The Glossy Ibis (*Plegadis falcinellus*), a conservation significant/migratory species has been recorded near the Development Envelope. Assessments suggest that most of the Development Envelope does not have suitable habitat for the species (ELA 2020). Marshall Paddocks has the potential to support the species in years when there is sufficient rainfall for the area to become inundated with water (Bamford pers. Comm. 2020).

In addition to the above listed species, *Malurus elegans* (Red-winged Fairy-wren), which is not listed under either the EPBC or BC Act but is considered as regionally significant under Bush Forever (Government of WA 2000), may potentially occur in the area given the availability of suitable habitat (i.e. woodlands and forests) (ELA 2020).

Based on the previous terrestrial fauna surveys and database searches (DBCA 2020, DAWE 2020, ELA 2020, WRM 2020, Biologic 2020, Invertebrate Solutions 2020) a total of 35 fauna species of conservation significance were identified as having the potential to occur within the Development Envelope. However, 13 species have subsequently been assessed as unlikely to occur within the Development Envelope.

Table 35 lists species, their conservation status (Commonwealth and State level), distribution and habitat and likelihood of occurring within the Development Envelope. Additional expert fauna advice was provided (Bamford pers. comm. 2020) on the likelihood of occurrence/predicted status of the fauna within the Development Envelope and this advice is also included in Table 35**.**

Oceanic or pelagic species identified in the database searches were omitted from Table 35 given the Proposal is located more 10 km from the ocean.

Table 35: Conservation significant fauna potentially occurring within the Development Envelope

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
BIRDS				
Carnaby's Cockatoo *(Calyptorhynchus latirostris)*	EN	EN	Carnaby's Cockatoo is endemic to southwest WA with populations extending from the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (DotEE 2019b, DSEWPAC 2012c). Foraging habitat for this species includes native shrubland, kwongan heathland and woodland dominated by proteaceous plant species including Banksia, Hakea and Grevillea, Eucalypt and Corymbia woodlands and pine plantations (DSEWPAC 2012c).	**Recorded; Regular visitor** Carnaby's Cockatoos were observed foraging during the recent survey and the species has previously been observed foraging and flying in various locations in the Development Envelope (ELA 2020, Terrestrial Ecosystems 2018, Coffey 2015a, DBCA 2019a). Fifty percent of individual fauna records for the area from the DBCA database search were Carnaby's Cockatoo (DBCA 2019a). Suitable foraging, potential breeding trees and suitable roosting habitat occur at specified locations within the Development Envelope.
Baudin's Cockatoo *(Calyptorhynchus baudinii*)	EN	EN	Baudin's Cockatoo is found in southwest WA with populations extending from Albany northward to Gidgegannup and Mundaring (east of Perth), and inland to the Stirling Ranges and near Kojonup (DotEE 2019c, DSEWPAC 2012c). Baudin's Cockatoo foraging habitat includes Eucalyptus and/or Corymbia woodlands and forests and proteaceous woodland and heath (DSEWPAC 2012c).	**Potential; Vagrant** There are a few records of Baudin's Cockatoo in proximity to the Proposal but no records within the Development Envelope itself. The species may infrequently be seen foraging in proximity to the area. They are highly unlikely to breed in this location and not likely to rely on foraging or suitable roosting habitat within the Development Envelope (ELA 2020).
Forest Red-tailed Black Cockatoo *(Calyptorhynchus banksii naso)*	VU	VU	The Forest Red-tailed Black Cockatoo is found in southwest WA with populations extending north to Perth and east to Wundowie, Mount Helena, Christmas Tree Well, North Bannister, Mount Saddleback, Rocky Gully and the upper King River (DSEWPAC 2012c). Forest Red-tailed Black Cockatoo foraging habitat includes Jarrah and Marri woodlands and forests, but the species will also feed on she-oak (particularly *Allocasuarina fraseriana*) and a range of non-native species in suburban areas (e.g. introduced Cape Lilac, Kaffir Plum, *Eucalyptus caesia*) (DSEWPAC 2012c).	**Recorded; Regular visitor** Forest Red-tailed Black Cockatoos were recorded foraging on numerous occasions during fauna surveys (ELA 2020, Terrestrial Ecosystems 2018, AECOM 2016, Coffey 2015a). There are also numerous records of the species in proximity to the Development Envelope (DBCA 2019a). Suitable habitat for the species occurs within the parkland cleared areas that contain Eucalyptus/Corymbia and Mixed Eucalyptus/Corymbia Woodland habitats.

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Australian Painted Snipe (*Rostratula australis*)	EN	EN	The Australian Painted Snipe has been recorded at wetlands in all states of Australia, however it is most common in eastern Australia (DotEE 2019e). This species generally inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans, sometimes utilising areas that are lined with trees, or that have some scattered fallen or washed-up timber (DotEE 2019e).	**Unlikely; Irregular visitor in small numbers** Australian Painted Snipe are most common in Eastern Australia and are rarely recorded in Western Australia (DotEE 2019e). The species is considered unlikely to occur anywhere in the Development Envelope.
Fork-tailed Swift (*Apus pacificus*)	Mi	Mi	The Fork-tailed Swift is a non-breeding visitor to all states and territories of Australia. In Western Australia there are widespread but scattered records of the Fork-tailed Swift along much of the coastline, with some sparsely scattered inland records, especially in the Wheatbelt (DAWE 2020). They are almost exclusively aerial and are most commonly found over inland plains but sometimes above foothills or in coastal areas (DAWE 2020).	**Unlikely; Irregular visitor** This species is predominantly an aerial species and does not rely on specific terrestrial habitats. It may occasionally be seen foraging near the Development Envelope but is unlikely to solely rely on any of the habitats present (ELA 2020).
Glossy Ibis (*Plegadis falcinellus*)	Mi	Mi	The Glossy Ibis is widespread throughout most of the world and is the most widespread species of Ibis. In Australia it is generally located east of the Kimberley in Western Australia and the Eyre Peninsula in South Australia (DAWE 2020). The species feeds in very shallow water and nests in freshwater or brackish wetlands with tall dense stands of emergent vegetation such as reeds, papyrus or rushes and low trees or bushes. They show a preference for marshes at the margins of lakes and rivers but can also be found at lagoons, floodplains, wet meadows, swamps, reservoirs, sewage ponds, paddies and irrigated farmland.	**Unlikely; Irregular visitor in small numbers** The Glossy Ibis was recorded during recent surveys at Horse Swamp (Terrestrial Ecosystems 2019). This location is within 500 m of the Development Envelope. Most of the Development Envelope does not have suitable habitat for the species (Terrestrial Ecosystems 2019). The Marshall Paddocks area has the potential to support the species in years when the area become inundated with water (Bamford pers. comm. 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Rainbow Bee-eater *(Merops ornatus)*	Marine	NA	The Rainbow Bee-eater is widely distributed across most of mainland Australia where it occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (DAWE 2020).	**Recorded** The Rainbow Bee-eater was recorded during the ELA survey nesting within a sandy embankment (ELA 2020).
Curlew Sandpiper (Calidris ferruginea)	CR & Mi	CR	Curlew Sandpipers generally occur around the coasts but are also quite widespread inland. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding birds remain in Australia rather than migrating north. The species generally inhabits intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons (DAWE 2020).	**Unlikely** The species may be an irregular visitor in small numbers as there is some suitable habitat within 500m of the Development Envelope (Bamford pers. comm. 2020).
Australasian Bittern (*Botaurus poiciloptilus*)	EN	EN	The Australasian Bittern population can be divided into two sub-populations, the south-eastern and south-western sub-populations. The south-western sub population in WA likely only occur on the western coastal plain, with key populations being located in the Lake Muir area, Benger Swamp and Leschenault Inlet, where it prefers freshwater wetlands with tall dense vegetation (TSSC 2019, Bamford pers. comm. 2020).	**Unlikely; Vagrant** The species mainly occurs further south in south western WA. A recent waterbird survey undertaken by Terrestrial Ecosystems (2019) identified that there was a lack of suitable habitat available for many waterbird species within the Development Envelope. This species is therefore considered unlikely to occur (ELA 2020).
Common Greenshank(*Tringa nebularia*)	Mi	Mi	The Common Greenshank is a wader species that occurs in a variety of coastal and inland wetlands. In WA, it occurs around most of the coast from Cape Arid in the south to Carnarvon in the north-west and has the widest distribution of any shorebird in Australia. The species spends the non-breeding season in Australia but migrates north to breed (DAWE 2020).	**Unlikely** The species is known to occur nearby at Lake Gnangara (~7 km west). However, a recent waterbird survey undertaken by Terrestrial Ecosystems (2019) identified that there was a lack of suitable habitat available for many waterbird species within the Development Envelope. This species is therefore considered unlikely to occur (ELA 2020) There is potential habitat for this species at Horse Swamp and Marshall Paddocks at times when the areas are inundated with water (Bamford pers. comm. 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Wood Sandpiper(*Tringa glareola*)	Mi	Mi	The Wood Sandpiper is a wader species that inhabits inland shallow freshwater wetlands, often with other waders. They prefer ponds and pools with emergent reeds and grass, surrounded by tall plants or dead trees and fallen timber. They tend to occur more so in the north of Australia rather than southern parts (Morcombe 2000).	**Unlikely** There is only one record of this species approximately 3.8 km east of the Development Envelope. This species was not recorded during the recent waterbird survey undertaken by Terrestrial Ecosystems (2019) and no suitable habitat occurs within the Development Envelope (ELA 2020).
Peregrine Falcon *(Falco peregrinus)*	NA	OS	The Peregrine Falcon occurs across most habitats within Australia but is relatively uncommon. It usually nests in coastal and inland cliffs or open woodlands near water.	**Potential** There are numerous records of this species around Whiteman Park and it is known to breed within the Park. There are no records within the Development Envelope itself (DBCA 2019a). The species could potentially occur within the Development Envelope on an occasional basis and would be in the foraging range of a breeding pair (Bamford pers. comm. 2020) but is unlikely to rely on any of the habitats available within the Development Envelope (ELA 2020).
Red-winged Fairy-wren *(Malurus elegans)*	Not listed	Not listed	The Red-winged Fairy-wren is not listed under with the EPBC or BC Act, but is considered a regionally significant species under Bush Forever. This species is endemic to the south- east of WA and has a discontinuous distribution between Gingin Brook, Augusta and to the east of Albany (Bamford pers. comm. 2020). It generally inhabits the understorey of Karri forests and dense stream zone vegetation in Jarrah forests.	**Potential; likely to be locally extinct** This species has not been recorded during any of the surveys undertaken for the Proposal; however, it may occur in and around Whiteman Park where it has previously been recorded. While this species was historically present in dense vegetation along Bennett Brook, it is thought to now be locally extinct (Bamford pers. comm. 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
MAMMALS				
Western Ringtail Possum (*Pseudocheirus occidentalis*)	CR	CR	The Western Ringtail Possum occurs in the SW of WA where it inhabits the peppermint woodlands and peppermint/Tuart forests on the southern extremity of the Swan Coastal Plain (DPaW 2017).	**Unlikely** The Proposal is outside the known distribution of this species and it is considered to be locally extinct.
Woylie (*Bettongia penicillata ogilbyi*)	EN	CR	Woylies prefer patches of dense undergrowth with a continuous canopy that provide refuges against introduced predators. Scattered Woylie populations may be found throughout the Jarrah forest in the southwest corner of Western Australia (DEC 2012a).	**Locally extinct in the wild** There is a translocated population of Woylie within Whiteman Park (AECOM 2016, DEC 2012a), which occurs within 1km of the Development Envelope. This population is within a protected zone/fenced area within Whiteman Park.
Black-flanked Rock-wallaby (*Petrogale lateralis*)	EN	EN	The Black-flanked Rock-wallaby is endemic to Western Australia where it was formerly widespread. The species distribution has greatly declined, and it is now confined to small patches of suitable habitat in central and southern WA (DAWE 2020).	**Unlikely; Locally extinct** The species inhabits rocky areas and it is highly unlikely to occur in the Development Envelope due to a lack of suitable habitat (Bamford pers. comm. 2020).
Chuditch (*Dasyurus geoffroii*)	VU	VU	Chuditch currently only occurs in areas dominated by sclerophyll forest or drier woodland, heath and mallee shrubland and require adequate numbers of suitable den and refuge sites and sufficient prey biomass to survive (DEC 2012b). The majority of records are found in the contiguous Jarrah forests of the south west of Western Australia.	**Unlikely** There are no known established populations of Chuditch within the Perth metropolitan area, however there are some records of the species on the outskirts of the Greater Perth metropolitan region (Bamford pers. comm. 2020). There is a lack of suitable habitat for this species within the Development Envelope and so the species is considered unlikely to occur (ELA 2020).
Western Brush Wallaby *(Notamacropus irma)*	NA	P4	The Western Brush Wallaby is distributed across the south-west of WA from north of Kalbarri to Cape Arid. This species optimum habitat is open forest or woodland, seasonally wet flats with low grasses and open thickets (DotEE 2019e).	**Potential** There are numerous records of this species within Whiteman Park (DBCA 2019a). It is estimated that there are a population of around 200 individuals within Whiteman Park (Bamford pers. comm. 2020) The species may potentially be an irregular visitor to suitable habitats within the Development Envelope.

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Quenda *(Isoodon fusciventer)*	NA	P4	Quenda are widely but patchily distributed through south-western WA, from around Guilderton to east of Esperance and inland to Hyden. This species prefers low, dense vegetation such as heath and swampy habitat and is often associated with forests, woodland, shrubland and riparian areas (DEC 2012e).	**Recorded; Resident of Whiteman Park** A potential Quenda digging was recorded during the ELA 2019 survey and previously during AECOM's survey (2016) within the Development Envelope. There are numerous records of the species throughout Whiteman Park and one record of the Quenda adjacent to Bush Forever site 200 (DBCA 2019a). Quenda were also directly observed during WRMs recent wetland survey at Orchid Park (WRM 2019) and in revegetation adjacent to Tonkin Highway (GHD 2020a), both located close to but outside the Development Envelope.
Water Rat, Rakali *(Hydromys chrysogaster)*	NA	P4	The Water Rat is found mainly near permanent bodies of freshwater where it lives in burrows on low banks of rivers, lakes, wetlands, estuaries and even along the coast. Intact riparian vegetation and associated bank stability is critical to their survival.	**Potential; Likely Resident at Bennett Brook** DBCA (2019a) have recorded several individuals surrounding the Development Envelope, however, the species was not recorded during a recent wetland survey (WRM 2019). Suitable habitat occurs within watercourses and riparian vegetation habitats within and around the Development Envelope (ELA 2020).
Western False Pipistrelle (*Falsistrellus mackenziei*)	NA	P4	The Western False Pipistrelle occurs mostly in wet sclerophyll forests of Karri, Jarrah and Tuart, and generally occurs in the South West of WA. The majority of records of this species occur south and south east of Mandurah; however, there is one outlier record north of Perth (DBCA 2019a).	**Unlikely; Irregular visitor** This species inhabits the tall, dense Karri and Jarrah forests of the SW of WA. There is one outlier record of this species approximately 3 km east of the Development Envelope; however, there is a lack of suitable habitat within the Development Envelope itself and so this species is considered unlikely to occur (ELA 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
REPTILES				
Western Swamp Tortoise (*Pseudemydura umbrina*)	CR	CR	The Western Swamp Tortoise is only known from three locations including Ellenbrook Nature Reserve, Twin Swamps Nature Reserve and Mogumber Nature Reserve. None of these areas occur within the Development Envelope.	**Unlikely; Locally extinct** The closest known occurrence of this species is within the Twin Swamps Nature Reserve which is approximately 7 km east of the Ellenbrook section of the Development Envelope and is considered locally extinct.
Black-striped Snake *(Neelaps calonotos)*	NA	P3	The Black-striped Snake occurs only along the Swan Coastal Plain with the bulk of this species' known distribution occurring in the Perth region; however, there have been recent records of this species further north near Dongara and Eneabba suggesting it has a broader distribution (Bush et al. 2010). This species occurs on dunes and sand plains vegetated with heaths and Eucalypt/Banksia woodlands (Terrestrial Ecosystems 2018).	**Potential** This species has previously been recorded in and around Ellenbrook and around Bennett Springs (DBCA 2019a, Terrestrial Ecosystems 2018). The Black-striped Snake could potentially utilise the Banksia woodland habitat but it is unlikely (ELA 2020, Bamford pers. comm. 2020).
Jewelled Sandplain Ctenotus *(Ctenotus gemmula)*	NA	P3	There are three geographic populations for the Jewelled Sandplain Ctenotus, one is on the sand plain north of Perth, one is on the sand plain around the greater Perth metropolitan area and the largest geographic distribution is along the south coast of Western Australia (Terrestrial Ecosystems 2018). The species is generally scarce on the Swan Coastal Plain as this is the northern extent of its range (Bush et al. 2010).	**Potential** There are two records of this species approximately 4 km northeast of the Development Envelope (DBCA 2019b). The Jewelled Sandplain Ctenotus may potentially utilise the Banksia woodland habitats within the Development Envelope (ELA 2020) but it is unlikely (Bamford pers. comm. 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
AQUATIC FAUNA				
Black-striped Dwarf Galaxias / Black-stripe Minnow *(Galaxiella nigrostriata)*	EN	EN	The Black-stripe Minnow is restricted to the ephemeral peat wetlands of south-western Australia (TSSC 2018a). The closest known population of the species is at Melaleuca Park, approximately 12 km north of the Development Envelope in Ellenbrook. There is another known population in Kemerton north of Bunbury.	**Potential habitat/ considered to be locally extinct** The desktop wetland assessment undertaken for this Proposal indicates there are four wetlands within or adjacent to the Development Envelope that have potential Black-stripe Minnow habitat (Biologic 2020) However, an extensive fish survey of 30 sites conducted in 1997 & 1998 within Bennett Brook catchment, which includes the interconnected system of wetlands within Whiteman Park, did not find the Black-stripe Minnow (Bamford et al 1998). The most abundant and widespread species captured during this survey was the introduced Mosquito Fish (*Gambusia holbrooki*) which is a predatory and aggressive species known to significantly impact native fish populations, including the Black-stripe Minnow (Bamford et al 1998).
Carter's Freshwater Mussel *(Westralunio carteri)*	VU	VU	The species distribution ranges from Moore River in the north, to the south coast, west of Esperance (Klunzinger 2012, Klunzinger et al. 2015). *Westralunio carteri* occurs in greatest abundance in slower flowing permanent/semi-permanent stream and riverine habitats with stable sediments and low salinity, living two thirds to almost fully buried in sand and finer sediment. Experiments have indicated this species cannot survive prolonged periods of drying (i.e. 76% mortality occurring under experimental conditions, within five days of exposure to dry conditions) (Klunzinger et al. 2015, Biologic 2020).	**Potential** The species is a resident of Bennett Brook, where it has been recorded at Mussel Pool upstream from the proposed rail bridge, and approximately 1.7km downstream of the proposed rail bridge at Bennett Brook. No habitat suitable/ preferable to Carter's Freshwater Mussel was present within Bennett Brook where it is intercepted by the Development Envelope. This area was dry in mid-autumn and lacked suitable habitat, such as semi-permanent/permanent pools or flowing water with a sandy substrate (WRM 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
INVERTABRATES / SHORT RANGE ENDEMIC				
Swan Coastal Plain Shield-backed Trapdoor spider (*Idiosoma sigillatum*) DBCA Priority 3 / Confirmed SRE	NA	P3 SRE	A dominant idiopid trapdoor spider on the Swan Coastal Plain, where it occurs from Dalyellup north to at least Ledge Point (including Rottnest Island and Garden Island) with the eastern limit of its range along the sandy foothills of the Darling Escarpment, from Boyanup north to at least Gingin (Invertebrate Solutions 2020, refer WAM 2018b, Rix *et al.* 2018). Much of the habitat for this species within the Perth metropolitan area has been cleared for urban development and the species is unlikely to occur through much of its historical distribution in urban areas except in remnant habitats (Invertebrate Solutions 2020, Rix et al 2018).	**Potential; Low abundance** The species was not recorded during the field surveys, and hence is either absent from the area or present in very low abundance.
Millipede (*Antichiropus whistleri*)	NA	SRE	This species occurs north of the Swan River from Morley to Muchea with another cluster of records near Cataby, although much of its original habitat has now been cleared for urban development. *Antichiropus* all have limited powers of dispersal and conservative ecological requirements (Car et al. 2013). In addition, the above-ground activity of most *Antichiropus* species are limited to a very small window of opportunity when there is sufficient moisture for them to forage and mate during wetter winter months (Car et al. 2013).	**Potential; Low abundance** There is the potential for the species to occur in the Development Envelope. However, it was not recorded during the field surveys, and hence is either absent from the area or present in very abundance.
Spiny tree cricket (*Austrosaga spinifer*) – DBCA Priority 2 / Likely SRE	NA	P2 Likely SRE	Very few records exist for this spiny tree cricket, but it has been recorded from Boya on the edge of the Perth Darling Scarp approximately 10 km from the survey area and also in bushland near Melaleuca, east of Pinjar. The species is known to hide in shrubs and sing at night (Rentz 1993).	**Potential; Low abundance** There is the potential for the species to occur in the Development Envelope. However, it was not recorded during the field surveys, and hence is either absent from the area or present in such very abundance.

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Graceful Sunmoth (*Synemon gratiosa*) –	NA	P4	The species is generally restricted to the Swan Coastal Plain but has also been recorded from the Geraldton sandplains and is known at 49 locations (Bishop *et al.* 2010). The species has been removed from the *Biodiversity Conservation Act* and the EPBC fauna list, however due to their limited distribution, small populations and rarity in nature the Graceful Sunmoth is listed on the DBCA Priority fauna listing (Priority 4). Habitat for the Graceful Sunmoth is in the Swan Coastal Plain, Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *Lomandra hermaphrodita* is widespread.	**Potential** Habitat for the moth occurs within the Development Envelope with the presence of one of the species' preferred food plants, *Lomandra hermaphrodita* within the Banksia Woodland TEC areas (RPS 2020).
Isopod (*Pseudodiploexochus sp. indet*)	NA	Likely SRE	This species is known to occur more widely within the Gnangara region, however, it is rarely collected (Judd 2019).	**Recorded** The species was recorded within the Development Envelope during the recent SRE survey (Invertebrate Solutions 2020).
Isopods (*Spherillo sp*. 2, *Oniscoidea sp*. indet. and *Philosciidae sp.* indet.).	NA	Possible SRE	These species have a possible SRE status due to being data deficient (Invertebrate Solutions 2020). All the possible Isopod SRE species are known to occur more widely in the region or were recorded at multiple locations and/or habitats that were laterally continuous during the survey indicating that their distributions are wider than the current survey could determine.	**Recorded** The species was recorded within the Development Envelope during the recent SRE survey (Invertebrate Solutions 2020).
Pseudoscorpion (*Olpiidae sp*)	NA	Possible SRE	This species has possible SRE status due to being data deficient (Invertebrate Solutions 2020). All the possible SRE species are known to occur more widely in the region or were recorded at multiple locations and/or habitats that were laterally continuous during the survey indicating that their distributions are wider than the current survey could determine.	**Recorded** The species was recorded within the Development Envelope during the recent SRE survey (Invertebrate Solutions 2020).

Common name /Species	Conservation status*		Distribution and habitat	Likelihood of occurrence / status within the Development Envelope
	EPBC Act	BC Act		
Douglas' Broad-headed Bee *(Hesperocolletes douglasi*)	CR	CR	Very little is known of this species and floristic associations are still being determined with the currently known list including *Philotheca spicata, Patersonia occidentalis*, two species of *Stylidium*, a species of *Scaevola* and species from Fabaceae and Myrtaceae (Invertebrate Solutions 2020).	**Unlikely.** The species has a Low probability of being present within the Development Envelope due to its restricted distribution and the small area of potential habitat present within the Development Envelope (Invertebrate Solutions 2020).
Short-tongued bee *(Leioproctus douglasiellus)*	CR	EN	The native bee species *Leioproctus douglasiellus*, is known from the Swan Coastal Plain (SCP) where it has been recorded from Kenwick wetlands, Cannington and Forrestdale Lake and near Lithgow in the Blue Mountains of NSW (ALA 2019). It has been found on two plant species: *Goodenia filiformis* and *Anthotium junciforme.*	**Unlikely.** Due to the absence of both of these flora species within the Development Envelope (RPS 2020) it is considered to have a Low likelihood of occurrence. This species was not recorded during the 2019 survey and no significant impacts are anticipated to occur to this species.
A Native Bee *(Neophasiphae simplicior)*	CR	EN	This native bee has distribution in Western Australia from north of Geraldton, through the coastal fringe and along the southern coast to Cape Arid National Park (ELA 2019).	**Unlikely.** Most available records from the SCP are historical in nature and its current status in the Perth metropolitan area is unknown.

Source: ELA 2020, Terrestrial Ecosystems 2018, Invertebrate Solutions 2020 and Biologic 2020

* Conservation significant fauna listing definitions are as follows:

CR = listed as Critically Endangered under the EPBC Act.

EN = listed as Endangered under the EPBC Act.

VU = listed as Vulnerable under the EPBC Act.

Mi = listed as Migratory species under the EPBC Act.

S1 = Schedule 1: Fauna that is rare or is likely to become extinct as critically endangered fauna (CR) under the BC Act.

