Not all observations were recorded. No pigs or cane toads were detected during the surveys. See representative photos from the cameras in **Figure 40** to **Figure 42**.

Dingoes and wild dogs have been classified together as feral animals for the purposes of this project because it is unknown whether they are 'pure' dingoes or hybrids. Stephens (2011) reported that 88% of DNA samples tested in the NT were pure dingoes, but that the percentage of hybrids is higher in areas with larger human populations (>25,000). However, pure-breed dingoes are considered native and are therefore protected in the NT (and in most states / territories in Australia). Generally, in the NT, the term wild dog includes the dingo and feral domestic dogs (and hybrids) (DENR, 2019). Genetic testing has shown that a larger proportion of pure dingoes exist across northern Australia than southern Australia, where more hybrids exist (Stephens, 2011), however the distribution of testing appears to have been patchy.

Figure 40 Cat at Site 15-2 (Map 11)

Figure 41 Cat at Site 15-3 (Map 11)

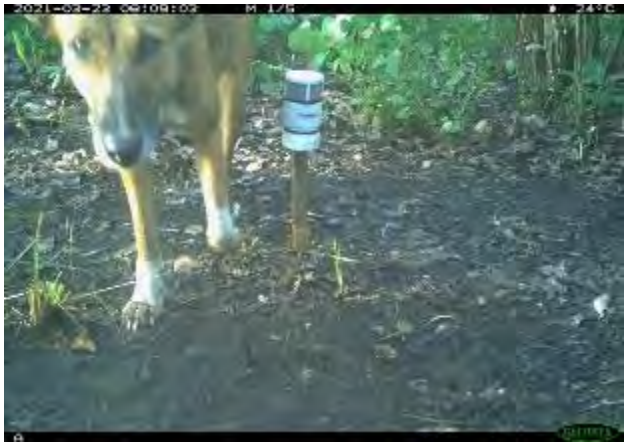


Figure 42 Wild Dog at Site 37-4 (Map 19)

7 Avoidance Buffer Recommendations

Two levels of avoidance restrictions are recommended:

1. Level 1 (highest priority):
    a. Within 20 m of 'patches'[16] of *Typhonium jonesii* and/or *T. mirabile*.
    b. Within 100 m of the following sensitive and/or significant vegetation communities:
        i. W1a (*Grevillea pteridifolia* mid isolated trees over *Pandanus spiralis* mid sparse shrubland over *Eulalia mackinlayi*, *Eriachne burkittii* and *Ectrosia* sp. tall open tussock grassland)
        ii. W2a (*Melaleuca viridiflora* and / or *M. nervosa* low open forest over *Pandanus spiralis, Grevillea pteridifolia* mid sparse shrubland over *Eriachne sp., Aristida sp.* mid tussock grassland).
    c. Within 200 m of any threatened species classified as 'endangered' (i.e., Brush-tailed Phascogales and Brush-tailed Rabbit-rats).
2. Level 2 (low to medium priority):
    a. Within 50 m preferred of 'patches' of *Typhonium jonesii* and/or *T. mirabile*.
    b. Vegetation communities associated with seasonally saturated or inundated soils (potentially significant vegetation types):
        i. E5 (*Corymbia nesophila*, *Eucalyptus miniata* tall open forest over *Acacia* spp. and *Livistona humilis* tall shrubland over *Eriachne* spp. and mixed species tall tussock grassland).
        ii. E7b (*Eucalyptus miniata*, *Corymbia bleeseri* mid woodland over *Acacia* spp. mid open shrubland over *Sorghum plumosum*, *Eriachne* spp. and *Eulalia mackinlayi* tall tussock grassland. Additional species present include *Melaleuca viridiflora*, *M. nervosa* and *Corymbia porrecta*).
        iii. W1b (*Grevillea pteridifolia* low isolated trees over *Pandanus spiralis* tall isolated shrubs over *Sorghum* spp. tall closed tussock grassland)
        iv. W2b (*Lophostemon lactifluus*, *Melaleuca viridiflora*, *Buchanania obovata* low woodland over *Pandanus spiralis*, *Livistona humilis*, *Grevillea pteridifolia* tall shrubland over *Eriachne burkitii*, *Eulalia mackinlayi* mid tussock grassland)
        v. W2c (*Melaleuca viridiflora +/- M. nervosa*, *Grevillea pteridifolia* low open woodland over *Livistona humilis, Pandanus spiralis* mid open to sparse shrubland over *Eriachne* sp., *Aristida* sp. mid tussock grassland)
        vi. W3a (*Corymbia porrecta* (unconfirmed), *Melaleuca nervosa +/- M. viridiflora*, *Grevillea pteridifolia* low open woodland over *Livistona humilis, Acacia* spp. mid open shrubland over *Sorghum* spp. tall tussock grassland).

Level one (highest priority) avoidance restrictions are those areas that meet the NT *Land Clearing Guidelines* (DENR, 2021). Level two (medium) avoidance restrictions are those areas that may not strictly meet the NT *Land Clearing Guidelines* (DENR, 2021) however do exhibit elements of sensitivity or significance as related to the guidelines. As such, these areas should be avoided, where possible.

Maps showing these level 1 and 2 avoidance buffer recommendations are provided in **Appendix I**.

[16] *A 'patch' has been defined as a group of five or more individuals within 50 m.*

8 Proposed Gravel Pit Areas

Based on the results of the surveys, and the subsequent avoidance buffer recommendations in **Section 7**, DIPL reviewed the locations of the proposed gravel pit survey areas. The subsequent 'proposed gravel pit areas' comprise much smaller areas to reduce impacts to biodiversity. These are shown in **Appendices A and I**.

It is important to note that the 'proposed gravel pit areas' are the boundary within which a 1 ha pit will be 'open' at any one time. These have been nominated as areas that have yet to be geotechnically assessed though encompass probable areas of resource extraction. Once the required geotechnical assessments are conducted and the most suitable areas determined, the general process will be that a 1 ha pit is constructed, the required resources extracted and then it will be closed and rehabilitated. Following this, the next pit is chosen and constructed. The 'proposed gravel pit area' is not the total area of clearance, even though it is used as the basis for the impact assessment in this report.

9 Revised Threatened Species Likelihood of Occurrence Assessment

A revised assessment of the likelihood of occurrence of threatened species was conducted. It was based on the data collected and interpreted during the surveys. However, it *addresses only the 'proposed gravel pit areas', 'water points' and 'road realignment areas' which are largely along the Pirlangimpi and Pickertaramoor Roads, except for one proposed gravel pit area at the southern end of the Milikapiti Road*.

The assessment re-considers each species that was originally considered to potentially occur, noting that the lack of detection of a species does not necessarily preclude its presence there. **Table 32** provides the results of the finalised assessment.

This assessment is based on information known at the date of this report and habitat changes over time may lead to changes in the conclusions made herein.

Table 32 Final threatened species likelihood of occurrence assessment within the disturbance footprint[17]

Species	Map number													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Threatened Flora														
Cycas armstongii	✓	✓	✓	✓	✓	U	✓	P	P	✓	P	✓	✓	P
Typhonium jonesii	U	P	U	P	✓	U	U	✓	P	U	✓	✓	✓	U
Typhonium mirabile	U	P	U	P	✓	U	U	P	P	U	U	U	U	U
Threatened Birds														
Masked Owl	P	P	P	P	P	P	P	P	✓	✓	P	P	P	P
Partridge Pigeon	✓	✓	✓	✓	✓	✓	L	✓	✓	L	✓	✓	✓	✓
Red Goshawk	P	P	P	P	P	U	P	P	P	P	P	P	P	P
Threatened Mammals														
Brush-tailed Rabbit-rat	✓	P	P	P	P	U	P	P	P	P	P	P	P	P
Black-footed Tree-rat	✓	✓	P	✓	P	✓	P	✓	P	P	P	P	✓	✓
Brush-tailed Phascogale	P	P	P	P	P	U	P	P	✓	P	P	✓	P	✓
Butler's Dunnart	P	P	P	P	P	U	P	P	P	P	P	P	P	P
Pale Field-rat	U	✓	U	✓	U	✓	U	P	✓	U	P	P	P	U
Northern Brushtail Possum	✓	✓	L	✓	L	U	L	✓	✓	L	✓	✓	✓	✓
Threatened Reptiles														

[17] *The 'disturbance footprint' comprises the 'proposed gravel pit areas', 'water points' and 'road realignment areas'. It does not include the larger 'potential gravel pit survey areas'.*

Species	Map number													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mertens' Water Monitor[18]	U	U	U	U	U	✓	U	U	P	U	P	P	P	U
Yellow-spotted Monitor	U	U	U	U	U	P	U	U	P	U	U	P	P	U

Key: ✓ = presence confirmed during survey, L = presence not confirmed during survey but likely to be present, P = presence not confirmed during survey but is possibly present, at least on occasion (e.g., while dispersing from its former home range), U = presence not confirmed during survey and is unlikely to be present.

[18] *Habitat for Merten's Water Monitors within the survey area comprise 'seasonal' habitat only, that they utilise during the wet season when those areas hold temporary water. During the dry season, individuals are likely to retract back to sources of permanent water.*

10 Final Impact and Risk Assessment

10.1 Considerations

The impact assessment is based on the *disturbance footprint*, which includes the refined 'proposed gravel pit areas' (not the 'potential gravel pit survey areas'), the road realignment area (including a 300 m section of road to be diverted around an identified yellow ochre site) and the water points. However, two water point areas that contain individuals of *Typhonium jonesii* and *T. mirabile* will be modified or re-located to avoid the loss of these individuals. These are in map areas 5 and 12. Advice received from DIPL (D. Browne) states that the water bore at these locations can be placed in a nearby area where no individuals of these species were detected, and water tanks can be installed (rather than a turkey's nest) for water storage. In this regard, the subsequent impact assessment excludes these individuals.

Table 33 shows the number of considerations for each map area required for the assessment of impacts in relation to this disturbance footprint. **Table 34** summarises this according to the disturbance component.

The following interpretations apply:

- The proposed gravel pit area at the south end of the Milikapiti Road (in Map 14) has been included in the calculations. The remainder of Milikapiti Road has not been included in this impact assessment.
- Proposed gravel pit areas and road re-alignment areas have been given a higher priority than water points. Therefore, vegetation community areas that intersect both proposed gravel pit areas and a water point (in the same spot) have been included in the proposed gravel pit area calculation and not the water point. This is to avoid doubling up on areas to be potentially cleared or disturbed.
- Water points along only the Pirlangimpi and Pickertaramoor Roads have been included, whereas any water points along Milikapiti Road have been excluded.

The densities of large trees (diameter at breast height greater than 40 cm) across the survey area were not measured given the large extent of the survey area (1,520 ha) and the anticipated extensive time required to measure and map the trees. Rather, general observations were made in relation to the relative size and density of trees in each part of the survey area, and in conjunction with the threatened fauna survey results, were expected to aid in the subsequent delineation of the refined 'proposed gravel pit areas' and the impact assessment for each species.

Table 33 Maximum amount of vegetation loss (darker blue shading is a significant community, lighter blue is a partially significant community)

Vegetation community code	Vegetation community	Map number														TOTAL (ha)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Proposed gravel pit areas																
E1	*Eucalyptus miniata*, *E. tetrodonta*, *Corymbia nesophila* tall open forest	19.5	13.3	0	24.4	0	0	0	0	0	0	0	8.4	0	5.1	**70.7**
E2	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0	0	13.8	0	0	0	26.8	7.7	0	12.9	0.4	0	0	**61.6**
E3	*Eucalyptus tetrodonta* and *E. miniata* mid sparse to open woodland	0	0	0	0	0	0	0	0	8.1[19]	0	3.1	0	0	0	**11.2**
E4	*Eucalyptus miniata*, *E. tetrodonta* tall open forest	0	0	0	0	0	0	0	0	0.4[20]	0	2.5	5.9	29.3	0	**38.1**
E5	*Corymbia nesophila, Eucalyptus miniata tall open forest*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
E6	*Eucalyptus miniata*, *Corymbia nesophila*, *C. latifolia* mid open forest	9.9	0	0	0	0	0	0	0	0	0	0	0	0	0	**9.9**
E7a	*Corymbia bleeseri*, *C. nesophila* mid woodland	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	**1.5**
W1b	*Grevillea pteridifolia* low isolated tree over *Sorghum* spp. tall closed tussock grassland	0	0	0	0	0	15	0	0	0	0	0	0	0	0	**15**
W2a	*Melaleuca viridiflora* and / or *M. nervosa* low open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W2c	*Melaleuca viridiflora* +/- *M. nervosa*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	**0.5**
W2d	*Grevillea pteridifolia*, *Grevillea heliosperma*, *Planchonia careya* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	**0.2**
W3a	*Corymbia porrecta* (unconfirmed), *Melaleuca nervosa* +/- *M. viridiflora*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	**0.1**
P	Plantation	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	**0.4**

[19] Includes 0.2 ha of clearance for the road diversion at the yellow ochre site.

[20] The road diversion at the yellow ochre site.

Vegetation community code	Vegetation community	Map number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL (ha)
C[21]	Cleared (with no or little revegetation)	4.5	0	0	4.2	0	3.5	0	1.7	4.5	0	0.3	1.2	1.9	3.5	**25.3**
Sub-total		**33.9**	**13.3**	**0**	**42.4**	**0**	**19.1**	**0**	**28.5**	**20.7**	**0**	**18.8**	**15.9**	**32.9**	**9**	**234.5**
Road re-alignment areas																
E1	*Eucalyptus miniata*, *E. tetrodonta*, *Corymbia nesophila* tall open forest	1.9	0	2.8	2.6	0	0	0	0	0	0	0	2.5	0	0	**9.8**
E2	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0	0	0.7	0	1.8	0	4.5	0	0	9.2	0	0	0	**16.2**
E3	*Eucalyptus tetrodonta* and *E. miniata* mid sparse to open woodland	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	**1.4**
E4	*Eucalyptus miniata*, *E. tetrodonta* tall open forest	0	0	0	0	0	0	0	1.1	0	0	0.8	0	0	0	**1.9**
E5	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	**0.6**
E6	*Eucalyptus miniata*, *Corymbia nesophila*, *C. latifolia* mid open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E7a	*Corymbia bleeseri*, *C. nesophila* mid woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W1b	*Grevillea pteridifolia* low isolated tree over *Sorghum* spp. tall closed tussock grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W2a	*Melaleuca viridiflora* and / or *M. nervosa* low open forest	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	**1.1**
W2c	*Melaleuca viridiflora* +/- *M. nervosa*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
W2d	*Grevillea pteridifolia*, *Grevillea heliosperma*, *Planchonia careya* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W3a	*Corymbia porrecta* (unconfirmed), *Melaleuca nervosa* +/- *M. viridiflora*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
P	Plantation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
C_{13}	Cleared (with no or little revegetation)	1.1	0	0.3	0	0	0	0	0.1	0	0	1.2	0.5	0	0	**3.2**
Sub-total		**3**	**0**	**3.1**	**3.3**	**0**	**4.5**	**0**	**5.7**	**0**	**0**	**12.6**	**3**	**0**	**0**	**35.2**
Water points (both existing and proposed)																

[21] Some cleared areas are revegetating and contain isolated or small stands of young trees or shrubs (such as *Melaleuca viridifolia* or *Grevillea pteridifolia*). Importantly, these areas may rapidly revegetate (some already are) and could comprise dense forests within a relatively short amount of time (especially in wetter areas). Such areas could comprise habitat for biodiversity.

Vegetation community code	Vegetation community	Map number														TOTAL (ha)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
E1	*Eucalyptus miniata*, *E. tetrodonta*, *Corymbia nesophila* tall open forest	0	2.8	1.7	1.7	5.7	0	2	0	0	2	0	2.8	0	0	**18.7**
E2	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0	0	0	0	0	0	0.2	2.9	0	0	0	0	0	**3.1**
E3	*Eucalyptus tetrodonta* and *E. miniata* mid sparse to open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E4	*Eucalyptus miniata*, *E. tetrodonta* tall open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E5	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E6	*Eucalyptus miniata*, *Corymbia nesophila*, *C. latifolia* mid open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E7a	*Corymbia bleeseri*, *C. nesophila* mid woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W1b	*Grevillea pteridifolia* low isolated tree over *Sorghum* spp. tall closed tussock grassland	0		0	0	0	0	0	0	0	0	0	0	0	0	**0**
W2a	*Melaleuca viridiflora* and / or *M. nervosa* low open forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W2c	*Melaleuca viridiflora* +/- *M. nervosa*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W2d	*Grevillea pteridifolia*, *Grevillea heliosperma*, *Planchonia careya* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
W3a	*Corymbia porrecta* (unconfirmed), *Melaleuca nervosa* +/- *M. viridiflora*, *Grevillea pteridifolia* low open woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
P	Plantation	0	0	1.1	0	0	0	0	0	0	0	0	2.7	0	0	**3.8**
C_{13}	Cleared (with no or little revegetation)	0	0.4	0.3	0.6	0.6	0	1.3	0	0.3	1.1	0	0.7	0	0	**5.3**
Sub-total		**0**	**3.2**	**3.1**	**2.3**	**6.3**	**0**	**3.3**	**0.2**	**3.2**	**3.1**	**0**	**6.2**	**0**	**0**	**30.9**
TOTAL		**36.9**	**16.5**	**6.2**	**48**	**6.3**	**23.6**	**3.3**	**34.4**	**23.9**	**3.1**	**31.4**	**25.1**	**32.9**	**9**	**300.6**

Table 34 Maximum area of vegetation community clearance per disturbance type (darker blue shading indicates a significant community, lighter blue indicates a partially significant community)

Vegetation community code	Vegetation community	Maximum clearance (ha)			
		Proposed gravel pit area	Road realignment areas	Water points	Total
E1	*Eucalyptus miniata*, *E. tetrodonta*, *Corymbia nesophila* tall open forest	70.7	9.8	18.7	**99.2**
E2	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	61.6	16.2	3.1	**80.9**
E3	*Eucalyptus tetrodonta* and *E. miniata* mid sparse to open woodland	11	1.4	0	**12.4**
E4	*Eucalyptus miniata*, *E. tetrodonta* tall open forest	37.7	1.9	0	**39.6**
E5	*Corymbia nesophila*, *Eucalyptus miniata* tall open forest	0	0.6	0	**0.6**
E6	*Eucalyptus miniata*, *Corymbia nesophila*, *C. latifolia* mid open forest	9.9	0	0	**9.9**
E7a	*Corymbia bleeseri*, *C. nesophila* mid woodland	1.5	0	0	**1.5**
W1b	*Grevillea pteridifolia* low isolated tree over *Sorghum* spp. tall closed tussock grassland	15	0	0	**15**
W2a	*Melaleuca viridiflora* and / or *M. nervosa* low open forest	0	1.1	0	**1.1**
W2c	*Melaleuca viridiflora* +/- *M. nervosa*, *Grevillea pteridifolia* low open woodland	0.5	1	0	**1.5**
W2d	*Grevillea pteridifolia*, *Grevillea heliosperma*, *Planchonia careya* low open woodland	0.2	0	0	**0.2**
W3a	*Corymbia porrecta* (unconfirmed), *Melaleuca nervosa* +/- *M. viridiflora*, *Grevillea pteridifolia* low open woodland	0.1	0	0	**0.1**
P	Plantation	0.4	0	3.8	**4.2**
C	Cleared (with no or little revegetation)	25.3	3.2	5.3	**33.8**
TOTAL		**233.9**	**35.2**	**30.9**	**300.0**

10.2 Threatened Flora

10.2.1 Cycas armstrongii

10.2.1.1 Densities within the Disturbance Footprint

Two map areas within the disturbance footprint contained sections of high-density *C. armstrongii* individuals (map areas 5 and 13[22]), though their distribution was patchy. All other areas either did not contain the species or only in low to moderate densities. Map area 5 consists of two water points only, one of which (PR7) was observed to contain high numbers of cycads. Map area 13 contained a patchy distribution of the species, with some high-density patches observed in the tall *E. miniata* open forests (vegetation community E4). It was observed as being either absent or in very low densities in the *Corymbia bleeseri* open woodlands and tall *C. nesophila* open forests (vegetation communities E7a and E5, respectively).