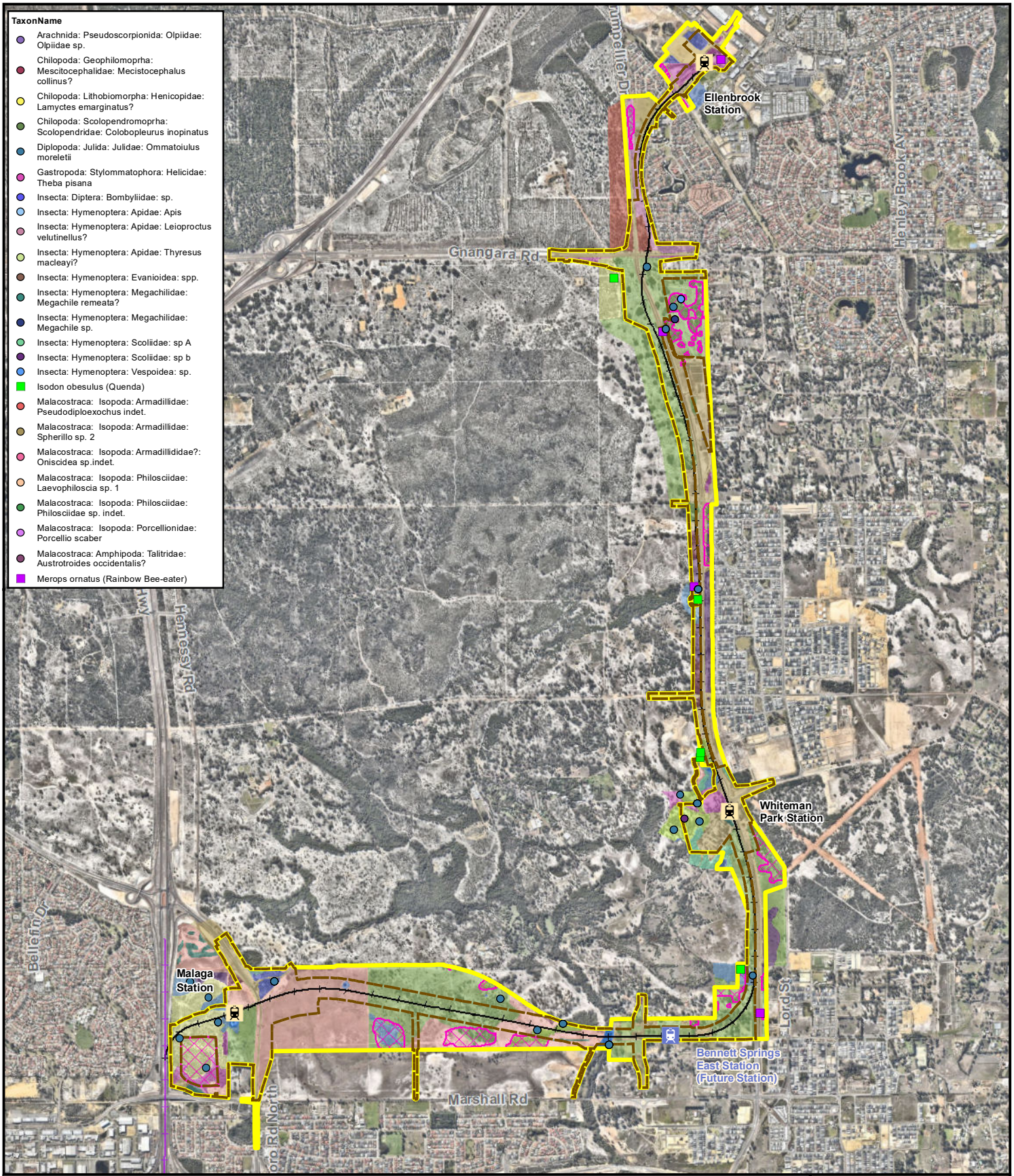
S2 = Schedule 2: Fauna that is rare or likely to become extinct as endangered fauna (EN) under the BC Act.

S3 = Schedule 3: Fauna that is rare or likely to become extinct as vulnerable fauna (VU) under the BC Act.

S5 = Schedule 5: Migratory birds protected under an international agreement (IA) under the BC Act.

P3 = Priority 3: poorly known species known from several specimens or records but not under imminent threat and need further survey. Listed by DBCA.

P4 = Priority 4: Rare, Near Threatened and other species in need of monitoring but not currently threatened; could become threatened if present circumstances change. Listed by DBCA.



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 18 **Terrestrial Fauna Habitat**

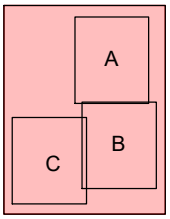
Public Transport Authority

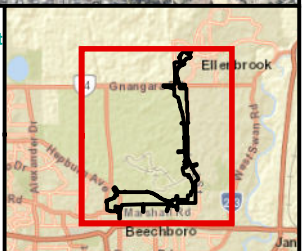
Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Terrestrial Fauna Habitat

- Banksia Woodland
- Cleared Paddock
- Constructed wetland/drainage
- Flooded Gum Woodland
- Infrastructure/Cleared
- Mixed Banksia/Eucalyptus/Corymbia Woodland
- Mixed Eucalyptus/Corymbia Woodland
- Modified vegetation
- Paddock with Eucalyptus/Corymbia
- Paddock with Melaleuca
- Paperbark Woodland
- Parkland cleared
- Pine Plantation
- Scattered trees/shrubs
- Shrubland
- Wetland/water course (open water areas)





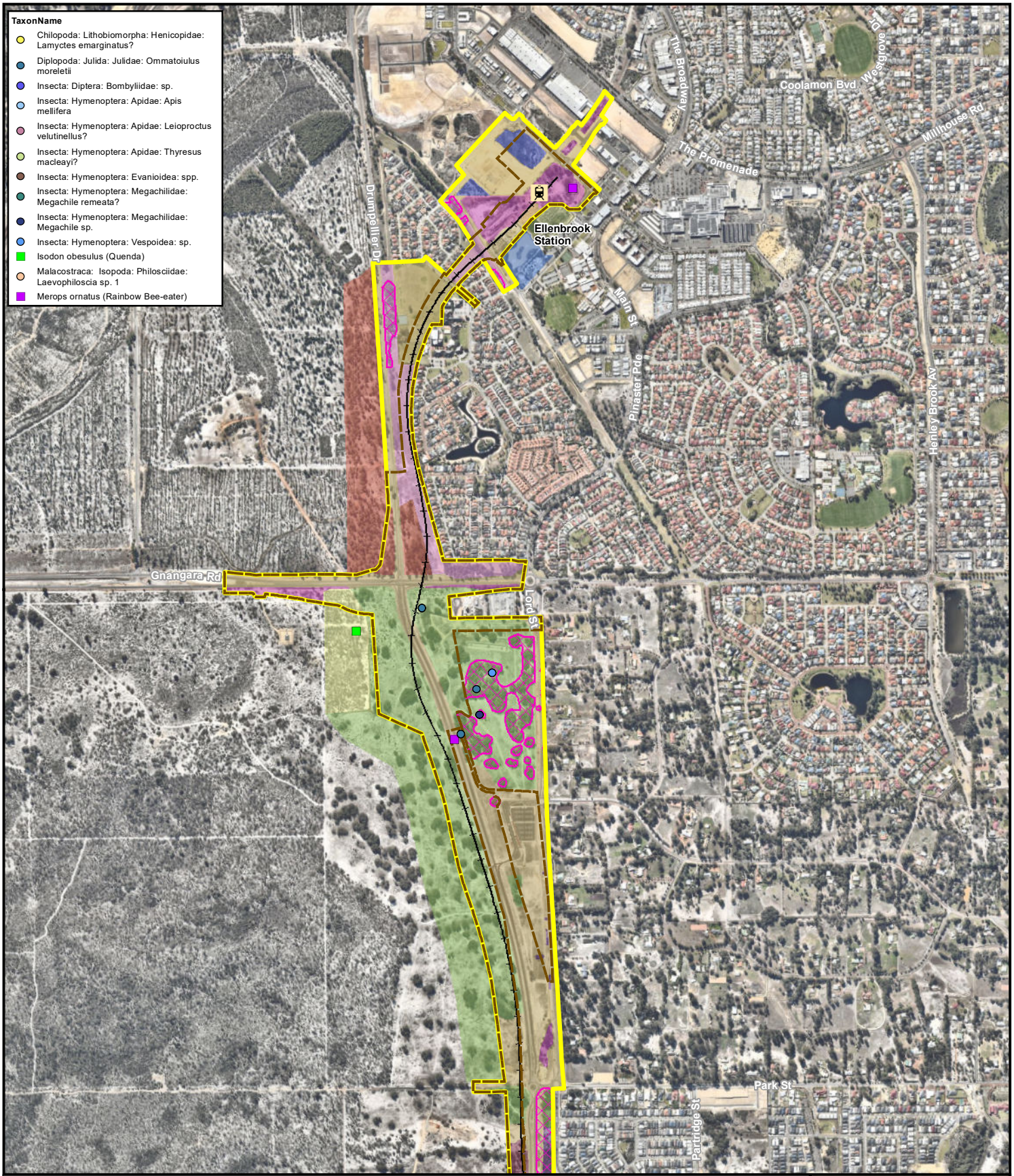
Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

Scale: 1:40,500 @ A4
Coordinate System: GDA 1994 MGA Zone 50

0 200 400 600 m

N

Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0128_A4P_Mapbook_v4.mxd



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 18A **Terrestrial Fauna Habitat**

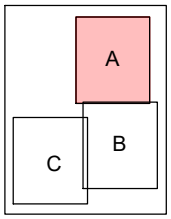
Public Transport Authority

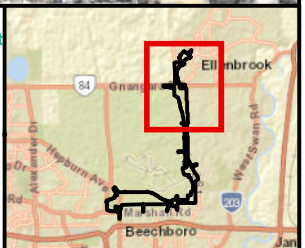
Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention
- Proposed Railway Station
- Indicative Railway Alignment

Terrestrial Fauna Habitat

- Banksia Woodland
- Constructed wetland/drainage
- Infrastructure/Cleared
- Mixed Banksia/Eucalyptus/Corymbia Woodland
- Modified vegetation
- Paddock with Eucalyptus/Corymbia
- Paddock with Melaleuca
- Parkland cleared
- Pine Plantation
- Shrubland





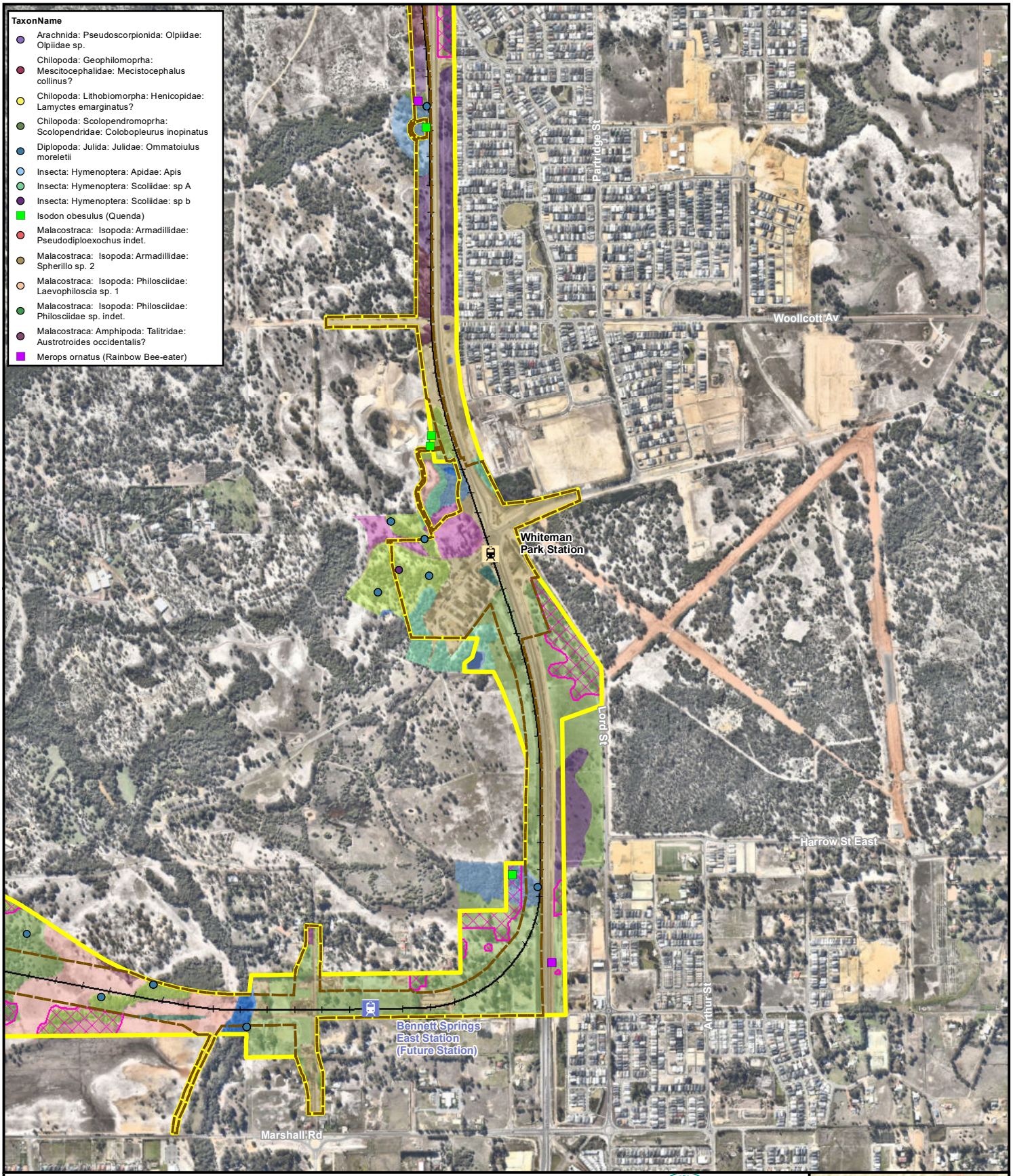
Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

Scale: 1:20,000 @A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0128_A4P_Mapbook_v4.mxd



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 18B **Terrestrial Fauna Habitat**

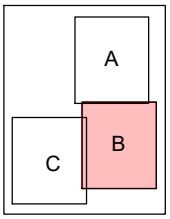
Public Transport Authority

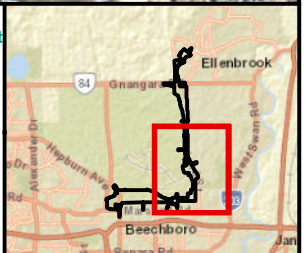
Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Terrestrial Fauna Habitat

- Cleared Paddock
- Constructed wetland/drainage
- Flooded Gum Woodland
- Infrastructure/Cleared
- Mixed Banksia/Eucalyptus/Corymbia Woodland
- Mixed Eucalyptus/Corymbia Woodland
- Modified vegetation
- Paddock with Eucalyptus/Corymbia
- Paddock with Melaleuca
- Paperbark Woodland
- Scattered trees/shrubs
- Wetland/water course (open water areas)





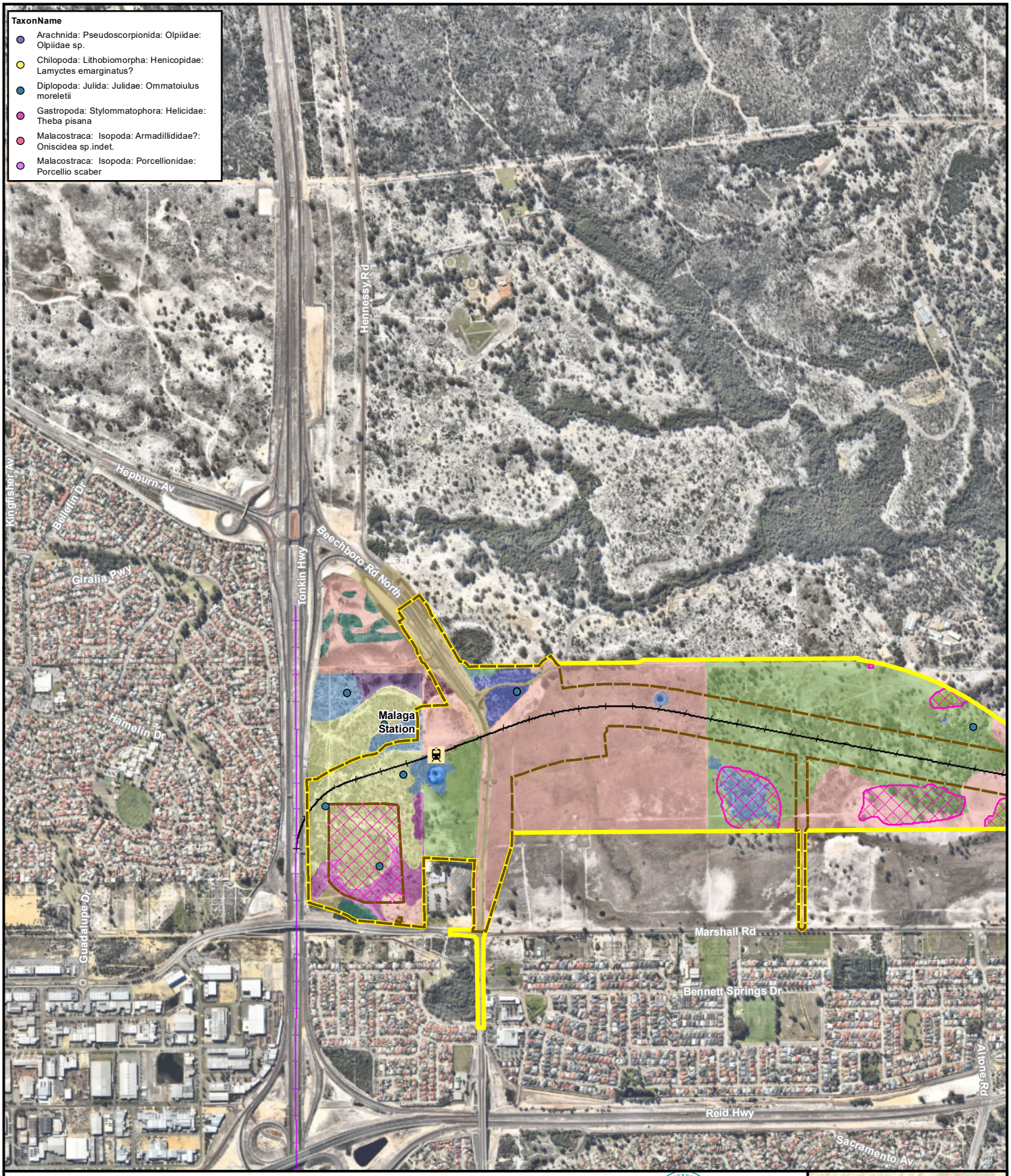
Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0128_A4P_Mapbook_v4.mxd



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 18C **Terrestrial Fauna Habitat**

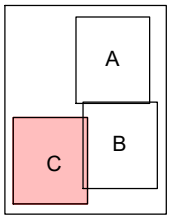
Public Transport Authority

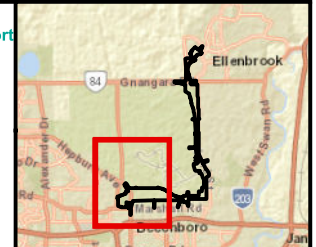
Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Indicative Railway Alignment

Terrestrial Fauna Habitat

- Banksia Woodland
- Cleared Paddock
- Constructed wetland/drainage
- Infrastructure/Cleared
- Mixed Banksia/Eucalyptus/Corymbia Woodland
- Mixed Eucalyptus/Corymbia Woodland
- Modified vegetation
- Paddock with Eucalyptus/Corymbia
- Paddock with Melaleuca
- Paperbark Woodland
- Scattered trees/shrubs
- Shrubland
- Wetland/water course (open water areas)





Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

Scale: 1:20,000 @A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0128_A4P_Mapbook_v4.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

6.4.4. Short-range endemics and conservation significant invertebrates

Short range endemic (SRE) invertebrates are species with restricted distributions, typically isolated in specific habitats or bioregions. Conservation significant invertebrates are species of invertebrates listed under State or Commonwealth legislation or as Priority fauna by the DBCA. A small number of SRE invertebrates are listed as conservation significant, however the vast majority do not have a conservation significance listing due to poor knowledge of individual species' distribution and habitat requirements (Invertebrate Solutions 2020).

A desktop assessment and field survey targeting SRE and conservation significant invertebrate fauna was undertaken within the Development Envelope (Invertebrate Solutions 2020). The field survey recorded 219 individual invertebrate specimens representing 23 taxa of invertebrates from six classes, 10 orders and 16 families.

The survey recorded the following:

- No species are confirmed SRE or conservation significant invertebrates.
- One species – the isopod *Pseudodiploexochus sp*. indet is a likely SRE species.

Four are possible SRE species:

- Three isopods (*Spherillo sp*. 2, *Oniscoidea sp*. indet. and *Philosciidae sp*. indet.).
- One pseudoscorpion *Olpiidae sp*.

The Likely SRE isopod *Pseudodiploexochus sp*. indet. is known to occur more widely within the Gnangara region, however, it is rarely collected (Judd 2019). The four Possible SRE species have a possible SRE status due to being data deficient (Invertebrate Solutions 2020).

An additional four species have a high likelihood of occurring in the Development Envelope including:

- Trapdoor spider (*Idiosoma sigillatum*) –Priority 3 / Confirmed SRE.
- Millipede (*Antichiropus whistleri*) – Confirmed SRE.
- Spiny tree cricket (*Austrosaga spinifer*) –Priority 2 / Likely SRE.
- Graceful Sunmoth (*Synemon gratiosa*) –Priority 4.

Although the three BC Act Priority species and one Confirmed SRE species are considered to have a high likelihood of occurrence, *Idiosoma sigillatum, Antichiropus whistleri* and *Austrosaga spinifer* were not recorded during the field surveys, and hence are either absent from the area or present in low abundance. The Proposal is not expected to have a significant impact on these species due to their absence or low numbers and restricted area of clearing within potentially suitable habitat (Invertebrate Solutions 2019).

The presence of the Graceful Sunmoth can only be determined by surveying in March, however a detailed survey or assessment of its presence is not considered necessary due to the removal of its listing by the State and Commonwealth.

6.4.5. Black Cockatoo species

Carnaby's Cockatoos and Forest Red-tailed Black Cockatoos have been recorded within the Development Envelope during recent surveys (ELA 2020, Terrestrial Ecosystems 2018, AECOM 2016). Baudin's Cockatoo was recorded nearby in Whiteman Park and is therefore considered to have the potential to occur in the Development Envelope (AECOM 2016). The two records of Baudin's in Whiteman Park were located ~600 m west and 1.6 km north of the Development Envelope (ELA 2020, DBCA 2019a).

Carnaby's Cockatoo and Forest Red-tailed Black Cockatoos have been observed flying over the Development Envelope and directly observed foraging in the paddocks with Eucalyptus / Corymbia habitat during recent surveys (ELA 2020). There are also numerous DBCA records of Carnaby's and Forest Red-tailed Black Cockatoos near the Development Envelope (DBCA 2019a).

Foraging habitat

Foraging habitat suitable for the three Black Cockatoo species was recorded within the Development Envelope, mostly associated with the following fauna habitats (ELA 2020):

- Banksia woodland.
- Mixed Eucalyptus / Corymbia woodland.
- Pine plantation.
- Scattered trees / shrubs.
- Paddock with Eucalyptus/ Corymbia.

Banksia Woodland and Pine Plantation habitats provide suitable foraging habitat for Carnaby's Cockatoo, and to a much a lesser extent Baudin's Cockatoo, whereas the remaining fauna habitats provide suitable foraging habitat for all three species of Black Cockatoo (ELA 2020).

Forest Red-tailed Black Cockatoos were observed foraging in the Marri trees present within the northern section of the Development Envelope and Carnaby's Cockatoos were observed foraging in the Marri trees in the north eastern section (Figure 19). Foraging evidence from both Carnaby's Cockatoo and Forest Red-tailed Black Cockatoos in the form of chewed Marri nuts, Pine cones and Banksia infructescences was also observed throughout the Development Envelope. Evidence of foraging by both Carnaby's Cockatoo and Forest Red-tailed Cockatoos was found mainly within the Banksia Woodland, Pine Plantation, Mixed Eucalyptus/ Corymbia Woodland and Paddocks with Eucalyptus / Corymbia fauna habitats. The location of Carnaby's and Forest Red-tailed Black Cockatoo sightings and foraging evidence is illustrated in Figure 19.

The foraging habitat quality has been assessed and rated into four quality ratings (from no habitat value to high value), for each of the three species of Black Cockatoo (ELA 2020). Areas rated as having no habitat value for Black Cockatoos contains no or very few plants that provide a food source for Black Cockatoos. Low value habitat contains a few plants that would occasionally provide a food source for Black Cockatoos. Moderate value habitat contains plants that are a preferred food source for Black Cockatoos and high value habitat contains an abundance of plants that are a preferred food source for Black Cockatoos (ELA 2020).

Foraging habitat quality relevant to each of the three species of Black Cockatoos within the Development Envelope and Footprint is presented in Table 36 and Figure 19.

The majority of the Development Envelope (331 ha or 71.4%) is mapped as having low to no foraging habitat value for all three species. There are, however, a number of moderate to high quality foraging areas along Drumpellier Drive to the west of Whiteman Park station and some small areas north and west of Malaga Station (ELA 2020), as well as an area of pine plantation that occurs within the Development Envelope, which provides good quality foraging and roosting habitat for Carnaby's Cockatoo. There is no high quality Baudin's Cockatoo foraging habitat within the Development Envelope.

Table 36: Black Cockatoo foraging habitat quality rating

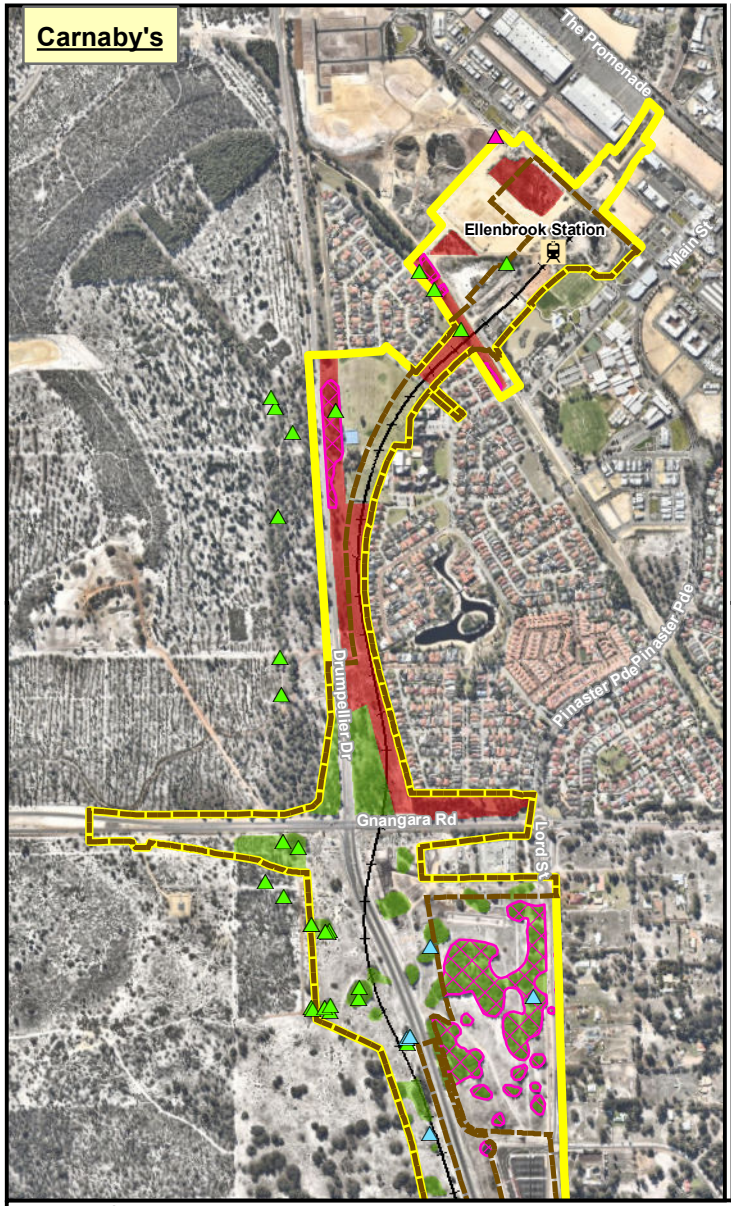
Rating / Habitat characteristics	Carnaby's		Forest-red Tailed		Baudin's	
	Development Envelope (ha)	Footprint (ha)	Development Envelope (ha)	Footprint (ha)	Development Envelope (ha)	Footprint (ha)
Nil	331.1	167.6	347.2	180.9	331.1	167.6
Low	37.0	27.3	45.8	30.2	56.7	38.6
Moderate	19.7	11.3	9.4	4.3	76.0	42.8
High	76.0	42.8	61.4	33.7	0.0	0.0
Total Foraging Habitat	**132.7**	**81.4**	**116.6**	**68.1**	**132.7**	**81.4**

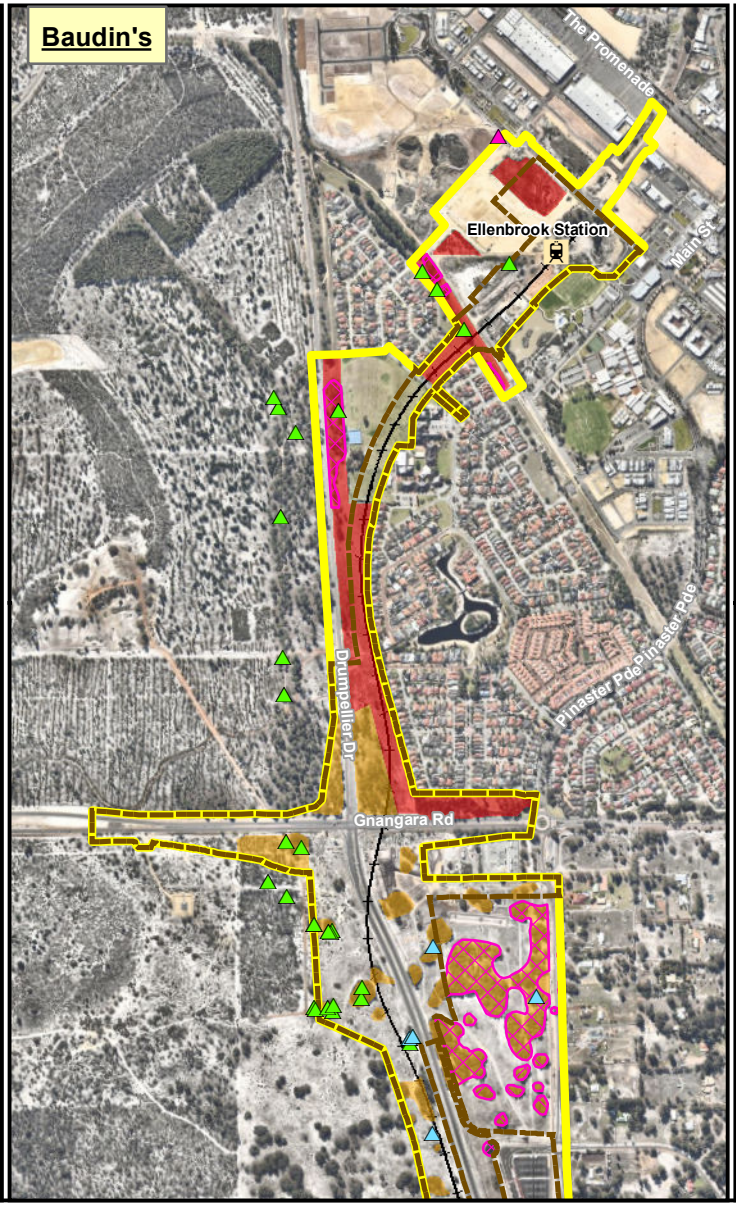
Source: ELA 2020

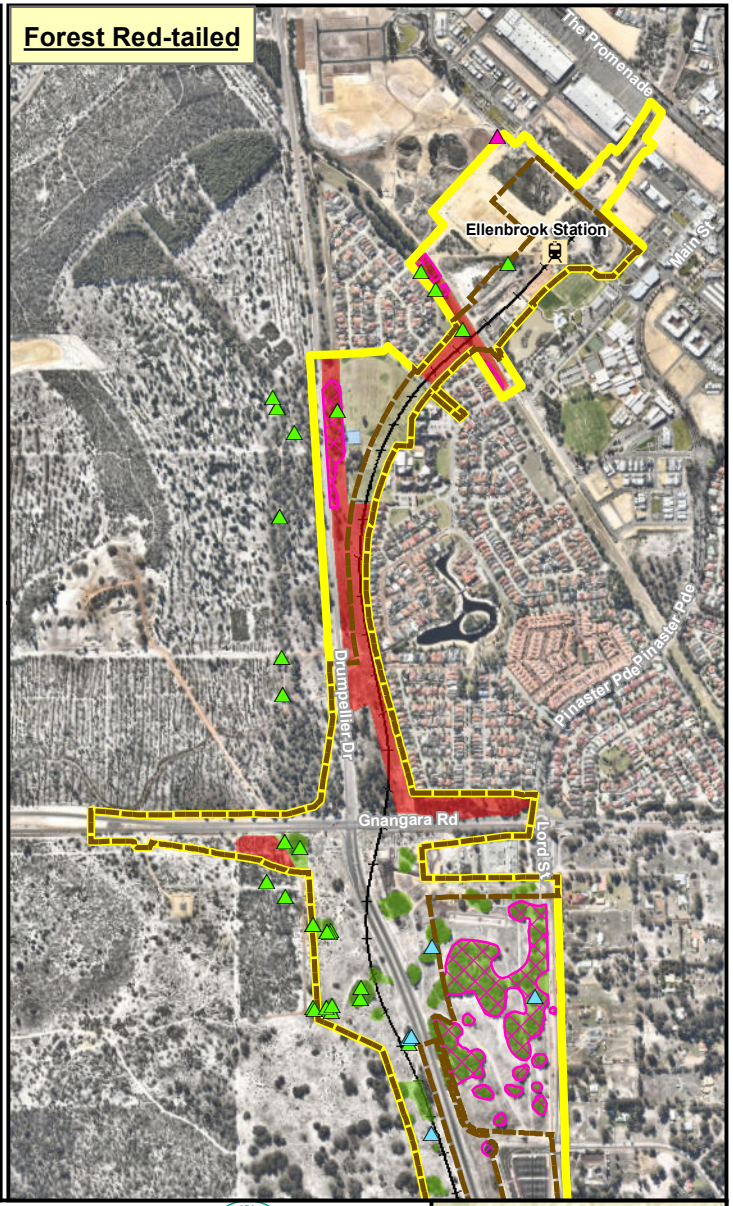
The Development Envelope contains 132.7 ha of suitable foraging habitat for Carnaby's and Baudin's Cockatoos. Within this there is 116.6 ha of suitable foraging habitat for Forest Red-tailed Black Cockatoos.

Within the Footprint there is 81.4 ha of Black Cockatoo suitable foraging habitat for Carnaby's and Baudin's Cockatoos and within this area there is 68.1 ha of suitable foraging habitat for Forest Red-tailed Black Cockatoos. The Footprint intersects with 54.1 ha of moderate to high value foraging habitat for Carnaby's Cockatoo, 38 ha of moderate to high value foraging habitat for Forest Red-tailed Black Cockatoo and 42.8 ha of moderate value foraging habitat for Baudin's Cockatoo.

There is an estimated 11,619 ha of regional foraging habitat for Black Cockatoos within a 10 km buffer of the Development Envelope. Regional Black Cockatoos foraging habitat (within a 10 km buffer of the Development Envelope) is shown in Figure 20.







METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 19A **Black Cockatoo Foraging Habitat (Carnaby's, Baudin's and Forest Red-tailed)**

Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Indicative Railway Alignment

Black Cockatoo Foraging Habitat Quality

- High
- Moderate
- Low

Taxon Name

- Black Cockatoo sp.
- Calyptorhynchus banksii naso (Forest Red-tailed Black Cockatoo)
- Calyptorhynchus latirostris (Carnaby's Black Cockatoo)

A B E D C

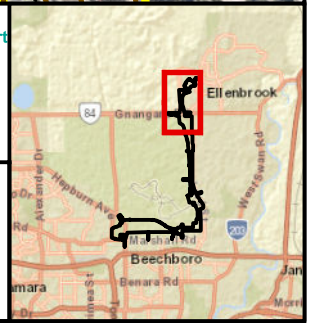
Public Transport Authority

Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

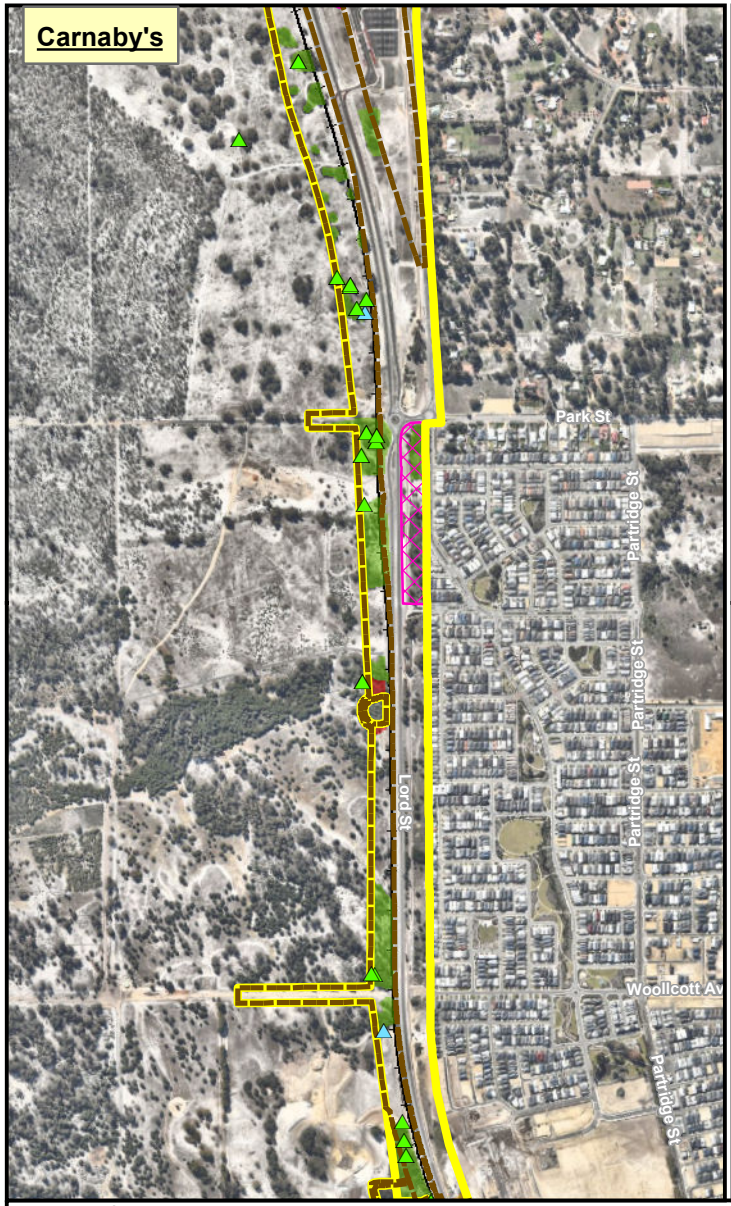
N

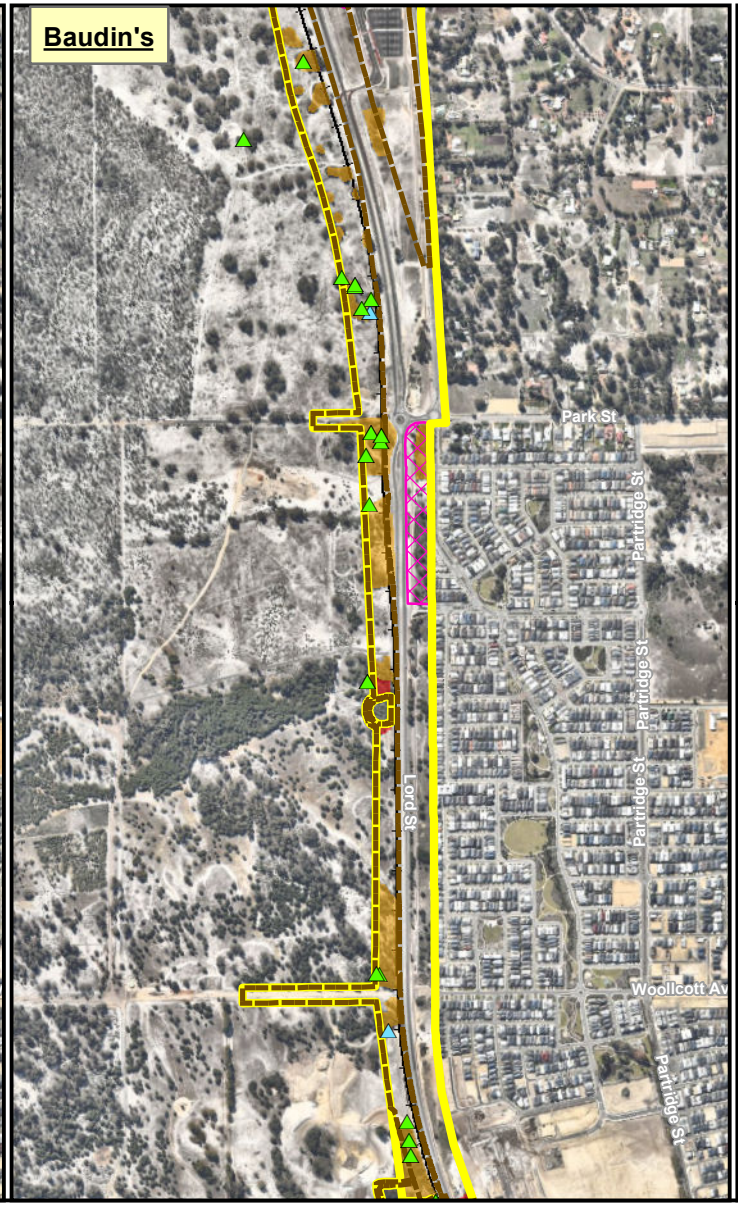
Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

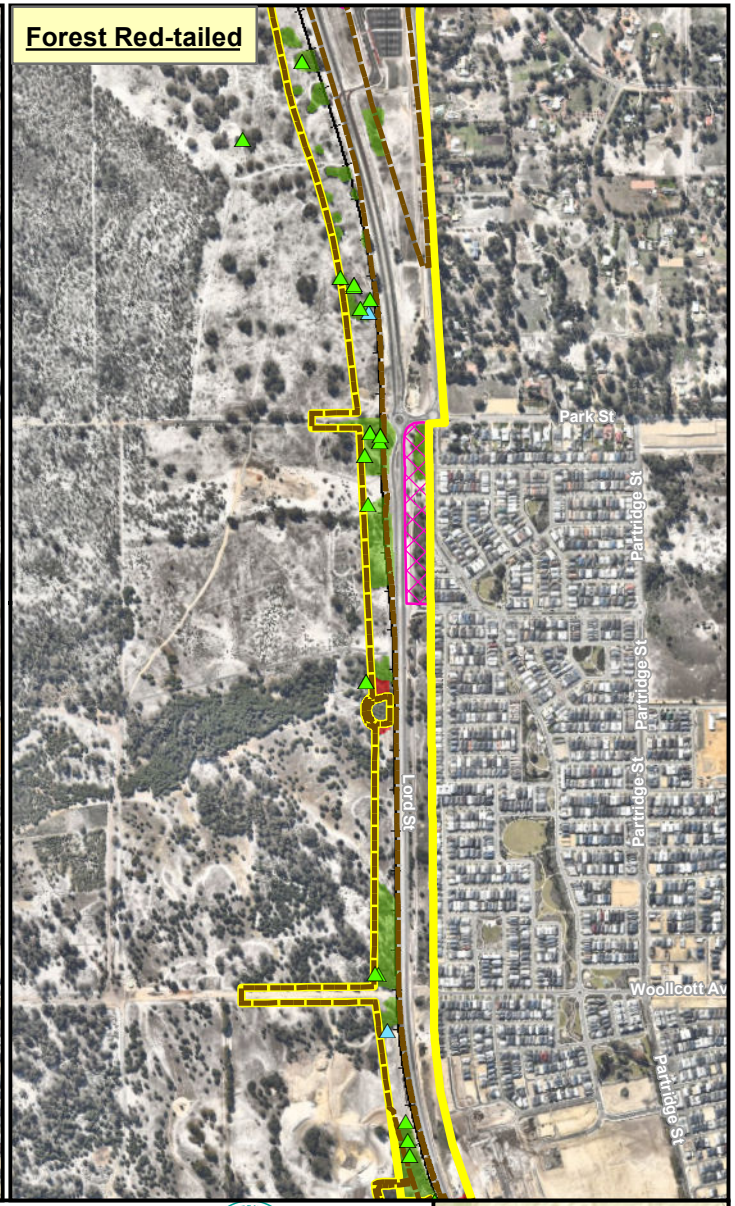
0 100 200 400 m



Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0129_A4P_Mapbook_v3.mxd







METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 19B **Black Cockatoo Foraging Habitat (Carnaby's, Baudin's and Forest Red-tailed)**

Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Indicative Railway Alignment

Black Cockatoo Foraging Habitat Quality

- High
- Moderate
- Low

Taxon Name

- Black Cockatoo sp.
- Calyptorhynchus banksii naso (Forest Red-tailed Black Cockatoo)

A B E D C

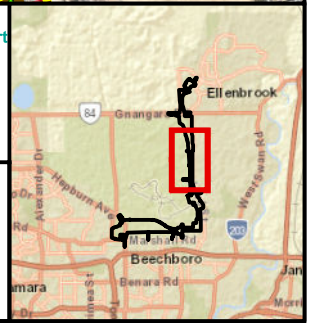
Public Transport Authority

Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

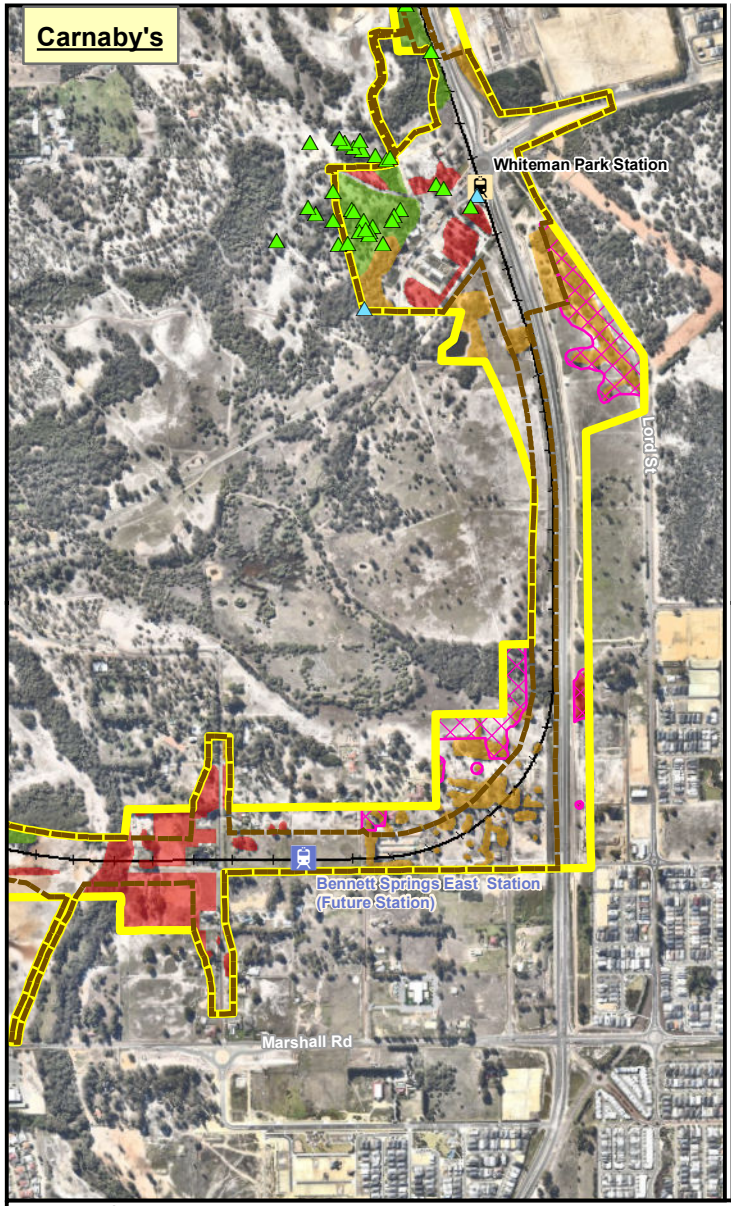
N

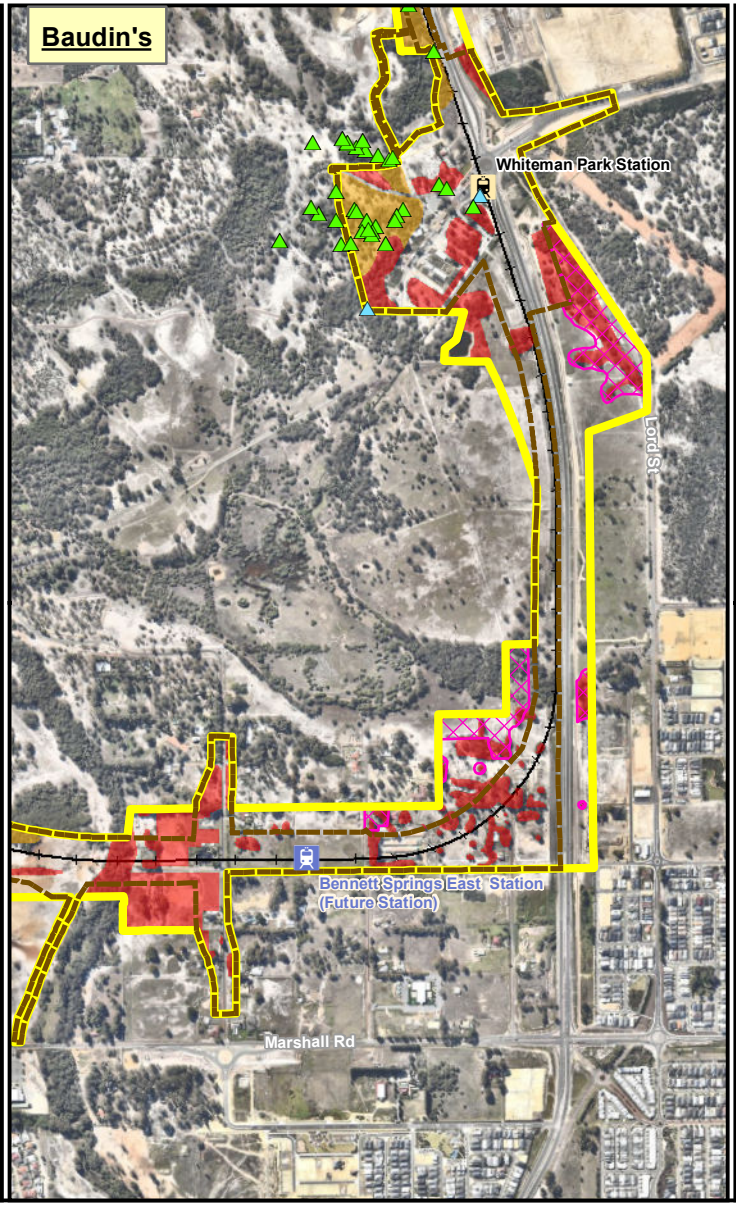
Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