10.2.1.2 Tiwi Islands Population

As of October 2021, a total of 355 records of *C. armstrongii* exist in the NT Fauna Atlas on the Tiwi Islands. It is reported as being common (e.g., Flora NT, 2013). Woinarski *et al*. (2000) classifies the species as having a lower conservation priority.

10.2.1.1 Assessment of Impacts

Cycas armstrongii is listed as vulnerable under the NT TPWC Act and is not listed under the EPBC Act. To assist in determining the significance of the individuals within the disturbance footprint, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**) in lieu of NT-specific criteria. Threats to the species include land clearing for agriculture and forestry, introduced grasses (including Gamba Grass and Mission Grass) and frequent extensive, intense fires (Kerrigan *et al*., 2006). Whilst cycads were not observed in all locations, potentially suitable habitat (i.e., eucalypt communities) is quantified in **Table 36**.

Table 35 Significant impact assessment for Cycas armstrongii

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population	**Unlikely** The loss of, at most, 247.5 ha of potentially suitable habitat is unlikely to impact the regional population of the species because: ▪ Cycads within the two map areas that were observed to contain higher densities are patchily distributed and therefore the entire extent of that disturbance component is unlikely to contain high density cycads. ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including at the yellow ochre site)) and water source points (12 sites), rather than one large clearance area.
Reduce the area of occupancy of an important population	
Fragment an existing important population into two or more populations	
Adversely affect habitat critical to the survival of a species	
Disrupt the breeding cycle of an important population	

[22] *Those map areas observed to also contain high densities of C. armstrongii along the Milikapiti Road are not included in the 'disturbance footprint'.*

Significant Impact Criteria for 'vulnerable' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time. ▪ High density patches will be avoided (determined through pre-clearance micro-siting surveys as described in **Section 11**).
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** Some areas of the proposed works are located adjacent to existing disturbed areas and are fragmented. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. The importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. It is possible that such weed species could be introduced or spread during earthworks associated with the road upgrades. However, appropriate controls should be able to be implemented to the point where such weeds do not adversely affect the species' habitat.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The relatively small footprint in suitable habitat (in comparison to the 30,000 ha cleared for forestry on the Tiwi Islands) and as such, assuming that standard (and strict) weed management and monitoring measures are implemented, the project is unlikely to interfere with the recovery of the species.

Table 36 Eucalypt communities within the disturbance footprint (green shading indicates map areas where higher densities of cycads were observed)

Disturbance component	Map number														TOTAL (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Proposed gravel pit area	29.4	13.3	-	38.2	-	0	-	26.8	15.6	-	18.5	14.7	30.8	5.1	192.4
Water point	-	2.8	1.7	1.7	5.7	-	2	0	2.9	2	-	2.8	-	2.9	24.5
Road realignment area*	1.9	-	2.8	3.3	-	2.4	-	5.6	-	-	11.5	2.5	-	-	30
Yellow ochre site	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-	0.6
TOTAL	**31.3**	**16.1**	**4.5**	**43.2**	**5.7**	**2.4**	**2**	**32.4**	**19.1**	**2**	**30**	**20**	**30.8**	**8**	**247.5**

10.2.2 Typhonium jonesii

10.2.2.1 Individuals within the Disturbance Footprint

The disturbance footprint comprises 300 ha across the Pirlangimpi and Pickertaramoor Roads, and the southern end of the Milikapiti Road (in Map 14). Across this area, 25 *Typhonium jonesii* individuals were detected (**Table** 37). As discussed in **Section 9**, there may be other individuals that were not detected within the disturbance footprint. However, these are likely to occur infrequently.

As noted in **Section 10.1**, DIPL has subsequently confirmed that the 16 individuals detected within the water point area in map 12 will be avoided and an alternative location will be chosen which does not contain the species. On this basis, the subsequent impact assessment in **Section 10.2.2.4** excludes these individuals.

Table 37 Number of Typhonium jonesii individuals detected within the disturbance footprint

Disturbance component	Map number														TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Proposed gravel pit area	0	0	-	0	-	0	-	2	0	-	0	0	4	0	6
Water point	-	0	0	0	1	-	0	0	0	0	-	16[23]	-	0	17
Road realignment area	0	-	0	0	-	0	-	0	-	-	1	1	-	-	2
TOTAL	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**0**	**1**	**17**	**4**	**0**	**25**

* '-' means that component is not relevant to that map area.

10.2.2.2 Tiwi Islands Population

As of October 2021, a total of 669 *Typhonium jonesii* individuals has been recorded in the NT Flora Atlas. This does not include the 1,212 individuals detected during surveys for this project. The results of this survey increase the entire known population of this species to 1,881 (an increase of 281%).

10.2.2.3 Preliminary Estimation of Revised Extent of Occurrence and Area of Occupancy

Incorporating the new records of *T. jonesii* obtained during this survey to existing data results in an increase in a previously estimated (DENR, 2018) Extent of Occurrence (EoO) by 183 km^2 to 1,937 km^2 and the known Area of Occupancy (AoO) by 44 km^2 to 168 km^2 (42 grid cells) (**Table 38**). **Figure 43** displays the revised EoO and AoO at the standard 2 km by 2 km reference scale (IUCN, 2019). However, DENR (2018a) explains that the actual AoO is highly likely to be less than estimated due to the localised patchy distribution and fragmented nature of *Typhonium* species. Consequently, the actual AoO is likely to be only a fraction of the estimated AoO.

The estimations of EoO and AoO have not been peer reviewed and, as such, should be treated as preliminary.

Table 38 Estimated Extent of Occurrence (EoO) and Area of Occupancy (AoO) comparison from a previous assessment (DENR, 2018a) and the current survey

Disturbance component	EoO (km^2)	AoO (km^2)
Previous estimate (DENR, 2018a)	1,754	124 (31 grid cells)
New estimate	1,937	168 (42 grid cells)

[23] *These 16 individuals will be avoided, as subsequently advised by DIPL.*

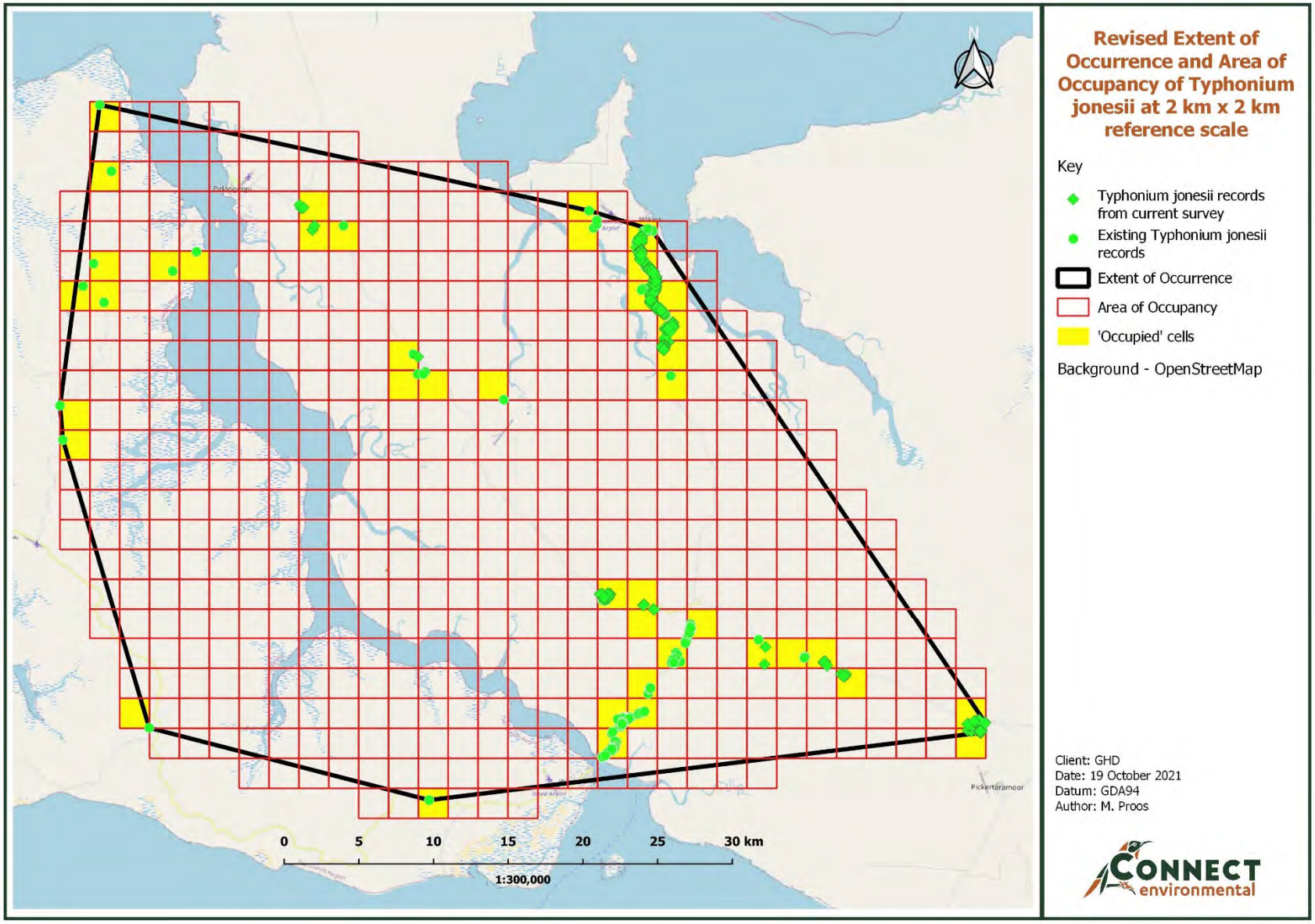


Figure 43 Revised estimated Extent of Occurrence and Area of Occupancy of Typhonium jonesii at 2 km x 2 km reference scale

10.2.2.4 Assessment of Impacts

Excluding the 16 individuals detected within the water point within map area 12 (as DIPL has subsequently confirmed their commitment to avoiding these individuals), a total of nine *T. jonesii* individuals, representing 0.5% of the estimated known global population, will be removed. These nine are scattered throughout the disturbance footprint rather than in a single patch. It is possible that additional individuals were not detected within the disturbance footprint. However, the survey effort was expected to be sufficient to detect patches and probably most individuals and, as such, any undetected individuals are probably infrequent. Conversely, the estimated known global population is highly likely to be an underestimate given that substantial areas of the Tiwi Islands appear to remain unsurveyed. Consequently, the proportion of the actual population of *T. jonesii* to be impacted by the project is likely to be less than 0.5%.

To assist in determining the significance of the individuals within the disturbance footprint, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**).

Table 39 Significant impact assessment for Typhonium jonesii

Significant Impact Criteria for 'endangered' species	Assessment
Lead to a long-term decrease in the size of a population	**Unlikely** Delineation of sub-populations has not been conducted for this species (as part of this project), however it is unlikely that the loss of nine individuals will result in a long-term decrease in the size of the population. These are scattered throughout the disturbance footprint (**Table 37**).
Reduce the area of occupancy of the species	**Unlikely** The revised estimated AoO for this project is 168 km^2 (42 grid cells). The loss of nine individuals will not reduce the AoO.
Fragment an existing population into two or more populations	**Unlikely** The loss of nine individuals represents 0.5% of the estimated known global population. This is likely to be an overestimate given that large areas of potential habitat remain unsurveyed. As such, an existing population is unlikely to be fragmented as a result of the project.
Adversely affect habitat critical to the survival of a species	**Unlikely** The survey effort and results, and subsequent delineation of the proposed gravel pits, demonstrates that the larger and more concentrated patches of the species have been avoided and only areas that did not (or are unlikely to) contain many individuals will be affected. In this regard, habitat critical to the survival of the species is unlikely to be adversely affected.
Disrupt the breeding cycle of a population	**Unlikely** The small number and scattered nature of the individuals to be affected is unlikely to disrupt the overall breeding cycle and success of the associated sub-populations.

Significant Impact Criteria for 'endangered' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** The survey effort and results, and subsequent delineation of the proposed gravel pits, demonstrates that the larger and more concentrated patches of the species have been avoided. This indicates, primarily, that habitat with lower, or no, suitability will mostly be affected. In this regard, the availability and quality of habitat is unlikely to be adversely affected to the extent that the species is likely to decline.
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	**Possible** Grassy weed species known to occur on the Tiwi Islands, such as Gamba Grass and Mission Grass, are a reported key threat to *Typhonium jonesii* (TSSC, 2014). It is possible that such weed species could be introduced or spread during earthworks associated with the road upgrades. However, appropriate controls should be able to be implemented to the point where such weeds do not adversely affect the species' habitat.
Introduce disease that may cause the species to decline	**Unlikely** The author is not aware of any diseases that may cause the species to decline.
Interfere with the recovery of the species	**Unlikely** The survey effort and results, and subsequent delineation of the proposed gravel pits, demonstrates that the larger and more concentrated patches of the species have been avoided. This indicates, primarily, that habitat with lower, or no, suitability will mostly be affected. In addition, the loss of nine individuals represents 0.5% of the estimated known global population. This is likely to be an overestimate given that large areas of potential habitat remain unsurveyed. The relatively small footprint in suitable habitat, the small number of individuals to be lost and assuming that standard (and strict) weed management and monitoring measures are implemented, the project is unlikely to interfere with the recovery of the species.

10.2.3 Typhonium mirabile

10.2.3.1 Individuals within the Disturbance Footprint

The disturbance footprint comprises 300 ha across the Pirlangimpi and Picketaramoor Roads, and the southern end of the Milikapiti Road (in Map 14). Across this footprint, a total of two *Typhonium mirabile* individuals were detected (**Table 40**). Survey effort was considered to be sufficient. As discussed in **Section 9**, there may be other individuals that were not detected within the disturbance footprint. However, these are likely to occur infrequently.

As noted in **Section 10.1**, DIPL has subsequently confirmed that the two individuals detected within the water point area in map 5 will be avoided and an alternative location will be chosen which does not contain the species. On this basis, the subsequent impact assessment in **Section 10.2.3.3** excludes these individuals.

Table 40 Number of Typhonium mirabile individuals detected within the disturbance footprint

Disturbance component	Map number														TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Proposed gravel pit area	0	0	-	0	-	0	-	0	0	-	0	0	0	0	0
Water point	-	0	0	0	2[24]	-	0	0	0	0	-	0	-	0	2
Road realignment area	0	-	0	0	-	0	-	0	-	-	0	0	-	-	0
TOTAL	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**

* '-' means that component is not relevant to that map area.

10.2.3.1 Tiwi Islands Population

As of October 2021, a total of 210 *Typhonium mirabile* individuals has been recorded in the NT Flora Atlas. This does not include the 772 individuals detected during surveys for this project. The results of this survey increase the entire known population of this species to 982 (an increase of 477%).

10.2.3.2 Preliminary Estimation of Revised Extent of Occurrence and Area of Occupancy

Incorporating the new records of *T. mirabile* obtained during this survey to existing data results in an increase in a previously estimated (DENR, 2018) Extent of Occurrence (EoO) by 218 km^2 to 1,435 km^2 and the known Area of Occupancy (AoO) by 24 km^2 to 148 km^2 (37 grid cells) (**Table 38**). **Figure 44** displays the revised EoO and AoO at the standard 2 km by 2 km reference scale (IUCN, 2019). However, DENR (2018a) explains that the actual AoO is highly likely to be less than estimated due to the localised patchy distribution and fragmented nature of *Typhonium* species. Consequently, the actual AoO is likely be only a fraction of the estimated AoO.

The estimations of EoO and AoO have not been peer reviewed and, as such, should be treated as preliminary.