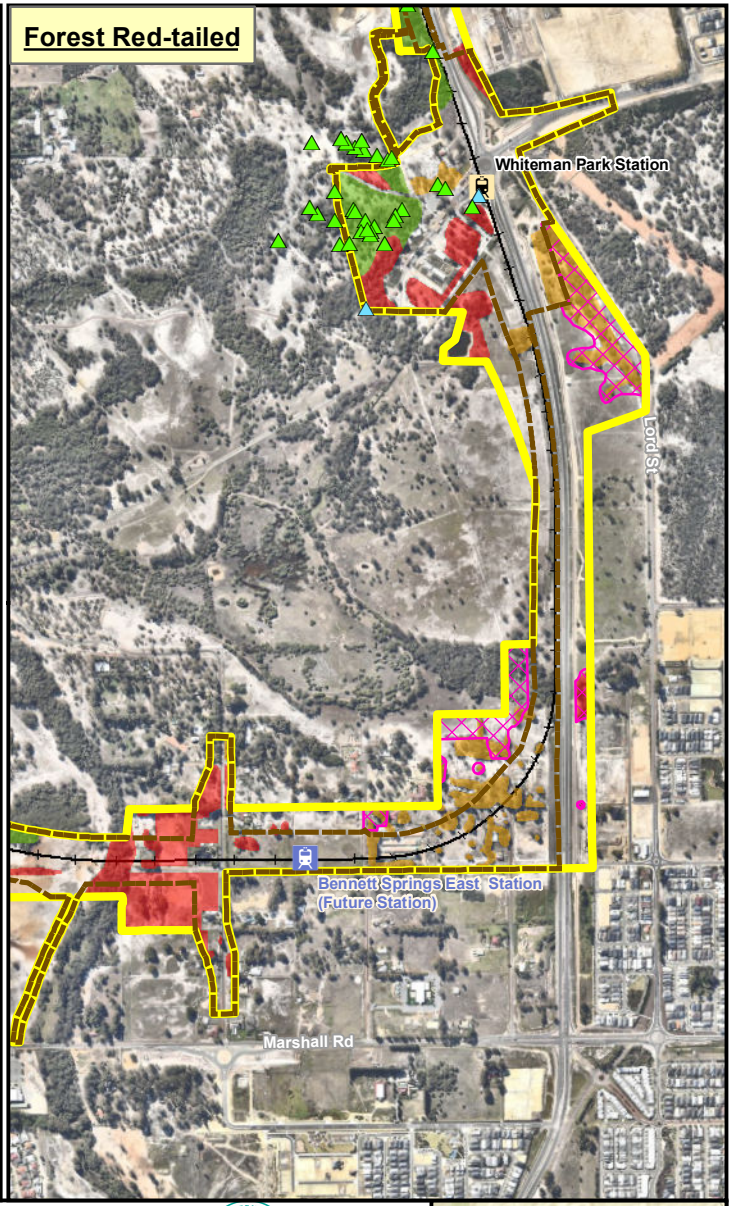
0 100 200 400 m



Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0129_A4P_Mapbook_v3.mxd







METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 19C **Black Cockatoo Foraging Habitat (Carnaby's, Baudin's and Forest Red-tailed)**

Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Black Cockatoo Foraging Habitat Quality

- High
- Moderate
- Low

Taxon Name

- Black Cockatoo sp.
- Calyptorhynchus banksii naso (Forest Red-tailed Black Cockatoo)

A B E D C

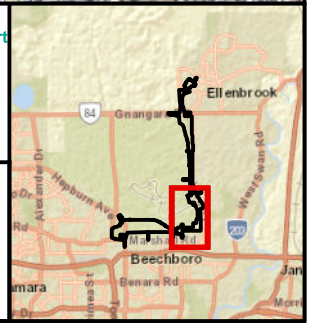
Public Transport Authority

Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

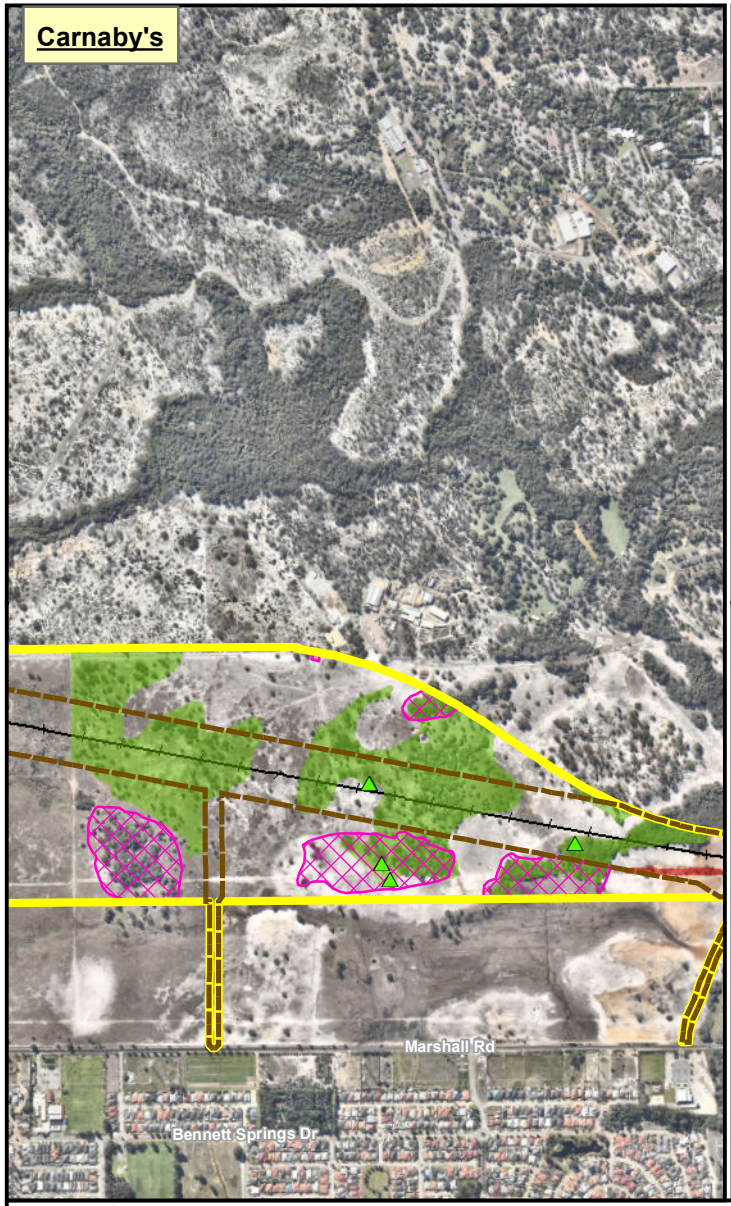
N

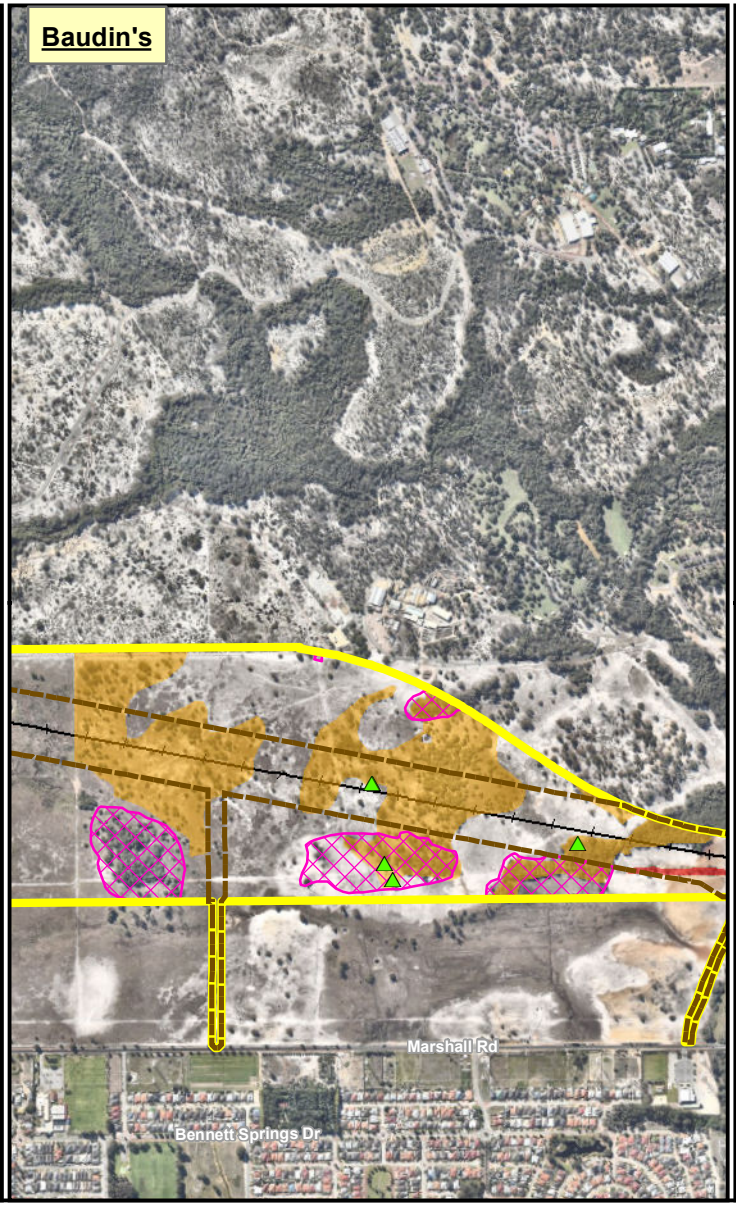
Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

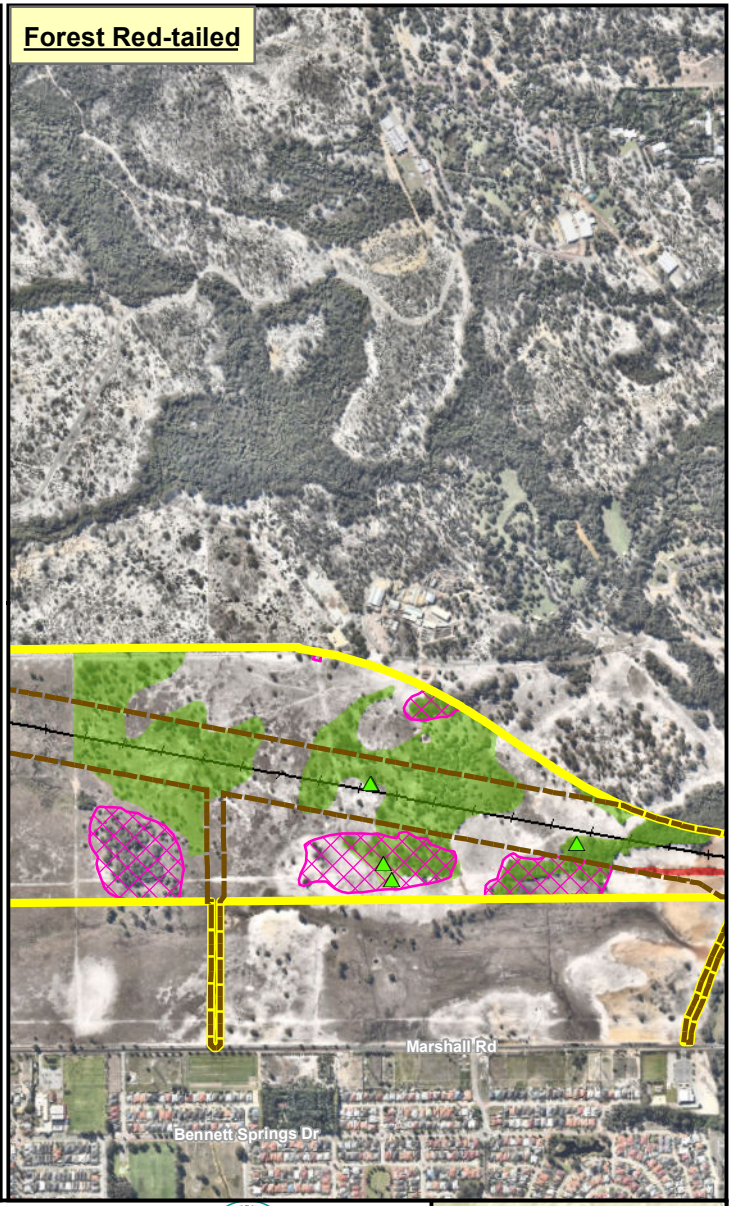
0 100 200 400 m



Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0129_A4P_Mapbook_v3.mxd







METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 19D **Black Cockatoo Foraging Habitat (Carnaby's, Baudin's and Forest Red-tailed)**

Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Indicative Railway Alignment

Black Cockatoo Foraging Habitat Quality

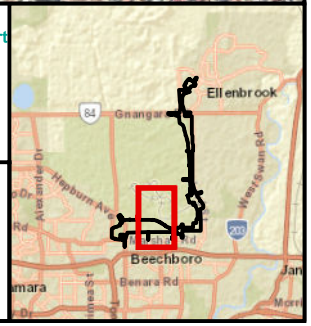
- High
- Moderate
- Low

Taxon Name

- Black Cockatoo sp.

A
B
E D C

Public Transport Authority



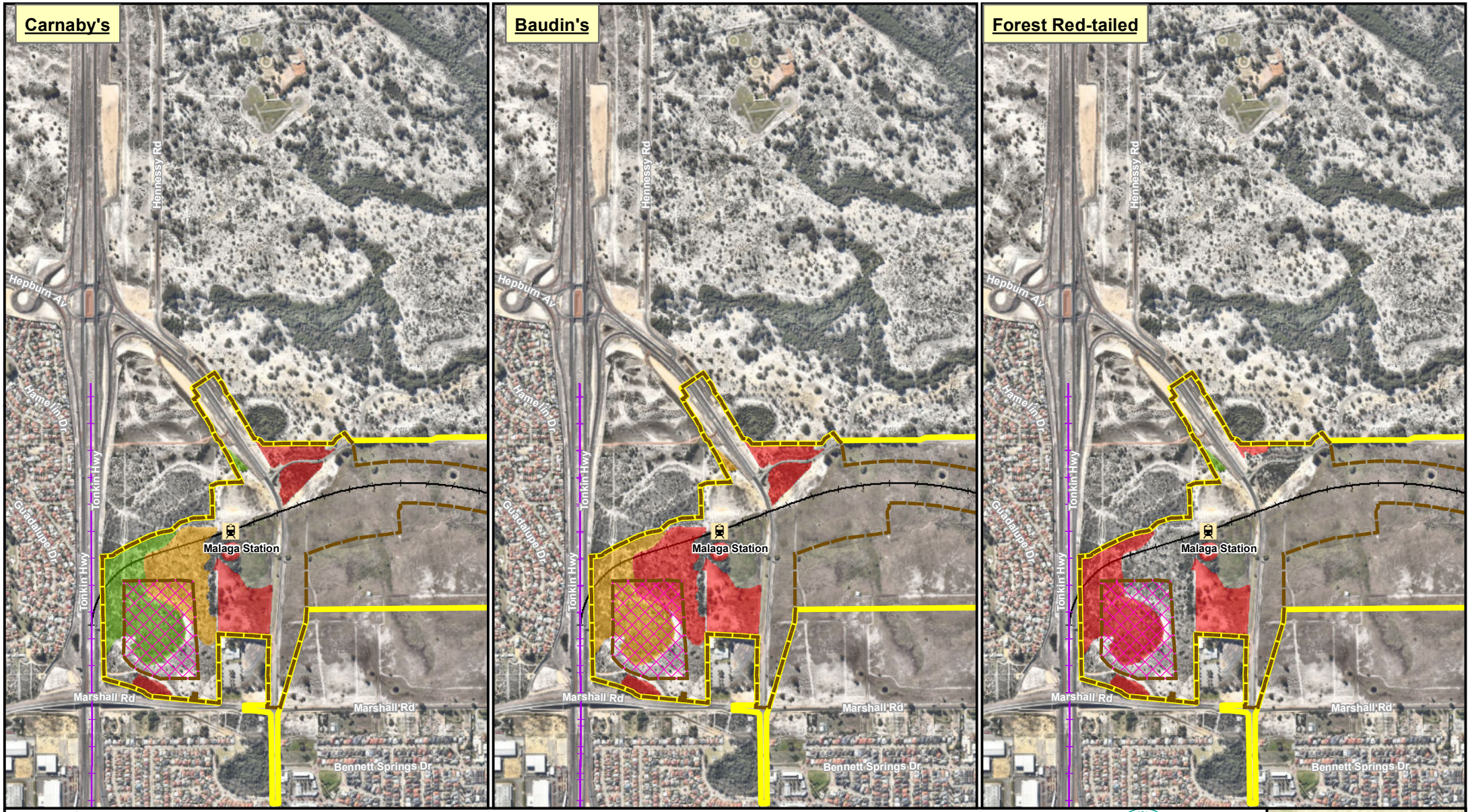
Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

N

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

0 100 200 400 m

Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0129_A4P_Mapbook_v3.mxd



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 19E **Black Cockatoo Foraging Habitat (Carnaby's, Baudin's and Forest Red-tailed)**

Legend

- Development Envelope
- Indicative Footprint
- Native Vegetation Retention Area
- Proposed Railway Station
- Indicative Railway Alignment

Black Cockatoo Foraging Habitat Quality

- High
- Moderate
- Low

A B E D C

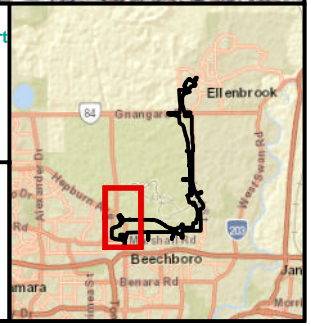
Public Transport Authority

Date Printed: 19/07/2020
Created By: R.McGregor
Approved by: M.Erskine

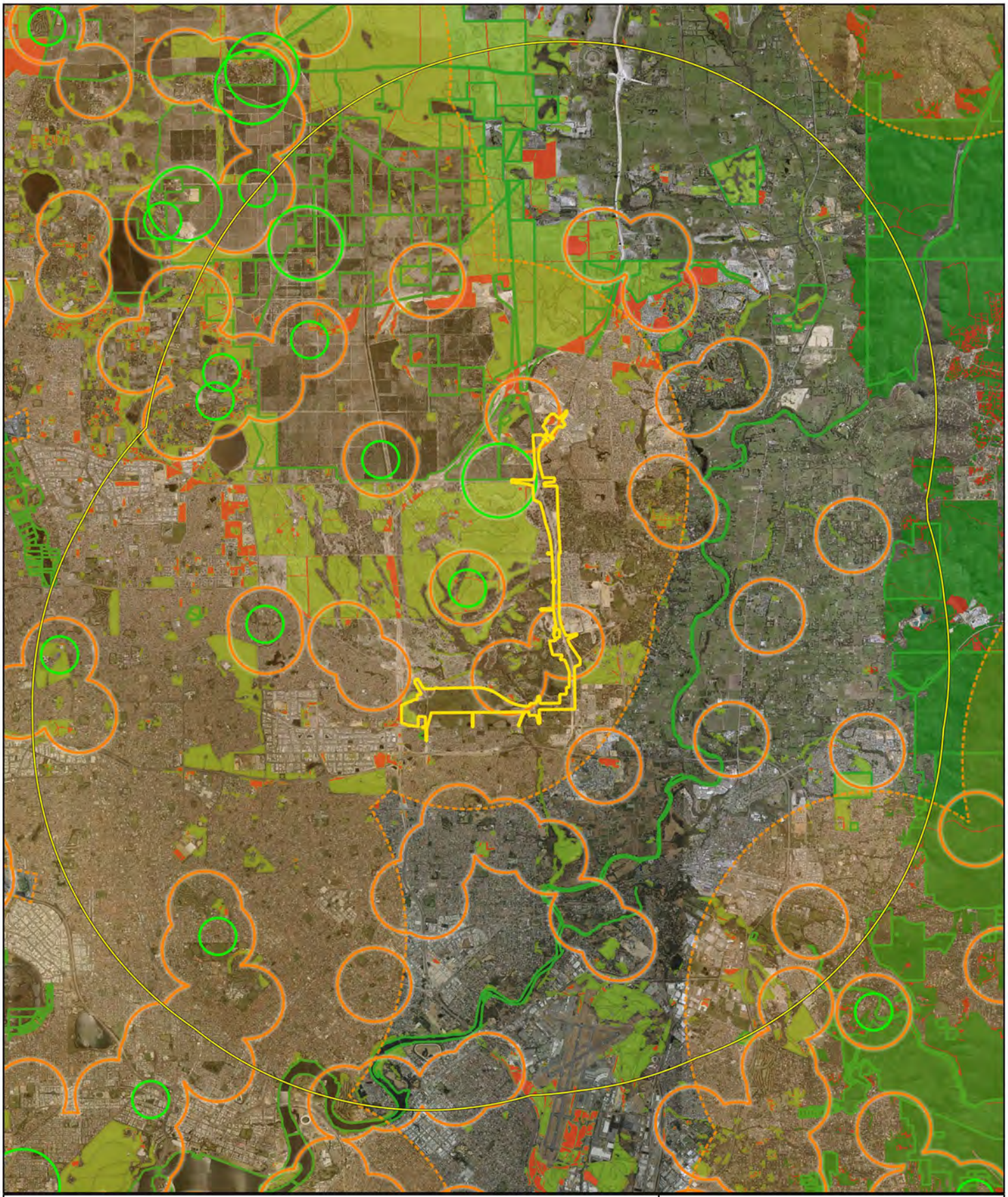
N

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

0 100 200 400 m



Document Path: \\ptcvwpfsipmp01\B_PlanningProperty\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0129_A4P_Mapbook_v3.mxd



Black-Cockatoo Regional Context

Legend

- MEL_P2_Development_Envelope
- 10km buffer
- Confirmed Black-Cockatoo Roosting Sites Buffered [DBCA-050 2020]
- Unconfirmed Black-Cockatoo Roosting Sites Buffered [DBCA-064 2020]
- Carnaby's Cockatoo Confirmed Roost Sites Buffered 6km [DBC-050 2018]
- Black-Cockatoo Breeding Sites Buffered [DBCA-063 2019]
- Carnaby's Cockatoo Areas Requiring Investigation as Feeding (Swan Coastal Plain) [DBCA-057 2011]
- Carnaby's Cockatoo Areas Requiring Investigation as Feeding (Jarrah Forest) [DBCA-056 2011]
- Carnabys Cockatoo Forging Habitat Loss (2009-May 2020)
- DBCA Managed Lands and Waters [2016]

Created by: A.D.Moore
Date: 9/6/2020
Background image: WA Locate Mosaic
Coordinate system: GDA94 MGA zone 50

0 1 2 3 4 5 km

Figure 20

BAMFORD CONSULTING ECOLOGISTS

Black Cockatoo potential breeding trees

Black Cockatoo potential breeding trees include tall trees with a diameter at breast height (DBH) over 500 mm. Suitable breeding tree species include Tuart, Flooded Gum, Coastal Blackbutt and Marri as well as a number of non-native Eucalyptus species such as *Eucalyptus camaldulensis* and other planted Eucalypts.

ELA (2020) identified a total of 680 Black Cockatoo potential breeding trees within the Development Envelope, including 40 with hollows (defined in surveys as larger than 10cm in size). There are 423 Black Cockatoo potential breeding trees including 33 trees with hollows >10 cm within the Footprint. The NVRAs will retain 201 Black Cockatoo potential breeding trees including 4 trees with hollows. Black Cockatoo potential breeding trees are mapped in Figure 21.

No evidence of Black Cockatoos breeding (i.e. chew marks around hollows or individual birds inspecting hollows) was observed in any of the 40 hollows during surveys undertaken for the Proposal (ELA 2020, Kirkby 2020, Appendix J).The PTA commissioned Tony Kirkby to survey all of the identified 40 Black Cockatoo potential breeding trees with hollows >10 cm within the Proposal's Development Envelope for suitability for Black Cockatoo nesting purposes. None of the 40 trees with hollows were found to be suitable for Black Cockatoo nesting purposes. All hollows present were either too small, of an incorrect angle, too close to the ground, too shallow or a combination of these factors (Kirkby 2020). There was evidence that up to six tree hollows were utilised by Galahs *Eolophus roseicapilla* (Kirkby 2020).

There are only a few known occurrences of Carnaby's breeding within the Swan Coastal Plain. The closest known area is at Joondalup Health Campus, approximately 18 km west of the Development Envelope, where chicks have successfully fledged from nests made in natural hollows as well as artificial hollows (Roberts 2016). Other known breeding sites have also been recorded in the Baldivis and Mandurah areas, although both locations are over 40 km from the Development Envelope (Birdlife 2018, ELA 2020).

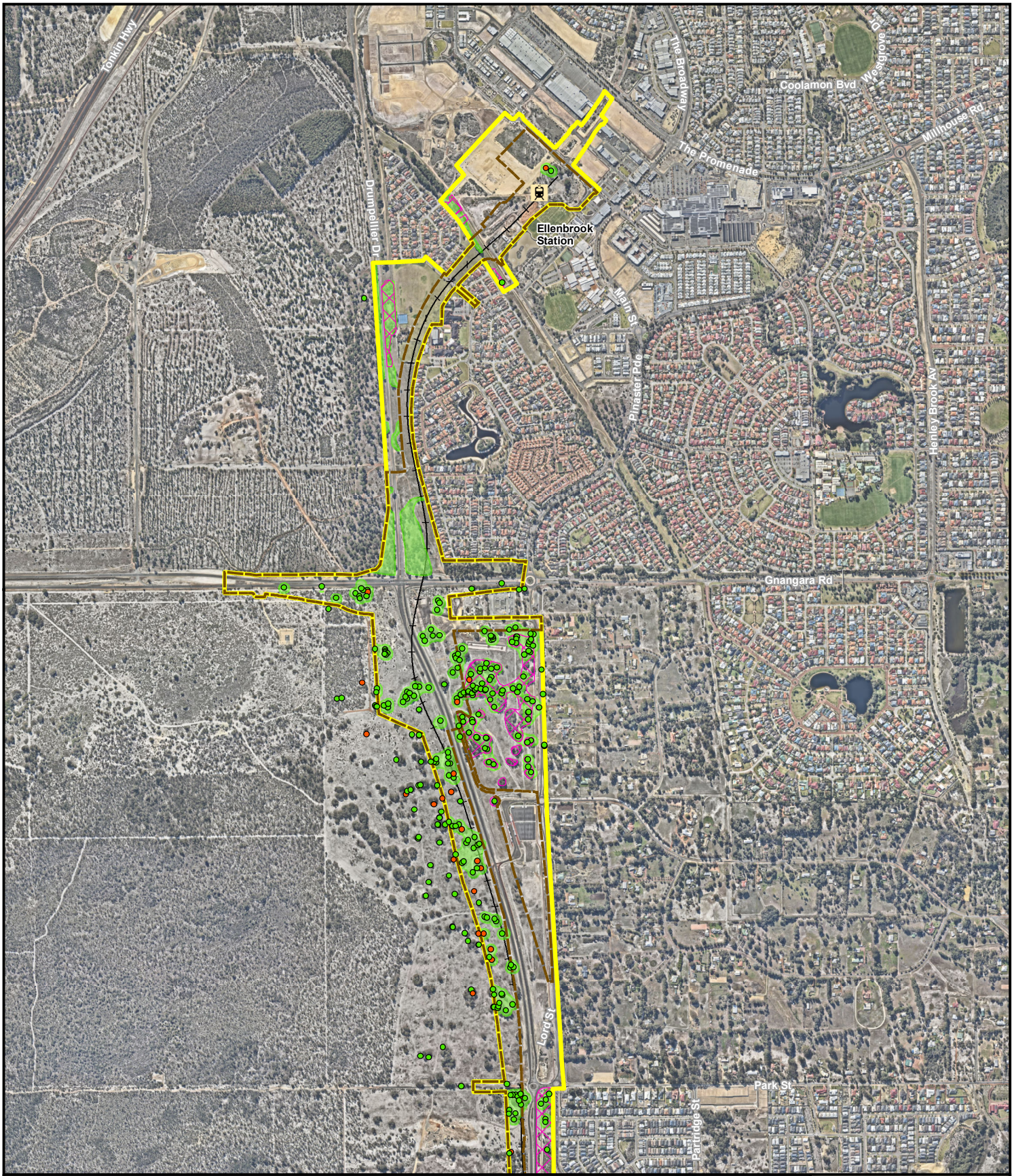
The closest known breeding site for Forest Red-tailed Black Cockatoos on the Swan Coastal Plain is approximately 30 km south west of the Development Envelope at Murdoch University (ELA, 2020, Terrestrial Ecosystems 2018, Birdlife 2015). There are known breeding sites in the nearby Jarrah forest at Red Hill approximately 5 km to the east (Bamford pers. comm. 2020). The Development Envelope it is located outside the known breeding range for Baudin's Cockatoo (ELA 2020, Kirkby 2020).

Potential suitable roosting habitat

There is 47.6 ha of potential suitable roosting habitat identified within the Development Envelope, of which 30.3 ha is within the Footprint (Figure 21). Most of the Black Cockatoo potential breeding trees recorded also provide suitable roosting habitat for all three species of Black Cockatoo. In addition, a number of tree species that are suitable for roosting but not for breeding were also recorded throughout the area and include the Pine Plantations (*Pinus* spp.) and introduced/ planted Eucalyptus species such as Lemon Scented Gum (*Eucalyptus citriodora*) (ELA 2020, Groom 2011, Johnstone et al. 2011).

Carnaby's Cockatoo and Baudin's Cockatoo roosting habitat generally includes tall trees in proximity to riparian environments, whereas Forest Red-tailed Black Cockatoos generally roost in any tall tree, particularly Jarrah and Marri, or any large trees on the edges of forests. Potential roosting habitat for all three Black Cockatoo species occurs within the Eucalyptus / Corymbia woodland, Wetland, Dampland and Pine Plantation habitat types (ELA 2020, Terrestrial Ecosystems 2018, Coffey 2015b, PGV Environmental 2014).

No known roosting sites for any of the three species of Black Cockatoo occur within the Development Envelope (Figure 21). The closest known Carnaby's Cockatoo roost sites are in the Gnangara-Pinjar Pine Plantation just north of Ellenbrook (~380 m to the north west of the Development Envelope) (ELA 2020). There are multiple known roost sites for both Carnaby's and Forest Red-tails within Whiteman Park (~730 m west) and at a private property in Henley Brook (~340 m east) (ELA 2020, Birdlife 2018, Birdlife 2015). The location of nearby Black Cockatoo roost sites is shown on Figure 20.



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 21A **Carnaby's and Forest Red-tailed Black Cockatoo Habitat**

Public Transport Authority

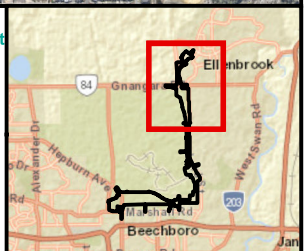
Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Indicative Railway Alignment
- Native Vegetation Retention Area

Carnaby's and Forest Red-tailed Black Cockatoos

- Suitable Roosting
- Black Cockatoo Potential Breeding Tree with Hollow
- Black Cockatoo Potential Breeding Tree

A
C
B



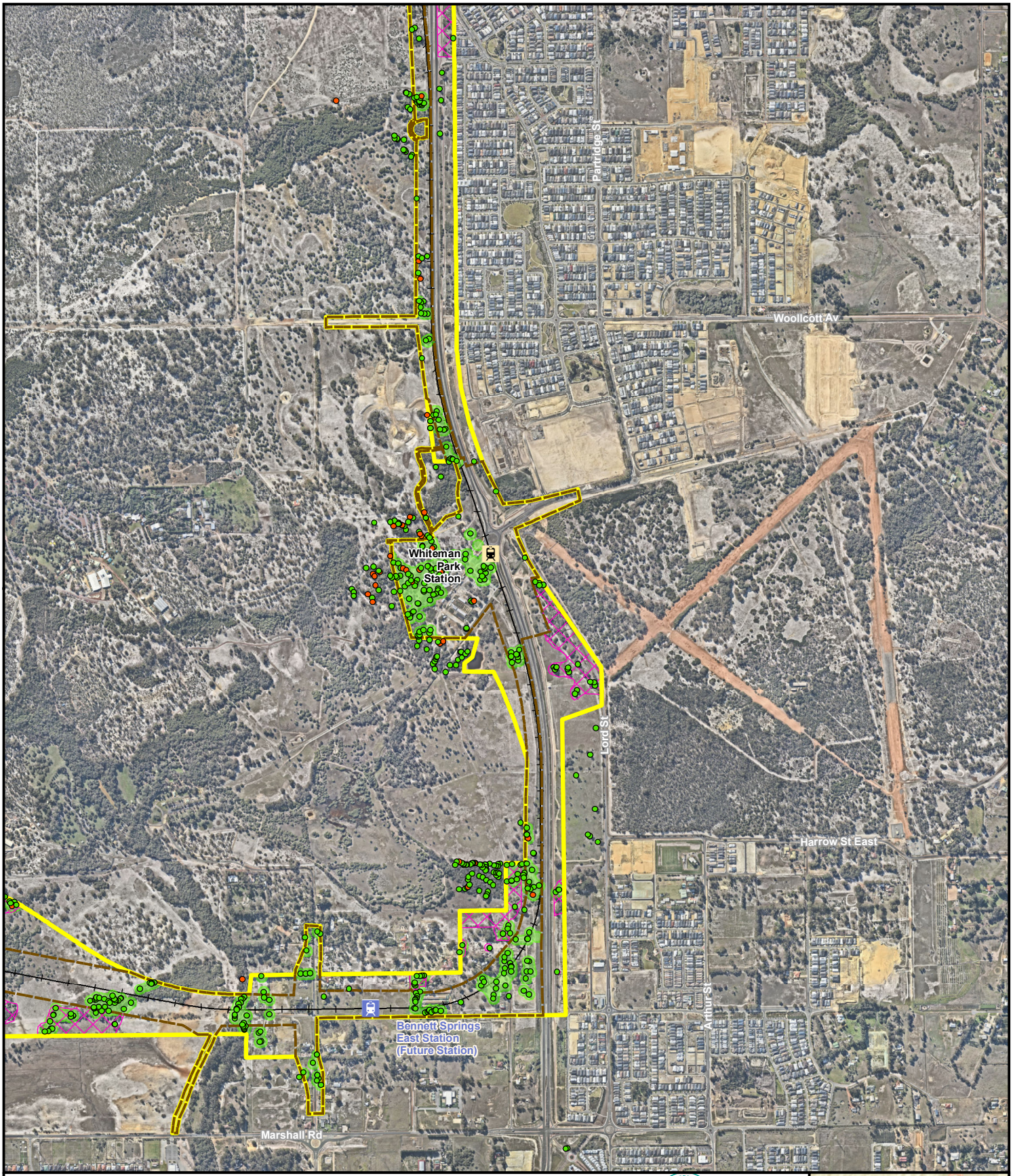
Date Printed: 17/07/2020
Created By: D.Whiteley
Approved by: C.Baxter

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0130_A4P_Mapbook_v2.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 21B **Carnaby's and Forest Red-tailed Black Cockatoo Habitat**

Public Transport Authority

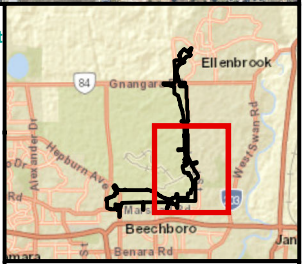
Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment
- Native Vegetation Retention Area

Carnaby's and Forest Red-tailed Black Cockatoos

- Suitable Roosting
- Black Cockatoo Potential Breeding Tree with Hollow
- Black Cockatoo Potential Breeding Tree

A
B
C



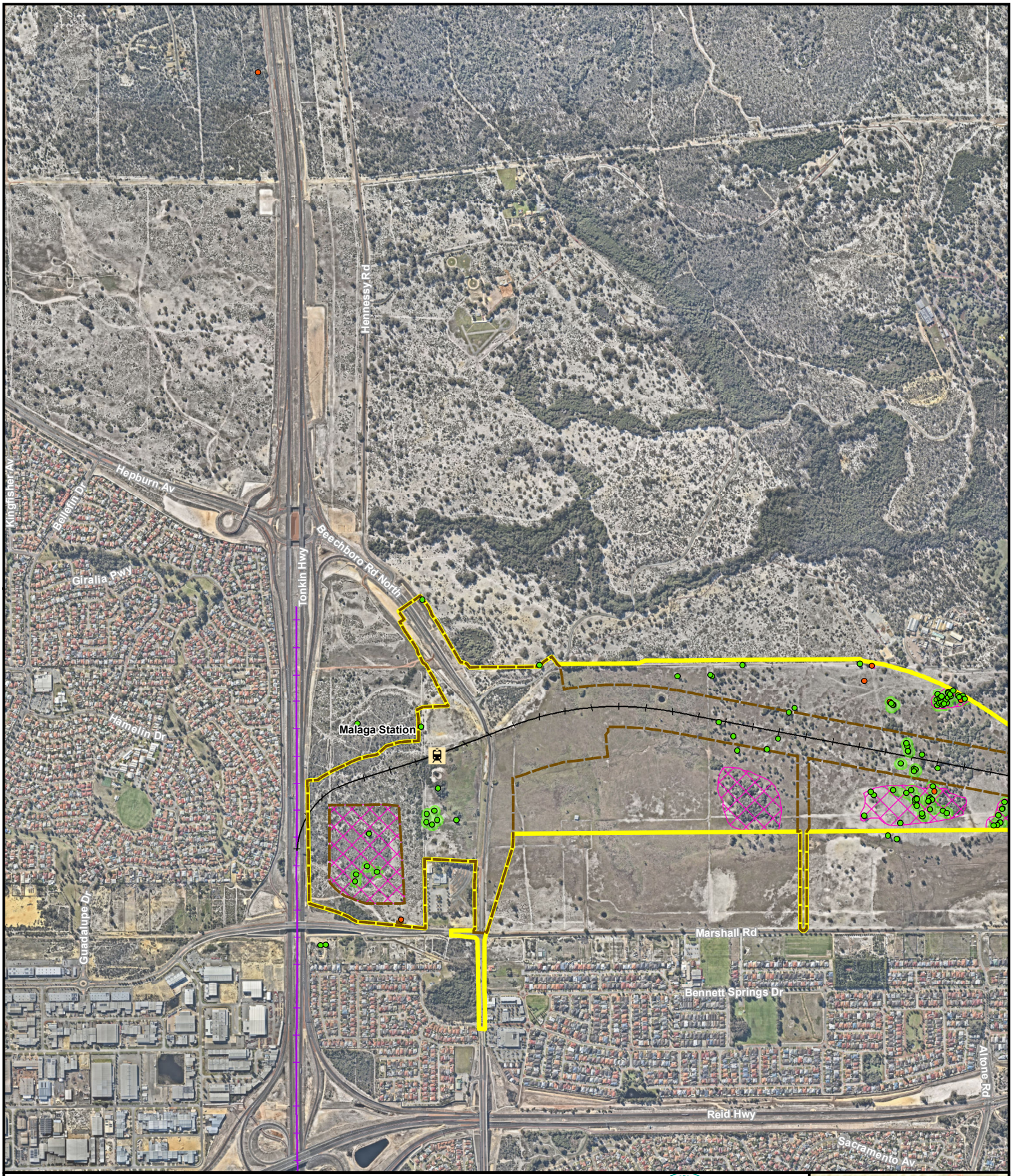
Date Printed: 17/07/2020
Created By: D.Whiteley
Approved by: C.Baxter

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0130_A4P_Mapbook_v2.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 21C **Carnaby's and Forest Red-tailed Black Cockatoo Habitat**

Public Transport Authority

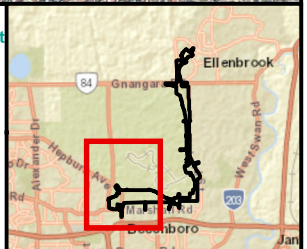
Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Indicative Railway Alignment
- Native Vegetation Retention Area

Carnaby's and Forest Red-tailed Black Cockatoos

- Suitable Roosting
- Black Cockatoo Potential Breeding Tree with Hollow
- Black Cockatoo Potential Breeding Tree

A
C
B



Date Printed: 17/07/2020
Created By: D.Whiteley
Approved by: C.Baxter

Scale: 1:20,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0130_A4P_Mapbook_v2.mxd

6.4.6. Wetland and migratory bird species

The PTA commissioned a wetland bird survey for the Proposal that was undertaken during 2018 and 2019 at several wetlands including Horse Swamp, Bennett Brook, Mussel Pool and seasonal wetlands and dams within and adjacent to Whiteman Park. A total of 26 water bird species were identified with one listed migratory species, the Glossy Ibis (*Plegadis falcinellus*), recorded at Horse Swamp (Terrestrial Ecosystems 2019). This species has a regional distribution across the east of the Kimberley region in WA and is also known to be patchily distributed in the rest of WA, with core breeding for the Glossy Ibis located outside WA (DotEE 2019f). The Development Envelope was assessed as having no habitat suitable for this species (ELA 2020), with the exception of years of high rainfall when inundation of Marshall Paddocks may occur (Bamford pers. Comm. 2020). All species recorded during the 2018 and 2019 surveys are common on the Swan Coastal Plain (Terrestrial Ecosystems 2020), except the Glossy Ibis (Bamford pers. comm. 2020).

The wetland areas in Whiteman Park are breeding sites for numerous wetland birds including Banded Lapwing, Pacific Black Duck, Black Swan, Black-fronted Dotterel, Dusky Moorhen, Black-winged Stilt, Eurasian Coot, Australasian Grebe, Grey Teal and Australian Wood Duck. None of these species are considered migratory species (Terrestrial Ecosystems 2020).

The draft Perth and Peel Green Growth Plan for 3.5 million (DPC 2015) document the important habitat for migratory shorebirds across the Perth and Peel region. No migratory wetland species habitat areas identified in the draft Perth and Peel Green Growth Plan for 3.5 million (DPC 2015) are found within the Development Envelope.

6.4.7. Mammals

Three mammal species of conservation significance are likely to occur within the Development Envelope, the Western Brush Wallaby (*Notamacropus irma*), Quenda (*Isoodon obesulus subsp. fusciventer*) and Water Rat or Rakali (*Hydromys chrysogaster)* all of which are confirmed to occur at Whiteman Park, (ELA 2020, AECOM 2016).

Quenda diggings were also recorded in the Banksia Woodland habitat south of Gnangara Road, located within 100 m of the Development Envelope, and in the Flooded Gum Woodland habitat just north of Bennett Springs. Additional indirect evidence of Quenda was recorded at the southern portion of the Development Envelope, south of Reid Highway (AECOM 2016).

Quenda is found in woodland, heath and shrub communities on the Swan Coastal Plain and prefers a combination of sandy soils and dense heathy vegetation (Van Dyck & Strahan 2008). The Quenda is considered likely to utilise the Banksia Woodland, Marri Woodland and Melaleuca Woodland habitats (ELA 2020). Wetland habitats are considered to provide high value habitat to fauna, particularly for Quenda (where thick understorey is present) and the Water Rat (Biologic 2020). The Western Brush Wallaby's optimum habitat is open forest or woodland, seasonally wet flats with low grasses and open thickets (DotEE 2019e).

Whiteman Park also contains a population of Western Grey Kangaroo (*Macropus fuliginosus*), a large proportion of which inhabit the Marshall Paddocks farmland grazing area (Bamford, 2020). The Western Grey Kangaroo is not a listed conservation significant species but is native to this area. The presence of Western Grey Kangaroos in Whiteman Park is considered important to the local community.

6.4.8. Aquatic fauna

Numerous wetlands adjacent to or intercepting the Development Envelope have the potential to support aquatic fauna. A preliminary desktop values assessment was undertaken to determine the presence and location of wetlands potentially impacted by the Proposal (WRM 2019). This assessment identified eight key wetlands (including Bennett Brook) as being either close to or within the Development Envelope and with the potential to be impacted by the Proposal and/or with sufficient environmental values to require further investigation.

Additional studies and surveys conducted to assess aquatic fauna values and impacts related to the Proposal are outlined below.

Black-stripe Minnow (*Galaxiella nigrostriata*)

The Black-stripe Minnow (*Galaxiella nigrostriata*) is listed as Endangered under the EPBC Act and BC Act. The species is endemic to south-western Australia and most commonly occurs in shallow ephemeral waterbodies of peat flats (WRM 2019). The Black-stripe Minnow's preferred habitat includes shallow, seasonal, tannin stained water bodies with intact riparian vegetation, which provides shade and a complex refuge habitat (WRM 2020). The closest known population of Black-stripe Minnow is at Melaleuca Park several kilometres north of the northern extent of the Development Envelope (WRM 2019).

The Black-Stripe Minnow can survive dry summer conditions by aestivating (the process of animal dormancy during hot dry season) into moist soils until the first rains and is known to disperse in years of high rainfall (WRM 2019). There is a lack of knowledge of the Black-stripe Minnow aestivation duration, depth, timing and physiological tolerances. However, the species survival would likely depend upon habitats where soil moisture is retained to the end of the dry season (Biologic 2020). Unlike some aestivating frog species, Black-stripe Minnows do not build a cocoon to aestivate, rather the species survives in the wet mud, moving down with the water level in burrows in the bed of the wetland (Biologic 2020, Bamford pers. comm. 2020).

The wetland desktop assessment undertaken by Biologic (2020) utilised existing desktop information, the results of the WRM 2019 values assessment and additional environmental survey information to assess the potential impact of the Proposal on eight key wetlands. Biologic (2020) completed an assessment of habitat suitability and the likelihood of occurrence of the Black-stripe Minnow at each wetland. The proximity to or area intercepted by the wetland and the likelihood of suitable habitat for the Minnow are outlined in Table 37 (Biologic 2020). Wetland locations are illustrated in Figure 34.

Of the eight wetlands assessed only four of these contained habitats that were potentially suitable for the Black-stripe Minnow, and only two of these are within the Development Envelope (Biologic 2020). Although Biologic (2020) indicated that potential suitable Black-stripe Minnow habitat may be present within or adjacent to the Development Envelope, the species has not been confirmed and previous research in the surrounding area suggests it is locally extinct (Bamford et al 1998).

Table 37: Potential wetland habitat for Black-stripe Minnow and proximity to Development Envelope

Wetland	Distance to Development Envelope	Area intersecting Development Envelope	Black-stripe Minnow habitat suitability
UFI 8679 Unnamed Resource Enhancement Wetland (REW)	116 m Whiteman Station area	NA	**Potential** The appropriate habitat is present, including soils comprising a high proportion of clay which hold moisture for long periods. Although recent land clearing has fragmented this wetland and led to some level of isolation from other wetlands, linkage still exists with other wetlands near UFI 8679 and moist patches of soil were still apparent in autumn 2020. The presence of Black-stripe Minnow within UFI 8679 cannot be discounted without a targeted survey.
UFI 8724 – Horse Swamp Conservation Category Wetland (CCW)	64 m	NA	**Unlikely** The degraded condition of Horse Swamp and the fact that soils appeared to be completely dry in autumn 2020, indicate it may not support a population of Black-stripe Minnow.
UFI 8727 Unnamed Multiple Use Wetland (MUW)	NA	0.3 ha	**Unlikely** The wetland is unlikely to provide suitable habitat for the Black-stripe Minnow, due to the fact that the soil was dry at the time of Biologic's site visit in autumn 2020.
UFI 8728 Unnamed CCW	NA	1.2 ha	**Unlikely** This wetland is highly ephemeral, with no water being present in October 2019 and only a small pool present in November 2018. As such it does not provide suitable habitat for the Black-stripe Minnow.
UFI 8418 Orchid Park CCW	5 m	NA	**Potential** This wetland comprises a shallow, seasonal, tannin-stained water body with intact riparian vegetation providing shade and complex refuge habitat. Recent 'isolation' from surrounding wetland systems may not preclude the presence of Black-stripe Minnow.

Wetland	Distance to Development Envelope	Area intersecting Development Envelope	Black-stripe Minnow habitat suitability
UFI 8429 Unnamed CCW	NA	0.03 ha	**Unlikely** While this wetland habitat is considered consistent with that preferred by the Black-stripe Minnow, the small size of the water body, the isolated nature of the wetland, and lack of significant water flow indicates that the Black-stripe Minnow is unlikely to inhabit the wetland. The portion of the wetland periphery within the Development Envelope is also degraded and separated by an informal track from the main part of the wetland.
UFI 8678 Unnamed REW	NA	0.77 ha	**Unlikely** The habitat at UFI 8678 was considered consistent with that preferred by the Black-stripe Minnow (*Galaxiella nigrostriata*), however WRM (2020) suggested that the small size of the water body and its isolation from other wetlands means that it is unlikely to support a population of Black-stripe Minnow (WRM 2020).
UFI 15259 Bennett Brook CCW	NA	0.9 ha	**Potential** The wetland area is large and connected to several smaller wetlands and Bennett Brook itself. The wetland is considered to comprise suitable habitat at some locations for the Black-stripe Minnow, particularly within the wetland area adjacent to Bennett Brook, north of the Development Envelope. The presence of Black-stripe Minnow could only be confirmed through targeted sampling. The section of the Brook intersected by the Development Envelope was dry at the time of survey and therefore considered to be lacking in suitable habitat for the species (Biologic 2020). Groundwater monitoring data recorded at BH015 located at the proposed bridge crossing of Bennett Brook, indicates that dry season minimum groundwater levels are below the riverbed, suggesting that the habitat would be unsuitable for the species to aestivate.