Table 41 Estimated Extent of Occurrence (EoO) and Area of Occupancy (AoO) comparison from a previous assessment (DENR, 2018a) and the current survey

Disturbance component	EoO (km^2)	AoO (km^2)
Previous estimate (DENR, 2018a)	1,217	124 (31 grid cells)
New estimate	1,435	148 (37 grid cells)

[24] *These two individuals will be avoided, as subsequently advised by DIPL.*

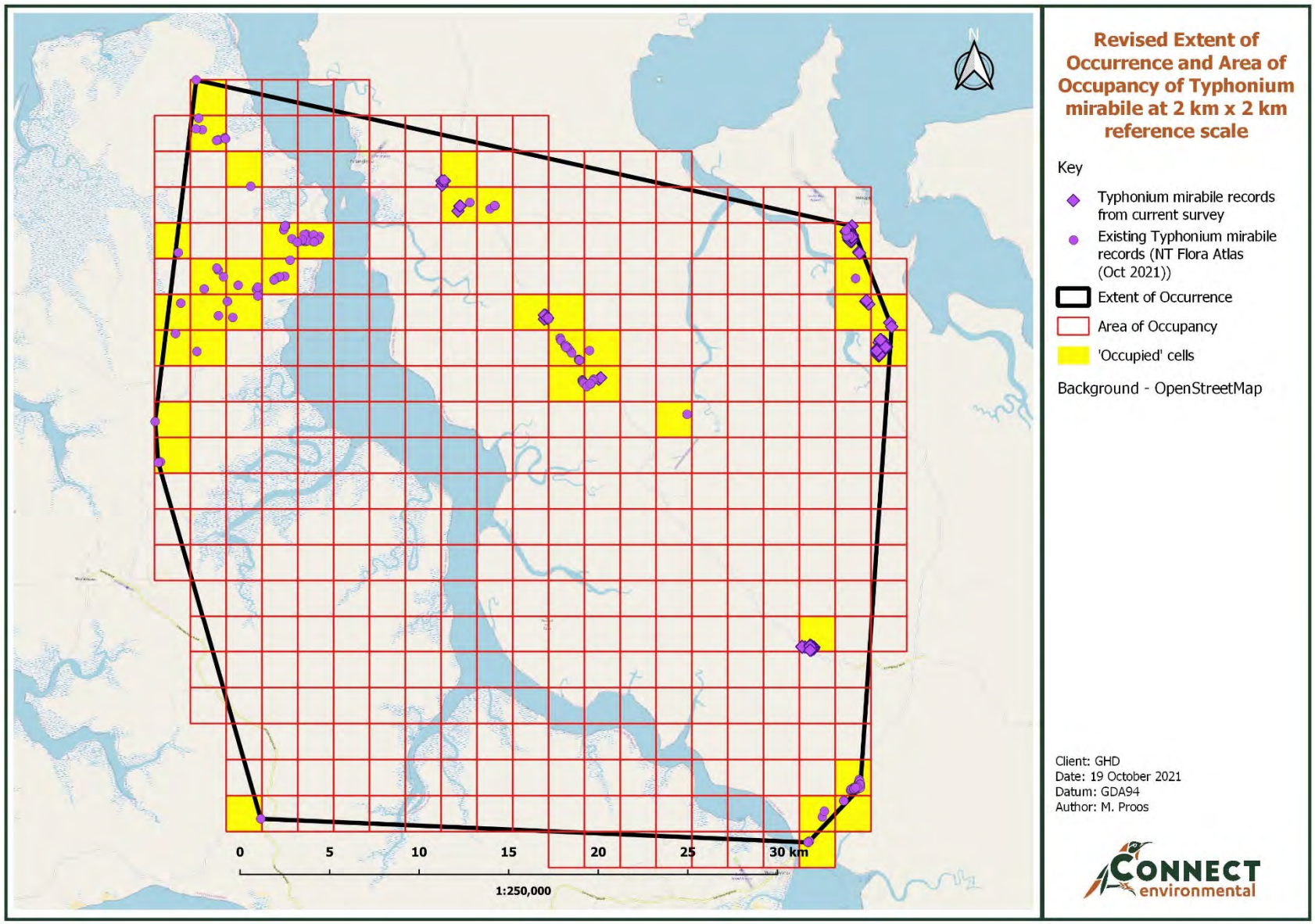


Figure 44 Revised estimated Extent of Occurrence and Area of Occupancy of Typhonium mirabile at 2 km x 2 km reference scale

10.2.3.3 Assessment of Impacts

Excluding the two *T. mirabile* individuals within the water point areas of map area 5 (as DIPL has subsequently confirmed their commitment to avoiding these individuals), no known individuals of the species will be removed. It is possible that additional individuals were not detected within the disturbance footprint. However, the survey effort was expected to be sufficient to detect patches and probably most individuals and, as such, any undetected individuals are probably infrequent. Conversely, the estimated known global population is highly likely to be an underestimate given that substantial areas of the Tiwi Islands appear to remain unsurveyed.

Given that no known individuals of *T. mirabile* are within the disturbance footprint, the project is unlikely to significantly impact *T. mirabile*, though it is important to implement measures to reduce potential indirect impacts such as weed monitoring and control.

10.3 Threatened Fauna

Records of any threatened species should be treated as important, although each record ought to be put into a local and regional context. This has been conducted here using as much relevant information as possible.

10.3.1 Potentially suitable habitat

The extent of potentially suitable habitat for each threatened species within the disturbance footprint has been quantified in **Table 42**. Habitat interpretations for each species is provided in the following sections. It is important to note that these extents <u>are not</u> the areas within which each species was necessarily found. Rather, these extents include apparently suitable habitat where the species was not detected.

Table 42 Areas of potential habitat for threatened fauna within the disturbance footprint

Disturbance component	Map number														TOTAL (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Masked Owl, **Partridge Pigeon**, **Red Goshawk** (foraging habitat only), **Brush-tailed Rabbit-rat**, **Brush-tailed Phascogale**, **Pale Field-rat** (secondary habitat), **Butler's Dunnart**, **Northern Brushtail Possum** – Eucalypt dominated communities (E1 to E7)															
Proposed gravel pit area	29.4	13.3	-	38.2	-	0	-	26.8	15.6	-	18.5	14.7	30.8	5.1	192.4
Water point	-	2.8	1.7	1.7	5.7	-	2	0	2.9	2	-	2.8	-	2.9	24.5
Road realignment area*	1.9	-	2.8	3.3	-	2.4	-	5.6	-	-	11.5	2.5	-	-	30
Yellow ochre site road diversion	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-	0.6
TOTAL	**31.3**	**16.1**	**4.5**	**43.2**	**5.7**	**2.4**	**2**	**32.4**	**19.1**	**2**	**30**	**20**	**30.8**	**8**	**247.5**
Black-footed Tree-rat – Eucalypt dominated communities (E1 to E7) <u>**and**</u> seasonally saturated or inundated (Melaleuca) areas (though not grasslands) (communities W2a, W2b, W2c, W2d, W3a))															

Disturbance component	Map number														TOTAL (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Proposed gravel pit area	29.4	13.3	-	38.2	-	0.6	-	26.8	15.6	-	18.5	14.7	31	5.1	193.2
Water point	-	2.8	1.7	1.7	5.7	-	2	0	2.9	2	-	2.8	-	2.9	24.5
Road realignment area*	1.9	-	2.8	3.3	-	4.5	-	5.6	-	-	11.5	2.5	-	-	32.1
Yellow ochre site road diversion	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-	0.6
TOTAL	**31.3**	**16.1**	**4.5**	**43.2**	**5.7**	**5.1**	**2**	**32.4**	**19.1**	**2**	**30**	**20**	**31**	**8**	**250.4**
Masked Owl (foraging habitat only), **Pale Field-rat** ('primary' habitat), **Merten's Water Monitor** ('seasonal' habitat) – Riparian and seasonally saturated or inundated (Melaleuca) areas (communities W1a, W1b, W2a, W2b, W2c, W2d, W3a).															
Proposed gravel pit area	0	0	-	0	-	15.6	-	0	0	-	0	0	0.2	0	15.8
Water point	-	0	0	0	0		0	0	0	0	-	0	-	0	0
Road realignment area*	0	-	0	0	-	2.1	-	0	-	-	0	0	-	-	2.1
TOTAL	**0**	**0**	**0**	**0**	**0**	**17.7**	**0**	**0**	**0**	**0**	**0**	**0**	**0.2**	**0**	**17.9**

* = these areas are exposed to edge effects and may not constitute ideal habitat for the species.

10.3.2 Species Richness

Threatened fauna species, and cats, detected in each relevant map area (i.e., as per the disturbance footprint) are shown in **Table 43**.

Table 43 Threatened fauna and cats detected in each map area

Species	Map number														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Red Goshawk															1
Partridge Pigeon	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	16
Masked Owl										✓					1
Brush-tailed Rabbit-rat	✓														1
Black-footed Tree-rat	✓	✓		✓		✓		✓					✓	✓	9

Species	Map number														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Brush-tailed Phascogale									✓			✓		✓	3
Pale Field-rat		✓		✓		✓			✓						5
Butler's Dunnart[25]	?	?													
Northern Brushtail Possum	✓	✓		✓				✓	✓		✓	✓	✓	✓	17
Merten's Water Monitor						✓									1
Cat (not included in total numbers in last row)									✓		✓				2
TOTAL*	**5**	**5**	**1**	**4**	**1**	**4**	**0**	**3**	**4**	**1**	**2**	**3**	**3**	**4**	**-**

* Includes suspected Butler's Dunnart records

10.3.3 Red Goshawk

10.3.3.1 Significance of the Individuals Detected

Two Red Goshawks (*Erythrotriorchis radiatus*) were observed in total – one flying over the Map 19 area near Milikapiti and the other near the Milikapiti airport (outside the survey area). There were no other detections, including of nests, during the surveys.

There are 23 previous records in the NT Fauna Atlas of the species on the Tiwi Islands, of which seven are from the last ten years (**Figure 45**). The Atlas of Living Australia contains an additional 16 records from the last ten years (**Figure 45**). These records provide some indication of their distribution on the Tiwi Islands, though is an incomplete picture given the apparent lack of survey effort in large parts of the remainder of the islands. It is understood that Tiwi Plantations Corporation Pty Ltd monitor Red Goshawks as part of the *Variation of conditions attached to approval (reference EPBC 2001/229*; DAWE, 2020), however it is unclear whether the data obtained from this monitoring is contained within the NT Fauna Atlas.

Red Goshawks occur in very low densities and estimations of the population size on the Tiwi Islands range from 100 (Birdlife International, 2016) to 200 (Garnett, *et al*., 2011). Whether this suggests that there are 50 nesting attempts each year is uncertain. The sighting of two Red Goshawks during this survey, of which only one was within the survey area, confirms their presence there, though does not provide substantial additional information in relation to their utilisation of habitats within the survey area.

10.3.3.2 Significance of Potential Impacts

The Red Goshawk is listed as vulnerable under both the EPBC and TPWC Acts. To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken

[25] *Butler's Dunnart presence was suspected via camera footage, though not confirmed.*

(**Table 45**). To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 44**.

Woinarski *et al*. (2003) indicates that 5,725 km^2 of eucalypt forests and woodlands occur on the Tiwi Islands, noting that approximately 30,000 ha (300 km^2) has been cleared for plantation forestry (ABC, 2020). In lieu of sourcing other estimates of potential habitat for Red Goshawks across the Tiwi Islands (noting that Hemal *et al*. (2008; cited in AECOM, 2021) estimate 4,436 km^2 of woodland habitat on Melville Island), a figure of approximately 5,400 km^2 (for the whole extent of the Tiwi Islands).

Given their widespread distribution on the Tiwi Islands, all tall, eucalypt open forests and woodlands within the proposed footprint has been classified as potential foraging habitat (refer to **Table 42**). This quantification has been used for the impact assessment, however it is recommended that pre-clearance surveys be conducted in prior to the commencement of construction and in the same breeding season to determine whether the species has constructed nests within or close to the areas to be cleared. If any nests are found, appropriate avoidance buffers should be placed around the nests. Further information regarding impact mitigation for this species is in **Section 11**.

Defining important populations for the species is listed as a priority in both the *National recovery plan for the red goshawk* (DERM, 2012) and the EPBC Act *Conservation Advice* for the species (TSSC, 2015a). As is understood, this has not been achieved to date. However, the population on the Tiwi Islands is described as a separate subpopulation (Garnett *et al*., 2010) and a stronghold for the species in the NT. It comprises approximately 15% of the total population in Australia (TSSC, 2015a). As such, it appears that the Tiwi Islands are important for the species, at least in the NT.

Table 44 Assessment of habitat critical to the survival of the Red Goshawk

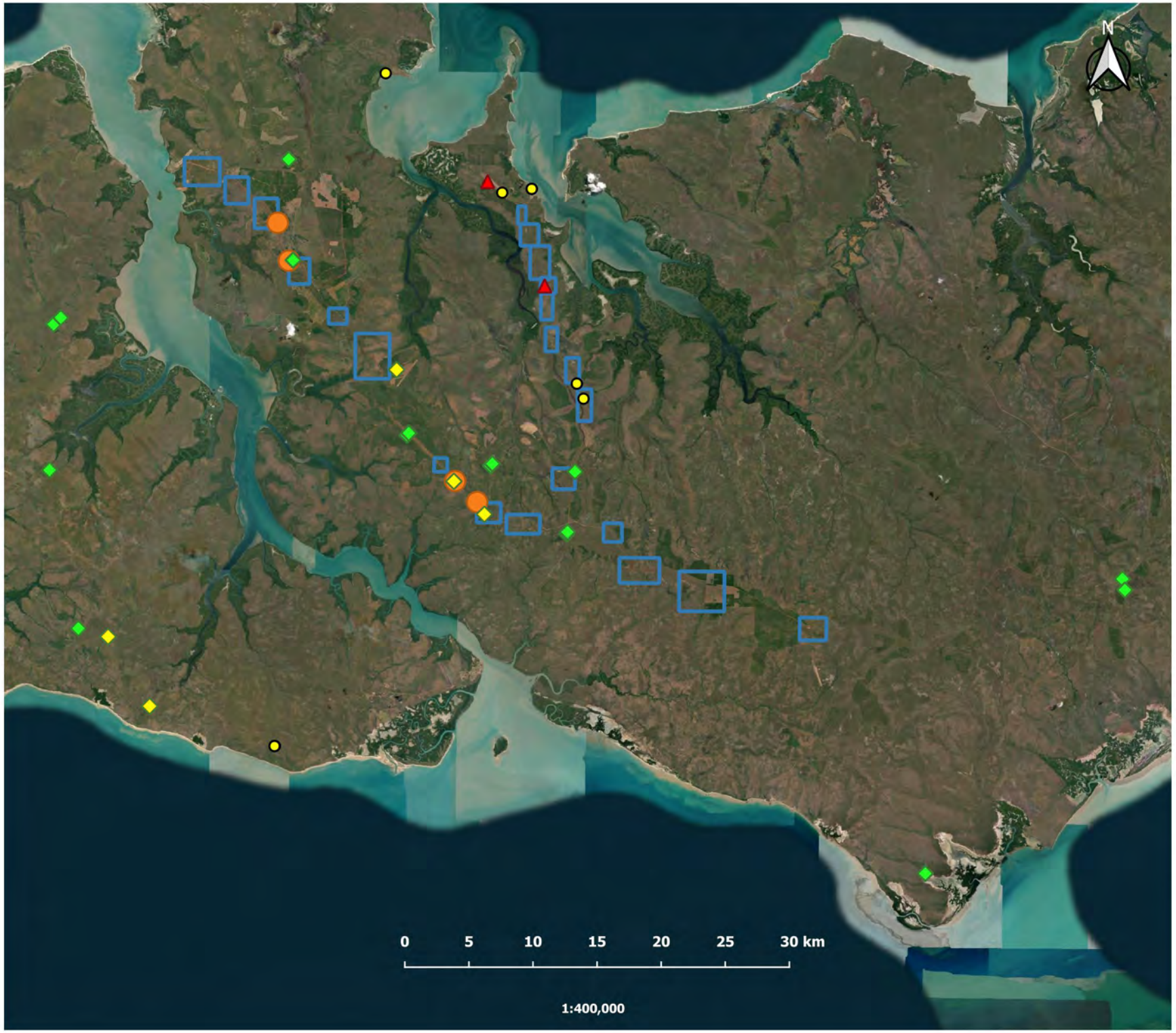
Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** DERM (2012) indicates that habitat critical for the survival of the species must contain suitable resources for nesting, food, water, shelter, essential travel routes, dispersal, and buffer areas. While it is possible that habitats within the disturbance footprint contain some elements of the resources required for the species, the fragmented nature of the disturbance footprints, the staggered approach to constructing pits, and the proximity of the disturbance footprint to existing cleared areas such as roads and old gravel pits suggests that these areas are not critical. Individuals of the species can have a home range of up to 200-290 km^2 (Czechura & Hobson, 2000 cited in TSSC, 2015a; Birdlife International, 2016). Up to 5,400 km^2 of suitable habitat remains on the Tiwi Islands (up to approximately 4,400 km^2 on Melville Island). Based on the distribution and age of the records on the Tiwi Islands, it appears plausible to assume that the species occurs across much of the tall eucalypt forests in the survey area. As such, 247.5 ha comprises 0.05% of all habitat on the Tiwi Islands. To note, whilst no nests were detected during the surveys, the timing of the surveys was not conducive to maximizing detection (i.e., the surveys were conducted prior to the breeding season). Therefore, while it is unclear whether or how often Red Goshawks nest within the
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	

Criteria	Assessment
	survey area, they probably do or have at some point in time. Their nests may be destroyed by fire or strong winds during the wet season.
for the reintroduction of populations or recovery of the species or ecological community	In addition, Woinarski (2006b) estimates that the clearance of around 30,000 ha for the Melville Island forestry operations could reduce the population of Red Goshawks there by 10%. Further, breeding success is reduced if more than 25% of forest within 4 km of a nest is cleare (Baker-Gabb, 2013 cited in Debus & Searle, 2014). Given the fragmented nature of the disturbance footprint, and ample similar habitat types across Melville Island, it appears as though the habitats within the disturbance footprint are unlikely to be necessary for the long-term maintenance of the species, to maintain the species' genetic diversity or for the reintroduction of the population on the Tiwi Islands.