Source: Biologic 2020

Carter's Freshwater Mussel

Carter's Freshwater Mussel (*Westralunio carteri*) is listed as Vulnerable under the EPBC Act and BC Act. It is found in perennial (permanent / semi-permanent) stream and riverine habitats with a distribution ranging from Moore River in the north, to the south coast, west of Esperance (Klunzinger 2012, Klunzinger *et al*. 2015).

Carter's Freshwater Mussel is currently under threat across south-western Australia due to secondary salinisation, loss of suitable host species, nutrient pollution, habitat loss, water extraction, as well as sedimentation resulting in increased turbidity. Reservoir dewatering and declining rainfall also appear to have had a negative effect on populations (Klunzinger *et al.* 2012).

The PTA commissioned a survey for the Proposal, targeting Carter's Freshwater Mussel. The survey was conducted at eight sites along Bennett Brook, incorporating four sites upstream and four sites downstream of the proposed railway bridge over Bennett Brook, with one site located at the proposed rail bridge crossing (refer Appendix K) (WRM 2020).

No habitat suitable / preferable for Carter's Freshwater Mussel was present within Bennett Brook where it is intercepted by the Development Envelope. This area was dry in mid-autumn and lacked suitable habitat, such as semi-permanent/permanent pools or flowing water with a sandy substrate. Dehydration exposure experiments have previously demonstrated that the species cannot survive prolonged drying (Klunzinger 2012) and it is therefore unlikely to establish a population at the bridge crossing location.

The recent targeted Carter's Freshwater Mussel survey, undertaken in mid-autumn 2020 identified areas within Bennett Brook that are subject to prolonged drying and are therefore unlikely to contain suitable habitat for the species. The survey also recorded areas of permanent water that are more likely to support the species throughout the summer and autumn months when Bennett Brook is not flowing (WRM 2020). Carter's Freshwater Mussels were located approximately 1.7 km downstream, at the Reid Highway bridge and almost 1 km upstream at Mussel Pool (WRM 2020).

Frogs

An autumn frog survey was undertaken at a range of known habitat sites within and around the Development Envelope in order to inform the status of wetland health, assist with wetland impact assessment and provide baseline data for future monitoring (Bamford 2020a). The survey scope was intended to provide information on the species richness, distribution and abundance of frogs across a suite of sites, including locations along Bennett Brook upstream and downstream of the proposed railway bridge, and at nearby wetlands.

The frog assemblage of Whiteman Park is well-documented (Bancroft and Bamford 2008) and comprises the following nine species:

Tree-Frogs.

- Slender Tree Frog (*Litoria adelaidensis*).
- Motorbike Frog (*Litoria moorei*).

Ground Frogs

- Quacking Frog (*Crinia georgiana*).
- Glauert's Froglet (*Crinia glauerti*).
- Squelching Froglet (*Crinia insignifera*).
- Moaning Frog (*Heleioporus eyrei*).
- Western Banjo Frog (*Limnodynastes dorsalis*).
- Turtle Frog *Myobatrachus gouldii* (not part of this survey).
- Crawling Toadlet (*Pseodophryne guentheri*).

None of the frog species recorded in Whiteman Park and listed above are of conservation significance. All expected frog species were confirmed to be present with the exception of the Crawling Toadlet, Turtle Frog and the Quacking Frog (Bamford 2020a). The six remaining frog species were recorded with the Banjo Frog and Motorbike Frog seen only in very small numbers, with the former recorded at one site and the latter at two sites. Of the remaining species, only the Moaning Frog was widespread and calling in large numbers. Small numbers of frogs were recorded with the exception of Glauert's Froglet which was abundant at one location. Frog sightings were scattered throughout the survey sites and did not include recently metamorphosed specimens (Bamford 2020a).

6.5. Potential impacts to terrestrial fauna

The potential impacts to fauna from construction and operation of the Proposal within the Development Envelope are outlined in Table 38.

Table 38 - Potential construction and operational impacts to fauna

Proposal Stage	Impact Type	Activities	Potential Impacts
Construction	Direct	• Clearing of native vegetation. • Movement of machinery and vehicles.	• Direct impacts to fauna habitat due to clearing of 188.7 ha of fauna habitat and construction of permanent infrastructure. • Potential impacts to conservation significant fauna including SREs due to clearing. • Potential impacts to ecological connectivity within Whiteman Park and Bush Forever sites as the Development Envelope intersects two mapped regional ecological linkages. • Impacts to the connectivity of fauna habitat due to proposed clearing at Malaga TEC which contains moderate to high value fauna habitat. • Injury or mortality to fauna from vehicle and machinery movement.
Construction	Indirect	• Cut and fill works. • Construction of permanent and temporary infrastructure including rail, roads, buildings, hard stand and laydown areas. • Lighting (and noise) during construction and operation.	• Habitat degradation through spread of weeds and dieback, altered hydrology and edge effects. • Injury or mortality to fauna entering excavated areas • Short term impacts from noise, vibration and light effecting fauna numbers, movement and behaviour. • Changes in feral animal abundance and/or movement. • Potential indirect impacts from chemical or hydrocarbon spills to fauna values.
Operation	Direct	• Operation and maintenance of the railway line.	• Injury or mortality from train or maintenance vehicle interactions.

Proposal Stage	Impact Type	Activities	Potential Impacts
Operation	Indirect	• Operation and maintenance of the railway line	• Habitat degradation through the spread of weeds and dieback, altered hydrology and edge effects. • Changes in feral animal abundance and/or movement. • Barrier effects on fauna habitat through Marshall Paddock within Whiteman Park and near Malaga Station • Potential indirect impacts to fauna values from chemical or hydrocarbon spills. • Modification of fauna behaviour due to noise, vibration and light.

6.6. Assessment of impacts to terrestrial fauna

The Proposal has been assessed as having the potential to cause direct and indirect impacts to terrestrial fauna. Direct impacts are associated with permanent loss of fauna habitat, while indirect impacts include degradation of habitat over time, loss of habitat connectivity, fauna injury, altered hydrology and edge effects.

6.6.1. Permanent loss of fauna habitat

The Proposal Footprint will impact 249 ha of land within the 463.8 ha Development Envelope, of which, 30.5 ha (12%) is considered moderate to high value fauna habitat. The remainder of the habitat being impacted (158.2 ha) is either low or of no habitat value, with a further 60.3 ha of the Footprint encompassing areas that already contain existing transport infrastructure. Table 39 outlines the type and area of fauna habitats that are contained within the Development Envelope, Footprint and Native Vegetation Retention Areas (NVRAs). The NVRAs protect 13.5 ha of moderate to high value fauna habitat.

Table 39: Fauna habitat types and impact*

Habitat Types	Condition / Habitat Value	Development Envelope (ha)	Footprint (ha)	NVRAs (ha)
Moderate to high fauna habitat value				
Banksia Woodland	Good to very good	19.2	11.7	7.5
Mixed Eucalyptus / Corymbia Woodland	Good	9.5	7.0	2.1
Mixed Banksia / Eucalyptus/ Corymbia Woodland	Good	4.5	4.0	0.0
Flooded Gum Woodland	Good	3.1	1.7	0.0
Paperbark Woodland	Good to Degraded	9.1	4.7	3.9
Wetland / water course (open water areas)	Variable	1.8	1.4	0.0
Low to no fauna habitat value				
Shrubland	Highly fragmented.	5.0	4.1	0.0

Habitat Types	Condition / Habitat Value	Development Envelope (ha)	Footprint (ha)	NVRAs (ha)
Moderate to high fauna habitat value				
Pine Plantation	Degraded	3.3	3.3	0.0
Scattered trees/ shrubs	Degraded	2.2	2.2	0.0
Paddock with Eucalyptus/ Corymbia	Degraded	160.2	82.0	20.1
Paddock with Melaleuca	Degraded	11.7	2.8	1.3
Constructed wetland/ drainage	Degraded	0.8	0.4	0.0
Modified vegetation	Degraded	17.9	12.8	2.7
Parkland cleared	Degraded	12.7	8.1	1.7
Cleared Paddock	Degraded	89.4	42.5	4.2
Total area of fauna habitat		**350.4**	**188.7**	**43.5**
Infrastructure/Cleared	Nil	**113.4**	**60.3**	**1.5**
Total area		**463.8**	**249.0**	**44.9**

ELA 2020

* Areas have been rounded to the nearest tenth of a hectare. This may cause some totals to appear incorrectly calculated.

Habitat loss at a regional scale has been assessed against the extent of vegetation complexes found within the Development Envelope remaining within the City of Swan and the Swan Coastal Plain (Table 29). The Proposal will result in the loss of 2% of similar habitat remaining within the City of Swan and 0.1% across the Swan Coastal Plain. The total loss of potential habitat for conservation listed fauna species that are recorded or likely to occur within the Development Envelope and the significance of the impact is described in Table 40.

Table 40: Assessment of significance of impacts from clearing on conservation listed fauna and habitat

Common name /Species	Conservation status*		Habitat within Footprint (ha)	Potential impact and significance
	EPBC Act	BC Act		
Birds				
Carnaby's Cockatoo *Calyptorhynchus latirostris*	EN	EN (S2)	Foraging 81.4 ha Potential Breeding trees 423	**Moderate / high impact** Despite the representation of appropriate habitat in conservation areas, this species is under significant threat of decline. The residual impact to Carnaby's Cockatoo from habitat clearing for the Proposal is significant based on the Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (DPaW 2013), Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan and the WA Environmental Offset Guidelines (Government of WA 2014a). Impacts to Black Cockatoos are assessed in further detail below.

Common name /Species	Conservation status*		Habitat within Footprint (ha)	Potential impact and significance
	EPBC Act	BC Act		
Baudin's Cockatoo *Calyptorhynchus baudinii*	EN	VU (S3)	Foraging 81.4 ha	**Low impact** Baudin's may be an occasional / vagrant visitor to this area, however the Proposal is at the limit of this species range and it is highly unlikely that this species will breed or roost in this area. It is unlikely that this Proposal will have a significant impact on this species based on the Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery (Australian Government 2008). Impacts to Black Cockatoos are assessed in further detail below.
Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*	VU	VU (S3)	Foraging 68.1 ha Potential Breeding trees 423	**Moderate / high impact** Residual impact to this species from habitat clearing from the Proposal is likely to be significant based on the Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery (Australian Government 2008) and the WA Environmental Offset Guidelines (Government of WA 2014). Assessment of impacts to Black Cockatoos are assessed in further detail below.
Rainbow Bee-eater *Merops ornatus*	Marine	-	Variety of habitats, part of general fauna habitat loss	**Low impact** Based upon the Significant Impact Guidelines 1.1 (DEWHA 2013), the Footprint does not support ecologically significant proportion of this species, contain critical habitat, occur at the limit of this species' range or occur within an area where this species is declining (NorthLinkWA 2015). The species nests in open ground and earthen banks, so the rail may create nesting habitat. This species is no longer listed by the Commonwealth due to its common occurrence, widespread distribution and mobile nature. The impact due to loss of suitable habitat in the Footprint is expected to be negligible.
Peregrine Falcon *Falco peregrinus*	-	OS (S5)	Variety of habitats	**Low impact** This is a highly mobile species with a large home range (ELA 2020). The species breeds in Whiteman Park and the Development Envelope, is within the foraging range of a breeding pair. Despite this the impact would be low as the species forages over several kilometres (Bamford pers. comm. 2020) and there are large areas of foraging habitat outside the Development Envelope.

Common name /Species	Conservation status*		Habitat within Footprint (ha)	Potential impact and significance
	EPBC Act	BC Act		
Red-winged Fairy-wren *Malurus elegans*	Not listed	Not listed	Variety of habitats, part of general fauna habitat loss	**Low impact** The species has not been recorded during any of the surveys but is likely to occur in and around Whiteman Park where it has previously been recorded. It may potentially occur within the Development Envelope and be impacted by proposed clearing. Impacts to the species are unlikely to be significant as it can utilise a variety of habitat throughout the large areas adjacent to the Proposal in Whiteman Park.
Mammals				
Western Brush Wallaby *Notamacropus irma*	NA	P4	Wide variety of habitats, part of general fauna habitat loss	**Low impact** The Western Brush Wallaby is a sedentary species with a home range of <10km (smaller in females than males) (Bamford pers. comm. 2020). There is a resident population in Whiteman Park. Although the Proposal may result in the local loss of potential habitat, the Development Envelope has limited habitat for the species. Given the proximity of the Development Envelope to larger areas of similar or better quality habitat locally it is not expected that the Proposal will have a significant impact on this species. The residual impact to this species is not significant.
Quenda *Isoodon fusciventer*	NA	P4	30.6 ha Banksia Woodland Mixed Banksia/ Eucalyptus/ Corymbia Woodland Mixed Eucalyptus/ Corymbia Woodland Flooded Gum Woodland Wetland/ Watercourse Paperbark Woodland	**Low impact** Remnant vegetation including Banksia and Eucalyptus woodlands and wetland areas within the Development Envelope may potentially be utilised by Quenda. The Proposal will result in local Quenda habitat loss. The species is widespread and is expected to occur in adjacent habitats based on the number of records in the vicinity of the Proposal. It is not expected that the Proposal will have a significant impact on this species and cause it to become rare or endangered. The residual impact to the Quenda is not significant given the proximity of the Development Envelope to larger areas of similar or better quality habitat.
Water Rat, Rakali *Hydromys chrysogaster*	NA	P4	1.4 ha Wetland/ Watercourse	**Low impact** Remnant vegetation including in riparian / wetland areas within the Development Envelope has the potential to be utilised by the Water Rat. The Proposal will result in minor local loss of potential habitat at Bennett Brook. Given the small area of impact and the proximity of the Development Envelope to larger areas of similar or better quality habitat locally it is not expected that the Proposal will have a significant impact on this species or cause it to become rare or

Common name /Species	Conservation status*		Habitat within Footprint (ha)	Potential impact and significance
	EPBC Act	BC Act		
				endangered. The residual impact to this species is not significant.
Reptiles				
Black-striped Snake *Neelaps calonotos*	NA	P3	22.8 ha Representing 0.5% local habitat loss Banksia Woodland Mixed Banksia/ Eucalyptus/ Corymbia Woodland Mixed Eucalyptus/ Corymbia Woodland	**Low impact** The Black-striped Snake could potentially utilise the Banksia and remnant Eucalyptus woodlands. The Proposal will result in the local loss of potential habitat for this species. Given the proximity of the Development Envelope to larger areas of similar or better quality habitat locally, it is not expected that the Proposal will have a significant impact on this species and cause it to become rare or endangered. The residual impact to the Black-striped Snake is not significant.
Jewelled Sandplain Ctenotus *Ctenotus gemmula*	NA	P3	11.7 ha Representing 0.3% local habitat loss Banksia Woodland	**Low impact** The Proposal will result in the local loss of potential habitat for this species. While this species may potentially utilise the Banksia woodland habitats within the Development Envelope, given the proximity of the Development Envelope to larger areas of similar or better quality habitat locally, and the lack of records in and around the Development Envelope, it is not expected that the Proposal will have a significant impact on this species and cause it to become rare or endangered. The residual impact to the Ctenotus is not significant.
Aquatic Fauna				
Black-striped Dwarf Galaxias / Black-stripe Minnow *Galaxiella nigrostriata*	EN	En	0.77 ha	**Low impact** This species is likely to be locally extinct (Bamford 1998). Only one wetland with Potential habitat for this species intersects the Development Envelope. Assessment of potential impact to the Minnow and their significance are addressed in further detail below.
Carter's Freshwater Mussel *Westralunio carteri*	Vu	Vu	0.88 ha	**Low impact** The Development Envelope intersects Bennett Brook which is known to contain Mussels at other locations. However, the Mussels are unlikely to be present within the Development Envelop, as this location is dry for considerable periods of the year and is likely to only flow following higher rainfall events /winter rainfall, making it an unfavourable habitat for the Mussel. Potential impact to the Mussel and the significance of this impact is addressed in further detail below.

Common name /Species	Conservation status*		Habitat within Footprint (ha)	Potential impact and significance
	EPBC Act	BC Act		
Invertebrates and SREs				
Graceful Sun-moth (*Synemon gratiosa*)	NA	P4	11.7 ha Banksia woodland	**Low impact** The Sunmoth is only likely to occur within the Banksia woodland area. The species is more widespread and common than previously thought and its listing has been removed by the State and Commonwealth. It is unlikely that the Proposal will have a significant impact on this species.
Potential SREs	NA	NA	24.4 ha Banksia woodlands & wetland	**Low impact** The SRE survey indicated that most of the Development Envelope and Footprint is highly disturbed and unlikely to support significant SRE and conservation significant invertebrate species. The Banksia woodlands contain higher value habitat for potential SREs within the Development Envelope. The NVRA at Malaga Station will assist in protecting this potential SRE habitat. Wetland and woodland clearing have also been avoided as far as practicable. With reductions to the Development Envelope, buffering of wetlands and the introduction of NVRAs the Proposal is not likely to have a significant impact on potential SREs.

The impact of clearing and habitat loss on Black Cockatoos, SREs, invertebrates and other significant fauna is discussed in further detail below.

Impacts to other potentially conservation significant species that are likely to inhabit the Development Envelope have been assessed as low. The Proposal is a narrow linear infrastructure development that has been aligned as far as practicable with existing road infrastructure and cleared areas to minimise habitat fragmentation and edge effects. The 249 ha Footprint will impact 152.1 ha of habitat associated with native vegetation, or 3% of the estimated 4,000 ha of habitat available within Whiteman Park.

Loss of Black Cockatoo habitat

The Proposal will result in the permanent loss of up to:

- 81.4 ha of Carnaby's Cockatoo foraging habitat, representing 17.5% of the Development Envelope and 0.7% of the known regional foraging habitat.
- 68.1 ha of Forest Red-tailed Cockatoo foraging habitat, representing 14.7% of the Development Envelope and 0.6% of the known regional foraging habitat.
- 81.4 ha of Baudin's foraging habitat, representing 17.5% of the Development Envelope and 0.7% regional foraging habitat.

The Native Vegetation Retention Areas (NVRAs) protect 25.6 ha of Black Cockatoo foraging habitat.

The extent and value of foraging habitat within the Development Envelope, Footprint and NVRAs for each species is outlined in Table 41.

Table 41: Impacts to Black Cockatoo foraging habitat

Quality	Carnaby's Black Cockatoo			Forest Red-tailed Black Cockatoo			Baudin's Black Cockatoo		
	Development Envelope	Footprint	NVRA	Development Envelope	Footprint	NVRA	Development Envelope	Footprint	NVRA
High quality	76.0	42.8	17.8	61.4	33.7	12.3	0.0	0.0	0.0
Medium quality	19.7	11.3	5.7	9.4	4.3	3.7	76.0	42.8	17.8
Low quality	37.0	27.3	2.1	45.8	30.2	7.7	56.7	38.6	7.8
Total foraging habitat	132.7	81.4	25.6	116.6	68.1	23.7	132.7	81.4	25.6

Potential foraging, breeding and roosting habitat for the three species of Black Cockatoo occurs in proximity (within 7 km) to the Development Envelope as well as throughout the wider region (ELA 2020). As Black Cockatoos generally forage between 6-12 km from breeding or roosting sites, with foraging habitat within 7 km of a known breeding site considered critical to support breeding (EPA 2019), ELA (2020) assessed habitat within 7 km of the Development Envelope.

Suitable foraging habitat for Black Cockatoos within 7 km of the Development Envelope occurs within remnant native vegetation throughout Whiteman Park, Bush Forever sites 22, 300, 304, 200, 399, 195, 198, 480, 305, 192, and is sporadically distributed throughout the West Swan and Henley Brook suburbs as well as the wider Perth Metropolitan Area (Figure 20).

There is approximately 11,619 ha of potentially suitable foraging habitat within a 10 km buffer of the Proposal, which includes potential foraging habitat within the Swan Coastal Plain and Jarrah forest to the east of the Development Envelope. The proposed clearing of up to 84.1 ha of Black Cockatoo foraging habitat equates to approximately 0.6 – 0.7% of the potential foraging habitat within the regional context.

High quality foraging habitat for Carnaby's Cockatoos occurs within the Gnangara-Pinjar Pine Plantations, consisting mostly of *Pinus pinaster,* to the west and north of the Development Envelope. Pine plantations in the local area will be progressively cleared over time to reconnect intact remnants of native vegetation and maximise recharge of the Gnangara groundwater system (EPA 2019). As there is limited understanding of roosting and foraging behaviour in response to Pine clearing it is difficult to predict the significance of this clearing on Carnaby's Cockatoos (EPA 2019). A precautionary approach was taken by ELA (2020) in the assessment of regional and cumulative impacts of this Proposal on Black Cockatoo foraging habitat to exclude the adjacent Gnangara - Pinjar Pine plantations from the available regional Black Cockatoo foraging habitat (Figure 20).

Recent surveys determined that both Carnaby's and Forest Red-tailed Black Cockatoos are utilising habitats within the Development Envelope for foraging, however, there has been no evidence recorded of breeding or roosting in the Development Envelope (ELA 2020, Kirkby 2020). Baudin's Cockatoo could potentially utilise habitats within the Development Envelope for foraging, on an occasional basis. However, Baudin's Cockatoos are not likely to utilise the area for breeding or roosting, as this species generally roosts and breeds in the Jarrah Forrest and Warren bioregions of WA (ELA 2020).

The breeding success of Black Cockatoos is strongly influenced by the availability of food in proximity to breeding sites (EPA 2019). Black Cockatoo breeding sites that are also located within 1-2 km of suitable foraging habitat, generally have the highest fledgling success rate. However, birds will forage up to a maximum of 12 km from a breeding site (DSEWPaC 2012c). Whilst suitable foraging habitat, has been recorded within the Development Envelope, given that the closest known Black Cockatoo breeding site occurs greater than 12 km from the Development Envelope, none of the foraging habitat available within the Development Envelope is likely to support breeding for Black Cockatoos (ELA 2020).

Of the 680 Black Cockatoo potential breeding trees located in the Development Envelope, 201 trees will be retained in NVRAs. There are 423 Black Cockatoo potential breeding trees located within the Footprint that may be directly impacted by the Proposal (Table 42). Given that Baudin's Cockatoo is highly unlikely to utilise this area for breeding or roosting, the impacts are applicable to potential breeding habitat used by Carnaby's and Forest Red-tailed Black Cockatoos. There has been no evidence of breeding by any of the three Black Cockatoo species and a field survey of tree hollows indicated that none of the hollows are suitable for breeding purposes (ELA 2020, Kirkby 2020).

The impacts to Black Cockatoo potential breeding trees is at variance with the EPBC Act Referral Guidelines for Carnaby's and Forest Red-tailed Black Cockatoos (DSEWPAC 2012b) and this scale of action has been assessed to meet the DotEE's definition of a 'significant impact' (DEWHA 2013a) (Section 12.7). The PTA is proposing an Offsets Strategy to offset the significant residual impacts to Black Cockatoo foraging habitat and potential breeding trees (Section 11).

Table 42 summarises the number of Carnaby's and Forest Red-tailed Black Cockatoo potential breeding trees likely to be impacted by this Proposal.

Table 42: Carnaby's and Forest Red-tailed Black Cockatoo potential breeding trees

Potential Breeding trees	Development Envelope	Footprint	NVRA
Total Black Cockatoo potential breeding trees	680	423	201
Potential Black Cockatoo potential Breeding trees with hollows	40	33	4
Tree hollows suitable for breeding use	0	0	0

ELA 2020, Kirkby 2020

There are several known roosting sites for Carnaby's and Forest Red-tailed Black Cockatoos within 1 km of the Proposal and there have been direct observations of the species within the Development Envelope. There are no known roosts within the Development Envelope or Footprint. Native Vegetation Retention Areas will protect 11.6 ha of potential roosting habitat, or approximately 25% of the 47.6 ha of potential suitable roosting habitat within the Development Envelope.

While it is difficult to quantify local and regional roosting habitat availability for the two species, it is known that there are current preferred roosting sites neighbouring the Development Envelope. The current roost sites may be preferable as they are in a more secluded, densely vegetated and quiet location within Bush Forever site 304, compared with the habitat within much of the Development Envelope, which contains scattered trees generally close to existing road infrastructure and neighbouring urban development. The Proposal is not considered to have a significant impact on roosting habitat for Black Cockatoos, as no known roost sites are within the Development Envelope and no impacts to nearby roost sites are anticipated as a result of implementation of the Proposal.

The Proposal is considered to have a significant impact on Black Cockatoos as a result of its impact on:

- 81.4 ha of foraging habitat for Carnaby's and Baudin's Black Cockatoo, including 68.1 ha of foraging habitat for Forest Red-tailed Black Cockatoo
- 423 potential nesting trees, including 33 with hollows.

The PTA has prepared an Offsets Strategy to counterbalance the significant residual impacts to Black Cockatoo foraging habitat and potential breeding trees (Section 11).

Carter's Freshwater Mussel

It is unlikely there will be direct impacts to Carter's Freshwater Mussel from the Proposal, due to the lack of suitable habitat within the Development Envelope. Recent surveys undertaken by the PTA for this Proposal (WRM 2020) did not locate any populations within the Development Envelope and noted that, due to the lack of any standing water at this location, it was unlikely the species would survive. It is unlikely that the disturbance of up to 0.9 ha of potential habitat at Bennett Brook Rail Bridge will result in any significant impact to the species.

The proposal has the potential for indirect impacts resulting from erosion, siltation and sedimentation as there is a known population of Carter's Freshwater Mussel located approximately 1.7 km downstream from the Bennett Brook rail bridge. The potential impacts to Bennett Brook, including erosion and siltation, arising from construction activities will be controlled through the implementation of the CEMP and therefore construction of the Proposal is unlikely to impact downstream populations of Carter's Freshwater Mussels.

Any physical alteration of the channel bed during construction has the potential to affect downstream populations and disrupt the breeding cycle of Carter's Freshwater Mussel, if the current conditions for water flow including fish passage and associated dispersal of glochidia (larvae) is impacted. The PTA has designed a rail bridge to span Bennett Brook to ensure that Bennett Brook surface water flow is not impacted. Based on the Proposal design there will be no impact to the life cycle of Carter's Freshwater Mussel as surface water flows will not be impeded by the rail bridge.

Temporary dewatering activities necessary for the construction of Bennett Brook rail bridge will be subject to approval under the RIWI Act and will require the preparation of a Dewatering Management Plan to manage impacts associated with drawdown. The potential for changes to groundwater levels to affect groundwater fed pools distal to the Development Envelope is considered unlikely, as the PTA will implement measures including returning water to the aquifer during dewatering to ensure drawdown beyond the Development Envelope is adequately managed. Temporary groundwater abstraction and reinjection is discussed in more detail in Section 8.6.1.

Given that there were no individuals of Carter's Mussel found within the Development Envelope in the survey undertaken for the Proposal, the PTA's bridge design that does not impede flows through Bennett Brook, a CEMP will be implemented to manage potential sedimentation impacts and prevent offsite discharges and a Dewatering Management Plan will be developed to manage the potential for groundwater drawdown, the Proposal will not have a significant impact on Carter's Freshwater Mussel.

Black-Stripe Minnow

Of the eight wetlands assessed in Table 37, four were considered to potentially represent Black-stripe Minnow habitat (Figure 34). The Development Envelope intercepts two of these wetlands:

- 0.8 ha or 33% of 2.3 ha DBCA mapped extent of UFI 8678.
- 0.9 ha or 1% of 88.9 ha DBCA mapped extent of UFI 15259 Bennett Brook.

Direct impacts to Black-stripe Minnow are considered at each potential habitat in Table 43

Table 43: Assessment of impacts to potential Black-stripe Minnow habitat

Wetland	Distance to Development Envelope	Area (ha) intersecting Development Envelope	Impacts and significance
UFI 8679 Unnamed REW	116 m Whiteman Station area	NA	**No impact** No direct impact due to separation distance of greater than 50 m. Indirect impact only through changes to surface hydrology and ground water abstraction.
UFI 8418 Orchid Park CCW	5 m	NA	**No impact** No direct impact as wetland not within Development Envelope. Although the wetland is close to the Development Envelope, construction of the rail is more than 50 m from the wetland and therefore no direct impacts are likely.
UFI 8678 REW	NA	0.8 ha (0.5 ha clearing)	**Low impact** The eastern portion of this wetland is intercepted by the Development Envelope and a small portion is likely to be within the Footprint.
UFI 15259 Bennett Brook CCW	NA	0.88 ha	**Low impact** Direct impacts are unlikely as the sections of Bennett Brook intersected by the Development Envelope were dry at the time of survey and therefore considered to be unsuitable habitat for the Black-stripe Minnow (Biologic 2020). There may be the potential for indirect impacts as the greater Bennett Brook area has the potential to support Black-stripe Minnow. Groundwater monitoring data recorded at BH015 located at the proposed bridge crossing of Bennett Brook, indicates that dry season minimum groundwater levels are below the riverbed, suggesting that the habitat would be unsuitable for the species to aestivate.

Indirect impacts to Black-stripe Minnow populations potentially downstream could arise as a result of reductions in water quality through changes to surface water flow, physical disturbance to Bennett Brook resulting in turbidity downstream, as well as changes to surface and groundwater levels that affect water availability for the species. In particular, as the species requires tannin rich (dark) water, increased flow of 'clear' water into the wetland may impact the suitability of habitat. To maintain the hydrological conditions of wetlands as far as practicable and avoid causing an increase in flow of 'clean' water the CEMP (Appendix U) will be implemented. This will include implementation of surface water and stormwater management measures that include:

- Stormwater management will include the use of low bunds, silt fencing, bales or other erosion and siltation prevention equipment where necessary. The diversion of any open drains will be avoided during construction wherever possible.
- Stormwater to be held within the construction sites where practicable and only released beyond the footprint if water quality criteria are met.
- Construction planning will incorporate planning and controls (water quality and erosion) for major rainfall events (up to 1% AEP rainfall event) during all phases of construction.

This will ensure that indirect impacts resulting from surface water or stormwater flows will be minimised. The Bennett Brook rail bridge will be designed to minimise impact on the beds and banks of the watercourse and ensure unrestricted surface water flow.

Given the species is considered likely to be locally extinct (Bamford 2020c), the implementation of appropriate management measures to minimise the risk of impacting water quality at potential habitat is precautionary, and the Proposal is considered unlikely to have a significant impact on the Black-stripe Minnow.

Loss of conservation significant invertebrates and short range endemics

Investigations have determined that it is unlikely that any conservation significant invertebrates or SRE inhabit the Development Envelope and that those that might do are in very low numbers (Invertebrate Solutions 2020). A total of 24.4 ha of habitat of moderate value to SRE and conservation significant invertebrates will be impacted by the Footprint, comprising 5.2% of the Development Envelope.

Due to the absence of records of SREs or conservation significant invertebrates from the survey and the small scale of clearing in the local context, the Proposal is not considered to have a significant impact on SRE or conservation significant invertebrates.

6.6.2. Operational impacts

Potential operational impacts from the Proposal include:

- Loss of ecological connectivity.
- Fauna injury from vehicle strike.
- Degradation of habitat over time.

Impacts to ecological connectivity and fauna movement

Patterns of movement of fauna in the existing landscape are determined by the biology of the fauna species and the structure of that landscape (i.e. vegetation, soils and hydrology, and also infrastructure such as fences and buildings) and current fauna movements can be interpreted by considering these factors (Bamford pers. comm. 2020). The Proposal has been located in low value fauna habitat through Marshall Paddocks and adjacent to Drumpellier Drive to minimise significant impacts to ecological connectivity and fauna movement. The full length of the operating railway will be fenced in accordance with PTA standards to a height of at least 1.8 to 2.4 m. The rail fencing will create a barrier for some fauna. The key areas where fauna movements are potentially impacted are discussed below.

Regional ecological linkages

There are two ecological linkages intercepted by the Proposal, Greenway 13 (Bennett Brook) and Greenway 32. These are recognised as ecological linkages as they are where native vegetation is continuous or at least provides some close linkage across the landscape (Bamford pers. comm. 2020).

Ecological linkage Greenway 13 is an important linkage between Whiteman Park and areas to the south towards the Swan River. Whilst the linkage is intercepted by the Development Envelope at Bennett Brook, the connectivity will be retained under the proposed rail bridge, allowing fauna to continue to move through this habitat. Figure 16 illustrates how the rail bridge will be designed to avoid constructing structures within the bed or bank of the watercourse and maintain water flow and ecological function of Bennett Brook. Riparian vegetation removed at Bennett Brook during construction, in areas not required for permanent infrastructure, will be revegetated.

The Greenway 32 linkage between Bush Forever site 304 and Bush Forever site 200 is intercepted by the newly constructed Drumpellier Drive. This location was fenced to prevent kangaroo movement across the road. The Proposal has been located adjacent and parallel to Drumpellier Drive and while rail fencing is likely to be higher than the current fence, no further impacts to fauna habitat connectivity at this location are anticipated.

Given the Proposal will maintain the function of ecological linkage Greenway 13, and terrestrial fauna movement along Greenway 32 is already impacted by the presence of existing infrastructure, including fauna proof fencing, the Proposal is not considered to have a significant impact on ecological linkages.

Marshall Paddocks

Whiteman Park contains a population of Kangaroos, over half the total population is thought to inhabit the Marshall Paddocks area (Bamford 2020b). The installation of permanent rail infrastructure and fencing through Marshall Paddocks will restrict the movement of the existing kangaroo population. A fauna crossing that will accommodate larger animals including kangaroos is proposed at the Bennett Brook rail bridge. The fauna crossing will be designed so that the kangaroos and other large fauna will not be able to access the native vegetation and banks of Bennett Brook but rather cross under the bridge via an appropriately designed box culvert (Figure 16). Provision has also been made for an additional fauna crossing at another location within Marshall Paddocks (Figure 7), between Bennett Brook and Beechboro Road North, to facilitated continued movement of kangaroos throughout Marshall Paddocks.

As the Marshall Paddocks consist of paddocks with some parkland cleared trees scattered throughout, this area is considered low value fauna habitat, with the exception of large trees for Black Cockatoos (ELA 2020) and areas that become inundated with water that may support water birds at times (Bamford pers. comm. 2020). There are no records of conservation significant species being located within Marshall Paddocks (ELA 2020). Retaining connectivity in Marshall Paddocks for conservation significant species, beyond the proposed fauna crossings, is not considered necessary. Avian species and invertebrates are unlikely to be restricted by the rail fence and impacts to these fauna are not considered to be significant.

Malaga Banksia Woodlands

The Proposal will require clearing within the Banksia Woodlands at Malaga that may provide fauna habitat for a number of conservation significant species. The proposed clearing will separate the northern portion of this Banksia Woodland outside the Development Envelope from the area to be retained in the NVRA south of Malaga Station (Figure 18). The ecological connectivity of the Malaga Banksia Woodlands is restricted due to Tonkin Highway, Marshall Road and Beechboro Road North.

This habitat provides moderate to high value foraging habitat for Carnaby's and Baudin's Black Cockatoos. The proposed clearing will not prevent the Black Cockatoos from moving between the remaining patches of Banksia Woodland to forage. The foraging value of the vegetation cleared will be offset, as described in the Offsets Strategy (Section 11and Table 71).

The Banksia Woodlands at Malaga contain potentially suitable habitat for Quenda, Black-striped Snake, Jewelled Sandplain Ctenotus, Graceful Sunmoth and SREs. However, there are no records of these fauna being present (ELA 2020, Invertebrate Solutions 2020) and their presence at this location has been assessed as unlikely (ELA 2020, Invertebrate Solutions 2020, Bamford pers. comm. 2020). While the proposed clearing may create a barrier for fauna movement between the two patches of Banksia Woodlands, impacts to fauna movement from this clearing is not considered to be significant due to the small area of clearing, lack of records of these species at this location and existing barriers restricting wider fauna movement.

Fauna injury from vehicle strike or disturbance

Terrestrial fauna, including low flying birds may be struck by vehicles and machinery during construction and railway operations. Direct mortality during construction is likely to be low as vehicle speeds will be limited in order to manage dust emissions and in line with safe methods of work. Plants used for vegetation planting near the rail line will be selected to discourage Black Cockatoo or other birds from foraging. Rail drainage design will avoid pooling water which may attract fauna. Rail fencing will largely avoid the risk of fauna strike by trains.

PTA will install fences that span the whole length of the rail line. The fence height will be as specified in PTA Specification Fences and Noise Walls and will typically be either 1800mm or 2400mm depending on location and purpose.

Noise, vibration, lights and other anthropomorphic activity occurring during construction may disrupt fauna behaviour. However, given the short-term and localised nature of construction, it is anticipated that the impacts will not be significant. Operational railway noise, vibration and light impacts may cause some fauna to shift permanently to more favourable areas.

Given PTA's approach to landscaping its rail corridors to prevent attracting fauna and standard management measures aimed at minimising the risk of vehicle strike during construction outlined in the CEMP, the Proposal will not significantly impact fauna as a result of vehicle strike or disturbance.

Degradation of habitat

The construction and operation of the railway has the potential to cause degradation and modification to the surrounding habitat due to factors including altered surface and groundwater conditions, changes in feral animal movement and the spread of weeds and/or disease.

Altered surface and groundwater conditions

The Proposal may alter landforms and drainage patterns, which impact surface water flows, causing alteration to fauna habitats. Also, as the wetlands in this location are thought to be surface expressions of groundwater, dewatering and abstraction of groundwater has the potential to impact the availably of surface water and impact wetland habitats. Impacts to groundwater dependant vegetation can have flow on effects to fauna habitat values. Management measures outlined in the TECMP and CEMP will ensure significant impacts to fauna habitat arising from changes to surface and groundwater are avoided.

Increased spread of weeds, disease and/or soil pathogens

Increased local weed incursion and the introduction of dieback into the fauna habitat within or adjacent to the Development Envelope may cause the degradation of fauna habitat values. Weed species and dieback are most likely to be introduced during construction activities. With the implementation of the proposed hygiene management measures outlined in the TECMP and CEMP, the potential impacts to terrestrial fauna are not expected to be locally or regionally significant.

Change in feral animal abundance and/or movement

A number of introduced species have been recorded within the Development Envelope including foxes and cats (ELA 2020). Newly cleared areas, edge effects and barrier effects from rail fencing may lead to changes in feral animal movement. However, the abundance of feral animals is not expected to increase as a result of the Proposal as there will be no changes to available food sources. The Proposal is not likely to cause a significant impact to native fauna from changes to the number and movement of feral animals.

6.7. Mitigation

In developing the Proposal, the PTA has applied an iterative process to avoid and minimise impacts on fauna and fauna habitat. Table 44 provides a summary evaluation of the predicted impacts that the Proposal may have on the terrestrial fauna factor and the PTA's proposed mitigation hierarchy to minimise impacts.

Table 44: Summary assessment of impacts and application of the mitigation hierarchy for terrestrial fauna

EPA Objective:	**To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.**	
Potential impacts	**Assessment of impacts**	**Preliminary Mitigation Hierarchy**
Permanent loss of 188.7 ha of fauna habitat from vegetation clearing and installation of permanent infrastructure.	The impacts to fauna from clearing of vegetation is considered to have a significant impact on Carnaby's and Forest Red-tailed Black Cockatoos. Impacts to other fauna species are considered low and can be managed with the CEMP and TECMP. Residual impacts include: • Loss of 81.4 ha of foraging habitat for Carnaby's and Baudin's Black Cockatoo. • Loss of 68.1 ha of foraging habitat for Forest Red-tailed Black Cockatoo. • Loss of 423 potential nesting trees, including 33 trees with hollows.	*Avoid:* • The Proposal was designed to avoid clearing of habitat, with a particular emphasis on avoiding habitat of moderate or better value. • The Proposal has been aligned to avoid clearing of any potential Carter's Freshwater Mussel habitat and the rail bridge over Bennett Brook has been designed to maintain surface water flows (Figure 16). • The PTA will further investigate avoiding areas of fauna habitat during the detailed design phase, where practicable. • Impacts on high value habitat has been avoided through the establishment of NVRA's within the Development Envelope will retain 44.6 ha of fauna habitat, including up to 25.6 ha of Black Cockatoo foraging habitat (Figure 18, Figure 20). • The NVRAs will retain 201 (30%) of the Black Cockatoo potential breeding trees (Figure 21). • Adjustments to the Development Envelope have been implemented to avoid impacts to wetland habitats, including the inclusion of a NVRA to apply a 50 m precautionary buffer from the maximum known extent of Horse Swamp (Figure 6, Figure 1, Figure 34). • Clearing for temporary works has been avoided through the selection of previously cleared areas for construction access.

EPA Objective:	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	
Potential impacts	**Assessment of impacts**	**Preliminary Mitigation Hierarchy**
		Minimise: • The Footprint has been selected in order to minimise the extent of clearing of fauna habitats as far as practicable. • The Development Envelope has been reduced by 9.9 ha within Bush Forever site 304 minimising impacts to Black Cockatoo potential breeding trees and foraging habitat. • The Proposal was designed to place the temporary construction areas within existing cleared or Completely Degraded areas adjacent or near the rail corridor wherever practicable, to minimise vegetation clearing and impacts to fauna habitat. • The Proposal has been designed to minimise impacts on wetlands ensuring that any potential impacts on potential Black-stripe Minnow habitat is minimised. • Demarcation of the Development Envelope, Footprint and NVRAs in accordance with the CEMP. *Rehabilitate* • Areas cleared for the Proposal will be revegetated where no longer required for future infrastructure or management access and with consideration for operational safety requirements.
Barrier effects to fauna habitat.	The Proposal has the potential to create barrier effects to movement of fauna.	*Avoid:* • The Proposal has been aligned along Drumpellier Drive in order to avoid creating a new barrier to fauna movement. *Minimise:* • Provision of a fauna crossing at Bennett Brook rail bridge and the provision of a second fauna crossing in Marshall Paddocks (Figure 7), between Bennett Brook and Beechboro Road North will minimise impacts to ecological connectivity and reduce barrier effects to fauna movement.

EPA Objective:	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	
Potential impacts	**Assessment of impacts**	**Preliminary Mitigation Hierarchy**
		Rehabilitate • Disturbed and cleared riparian vegetation at Bennett Brook which was cleared for temporary construction areas will be revegetated
Adverse effects on surface water quality.	The Proposal has the potential to impact potential suitable habitat for the Carter's Freshwater Mussel and Black-stripe Minnow.	*Avoid:* • The proposal has been designed to avoid direct impacts on conservation significant aquatic species. *Minimise:* • A CEMP has been prepared and will be implemented by the PTA, which specifies requirements for managing surface water runoff and sediment loads. • WSUD will be applied to manage the quality of surface water runoff originating from hard stand areas such as carparks and train stations.
Fauna strike.	The Proposal has the potential to result in the death of conservation significant fauna as a result of vehicle strike during construction and operational phases.	*Avoid* • The PTA will ensure that any landscaping or revegetation undertaken will select species that do not encourage Black Cockatoos to forage or roost in close proximity to the railway. • The PTA will ensure that any landscaping or revegetation undertaken will be sufficient distance from the live railway. • Fencing will be erected along either side of the railway line to prevent fauna accessing the track. The fencing will be in accordance with PTA standards and will be between 1.8 and 2.4 m high. *Minimise:* • A CEMP has been prepared and will be implemented by the PTA, which specifies requirements for vehicle movements within the Development Envelope.

6.8. Predicted outcome

6.8.1. Residual impacts

With the implementation of the mitigation measures outlined in Section 6.7, the PTA is confident that all indirect and construction related impacts can be managed so that adverse impacts on surrounding fauna habitat can be avoided.

The implementation of the Proposal will result in the following direct residual impacts associated with the clearing of up to 188.7 ha of fauna habitat, including:

- Loss of 81.4 ha of foraging habitat for Carnaby's and Baudin's Black Cockatoo.
- Loss of 68.1 ha of foraging habitat for Forest Red-tailed Black Cockatoo.
- Loss of 423 potential nesting trees, including 33 trees with hollows.

The PTA has demonstrated that, through the application of the EPA's mitigation hierarchy, it has kept residual impacts on fauna resulting from the Proposal to as low as reasonably practicable. Changes to the design over several iterations has resulted in a significant reduction in the extent of fauna habitat being removed.

6.8.2. Significant residual impacts

An assessment of the significance of the residual impacts concluded that significant residual impacts from the Proposal are the permanent loss of:

- 81.4 ha of foraging habitat for Carnaby's and Baudin's Black Cockatoo.
- 68.1 ha of foraging habitat for Forest Red-tailed Black Cockatoo.
- 423 potential nesting trees, including 33 trees with hollows.

The PTA has prepared an Offset Strategy aimed at counterbalancing the significant residual impacts of the Proposal on Black Cockatoos (Section 11).

6.8.3. Predicted outcome

The PTA considers that through implementation of the mitigation hierarchy and application of the proposed management strategies, combined with the implementation of an Offsets Strategy for the Proposal, the Terrestrial Fauna environmental factor can be managed during the construction and operation of the Proposal, and the EPA's objective will be met.

7. Terrestrial environmental quality

This chapter describes how the values of the Terrestrial Environmental Quality factor, may potentially be impacted by the Proposal, considers the various construction and operational related activities that could either directly or indirectly impact Terrestrial Environmental Quality, assesses those impacts and determines that no significant residual impacts to Terrestrial Environmental Quality are predicted from the implementation of the Proposal. The assessment considered impacts to land such as contamination of soil and water, generation of ASS and waste and potential impacts to related environmental values such as vegetation and wetlands.

The PTA is confident that with the implementation of the proposed mitigation and management measures the Proposal will meet the EPA's objective to maintain the quality of land and soils so that environmental values are protected. Proposed mitigation measures will be managed through implementation of the CEMP (Appendix U), and ASS Management Strategy (Appendix W), TECMP (Appendix X), and a Dewatering Management Plan that will be prepared as a condition to licences obtained under the RIWI Act.

7.1. EPA objective

To maintain the quality of land and soils so that environmental values are protected.

7.2. EPA Policy and guidance

Key EPA policy and guidance is listed below. All environmental investigations have been undertaken to meet the requirements of these policies and guidelines:

- Environmental Factor Guideline: Terrestrial Environmental Quality (EPA 2016g).

7.3. Other policy and guidance

Additional policy and guidance on which this ERD is based is provided below.

- *Contaminated Sites Act 2003*.
- Assessment and Management of Contaminated Sites (DER 2014).
- Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes (DER 2015a).
- Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes (DER 2015b).
- Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia (DoH 2009).

7.4. Receiving environment

The EPA defines Terrestrial Environmental Quality as the chemical, physical, biological and aesthetic characteristics of soils (EPA 2016g).

7.4.1. Surveys and studies

Several studies have been conducted to identify and describe the characteristics of soils within the Development Envelope and identify potential contamination that may be present as a result of current and historical land use. These include a Preliminary Site Investigation (PSI) (Coffey 2020b, Appendix M) and Preliminary Acid Sulfate Soils (ASS) investigation (Coffey 2020a, Appendix L)

Table 45 lists the relevant environmental investigations that have been undertaken to inform the assessment of terrestrial environmental quality. The results of these studies have been summarised in the sections below.

Table 45: Summary of environmental investigations relevant to terrestrial environmental quality

Investigation	Details of investigation
Quarterly GME Report – December 2019 to February 2020	**Scope:** Quarterly monitoring including level gauging at: 62 groundwater locations, 12 surface water locations; flow gauging at five surface water locations; and quality sampling at 26 groundwater locations and seven surface water locations. This report presents a factual summary of the monitoring data collected between December 2019 to February 2020 with comparison to previous data for the assessment of trends and relevant guideline values. **Consultant:** Coffey **Survey date/s:** December 2019, January 2020 and February 2020 **Report date:** 5 June 2020 **Commissioned by:** PTA
Preliminary Acid Sulfate Soils Investigation, Malaga to Ellenbrook **Appendix L**	**Scope:** A preliminary Acid Sulfate Soil (ASS) investigation conducted to identify potential ASS within the Development Envelope. **Consultant:** Coffey **Survey date/s:** November / December 2019 **Report date:** April 2020 **Commissioned by:** PTA
Contamination Preliminary Site Investigation, Malaga to Ellenbrook **Appendix M**	**Scope:** A Preliminary Site Investigation (PSI) to identify potential contamination associated with current and historical land uses within the Development Envelope. The PSI included: 1. Broad desktop assessment of the Development Envelope; 2. Targeted desktop assessment – selected areas within the Development Envelope; and 3. Targeted site inspection – selected areas within the Development Envelope. **Consultant:** Coffey **Survey date/s:** December 2019 **Report date:** April 2020 **Commissioned by:** PTA
Preliminary Site Investigation Lots 352-355 Murray Road, Lot 10 Woollcott Avenue and Lot 822 Youle-Dean Road, Brabham WA	**Scope:** A PSI of a potentially contaminated site located adjacent to the Development Envelope, east of the proposed Whiteman Park Station. This study was commissioned by the Department of Communities to inform future land use planning. **Consultant:** Aurora Environmental **Survey date/s:** June 2017 **Report date:** 2017 **Commissioned by:** Department of Communities

Investigation	Details of investigation
Addendum to Preliminary Site Investigation Lots 352-355 Murray Road, Lot 10 Woollcott Avenue and Lot 822 Youle-Dean Road, Brabham WA	**Scope:** An addendum to the original PSI to conduct further assessment to identify potential contamination on Lot 822 Youle-Dean Road, Brabham. **Consultant:** Aurora Environmental **Survey date/s:** November 2017 **Report date:** 2017 **Commissioned by:** Department of Communities
Groundwater Monitoring Event Lexia Liquid Waste Disposal Facility	**Scope:** A groundwater assessment to identify and define groundwater contamination present at the site. **Consultant:** Golder **Survey date/s:** April 2016 **Report date:**2016 **Commissioned by:** LandCorp
Preliminary Site Investigation: Former liquid waste disposal facility	**Scope:** A PSI to assess the potential for contamination and the types of contaminants present at a site based on current and historical land uses and activities. Identification of potential contaminant pathways and sensitive receptors in the vicinity of the site provides a preliminary understanding of the risk posed by potential contamination. **Consultant:** Golder **Survey date/s:** 21 August 2014 (Site Walkover) **Report date:** 2015 **Commissioned by:** LandCorp
Detailed Site Investigation: Lexia Liquid Waste Disposal Facility	**Scope:** A Detailed Site Investigation to assess the presence, composition and extent of contamination at the former Lexia Liquid Waste Facility. **Consultant:** Golder **Survey date/s:** August 2015 **Report date:** 2015 **Commissioned by:** LandCorp
Northlink Acid Sulfate Soil Site Investigation	**Scope:** An acid sulfate soils investigation conducted for Northlink. This ASS assessment includes part of the Tonkin Hwy road reserve, including a section of the highway where the dive structure is proposed. The report informs regional context for ASS. **Consultant:** Coffey **Survey date/s:** September 2014 **Report date:** 2015 **Commissioned by:** Main Roads Western Australia

Investigation	Details of investigation
Northlink Preliminary Site Investigation	**Scope:** A PSI conducted for Northlink. This assessment includes part of the Tonkin Hwy road reserve, including a section of the highway where the dive structure is proposed. It provides some context for potential contamination within the broader region. **Consultant:** Coffey **Survey date/s:** September 2014 **Report date:** 2015 **Commissioned by:** Main Roads Western Australia
Due Diligence Report Long-stay Caravan Park, Marshall Road, Whiteman	**Scope:** A preliminary environmental impact assessment conducted by the Department of Housing to support land use planning for Lot 32 Hepburn Avenue, Cullacabardee, located within the Development Envelope southwest of the proposed Malaga Station. **Consultant:** RPS **Survey date/s:** N/A **Report date:** February 2015 **Commissioned by:** Department of Housing
Investigation into the Suitability of Marshall Road Precinct for Development for Urban Purposes	**Scope:** A preliminary environmental impact assessment to support land use planning for a 331 ha area of land within the Development Envelope east of the proposed Malaga Station. This work was commissioned by the Whiteman Park Board. **Consultant:** PPK **Survey date/s:** February 2002 **Report date:** 2002 **Commissioned by:** Whiteman Park Board

7.4.2. Geology and soil

Regional context

The Development Envelope lies within the Bassendean Dune System, on the boundary between the Bassendean Dunes System and Pinjarra Plain. Deep Bassendean Sands are typically interfingered with Guildford Clays that are characteristic of the Pinjarra Plain (PPK, 2002). Clayey sediments characteristic of the Guildford Formation are more common in the south-east towards Bennett Brook.