Table 45 Significant impact assessment for the Red Goshawk

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population	**Unlikely** While the species is in decline, it is not suspected to be rapid (Garnett *et al*. 2011 cited in Birdlife International, 2016). Further, nest success has not changed significantly since 2001 (S. Ryan, unpublished, cited in Garnett & Baker (eds), 2021). Woinarski (2006b) indicates that the Melville Island forestry operations (around 30,000 ha) could reduce the population of Red Goshawks there by 10%. In addition, a clearing threshold of 25% of forest within 4 km of a nest has been suggested as causing a reduction in breeding success (Baker-Gabb, 2013 cited in Debus & Searle, 2014). Based on this, it is unlikely that 247.5 ha (at most) of fragmented clearing of potential foraging habitat would lead to a long-term decrease in the size of the Tiwi Islands subpopulation, reduce its area of occupancy or fragment it. It is important to note that: ▪ The disturbance footprint is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time, as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ Up to 5,400 km^2 of potential habitat exists on the Tiwi Islands.
Reduce the area of occupancy of an important population	
Fragment an existing important population into two or more populations	
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
Adversely affect habitat critical to the survival of a species	**Unlikely** As discussed in **Table 44**, it appears unlikely that the area of the disturbance footprint is critical to the survival of the species.

Significant Impact Criteria for 'vulnerable' species	Assessment
Disrupt the breeding cycle of an important population	**Unlikely** While no nests were detected within the disturbance footprint, the survey timing was probably not ideal. However, the species reportedly nests in tall forests within 1 km of, and often beside, permanent water with an average distance of the nest tree to water of 164 m (Aumann & Baker-Gabb, 1991, cited in TSSC, 2015; DAWE, 2021). Regardless of whether the Tiwi Islands sub-population is an 'important' population (as defined in the Australian Government's *Significant Impact Guidelines* (DoE, 2013), it is unlikely that the proposed works will disrupt the breeding cycle of the Tiwi Islands sub-population because of the relatively small loss of habitats (0.05% of that within the Tiwi Islands), staggered clearing, and their fragmented nature (i.e., the loss of 247.5 ha of habitat is spread over 48 separate areas). Further, pre-clearance surveys for nests are recommended within all clearance areas in the lead up to the clearing. In addition, collaboration with PMP is recommended to seek information relating to their Red Goshawk monitoring data.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types (possibly except for areas with large hollow-bearing trees). In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition, fire regimes or intensities, and consequently prey availability, to the detriment of the Red Goshawk. Nevertheless, it is expected that the residual risk of significant incursion is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere substantially with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The TSSC (2015) lists key threats to the species as forestry operations (specifically on the Tiwi Islands), altered fire regimes leading to vegetation thickening and declines in the abundance of key prey species (from a range of factors). The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.



Red Goshawk records on the Tiwi Islands

Key

- This survey (2)
- NT Fauna Atlas (as of July 2021) (23)
- NT Fauna Atlas records - last ten years (7)
- Atlas of Living Australia records - last ten years (16)
- Historic Red Goshawk nests (4)
- Map area

Background - ESRI Satelitte

Figure 45

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.4 Partridge Pigeon

10.3.4.1 Significance of the Individuals Detected

There were 89 detections of Partridge Pigeons during the surveys, including seven on camera and 82 from ecologists' observations. Not all detections were within the survey area – some were detected between sites while driving. These records increase the number of records in the NT Fauna Atlas (180) by 49% to 269. There are 77 records of the species in the last ten years (excluding the records from this survey). The high number of detections is not unexpected given the existing records within the NT Fauna Atlas as well as those indicated anecdotally. The locations of records from this survey and the NT Fauna Atlas are shown in **Figure** 46.

10.3.4.2 Significance of the Potential Impacts

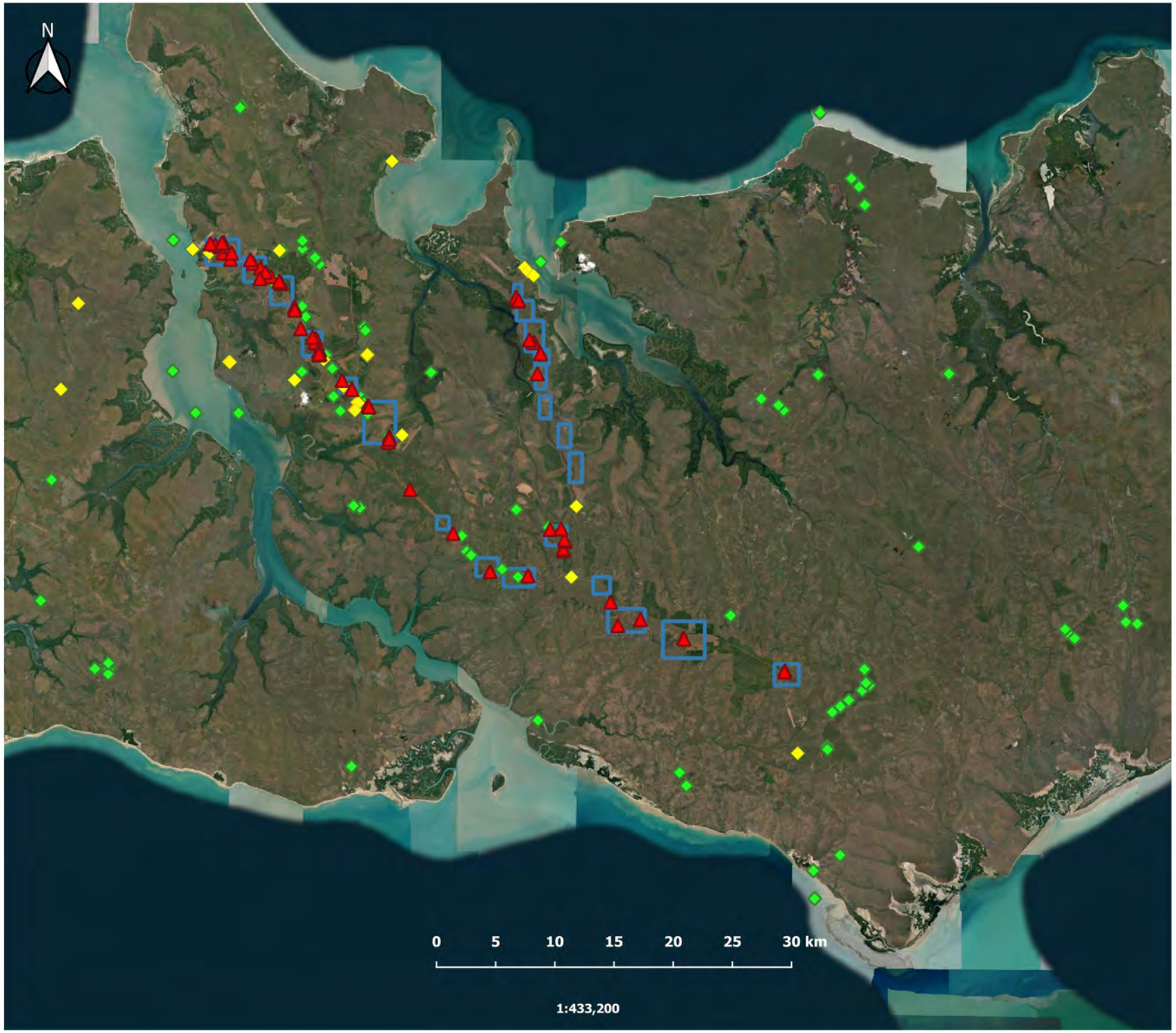
To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 47**). The species is listed as vulnerable under both the EPBC And TPWC Acts. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is provided in **Table 46**.

Table 46 Assessment of habitat critical to the survival of the Partridge Pigeon

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** Given the apparent widespread distribution of the species on the Tiwi Islands, their mobile nature, and the high number of records both during this survey and historically, it appears unlikely that the habitats within the disturbance footprint are critical to the survival of the species regionally. In addition, 34 of the 89 detections of the species during these surveys were along roads (observed while driving), suggesting the species remains abundant (notwithstanding any indication of trends in abundance across its range). Given there are over 4,600 km^2 of potentially suitable habitat on the Tiwi Islands (i.e., eucalypt forests and woodlands dominated by *E. miniata*, *E. tetrodonta* and *Corymbia nesophila*; Woinarski *et al*., 2003), of which large areas appear to be unsurveyed, it is likely that ample habitat exists across the islands, and a substantial population exists. In addition, much of the disturbance footprint is located along existing roads or cleared areas. Portions of these area are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 47 Significant impact assessment for the Partridge Pigeon

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population Reduce the area of occupancy of an important population Fragment an existing important population into two or more populations Adversely affect habitat critical to the survival of a species Disrupt the breeding cycle of an important population Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** The loss of, at most, 247.5 ha of suitable habitat is unlikely to impact the species regionally because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Key threats to the species including altered fire regimes, cats and grassy weeds (such as Gamba Grass) are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ Up to 5,400 km^2 of potential habitat exists on the Tiwi Islands.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition, fire regimes or intensities, and affect food availability to the detriment of the Partridge Pigeon (TSSC, 2015b). Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The TSSC (2015b) lists key threats to the species as altered fire regimes, cats and grassy weeds. The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.



Partridge Pigeon records on the Tiwi Islands

Key

- This survey (89)
- NT Fauna Atlas (as of July 2021) (180)
- NT Fauna Atlas records since 2011 (77)
- Map area

Background - ESRI Satelitte

Figure 46

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.5 Masked Owl

10.3.5.1 Significance of the Individuals Detected

There are 340 records of the species on the Tiwi Islands (second only to the Brushtail Possum out of all the threatened fauna), of which 45 are in the last ten years. The locations of records from this survey and the NT Fauna Atlas are shown in **Figure 47**. The high number and distribution of records on the Tiwi Islands suggests the species is widespread and abundant. Woinarski *et al*. (2003b) described the species as being unusually common. As such, it is expected that, while the three detections from this survey confirm their presence in those locations, these records are probably not particularly significant.

10.3.5.2 Significance of the Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 47**). The species is listed as endangered under both the EPBC and TPWC Acts. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 48**.

Table 48 Assessment of habitat critical to the survival of the Masked Owl

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** Given the apparent widespread distribution of the species and the available habitat across the Tiwi Islands, it appears unlikely that the habitats within the disturbance footprint are necessary for activities such as foraging, breeding, roosting or dispersal. The disturbance footprint is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites) which comprise 0.3-5.8% of a theoretical home range area (750 ha) in any one map area (refer to **Table 50**). This is explained further in **Table 49**. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition. In addition, given that Woinarski and Ward (2012) estimated that there may have been a 5% population decline of the species on the Tiwi Islands because of the loss of 260 km^2 (26,000 ha) of suitable habitat for plantation forestry, it is plausible to suggest that the loss of only about 0.9% (247.5 ha) of that amount probably won't affect the species. As such, the disturbance footprint probably isn't critical to the survival of the species.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 49 Significant impact assessment for the Masked Owl

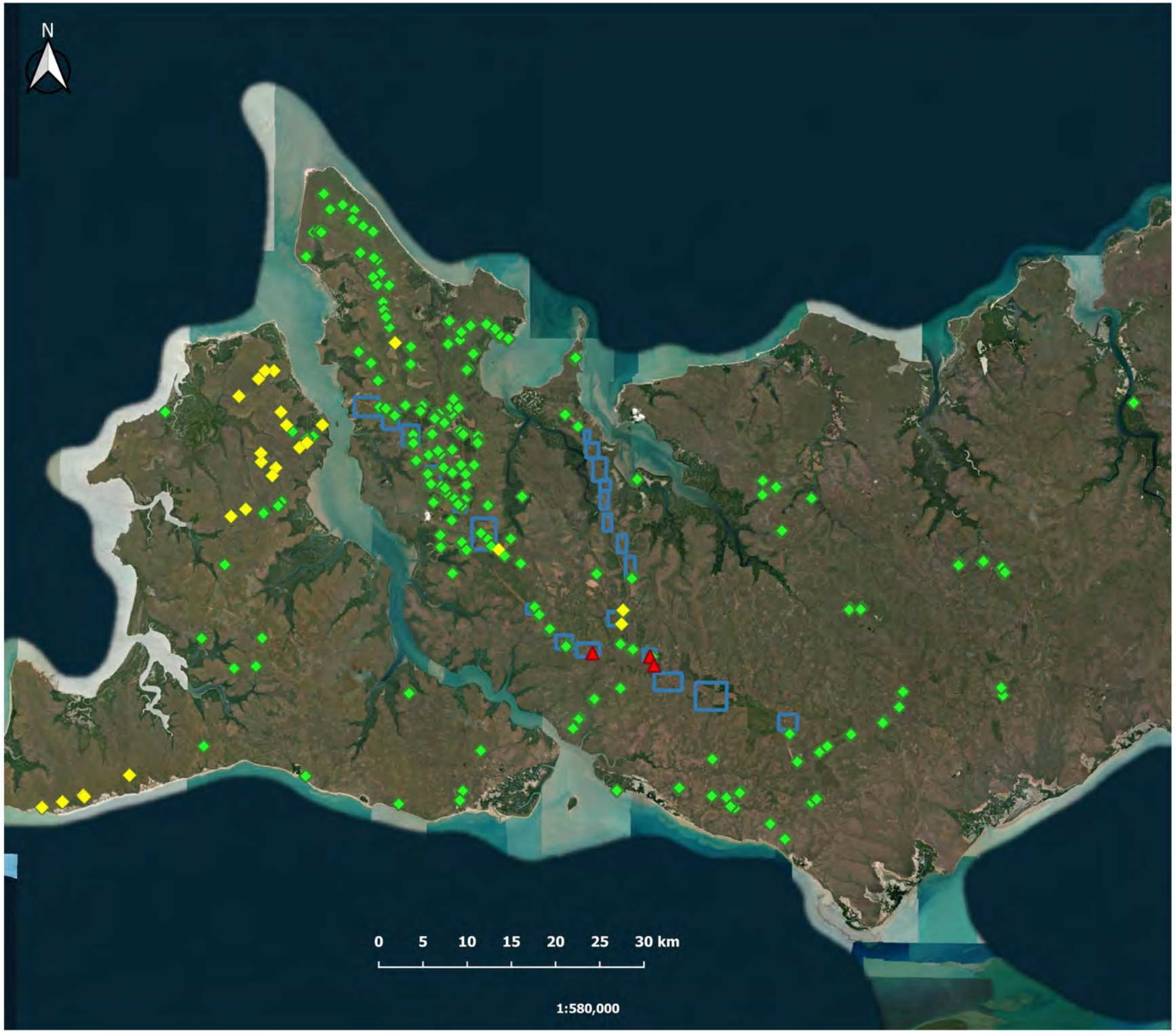
Significant Impact Criteria for 'endangered' species	Assessment
Lead to a long-term decrease in the size of a population	**Unlikely** The loss of, at most, 247.5 ha of potentially suitable habitat, and 17.9 ha of additional foraging habitat, is unlikely to lead to a long-term decrease in the size of a population, fragment an existing population into two or more populations, impact the availability or quality of habitat to the extent that the species is likely to decline or reduce the area of occupancy of the population on the Tiwi Islands because: ▪ The maximum proportion of a theoretical home range of a breeding pair of Masked Owls that will be impacted by the proposed works is 5.8% (in map 4; refer to **Table 50**). In other words, approximately 14 breeding pairs will lose between 0.3 and 5.8% of their available foraging habitat. This was calculated using an average home range of 750 ha based on estimates between 500-1000 ha[26] for other Masked Owl subspecies (Kavanagh & Murray, 1996; cited in Woinarski & Ward, 2012a). A visual representation of this is shown in **Figure 48**. This is oversimplified as there is likely to be overlap and variation in the extents of home ranges, however it gives some indication of the scale of impact in relation to loss of habitat in any one area. ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Woinarski and Ward (2012) estimate that there may have been a 5% population decline of the species on the Tiwi Islands because of the loss of 260 km^2 (26,000 ha) of suitable habitat for plantation forestry. The impacts from the maximum loss of vegetation for the current project (about 0.9% of 26,000 ha) is likely to be negligible in comparison. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ Over 4,600 km^2 of potential habitat exists on the Tiwi Islands.
Fragment an existing population into two or more populations	
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
Reduce the area of occupancy of a population	
Adversely affect habitat critical to the survival of a species	As discussed in **Table 48**, the disturbance footprint does not appear to be critical to the survival of the species.

[26] *Debus (2009) provides estimated home ranges of 400-1,500 ha.*

Significant Impact Criteria for 'endangered' species	Assessment
Disrupt the breeding cycle of a population	The breeding period of the mainland subspecies is from February to October, though commonly from March to July (Debus, 2009). This corresponds with the dry season and the most appropriate period to conduct earthworks required for the project. As such, it is expected that some breeding pairs may be disrupted while laying. Further, any nests within areas to be cleared would be destroyed unless the recommended protective measures are applied. These include pre-clearance surveys to ensure that no Masked Owl have nested within trees marked to be cleared. This is discussed further in **Section 11**. However, impacts to the breeding cycle from the proposed works are likely to be relatively small and localised and not significantly affect the regional population because: ▪ The disturbance footprint is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites). ▪ In any one map area, between 0.3% and 5.8% of a theoretical home range (750 ha) would be removed (refer to **Table 50**). ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season.
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not substantially impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition, fire regimes or intensities, and affect prey availability to the detriment of the Masked Owl (TSSC, 2015d). Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. Woinarski and Ward (2012) and the TSSC (2015d) lists key threats to the species as the loss of habitat from forestry plantations, invasive weeds, altered fire regimes and cats. The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.

Table 50 Maximum percentages of a theoretical home range size of 750 ha placed over each 'map area' in the disturbance footprint

	Map number														TOTAL (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Area of eucalypt dominated communities	31.3	16.1	4.5	43.2	5.7	2.4	2	32.4	19.1	2	30	20	30.8	8	247.5
% of 750 ha	4.2	2.1	0.6	5.8	0.8	0.3	0.3	4.3	2.5	0.3	4.0	2.7	4.1	1.1	N/A



Masked Owl records on the Tiwi Islands

Key

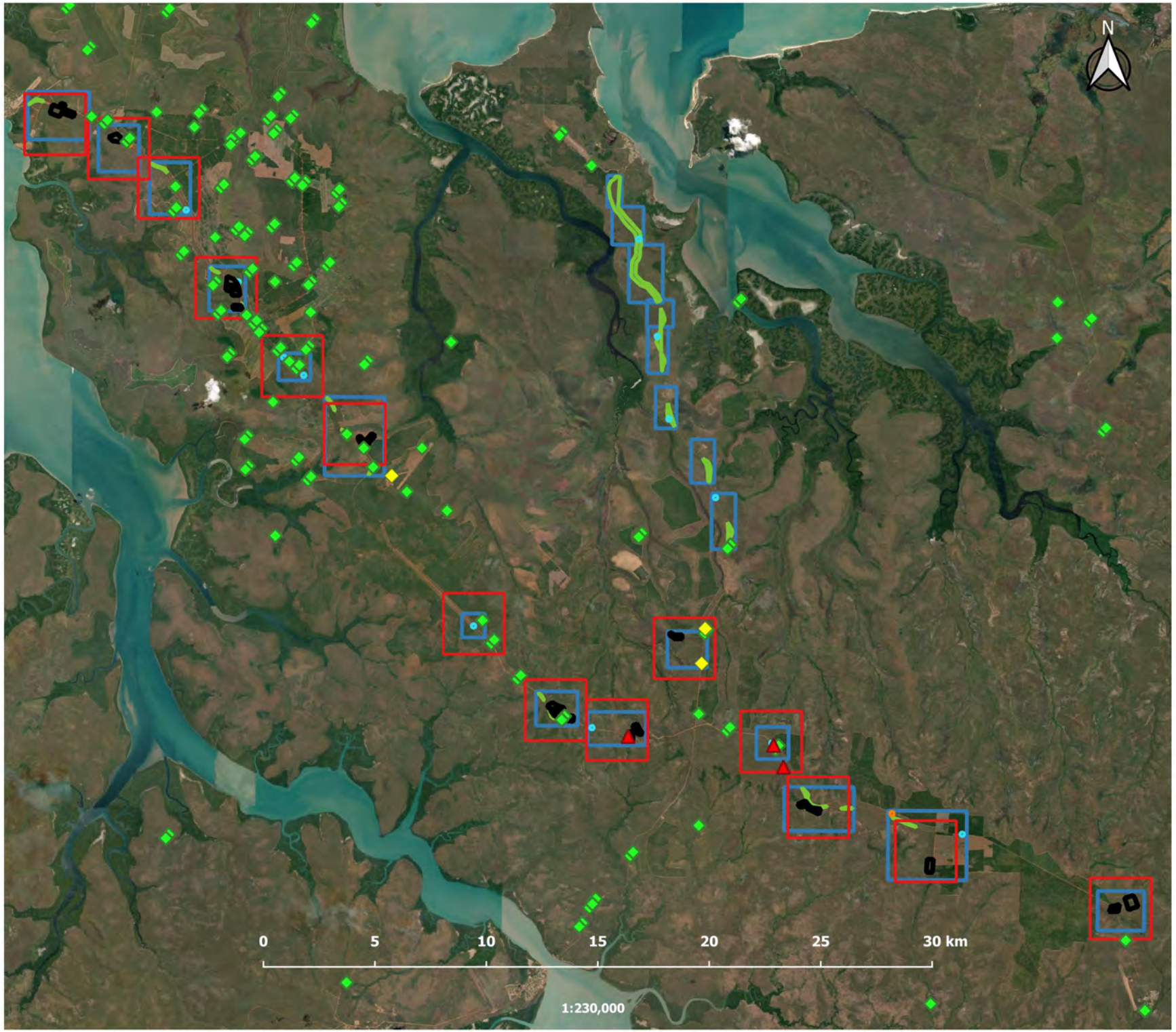
- This survey (3)
- NT Fauna Atlas (as of July 2021) (340)
- NT Fauna Atlas records since 2011 (45)
- Map area

Background - ESRI Satelitte

Figure 47

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental



Masked Owl records and theoretical home ranges in relation to map areas

Key

- This survey (3)
- NT Fauna Atlas (as of July 2021) (340)
- NT Fauna Atlas records - last ten years (45)
- A 750 ha area
- Map area
- Existing bores 100 m buffer
- Water points (proposed) 100 m buffer
- Proposed gravel pit area
- Road realignment

Background - ESRI Satelitte

Figure 48

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.6 Brush-tailed Rabbit-rat

10.3.6.1 Significance of the Individuals Detected

The Brush-tailed Rabbit-rat was detected by three cameras, all in Map 1 (the survey area closest to Pirlangimpi; refer to **Figure 49**), from a total of 100 camera sites (3,195 camera nights). Twelve of these were deployed in the Map 1 area. While there are some notable limitations in drawing conclusions from that data alone, as described below, this suggests that their distribution is patchy. Despite the high number of records on the Tiwi Islands in the NT Fauna Atlas, no records exist in the vicinity of the Milikapiti or Pickertaramoor Roads, which presumably would also have been surveyed in relevant areas prior to clearing for the forestry plantations. Given this, it was recommended in **Section 7** that avoidance buffers of 200 m be placed around the three detections made during these surveys.

Studies conducted by Davies *et al*. (2018) demonstrate that the species now only occurs in areas where cats generally don't exist, and a dense shrub layer exists. Further, a decrease of 64% in trap success for the species was observed between trapping conducted in 2000-2002 and 2015 (Davies *et al*., 2018). Whilst data from the current study is not able to be used to draw any such conclusions (e.g., cats were not detected at 95% of the camera sites and shrub density was not measured), the reported severity of declines may provide some indication of the paucity of detections during the current survey.

Nevertheless, when analysing the number of records, of the 325 recorded in the NT Fauna Atlas on the Tiwi Islands, 229 (70%) are from within the last ten years (**Figure 49**). This appears to indicate that the species remains relatively abundant in some areas (notwithstanding its reported decline). Further, the Tiwi Islands are reported to be a critical refuge for small mammals with healthy and widespread (though declining) populations (Davies *et al.* (2018a), Davies *et al*. (2020), Davies *et al*. (2021) and Stobo-Wilson *et al*. (2020)).

The paucity of detections in other areas may be related to:

- Those habitats not providing the required resources for the species.
- Known threats to the species are implicated in the species' decline to the point where those areas can no longer support the species.

However, the lack of detection across most of the survey area, particularly in areas where it has been recently (i.e., last ten years) detected nearby, does not mean the species doesn't occupy those areas. Reasons associated with survey effort or timing may be implicated in the lack of records in other areas. As such, apparently suitable habitat has been recognised regardless of recent detections (or lack thereof). **Table 42** provides a breakdown of the area of potentially suitable habitat across the disturbance footprint.

10.3.6.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**). Whilst the species is listed as Vulnerable under the EPBC Act, the significant impact assessment has been conducted in relation to its 'endangered' status under the NT TPWC Act. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table** 51.

Table 51 Assessment of habitat critical to the survival of the Brush-tailed Rabbit-rat

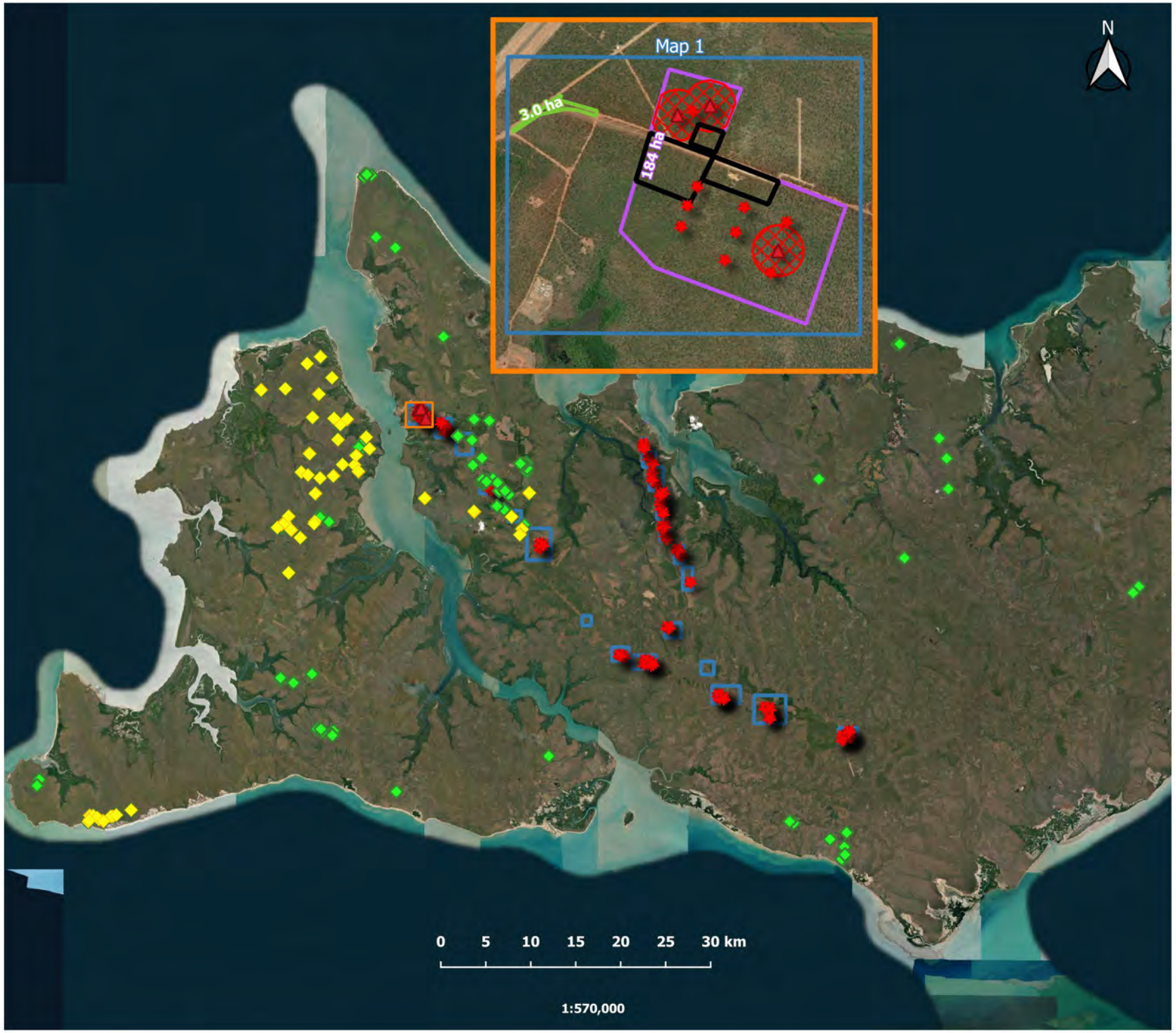
Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** Whilst the species was detected on only three cameras from a total of 100 camera sites, there are 229 other records of the species on the Tiwi Islands in the last ten years, suggesting that the species remains relatively abundant in some areas. The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. In areas where it was not detected during these surveys, and there are no historic records (refer to **Figure 49**), it may be appropriate to assume that there is a low likelihood of occurrence of the species in those areas. This comprises the area from map 7 to map 13 (and the Milikapiti Road, though that area is not included in this impact assessment). In addition, much of the disturbance footprint is located along existing roads or cleared areas. Portions of these area are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 52 Significant impact assessment for the Brush-tailed Rabbit-rat

Significant Impact Criteria for 'endangered' species	Assessment
Lead to a long-term decrease in the size of a population	**Unlikely** The locations of the three detections of the species during these surveys have each been recommended avoidance buffers of 200 m. Given that the reported home range of the species is 0.79 to 0.97 ha (Firth *et al*., 2006), a 200 m buffer (i.e., an area of 12.6 ha) is likely to sufficiently protect habitat resources within an appropriate distance from the detection site. In relation to the area of habitat to be impacted, the loss of, at most, 247.5 ha of potentially suitable habitat is unlikely to lead to a long-term decrease in the size of a population, reduce the area of occupancy of a population or fragment an existing population into two or more populations because:
Reduce the area of occupancy of a population	
Fragment an existing population into two or more populations	

Significant Impact Criteria for 'endangered' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	▪ The likelihood of the species occurring across the area from map 7 to 13 (and Milikapiti Road) appears low. ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season.
Adversely affect habitat critical to the survival of a species	**Unlikely** As discussed in **Table 51**, habitat within the disturbance footprint is unlikely to be critical to the survival of the species because: ▪ Avoidance buffers have been placed on sites where the species was detected. ▪ There are 229 records of the species within the last 10 years, suggesting the species remains locally abundant. ▪ It appears less likely to occupy the parts of the survey area from maps 7 to 13, based on the lack of detection during this survey and historically. ▪ The composition of the disturbance footprint is fragmented and located along existing tracks and previously cleared sites. Consequently, these areas are subjected to 'edge' effects.
Disrupt the breeding cycle of a population	**Unlikely** Brush-tailed Rabbit-rats breed from March to October (Kemper and Firth, 2008 cited in TSSC, 2008). This corresponds with the late wet season and dry season, the latter of which is the most appropriate period to conduct the earthworks required for the project. As such, any individuals within areas to be cleared would be disturbed. To alleviate this, avoidance buffers have been applied around any detections made during these surveys. These are discussed further in **Section 7**. In other areas where it was not detected during these surveys yet there are historic records (i.e., from the area of maps 2-5), impacts to the breeding cycle of those individuals from the proposed works are likely to be relatively small and localised because: ▪ The disturbance footprint is comprised of multiple smaller areas. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season. Throughout the remainder of the disturbance footprint (from maps 7-13), there appears to be a low likelihood of the species' occurrence, based on the lack of current or historic records. Overall, it is expected that the proposed works will not substantially affect the breeding cycle of any sub-populations of the species on the Tiwi Islands.

Significant Impact Criteria for 'endangered' species	Assessment
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types (with the possible exception of are with large hollow-bearing trees). In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of the Brush-tailed Rabbit-rat. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The TSSC (2016) lists key threats to the species as high frequency of extensive and intense fires, habitat loss (apparently from clearing for plantations on Tiwi Islands, manganese mining on Groote Eylandt), predation by feral cats, competition with introduced rodents, weeds and grazing by introduced herbivores (TSSC, 2016). The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.



Brush-tailed Rabbit-rat records on the Tiwi Islands

Key

- This survey (3)
- NT Fauna Atlas (as of July 2021) (325)
- NT Fauna Atlas records - last ten years (229)
- Map area
- Proposed gravel pit area
- Potential gravel pit survey areas
- Road realignment
- Existing bores 100 m buffer
- Water points (proposed) 100 m buffer
- Recommended avoidance buffer
- Camera locations

Background - ESRI Satelitte

Figure 49

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.7 Black-footed Tree-rat

10.3.7.1 Significance of the Individuals Detected

Black-footed Tree-rats were detected on 23 cameras across nine map areas (of 18 that contained cameras; **Figure 50**). This increases the current number of records on the Tiwi Islands in the NT Fauna Atlas (159) by 15% to 183 records. Fifty-nine of these were in the last ten years (**Figure** 50). Woinarski *et al*. (2012) indicate that the population has declined on the Tiwi Islands due to land clearing with Davies *et al*. (2018) noting a 63% decline in trap-success for this species from 2000 to 2015. The species was not detected in nine map areas where cameras were placed (i.e., maps 9, 11, 12, 15-20) and therefore their presence in those locations cannot be confirmed.

The results from the current survey may align with reported trends for this species (Davies *et al*., 2018) with the species not being detected along much of the Milikapiti Road where previous records exist. It was also not detected in map areas 11 and 12 from 18 cameras (though no previous records exist in that area). However, there appears to be nothing obvious to suggest that the individuals detected are part of an 'important' population (as defined in the Australian Government's *Significant Impact Guidelines* (DoE, 2013)).

In locations that the species was not detected, the length of camera deployment (four weeks) should have been sufficient to detect individuals if they occupied those areas. From the author's experience with this species (mostly on the NT mainland), its first detection at a site has never been after the third week, with most detections occurring in the first week. This aligns with Einoder *et al*. (2019) who state that the species has a high detectability.

Overall, the results indicate that the species generally remains widespread across the area surveyed (with some gaps).

10.3.7.1 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**). The species is listed as vulnerable under both the EPBC And TPWC Acts. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 52**.

The species home range is reported to be approximately 27 ha (± 8.4 ha) in fragmented habitats and 67 ha (± 10.4 ha) in unfragmented habitats (Rankmore, 2006 cited in EcOz, 2017). Using this as a guide, a theoretical home range area of 67 ha was placed over all records from this survey to determine the likely maximum percentage of home range that would be affected from the loss of habitats within the development footprint. The estimations are shown in **Table 55**. While this is a simplified approach as it assumes home ranges are all equal and does not account for overlapping home ranges, it does provide an indication of the anticipated maximum impact in an average-sized home range at that location.

It is important to note that the 'proposed gravel pit areas' are the boundary within which a 1 ha pit will be 'open' at any one time (i.e., 1 ha pits are constructed, the required resources extracted and then closed / rehabilitated, after which time the next pit is constructed). It is not the total area of clearance. However, for the purpose of this assessment, this total area is used. As such, the figures presented in **Table 55** are much higher than is realistic.

Overall, while the proposed road upgrades will affect those individual Black-footed Tree-rats that occupy the nominated clearance areas, they are unlikely to significantly impact the population of Black-footed Tree-rats on Melville Island (noting that the species has not been detected on Bathurst Island).

Table 53 Assessment of habitat critical to the survival of the Black-footed Tree-rat

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** Black-footed tree-rats were detected in nine map areas (out of 18 that contained cameras) (refer to **Figure 50**), and in addition to the records in the last ten years (in the NT Fauna Atlas), indicates the species remains present across much of the survey area. The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. The species is known to tolerate low levels of disturbance (DEPWS, 2021a) and given that much of the disturbance footprint is located along existing roads or cleared areas, the habitats in those areas (noting that pits will be a maximum 1 ha at any one time) are unlikely to be critical to the survival of the species regionally.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 54 Significant impact assessment for the Black-footed Tree-rat

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population	**Unlikely** The loss of, at most, 249.8 ha of suitable habitat (see **Table 42**) is unlikely to substantially affect the Tiwi Islands population because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Key threats to the species (TSSC, 2015c) including habitat loss and fragmentation (because of the extensive clearing to date on Melville Island), altered fire regimes, grassy weeds (such as Gamba Grass), cats and introduced large feral herbivores are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. ▪ The Tiwi Islands is reported to be a critical refuge for small mammals with healthy and widespread (though declining) populations (Davies *et al.* (2018a), Davies *et al*. (2020), Davies *et al*. (2021) and Stobo-Wilson *et al*. (2020)) and it is
Reduce the area of occupancy of an important population	
Fragment an existing important population into two or more populations	
Adversely affect habitat critical to the survival of a species	

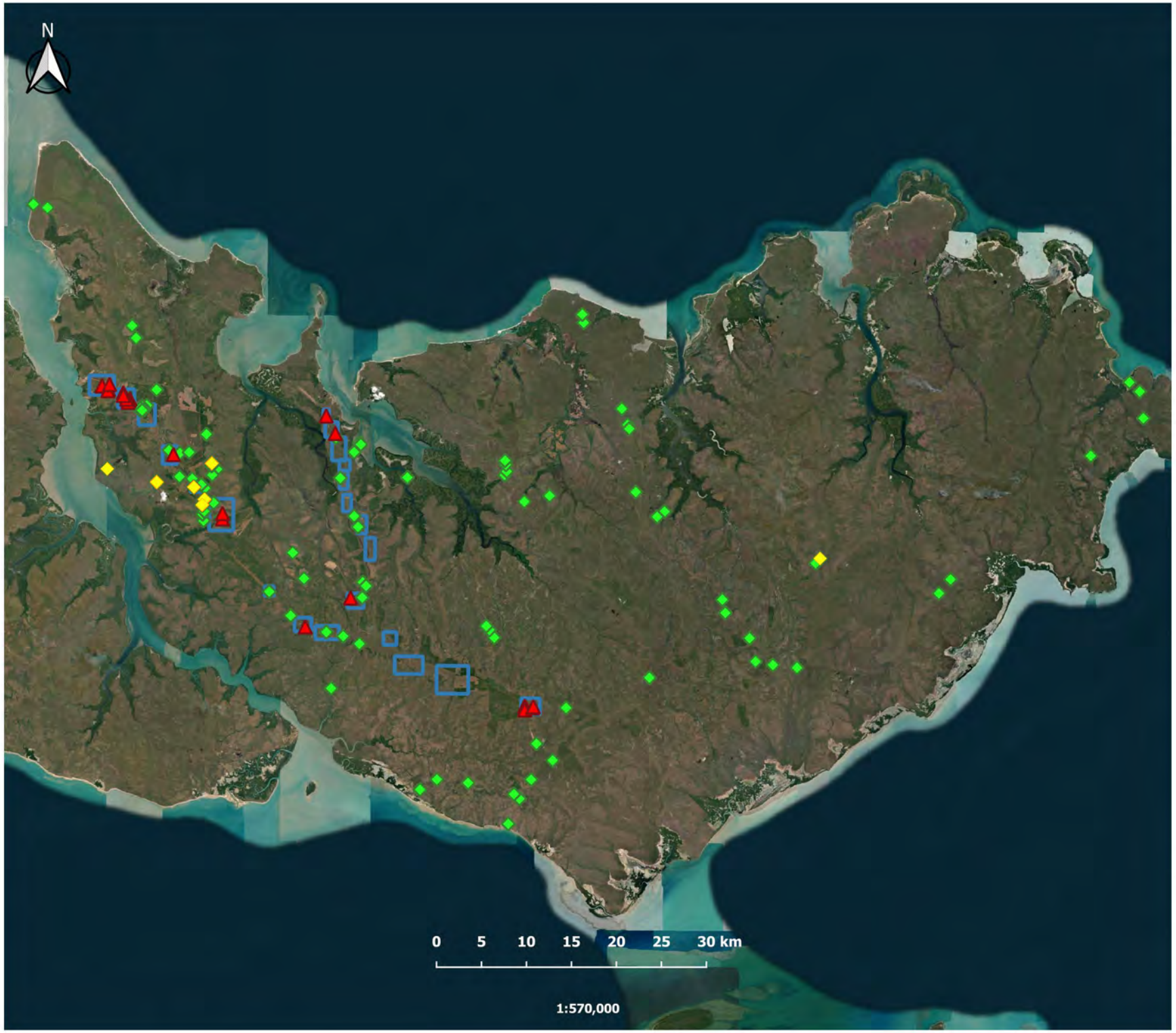
Significant Impact Criteria for 'vulnerable' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	not expected that the relatively small footprint for this project will substantially affect that. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here.
Disrupt the breeding cycle of an important population	**Unlikely** Given the fragmented nature of the disturbance footprint and the small clearance areas, it appears unlikely that the breeding cycle of an important population would be disrupted. Black-footed Tree-rats mostly breed in the mid to late dry season (Friend, 1987; Rankmore, 2006, cited in TSSC, 2015c). This corresponds with the most appropriate period to conduct the earthworks required for the project. As such, any individuals within areas to be cleared would be disturbed. However, impacts to the breeding cycle of those individuals from the proposed works are likely to be relatively small and localised because: ▪ The disturbance footprint is comprised of multiple smaller areas. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season. Overall, it is expected that the proposed works will not substantially affect the Melville Island population.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of the Black-footed Tree-rat. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.

Significant Impact Criteria for 'vulnerable' species	Assessment
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The TSSC (2015c) lists key threats to the species as habitat loss and fragmentation (because of the extensive clearing to date on Melville Island), altered fire regimes, grassy weeds (such as Gamba Grass), cats and introduced large feral herbivores. The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.

Table 55 Maximum percentage to be cleared of theoretical non-overlapping 67 ha home ranges for detections in each map area

Map	1	1	2	2	4	8	13	13	14
BFTR detections used for home range analysis	1	2	1	2	1	1	1	2	1
Home range area	67	67	67	67	67	67	67	67	67
Maximum area to be cleared within 67 ha[27]	20.8	5.7	13.2	3.1	35.3	19.9	6	10.9	8.8
% of theoretical home range	31.0	8.5	19.7	4.6	52.7	29.7	9.0	16.3	13.1

[27] *67 ha circle has been centred on the location of the detection*



Black-footed Tree-rat records on the Tiwi Islands

Key

- This survey (24)
- NT Fauna Atlas (as of July 2021) (159)
- NT Fauna Atlas records since 2011 (59)
- Map area

Background - ESRI Satelitte

Figure 50

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.8 Brush-tailed Phascogale

10.3.8.1 Significance of the Individuals Detected

The species was detected by four cameras in three map areas (9, 12 and 14). The distance from the detections in maps 12 to those in maps 9 and 14 (both about the same distance away) is approximately 14 km, and from map 9 to map 14 is 4.6 km. The NT Fauna Atlas (as of July 2021) contains six records of the species on the Tiwi Islands, all from 2007 and prior (refer to **Figure 51**). In addition to these records, three other studies have been identified that have detected the species, yet these records do not appear in the NT Fauna Atlas (as of the date of this report):

- A survey from June 2018 to May 2019 at Taracumbi on Melville Island (Geyle, *et al*., 2020), in which there were 16 detections at Taracumbi (see locations in **Figure 51**).
- A two-year camera survey from 2013 to 2015 to test the importance of pyro-diversity for native mammals on Melville Island (Davies et al. 2018b), in which there were nine detections at Taracumbi (exact locations unknown).
- A live trapping program in 2019 across four sites (two on Bathurst Island and two on Melville Island) (Davies *et al*., 2021), which captured the species on one occasion at Cache Point in the central north of Melville Island.

At the NT-wide scale, according to the NT Fauna Atlas, these records increase the total number by 4.7% to 89 records. Of note, all except one are from 2009 and prior (there is one record from 2018). Woinarski *et al*. (2014) indicate that the species experienced a >30% decline over ten years.

However, the species is difficult to detect using traditional survey methods (i.e., physical trapping) hence the low number of records may be somewhat expected. During the 2000's, less than ten individuals were recorded from over 350,000 trap nights (Woinarski & Ward, 2012). Based on this, and the results of this survey, it appears that the method utilised for this survey to detect Brush-tailed Phascogales (ground-based cameras) may be more suitable than traditional methods. However, the detectability of the species using the methods employed for this project (i.e., ground-based cameras) compared with tree-mounted cameras is uncertain. Given that another phascogale species (*P. tapoatafa*) is estimated to remain arboreal up to 90% of the time (Traill and Coates, 1993 and Scarff *et al*., 1998 cited in Geyle *et al*., 2020). Geyle *et al*. (2020) also indicates that timing is important.

Therefore, the lack of detection across most of the survey area, particularly in areas where it has been recently (i.e., last ten years) detected nearby, does not mean the species doesn't occupy those areas. As such, apparently suitable habitat has been recognised regardless of recent detections (or lack thereof). **Table 42** provides a breakdown of the area of potentially suitable habitat across the survey area.

10.3.8.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**). Whilst the species is listed as vulnerable under the EPBC Act, the significant impact assessment has been conducted in relation to its 'endangered' status under the NT TPWC Act. To inform the assessment, a discussion of 'habitat critical to the survival of the species' is also provided in **Table 52**.

Table 56 Assessment of habitat critical to the survival of the Brush-tailed Phascogale

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Possible** Whilst there are very few records on the Tiwi Islands (and mainland NT), it is suggested that traditional survey techniques (i.e., physical trapping) are not suitable for reliably detecting the species (Geyle *et al*., 2020). Consequently, estimating distribution and population trends for this species is difficult. However, given there are 20 records around the Three Ways and Taracumbi areas over the last three years (16 from the Geyle *et al*. (2020) study and four from this survey), their persistence is at least confirmed in that area. If the number and distribution of records is considered in isolation from the suitability of survey methods used in the past (i.e., taking a precautionary approach), then those records could be important and therefore that habitat could be critical to the survival of the species regionally. As such, 200 m buffers around any detections made during this survey have been recommended to reduce the scale of direct impacts. Much of the remainder of the disturbance footprint (where the species was not detected but may still comprise apparently suitable habitat) is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition. In addition, the total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here.
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 57 Significant impact assessment for the Brush-tailed Phascogale

Significant Impact Criteria for 'endangered' species	Assessment
Lead to a long-term decrease in the size of a population	**Unlikely** The locations of the four detections of the species during these surveys have each been recommended avoidance buffers of 200 m. Whilst the estimated home range for the species is reported as being variable (5-100 ha; Woinarski *et al*., 2014; Geyle *et al*., 2020) and probably dependent on the density of required resources, the recommended 200 m avoidance buffer around each detection (i.e., an area of 12.6 ha) and subsequent placement of the 'proposed gravel pit areas' abutting roadsides and existing gravel pits, will aid to protect the higher quality habitats within the local area. Further, it has been recommended in **Section 11** that
Reduce the area of occupancy of a population	
Fragment an existing population into two or more populations	

Significant Impact Criteria for 'endangered' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	clearance for gravel pits is kept to an absolute minimum and placed only immediately adjacent to existing pits. While the species was not detected in the remainder of the survey area, this could partly be due to the survey methods used. In this regard, all eucalypt forests have been classified as potential habitat from a precautionary perspective. As such, the loss of, at most, 247.5 ha of potentially suitable habitat is unlikely to lead to a long-term decrease in the size of a population, reduce its area of occupancy, fragment it or cause the species to decline because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season.
Adversely affect habitat critical to the survival of a species	**Unlikely** As discussed in **Table 51**, habitat within the disturbance footprint is unlikely to be critical to the survival of the species.
Disrupt the breeding cycle of a population	**Unlikely** Brush-tailed Phascogales breed in the early to mid-dry season (Rhind *et al*., 2008 cited in TSSC, 2010a). This partly coincides with the most appropriate period to conduct the earthworks required for the project. As such, any individuals within areas to be cleared would be disturbed. To alleviate this, avoidance buffers have been applied around any detections made during these surveys. These are discussed further in **Section 7**. In other areas where it was not detected during these surveys, impacts to the breeding cycle any individuals are similarly likely to be relatively small and localised because: ▪ The disturbance footprint is comprised of multiple smaller areas. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, all vegetation clearance will not be conducted in the same season.

Significant Impact Criteria for 'endangered' species	Assessment
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of the Brush-tailed Phascogale. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. The TSSC (2016) lists key threats to the species as high frequency of extensive and intense fires, habitat loss (apparently from clearing for plantations on Tiwi Islands, manganese mining on Groote Eylandt), predation by feral cats, competition with introduced rodents, weeds and grazing by introduced herbivores (TSSC, 2016). The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.

Brush-tailed Phascogale records on the Tiwi Islands

Key

- This survey
- Geyle et al (2020) records
- NT Fauna Atlas
- Map area
- Potential gravel pit survey area
- Road realignment area
- Existing bore 100 m buffer
- Water point 100 m buffer

Background - ESRI Satelitte

Figure 51

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.9 Pale Field-rat

10.3.9.1 Significance of the Individuals Detected

Pale Field-rats were detected seven times across five map areas (refer to **Figure 52**). Three were from eucalypt woodlands (in maps 2, 4 and 9), and not near densely vegetated creek lines (as is reported as their habitat preference). None were captured in pitfall traps. This increases the number of records within the NT Fauna Atlas (153) by 4.6% to 160. Excluding these surveys, the species is recorded 32 times in the last ten years in the NT Fauna Atlas. While most of these are from one general area on Bathurst Island (refer to **Figure 52**), survey effort across the remainder of the Tiwi Islands must be recognised as a factor.

Relevant surveys conducted over the last ten years have resulted in the following:

- 2021: Pale Field-rats were detected at two sites (from six) during surveys conducted for the Paru Road upgrade (AECOM, 2021). These records are presently not shown in the NT Fauna Atlas.
- 2019: Pale Field-rats were not detected on Melville Island during live trapping at two sites each comprising 30 rows of 10 traps, though they were detected at two sites on Bathurst Island (same array of traps; Davies *et al*,. 2021). These records do not appear to be in the NT Fauna Atlas.
- 2016-2017: Pale Field-rats were detected on ten occasions during a pitfall and camera survey in central west Melville Island (Potter, 2017). *At present, these are the only records of the species shown in the NT Fauna Atlas on Melville Island in the last ten years.*
- 2015: Pale Field-rats were detected at only one of 82 live-trapping sites, which is five less than during similar trapping in 2000-2002, indicating an 80% reduction in trap success (Davies *et al*., 2018a). This detection does not appear to be in the NT Fauna Atlas.
- 2013-2016: Pale Field-rats were detected on Bathurst Island during an extensive survey of mammals across ~370,000 km^2 of monsoonal northern Australia (Stobo-Wilson *et al*., 2020a; 2020b). These records appear to be in the NT Fauna Atlas.
- 2013-2015: Pale Field-rats were detected infrequently during camera trapping at four fire plots sites on Melville Island (four cameras placed in each of 18 fire plots (72 cameras in total)) (Davies *et al*., 2018b). The results do not appear in the NT Fauna Atlas and it is unclear at which locations Pale Field-rats were detected.

In total, including these survey results, there appear to be at least approximately 45-50 records of the species in the last ten years on the Tiwi Islands. While there has been a demonstrated substantial decline of the species on the Tiwi Islands (Davies *et al*., 2018a), its current area of occupancy is less clear.

Based on the above, the detections during these surveys are probably not unexpected given the habitats surveyed and the recent (<10 years) records. However, without additional data to more accurately assess this, it is difficult to determine whether the detections from the current survey form part of 'important' sub-populations (as defined in the Australian Government's *Significant Impact Guidelines* (DoE, 2013)).

10.3.9.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**). The species is listed as vulnerable under the TPWC Act, though is not listed under the EPBC Act. Nevertheless, the criteria in these guidelines are used in lieu of NT-specific guidelines. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 52**.

Table 58 Assessment of habitat critical to the survival of the Pale Field-rat

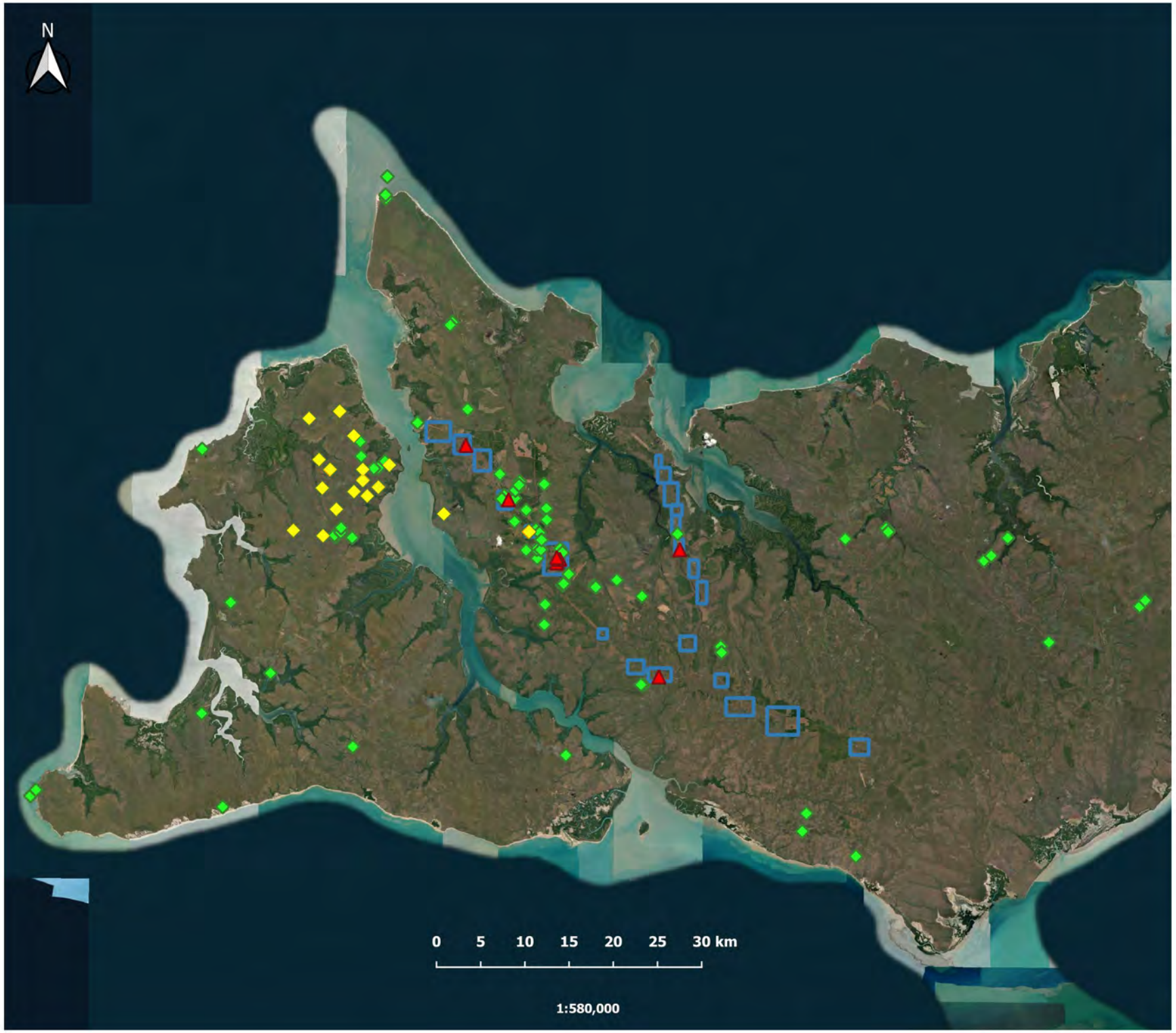
Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) to maintain genetic diversity and long-term evolutionary development, or for the reintroduction of populations or recovery of the species or ecological community	**Possible (though unclear)** The species was not detected in 13 (of 18) map areas where cameras were deployed. Within the five map areas where it was detected, the habitats may be critical to the survival of the species simply because there has been an 80% decline of the species over the last 15 to 20 years and its current area of occupancy is not well understood. However, it is important to note that: ▪ 7% (17.9 ha) of potential habitat for the Pale Field-rat within the disturbance footprint, which has been classified as 'primary' habitat for the purposes of this report, comprises approximately 0.07% of the total 'primary' habitat as classified in Woinarski *et al*. (2003) (comprised of 'sedgelands and grasslands', '*Melaleuca* open forests', '*Melaleuca* low woodlands' in **Table 7** (**Section 2.4**)). ▪ The remaining 93% (247.5 ha) of potential habitat for the Pale Field-rat within the disturbance footprint for Pale Field-rats comprises eucalypt woodland that is common and widespread on the Tiwi Islands (which has been classified as 'secondary' habitat for the purposes of this report), rather than the riparian and grassland habitats typically reported as being its preferred habitat (as in Young & Hill, 2012). ▪ Large parts of the Tiwi Islands remain unsurveyed. ▪ Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.

Table 59 Significant impact assessment for the Pale Field-rat

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population Reduce the area of occupancy of an important population Fragment an existing important population into two or more populations Adversely affect habitat critical to the survival of a species	**Unlikely** The species was not detected in 13 of 18 map areas where cameras were deployed. In the five map areas where it was detected, the proposed works are unlikely to impact the population on the Tiwi Islands because: ▪ The clearance areas are comprised of multiple smaller areas nominated for proposed gravel pits, road realignments and water source points, rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here.

Significant Impact Criteria for 'vulnerable' species	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	▪ Key threats to the species (Young & Hill, 2012) – reported to be altered fire regimes and cats – are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. ▪ The Tiwi Islands is reported to be a critical refuge for small mammals with healthy and widespread (though declining) populations (Davies *et al.* (2018a), Davies *et al*. (2020), Davies *et al*. (2021) and Stobo-Wilson *et al*. (2020)). ▪ 7% (17.9 ha) of potential habitat for the Pale Field-rat within the disturbance footprint, which has been classified as 'primary' habitat for the purposes of this report, comprises approximately 0.07% of the total 'primary' habitat as classified in Woinarski *et al*. (2003) (comprised of 'sedgelands and grasslands', '*Melaleuca* open forests', '*Melaleuca* low woodlands' in **Table 7** (**Section 2.4**)). ▪ The remaining 93% (247.5 ha) of potential habitat for the Pale Field-rat within the disturbance footprint for Pale Field-rats comprises eucalypt woodland that is common and widespread on the Tiwi Islands (which has been classified as 'secondary' habitat for the purposes of this report), rather than the riparian and grassland habitats typically reported as being its preferred habitat (as in Young & Hill, 2012).
Disrupt the breeding cycle of an important population	**Unlikely** Pale Field-rats breed during the dry season (Young & Hill, 2012). This coincides with the most appropriate period to conduct the earthworks required for the project. As such, any individuals within areas to be cleared would be disturbed. However, it is important to note: ▪ All road realignment areas are narrow and border the existing road, so probably wouldn't comprise important habitat. ▪ Of the seven detections of the species: o Only one was within an area proposed for clearing (map area 4) o The distance of the disturbance footprint to the other locations of the detections are approximately 170 m (map 2), 100 m (map 6; noting that similar habitats occur between the location of the detection and the proposed gravel pit area so the species may occupy that whole area) and 500 m (map 9). ▪ The disturbance footprint is comprised of multiple smaller areas. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, not all vegetation clearance will occur in the same season.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of the Pale Field-rat. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.

Significant Impact Criteria for 'vulnerable' species	Assessment
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species on the Tiwi Islands. Young and Hill (2012) list key potential threats to the species as altered fire regimes and cats. The proposed works are unlikely to exceed the pressures caused by any of these threats and therefore are unlikely to interfere with the recovery of the species.



Pale Field-rat records on the Tiwi Islands

Key

- This survey (7)
- NT Fauna Atlas (as of July 2021) (153)
- NT Fauna Atlas records since 2011 (32)
- Map area

Background - ESRI Satelitte

Figure 52

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.10 Butler's Dunnart

10.3.10.1 Significance of the Individuals Detected

No Butler's Dunnarts were confirmed to occur within the survey area. The dunnarts captured in pitfall traps did not have fused interdigital pads at their base (as per Cole & Woinarski, 2002). Further, while five dunnarts detected by cameras appeared to be Butler's Dunnarts (due to the lack of rufous colouring on the face and smaller body size than the Red-cheeked Dunnarts photographed; refer to **Figure 32** to **Figure 35** in **Section 6.6.9**), it is uncertain given that no Butler's Dunnarts were identified during the pitfall trapping survey. As such, we have classified those five as 'suspected' Butler's Dunnarts.

There are a total of 108 Butler's Dunnart records on the Tiwi Islands, of which 27 are from within the last ten years (**Figure 53**). Additional records (not appearing in the NT Fauna Atlas) include three from surveys conducted in 2021 for the proposed Paru Road upgrade (AECOM, 2021). Two additional surveys (refer to Stobo-Wilson *et al*., 2020a and Davies *et al*., 2018b) appeared to group dunnarts, and dunnarts/mice, and therefore it is unclear what detections were made.

The species is thought to be sparse, and in decline, across the Tiwi Islands (Woinarski *et al*., 2014; McKnight, 2015), yet there remains a 'reasonable' population (Woinarski *et al*., 2014). If the five suspected Butler's Dunnarts were true, this would confirm that some parts of the survey area are occupied by the species.

10.3.10.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 63**). The species is listed as vulnerable under the EPBC Act though is not listed under the TPWC Act. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 62**.

Table 60 Assessment of habitat critical to the survival of Butler's Dunnart

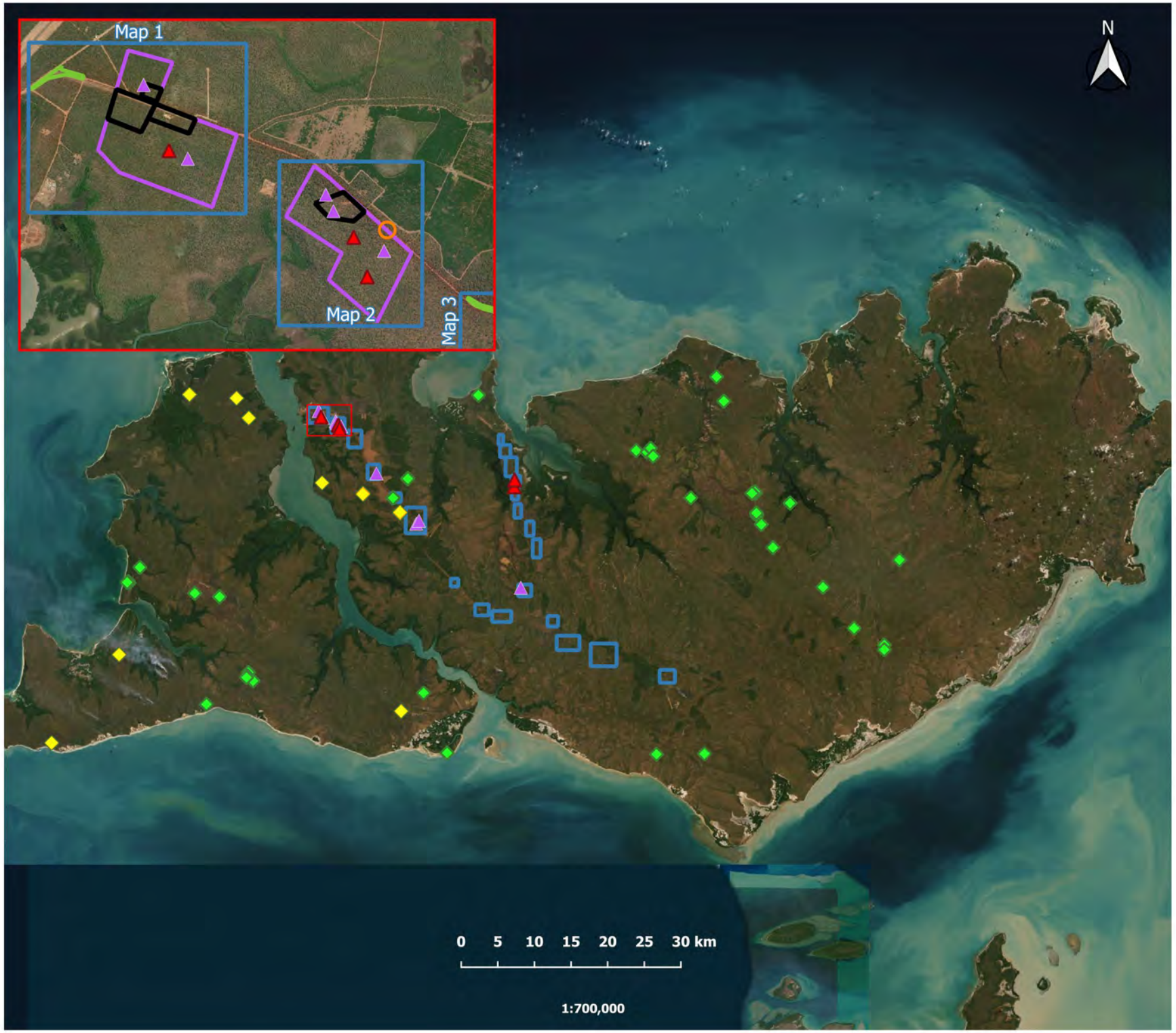
Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Possible** The species was not detected in 14 (of 18) map areas where cameras and pitfall traps were placed, so its presence in these areas is not confirmed. However, the species is known to have a low detectability (Ward, 2009) and given the distribution of pitfall sites across the survey area, it is plausible to suggest that the species occurs in other areas. However, the habitats within the four map areas where it may have been detected (i.e., the identities were not confirmed), could be critical to the survival of the species because the species' area of occupancy on the Tiwi Islands is unknown, though is thought to be sparse and in decline (Woinarski *et al*., 2014; McKnight, 2015). However, it is important to note that: ▪ Large parts of the Tiwi Islands remain unsurveyed.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	

Criteria	Assessment
for the reintroduction of populations or recovery of the species or ecological community	▪ None of the detections area located within the disturbance footprint. The disturbance footprints are located a minimum of 200 m from any (suspected) detections. ▪ Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.

Table 61 Significant impact assessment for Butler's Dunnart

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population Reduce the area of occupancy of an important population Fragment an existing important population into two or more populations Adversely affect habitat critical to the survival of a species Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** The species was suspected of occurring within only two map areas (1 and 2) (for the purposes of this impact assessment), despite cameras and pitfall traps being deployed across the survey area. Within these areas, none of the detections area located within the disturbance footprint, with all being a minimum of 200 m from area of proposed clearance. In addition, the loss of, at most, approximately 247.5 ha of habitat is unlikely to impact the population on the Tiwi Islands because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ Key threats to the species – reported to be altered fire regimes, invasive grasses, pigs, grazing and cats (Ward & Woinarski, 2012) – are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. ▪ Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.

Significant Impact Criteria for 'vulnerable' species	Assessment
Disrupt the breeding cycle of an important population	**Unlikely** Butler's Dunnarts are thought to breed from August to December (Ward & Woinarski, 2012). This partially coincides with the most appropriate period to conduct the earthworks required for the project. The species was possibly detected in two out of ten map areas that were surveyed using cameras and pitfall traps. In those areas, proposed gravel pit areas have been located at least 200 m from the suspected detections. In addition, within these areas, and the remainder of the disturbance footprint that may contain 'potential' habitat, it is important to note: ▪ All road realignment areas are narrow and border the existing road, probably reducing their quality, though these areas do act as buffers to disturbed areas). ▪ The disturbance footprint is comprised of multiple smaller areas. ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ The project is expected to take several years to complete and, as such, not all vegetation clearance will occur in the same season. Consequently, the project is unlikely to disrupt the breeding cycle of an important population.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not substantially impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of Butler's Dunnart. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species. Ward and Woinarski (2012) listed the key threats as altered fire regimes, invasive grasses, pigs, grazing and cats. It is not expected that the proposed works would exceed the pressures caused by any of these known threats and therefore is unlikely to interfere with the recovery of the species.



Butler's Dunnart records on the Tiwi Islands

Key

- This survey - suspected via camera traps (5)
- NT Fauna Atlas (as of July 2021) (108)
- NT Fauna Atlas records since 2011 (27)
- Red-cheeked Dunnart this survey
- Map area
- Potential gravel pit survey areas
- Road realignment areas
- Existing bores 100 m buffer
- Proposed gravel pit area

Background - ESRI Satelitte

Figure 53

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.11 Northern Brushtail Possum

10.3.11.1 Significance of the Individual Detected

Seventy-two cameras, out the 100 deployed, recorded the species in all but one of the 17 map areas where cameras were deployed. The species was not detected by any of the three cameras deployed in the seasonally inundated or saturated grasslands or *Melaleuca* woodlands in the Maxwell Creek area (map 6).

There are a total 6,353 records of the species on the Tiwi Islands in the NT Fauna Atlas, of which 97% (6,162) have been recorded in the last ten years (excluding the records from this survey). Most of these recent detections are concentrated in four areas (refer to **Figure 54**). As such, the high number of detections in this survey is not unexpected given the existing records within the NT Fauna Atlas.

10.3.11.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 63**). The species is listed as vulnerable under the EPBC Act though is not listed under the TPWC Act. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 62**.

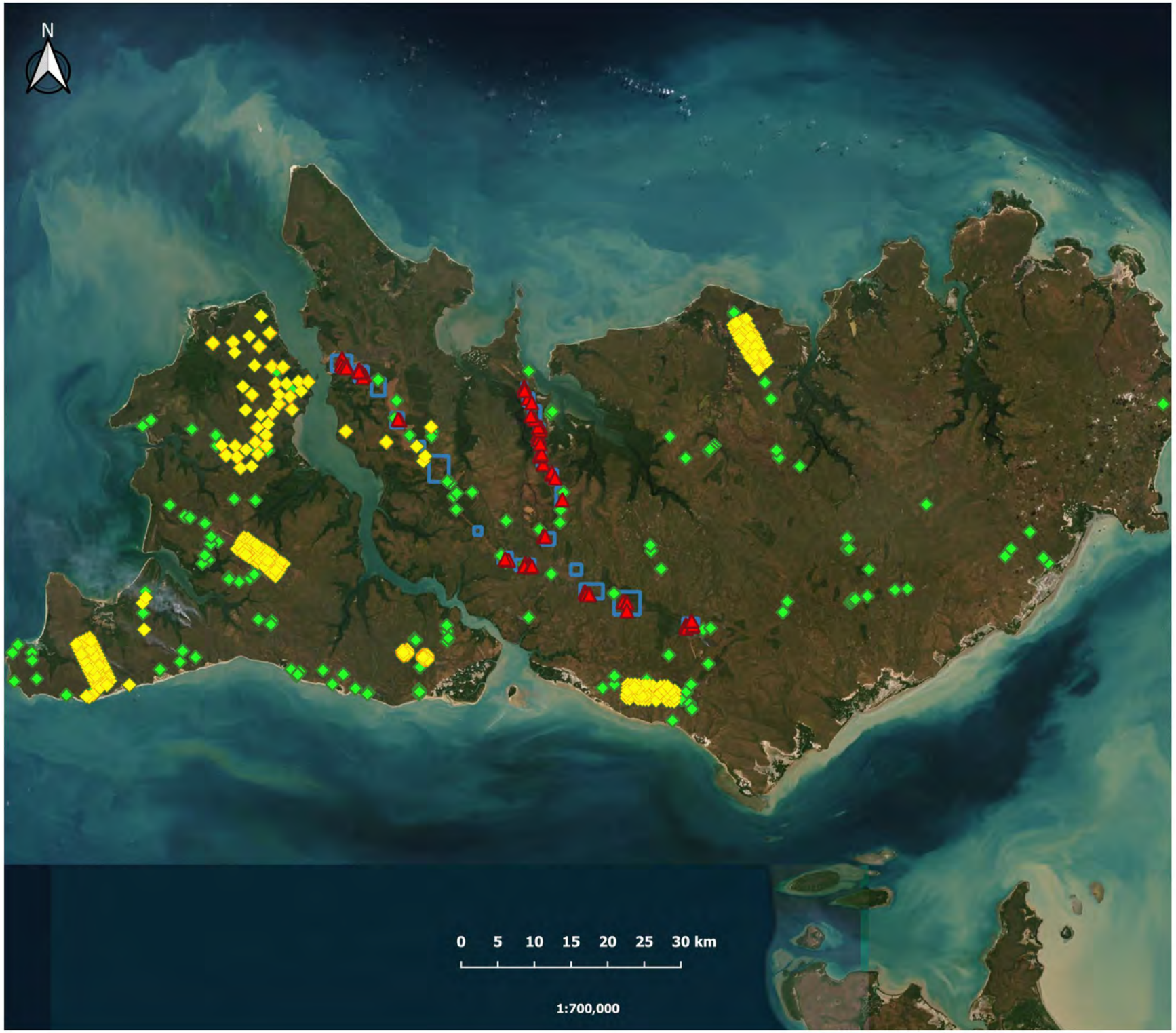
Table 62 Assessment of habitat critical to the survival of the Northern Brushtail Possum

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal	**Unlikely** The habitats within the disturbance footprint are unlikely to be critical to the survival of the species because: ▪ The species appears to be abundant and widespread on the Tiwi Islands. ▪ Given there are over 4,600 km^2 of potentially suitable habitat on the Tiwi Islands (i.e., eucalypt forests and woodlands dominated by *E. miniata*, *E. tetrodonta* and *Corymbia nesophila*; Woinarski et al., 2003), of which large areas appear to be unsurveyed, it is likely that ample habitat exists across the islands, and a substantial population exists. ▪ Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.
for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)	
to maintain genetic diversity and long-term evolutionary development, or	
for the reintroduction of populations or recovery of the species or ecological community	

Table 63 Significant impact assessment for the Northern Brushtail Possum

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population Reduce the area of occupancy of an important population Fragment an existing important population into two or more populations Adversely affect habitat critical to the survival of a species Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** The loss of, at most, approximately 247.5 ha of habitat is unlikely to impact the population on the Tiwi Islands because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ Key threats to the species (TSSC, 2021) – reported to be frequent, extensive, intensive fires, cats, invasive grasses, diseases carried by black rats, land clearing from agriculture, forestry and mining (particularly on the Tiwi Islands), grazing and climate change – are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. ▪ The Tiwi Islands are reported to be a critical refuge for small mammals with healthy and widespread (though declining) populations (Davies *et al.* (2018a, 2020, 2021) and Stobo-Wilson *et al*. (2020)). ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here. ▪ Over 4,600 km^2 of potential habitat exists on the Tiwi Islands.
Disrupt the breeding cycle of an important population	**Unlikely** Given the fragmented nature of the disturbance footprint, the small clearance areas, high number of Tiwi Island records and large areas of apparently suitable habitat, it appears unlikely that the breeding cycle of a population would be disrupted.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not substantially impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery onto the Tiwi Islands, and subsequent earthworks, could introduce and/or spread grassy weeds into potential habitat for the species. These events may alter vegetation composition and fire regimes or intensities to the detriment of the Northern Brushtail Possum. Nevertheless, it is expected that the residual risk of significant incursions is low given the required weed hygiene protocols for construction contractors on the Tiwi Islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.

Significant Impact Criteria for 'vulnerable' species	Assessment
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species. TSSC (2021) lists the key threats to the species as frequent, extensive, intensive fires, cats, invasive grasses, diseases carried by black rats, land clearing from agriculture, forestry and mining (particularly on the Tiwi Islands), grazing and climate change. The proposed works are unlikely to significantly increase any of these threats and, as such, are unlikely to interfere with the recovery of the species.



Northern Brushtail Possum records on the Tiwi Islands

Key

- This survey (72)
- NT Fauna Atlas (as of July 2021) (6,353)
- NT Fauna Atlas records since 2011 (6,162)
- Map area

Background - ESRI Satelitte

Figure 54

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

10.3.12 Merten's Water Monitor

10.3.12.1 Significance of the Individual Detected

The presence of the Merten's Water Monitor demonstrates that the species continues to exist on Melville Island. This is likely because Cane Toads are not currently on the Tiwi Islands (TLC, date unknown). Cane Toads are listed as the key threat to the species (Ward *et al*., 2006), however Crowley and Ziembicki (in Crowley, 2008) state that Mertens' Water Monitor populations can recover from areas where it has been affected by Cane Roads. Regardless, Cane Toads were not recorded during these surveys and Ward *et al*. (2006) do not list any other threatened processes as being implicated in the decline of Merten's Water Monitor, suggesting that the species is likely to persist in Cane Toad-free areas.

10.3.12.2 Significance of Potential Impacts

To assist in determining the significance of the potential impacts of the project on the species, an assessment against the significant impact criteria contained within the Australian Government's *Significant Impact Guidelines* (DoE, 2013) was undertaken (**Table 39**). The species is listed as vulnerable under the TPWC Act, though is not listed under the EPBC Act. Nevertheless, the criteria in these guidelines are used in lieu of NT-specific guidelines. To aid in the assessment, discussion of 'habitat critical to the survival of the species' is also provided in **Table 52**.

Table 64 Assessment of habitat critical to the survival of the Merten's Water Monitor

Criteria	Assessment
'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:	
for activities such as foraging, breeding, roosting, or dispersal for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) to maintain genetic diversity and long-term evolutionary development, or for the reintroduction of populations or recovery of the species or ecological community	**Unlikely** The habitats within the disturbance footprint do not appear to be critical to the survival of the species because: ▪ The species was not detected across most of the survey area (because suitable or 'seasonal' habitats were not present across most of it). ▪ 17.9 ha of 'seasonal' habitat for Merten's Water Monitor that is within the disturbance footprint constitutes approximately 0.07% of the total area of vegetation communities that comprise that habitat (i.e., 'sedgelands and grasslands', '*Melaleuca* open forests', '*Melaleuca* low woodlands' in Woinarski *et al*., 2003 (refer to **Table 7** in **Section 2.4**)). ▪ There are no Cane Toads on the Tiwi Islands (TLC, date unknown). ▪ The species appears to be widespread on the Tiwi Islands (refer to **Figure 52**). ▪ There are a relatively high number of recent (<10 years) records, and large areas of the Tiwi Islands remain unsurveyed. ▪ Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.

Table 65 Significant impact assessment for the Merten's Water Monitor

Significant Impact Criteria for 'vulnerable' species	Assessment
Lead to a long-term decrease in the size of an important population Reduce the area of occupancy of an important population Fragment an existing important population into two or more populations Adversely affect habitat critical to the survival of a species Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** The loss of, at most, 17.9 of 'seasonal' habitat (see **Section 6.6.9**) is unlikely to impact the population on the Tiwi Islands because: ▪ The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area. In comparison, approximately 30,000 ha of native vegetation has been cleared on Melville Island for forestry operations (ABC, 2020). ▪ A maximum of 17.9 ha of 'seasonal' habitat for Merten's Water Monitor is within the disturbance footprint, which constitutes approximately 0.07% of the total area of vegetation communities that comprise that habitat on the Tiwi Islands (i.e., 'sedgelands and grasslands', '*Melaleuca* open forests', '*Melaleuca* low woodlands' in Woinarski *et al*., 2003 (refer to **Table 7** in **Section 2.4**)). ▪ The key threat to the species (Ward *et al*., 2006) – Cane Toads – are likely to influence the distribution and abundance of the species far greater than the proposed works associated with this project. At present, no Cane Toads occur on the Tiwi Islands (TLC, date unknown). ▪ Within each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided here.
Disrupt the breeding cycle of an important population	**Unlikely** Given the fragmented nature of the disturbance footprint and the small clearance areas, it appears unlikely that the breeding cycle of a population would be disrupted.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Possible** The proposed works are located adjacent to existing disturbed areas, are fragmented, and will generally not substantially impact sensitive or significant habitat types. In this regard, the distribution and abundance of invasive fauna already present in the vicinity of the disturbance footprint are unlikely to be altered. However, the importation of machinery and/or equipment onto the Tiwi Islands could introduce Cane Toads, which is likely to significantly impact the species there. Yet, this risk probably remains low given the required hygiene protocols for importation of plant and equipment onto the Tiwi Islands, and that Cane Toads remain absent despite significant forestry operations, road works and other developments on the islands.
Introduce disease that may cause the species to decline	**Unlikely** The transfer of people, food, plant and equipment to and from the Tiwi Islands has not introduced, so far as is understood, any diseases that has caused the species to decline. As such, it is unlikely that the proposed works will be any different.

Significant Impact Criteria for 'vulnerable' species	Assessment
Interfere with the recovery of the species	**Unlikely** The proposed works are relatively minor in relation to existing threats faced by the species. Ward *et al*. (2006) list the main threat to the species as being Cane Toads. While there is a possibility that plant and equipment could harbour individuals of the species during importation, it should be expected that this risk is low given that required hygiene measures should be strictly implemented and enforced.

10.4 Yellow Ochre Site Road Diversion

The yellow ochre site along Pirlangimpi Road (in Map 9) was recently identified as a preferred road diversion site. The site was not targeted during field surveys given it was identified afterwards, though it is expected that sufficient information exists to allow for an adequate desktop impact assessment of the road diversion. Relevant mapping in **Appendices A, E and I** have been updated to include this diversion.

Following analysis of threatened species records and habitats, the preferred diversion would be located to the immediate south of the ochre site, with a total length of approximately 300 m. Based on a 20 m width, the total area of expected clearance is 0.6 ha. The assessment of impacts is as follows:

- The proposed road diversion contains a vegetation community comprising *Eucalyptus miniata* and *E. tetrodonta* tall open forest to woodland (i.e., communities E3 and E4). These communities are likely to constitute habitat for numerous threatened species including the Black-footed Tree-rat, Northern Brushtail Possum, Masked Owl and Partridge Pigeon.
- *Typhonium jonesii* and *T. mirabile* are unlikely to occur within that area because previous field surveys failed to locate any in the immediate vicinity in areas modelled by the NT Government as potentially containing the species. In addition, no existing records exist in that area.
- The Pale Field-rat was identified approximately 70 m south of the proposed road diversion route during surveys undertaken for this project. However, it is expected that this species is more likely to utilise the drainage line habitats to the west rather than up slope towards the road diversion.

Merten's Water Monitor records on the Tiwi Islands

Key

- This survey (1)
- NT Fauna Atlas (as of July 2021) (16)
- NT Fauna Atlas records since 2011 (2)
- Map area

Background - ESRI Satelitte

Figure 55

Client: GHD
Date: 19 October 2021
Datum: GDA94
Author: M. Proos

CONNECT environmental

11 Recommended Impact Mitigation

Minimum standards for environmental management for DIPL's civil and building works are described in the *Standard specification for environmental management* (version 2.0; DIPL, 2019). These relate to erosion and sedimentation, weeds, stockpiles, waste, water quality, vegetation, air quality and rehabilitation. As such, those measures are not repeated here. However, measures relating to specific areas or habitat attributes for relevant threatened species – designed to enhance DIPL's minimum controls – are described in **Table 66**.

Although the proposed works are minor in comparison to existing threats for threatened species on the Tiwi Islands (and across northern Australia), localised impacts are expected. These can effectively be reduced by implementing the measures described in this section. Avoidance buffers have already been recommended in **Section 7** and so are not described further here. In addition, risks associated with invasive grassy weeds, which probably threatens the viability of all species, require close management and monitoring. It is mentioned to emphasise its importance for the conservation of biodiversity.

Table 66 Recommended impact mitigation for threatened species (additional to the recommended avoidance measures in Section 7)

Scientific Name	Common Name	Recommended measures
Cycas armstrongii	Armstrong's Cycad	High density patches of cycads should be delineated and avoided within proposed clearance areas, including those observed in map 13 and water point PR7 (map 5).
Typhonium jonesii	Typhonium jonesii	Avoid vegetation clearance around existing water point 'EB1' to avoid a patch of at least 16 individuals.
Erythrotriorchis radiatus	Red Goshawk	Conduct surveys for Red Goshawk nests prior to construction (within the same breeding season (April to October)) in and within 300 m of proposed clearance areas. Where nests are located, no clearing should occur within 300 m of the nest for the remainder of that season.
Tyto novaehollandiae kimberli	Masked Owl (northern)	Conduct surveys for Masked Owl nests / nesting activity prior to construction (within the same breeding season (March to July)) in and within 300 m of proposed clearance areas. Where nests are located, no clearing should occur within 300 m of the nest for the remainder of that season.
Phascogale pirata	Northern Brush-tailed Phascogale	Limit the number and extent of pits within map areas 9, 12 and 14 to the absolute minimum required. Ensure any constructed pits are located adjacent to existing pits.
All mammals	-	Following further delineation of suitable gravel extraction points after the appropriate geotechnical investigations have been conducted, assessment of the distribution of large hollow-bearing trees across each area is recommended with the intention to avoid those areas with higher densities.

12 Conclusions

The threatened species identified in this report face several existing threats on the Tiwi Islands including inappropriate fire regimes, extensive and intense fires, cats and large-scale loss of critical or important habitat. It is reported that these are likely to be implicated in the apparent decline of these species on the Tiwi Islands. In comparison, the anticipated impacts from this project are unlikely to significantly impact the distribution or abundance of these species on the Tiwi Islands, although localised and small-scale impacts will be experienced by animals occupying those areas. Consequently, it is prudent to minimise these effects as much as possible.

While a maximum of approximately 270 ha of vegetation may be impacted, the composition of the disturbance footprint is important to note as this affects the nature and scale of impacts to the relevant species:

- The total clearance area is comprised of multiple smaller areas nominated for proposed gravel pits (23 areas), road realignments (14 sections (including the yellow ochre site)) and water source points (12 sites), rather than one large clearance area.
- In each proposed gravel pit area (which comprise approximately 78% of the maximum clearance area), pits are 1 ha in size and only one pit will be 'open' at any one time (as per the *Standard specification for environmental management, version 2.0* (DIPL, 2019)). Therefore, the extent of disturbance is likely to be much smaller than the numbers provided in the impact assessment.
- Much of the disturbance footprint is located along the existing roads or cleared areas for existing gravel pits or plantation. Such areas are likely to have reduced values for biodiversity associated with 'edge' effects – that is, the alteration of habitat characteristics resulting from increased levels of light, dust and noise and consequential changes to vegetation composition.

Three threatened flora species were detected – *Cycas armstongii*, *Typhonium jonesii* and *T, mirabile*. Important components identified include high density patches of *Cycas armstongii* and all patches of the two *Typhonium* species. Recommendations to avoid these areas have been made.

All threatened fauna species that were identified as having the potential to occur were detected, except for *Varanus panoptes*. Some were widespread and detected in most map areas (e.g., Partridge Pigeon, Black-footed Tree-rat, Northern Brushtail Possum), some are expected to be widespread based on historic and anecdotal records (e.g., Red Goshawk, Masked Owl, possibly Merten's Water Monitor), although the remainder – which comprises all other threatened small mammal species – are apparently patchily distributed.

However, it must be recognised that there are substantial gaps relating to many small mammal species' population structures, distribution and / or microhabitat requirements. So, in this regard, further studies are required to assess their conservation status more accurately on the Tiwi Islands. Given these gaps in knowledge, a precautionary approach has been applied and all apparent habitat across the disturbance footprint is classified as 'potential' habitat for most species. Nevertheless, the impact assessment considers both confirmed and potential habitats.

Additional recommendations are made to further reduce impacts including site-specific pre-clearance assessments for Red Goshawk and Masked Owl nests and areas of vegetation containing high densities of large hollow-bearing trees.

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14 Appendix A: Topography and slope

Figure 22 Black-footed Tree-rat at Site 44-1 (Map 6)

Figure 23 Black-footed Tree-rat at Site 45-3 (Map 4)

Figure 24 Black-footed Tree-rat at Site 46-1 (Map 2)

Figure 25 Black-footed Tree-rat at Site 21-1 (Map 13)

6.6.7 Brush-tailed Phascogale

6.6.7.1 Observations

Brush-tailed Phascogales (*Phascogale pirata*) were detected at four sites, in Maps 9 (one camera), 12 (two cameras) and 14 (one camera) (**Figure 51**). Photos of individuals from each of the four sites are shown in **Figure** 26 to **Figure 29**.

Given the conservation status of the species, and the paucity of records across its range, it was recommended in **Section 7** that avoidance buffers of 200 m be placed around these detections. DIPL accounted for this recommendation in their subsequent delineation of the proposed gravel pit areas (**Section 8**).

6.6.7.2 Habitat

The species is known from tall open forests dominated by *Eucalyptus miniata* (Darwin Woollybutt) and *E. tetrodonta* (Darwin Stringybark) (TSSC, 2010). This aligns with the vegetation types at each of the four detection sites (various combinations of *E. miniata*, *E. tetrodonta* and *Corymbia nesophila*).