Bassendean dunes comprise basal conglomerate overlain by deep horizons of dune quartz sand with heavy mineral concentrations (Geological Survey of WA and Geoscience Australia 2008). These siliceous dunes originated along the coastline, perhaps as calcareous sands of marine origin (Salama et al. 2005). Due to extensive leaching over hundreds of thousands of years, carbonate that was in these soils has been removed and erosion has caused the steep relief characteristic of coastal dunes to be modified, forming a broadly undulating landscape of low hills interspersed with poorly drained swamps in low lying depressions.

In Whiteman Park there is a small area where the Bassendean Sands are underlain by lacustrine sediments (lake deposits) or residual mud that comprises clay, silt and sand commonly gypsiferous and/or saline; playa, claypan and swamp deposits; peat; peaty sand and clay; halitic and gypsiferous evaporites.

Soil sampling conducted throughout the Development Envelope has confirmed that the underlying geology is consistent with the regional geological setting (Coffey 2020a). Underlying soils were dominated by the Bassendean Sand formation, characterised by grey, brown, and cream coloured silty sand and sand. Coffee rock was encountered at several locations and generally around the water table. Brown to pale brown clayey sands considered to be representative of Guildford Clays were identified at the base of some of the boreholes near Bennett Brook and Whiteman Park Station (Coffey 2020a).

Geological mapping

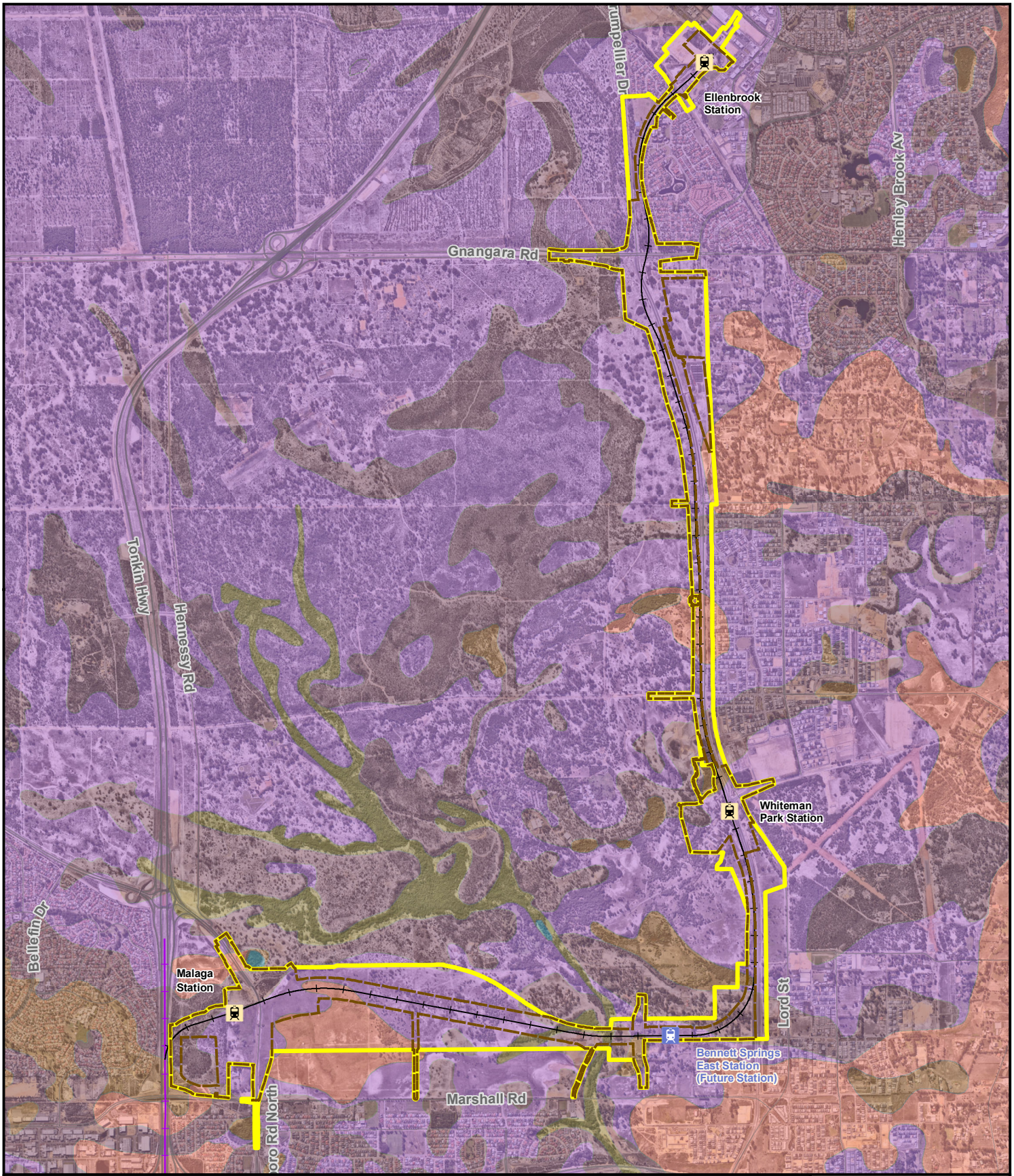
The Geological Survey of Western Australia has mapped five geological units within the Development Envelope (Figure 22):

- S8 – sand, very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin.
- S10 – as S8.
- Mgs1 – pebbly silt, strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin.
- Mcl – clayey silt, yellow brown to strong brown, blocky, mottled, soft, with variable clay content, dispersive in part, of alluvial origin.
- Cps – peaty clay - dark grey and black with variable sand content of lacustrine origin.

The majority of the Development Envelope is mapped as S8 or S10. All the geological units within the Development Envelope are common and well represented in the region.

Soil mapping

The Development Envelope lies within the Bassendean Zone, which has been described as mid-Pleistocene Bassendean sand, fixed dunes inland from the coastal dune zone, non-calcareous sands, podsolised soils with low lying wet areas (Purdie et al., 2004) (Figure 23). Seven soil landscape units have been mapped within the Development Envelope (Table 46). All landscape units are common and widespread throughout the region.



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 22 **Geology**

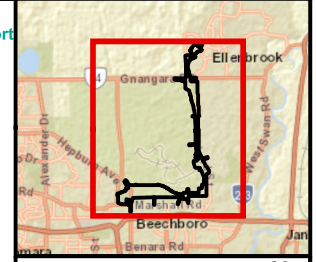
Public Transport Authority

Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

1:50k Perth Geology Surface

- Cps: PEATY CLAY - dark grey and black with variable sand content of lacustrine origin
- Mc1: CLAYEY SILT - yellow brown to strong brown, blocky, mottled, soft, with variable clay content, dispersive in part, of alluvial origin
- Mgs1: PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial or
- S10: SAND - as S8
- S8: SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin
- Water



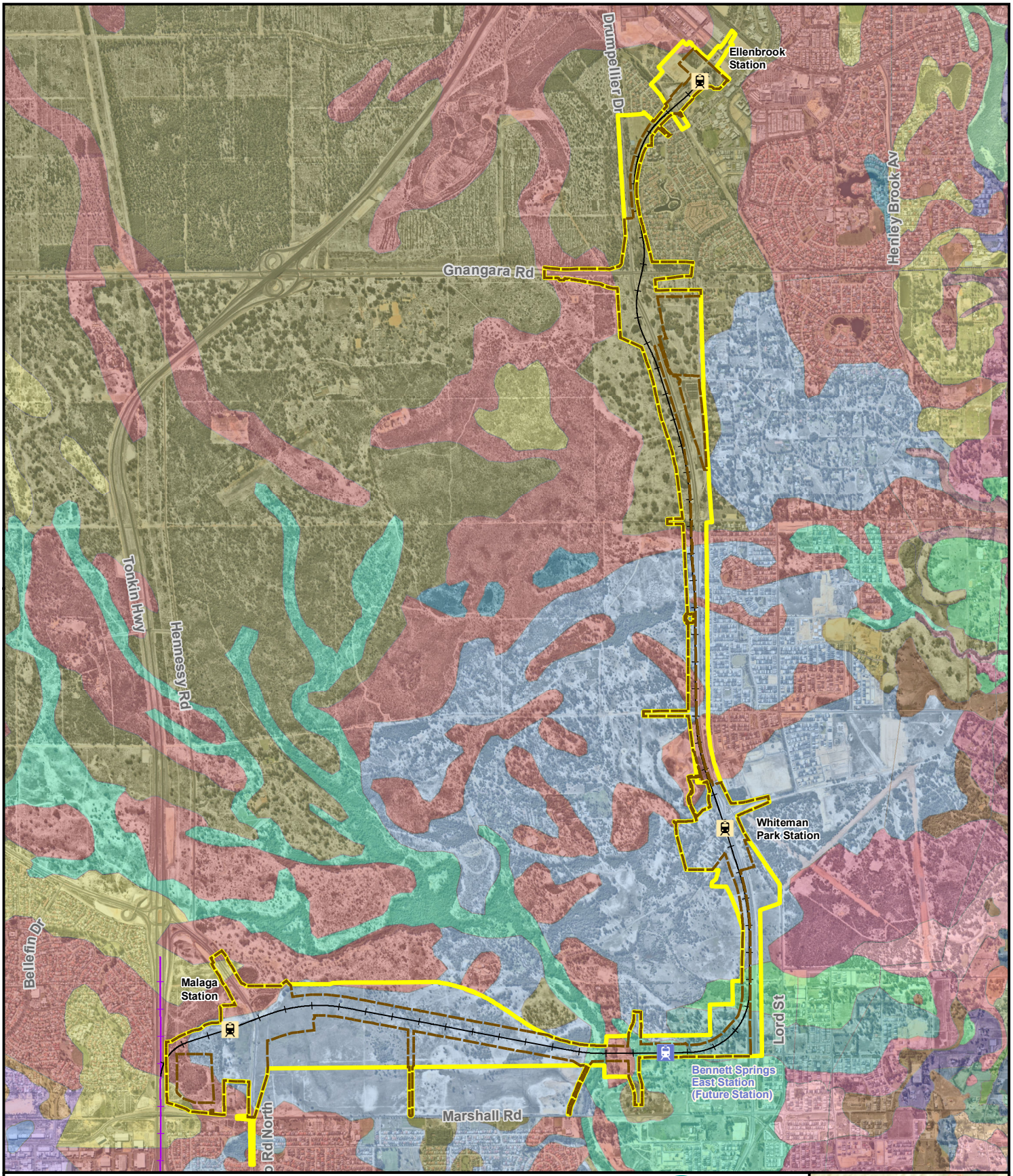
Date Printed: 13/06/2020
Created By: K.Du
Approved by: C.Baxter

Scale: 1:40,500 @A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0131_A4P_v1.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 23 **Soils**

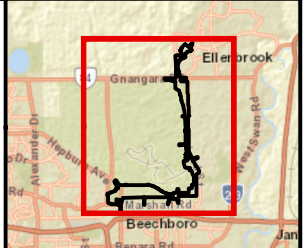
Public Transport Authority

Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Soil-Landscape Map Unit Symbol

- 212BsW_SWAMP
- 212Bs__Bas
- 212Bs__Bis
- 212Bs__Cps
- 212Bs__DL
- 212Bs__G
- 212Bs__J
- 212Bs__Ja
- 212Bs__Ks
- 212Bs__Ksg
- 212Bs__Mus
- 212Bs__S8
- 212Bs__VC
- 212Bs__Ws
- 212Bs__Ya
- 213PjCR_Cl
- 213PjCR_Csl
- 213PjHE_Hs
- 213PjHE_Hsd
- 213PjHE_Hsl
- 213PjSW_Ssl
- 213PjW_CLAYPAN
- 213PjW_SWAMP
- 213Pj__Mgs1
- 213Pj__S10
- 213Pj__VC
- 213Ya12x
- 213Ya_8x
- 213Ya_9x



Date Printed: 13/06/2020
Created By: K.Du
Approved by: C.Baxter

Scale: 1:40,500 @A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0132_A4P_v1.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Table 46: Soil-landscape units within Development Envelope

Zone	Unit	Description	Area within Development Envelope		Area within Footprint	
			ha	%	ha	%
212 Bassendean Zone	212Bs__Bis Bibra sand (Bassendean)	Deep grey sand with shallow winter watertable.	7.7	1.7	2.2	0.9
	212Bs__Ks Karrakatta sand (Bassendean)	Shallow layer of grey sand over yellow sand (sand dune).	18.4	4.0	9.6	3.8
	212Bs__J Bassendean, Joel Phase	Poorly drained depressions. Humus podzols. Scattered *Melaleuca preissiana, Eucalyptus rudis* and *Banksia ilicifolia* with a dense shrub layer.	4.4	0.9	4.2	1.7
	212Bs__Ya Bassendean Yanga Phase (Bassendean)	Flat, poorly drained complex landscape; soils include shallow sand over limestone or ferruginous pan, deep leached sand, and saline soils; dense *Melaleuca* spp. along drainage lines.	234.8	50.6	118.7	47.7
	212Bs__Ja Bassendean, Jandakot Phase	Jandakot low dunes. Slopes <10% and generally more than 5m relief. Grey sand over pale yellow sands generally underlain by humic and iron podsols; *Banksia* spp. low open woodland with a dense shrub layer.	60.4	13.0	33.7	13.5
	212Bs__G Bassendean, Gavin Phase	Flat or gently undulating landscape. Iron-humus podzols and some diatomite deposits. *Banksia* spp. Low open woodland with scattered emergent *Corymbia calophylla* and *Melaleuca pressiana* dense shrub layer.	127.7	27.5	71.7	28.8
	212Bs__DL Bassendean drainage lines Phase	Broad, shallow channels, peaty soils, fringe of *Melaleuca* spp. and *Eucalyptus rudis*; reeds and sedges in central zone.	10.7	2.3	9.0	3.6

7.4.3. Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils, sediments or organic substrates that contain iron sulfides, predominantly in the form of pyrites (DER 2015a). These soils commonly occur in environments prone to water logging or inundation. In WA they often occur in sediments associated with fresh groundwater dependent wetlands and beneath the water table in podzolised sandy soil profiles.

The Proposal will be constructed on Bassendean Sands, which do not meet the traditional definition of ASS (DER 2015a). Bassendean Sands are highly leached and contain no buffering capacity to neutralise the formation of acid and acid by-products. At the zone of groundwater fluctuation, the formation of ferruginous (iron rich) podzols known as coffee rock horizons are present and can be a major contributor to elevated iron concentrations in groundwater (Davidson 1995). The DWER recognises Bassendean Sands as being of interest regarding ASS, due to these sands being devoid of acid neutralising carbonate minerals and the potential to contain highly reactive pyrite (DER 2015a).

In Bassendean Sands the amount of pyrite is generally low with chromium reducible sulfur levels commonly less than 0.02%S (DER 2015a). However, dewatering or other disturbance in these sands are known to result in acidification of the shallow groundwater aquifer and the mobilisation of iron, aluminium and other metals into the surrounding environment. Research suggests the primary source of this acidification is coffee rock, which forms by the precipitation of humates and iron from groundwater, mainly in the zone of watertable fluctuation.

The Guildford Clays that are present beneath the Bassendean Sand are also known to be acid generating (Davidson 1995). It is understood that this is due to the presence of pyrites and other iron sulfides that can occur in these soils. These soils were confirmed to be in the Development Envelope at locations near Bennett Brook and Whiteman Park Station. These soils are only likely to be intercepted where deep earthworks or dewatering is required. Where Guildford Clays occur, the clay forms a semi-confining layer within the superficial aquifer, which is discontinuous in nature (Coffey 2020a).

ASS risk mapping

DWER has published a series of ASS risk maps (Figure 24). These maps are broad scale and designed for planning purposes only. DWER has advised that the maps are not intended to provide site specific information and should be read at the scale for their intended use (i.e. 1:50,000 to 1:100,00) (DER 2015a). Where smaller scale risk mapping is required, more detailed risk mapping is required.

DWER ASS risk maps are based on desktop information and some on-ground assessment conducted at a regional scale. The DWER risk mapping classifies ASS risk into two categories:

- Class I – high to moderate risk of ASS occurring within 3m of the natural soil surface
- Class II – moderate to low risk of ASS occurring within 3m of the natural soil surface, but high to moderate risk of ASS beyond 3 m of the natural soil surface

Areas that have not been mapped as Class I and Class II may still contain ASS. These maps were prepared at a broad scale and were only intended to be used for land use planning, to identify when ASS investigations are warranted. Areas with no ASS risk mapped may correspond with places that are less likely to contain ASS or areas that had insufficient data available to determine the ASS risk.

The DWER ASS risk mapping shows that most of the Development Envelope has a 'moderate to low risk of ASS occurring within 3 m of natural soil surface, but high to moderate risk of ASS beyond 3 m of natural soil surface' (Class II ASS risk) (Figure 24).

Four areas are mapped as having a 'high to moderate risk of ASS occurring within 3 m of natural soil surface' (Class I ASS risk) within the Development Envelope (Figure 24).

- North of the proposed Whiteman Park Station.
- North of the proposed Bennett Springs East Station (Future Station).
- Two areas west of the proposed Bennett Springs East Station (Future Station).
- Two areas near the eastern most edge of the Development Envelope where the dive structure is proposed at Tonkin Highway and north of the proposed Malaga Station.

Review of the DWER ASS Risk mapping identified that DWER ASS risk mapping within the Development Envelope is aligned with geological mapping at a scale of 1:50,000 and does not appear to have considered other environmental values present that often contain ASS, such as wetlands (wetlands within the Development Envelope are described in Section 8.4.2). Isolated peaty deposits associated with humic wetlands present a risk of net acid production from the oxidation of sulfide bearing minerals and organic materials, albeit the rate of generation is typically slower than that of the Bassendean Sands. The likelihood of ASS being present would therefore be higher in wetlands and associated areas.

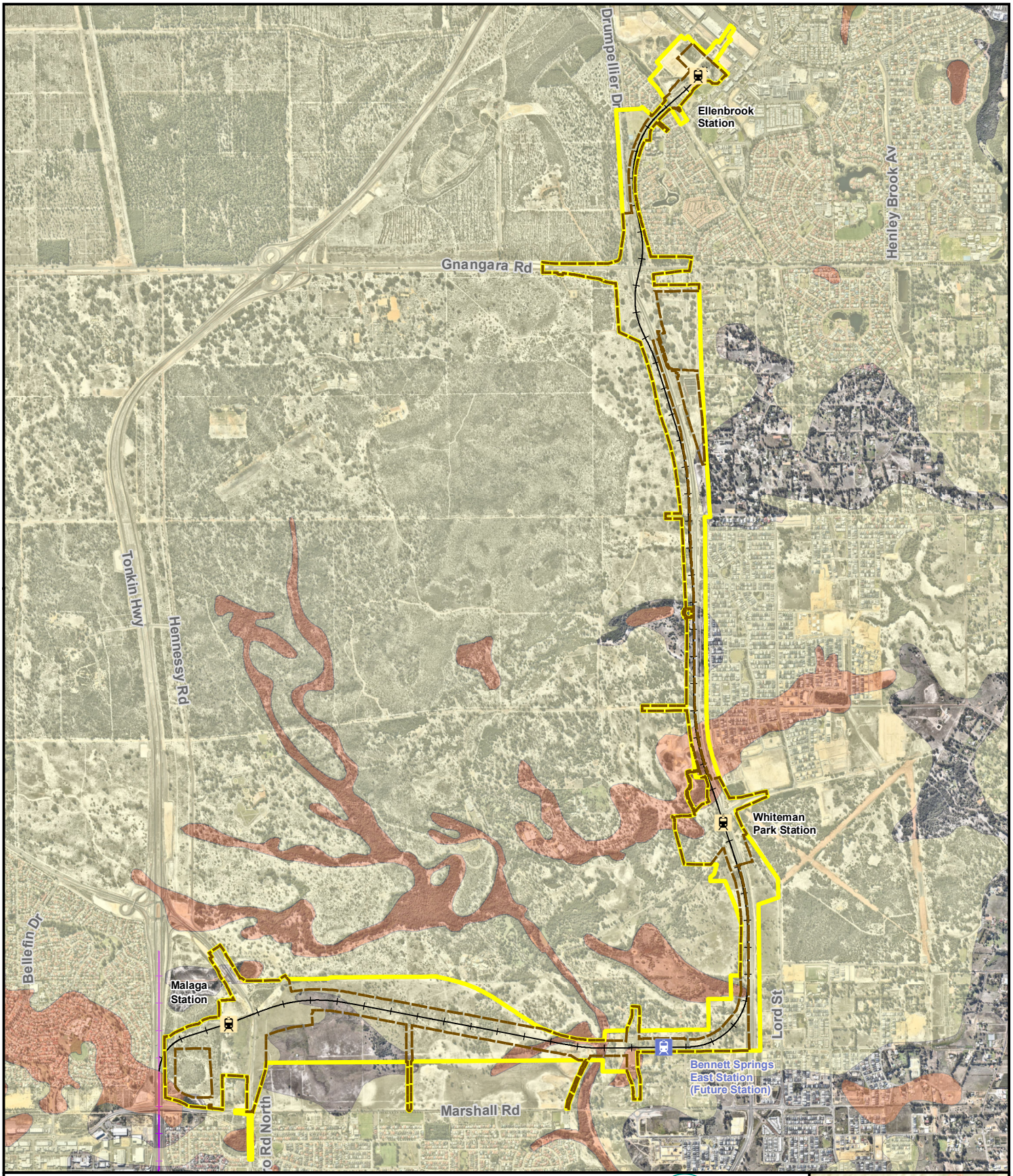
To obtain more certainty regarding potential ASS occurrence, the PTA commissioning a preliminary ASS investigation to obtain data on ASS risk specific to the Development Envelope (Coffey 2020a).

Table 47: DWER ASS risk mapping

ASS Risk	Area within Development Envelope		Area within Indicative Footprint	
	ha	%	ha	%
Class I[1]	25.2	5.4	16.2	6.5
Class II[2]	387	83.4	220.2	88.4
No ASS Risk mapped	51.7	11.1	12.8	5.1

1 - Class 1 risk: high to moderate risk of ASS occurring within 3 m of natural soil surface.

2 - Class II risk: moderate to low risk of ASS occurring within 3 m of natural soil surface, but high to moderate risk of ASS beyond 3 m of natural soil surface.



METRONET|Malaga to Ellenbrook Rail Works - Environmental Review Document

Figure 24 **Acid Sulfate Soil Risk Map**

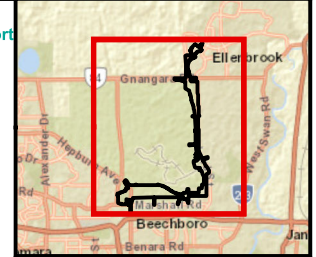
Public Transport Authority

Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Acid Sulphate Soil Risk

- High to moderate risk
- Moderate to low risk



Date Printed: 13/06/2020
Created By: K.Du
Approved by: C.Baxter

Scale: 1:40,500 @ A4
Coordinate System: GDA 1994 MGA Zone 50

N

0 200 400 600 m

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0133_A4P_v1.mxd

Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

ASS investigation

The purpose of the preliminary ASS investigation was to identify ASS within the Development Envelope and determine the potential for environmental impacts associated with the disturbance of ASS based on the Concept Design for the Proposal. Further ASS investigations will also be undertaken at locations where excavations are anticipated to disturb potential ASS (PASS).

The PTA commissioned Coffey to conduct the preliminary ASS investigation for the Proposal in 2019 (Appendix L). The ASS investigation included a desktop assessment and field sampling program that determined ASS potential within representative soils throughout the Development Envelope.

Results of the ASS investigation indicated that PASS was present in soils associated with a thin layer of coffee rock underlying Bassendean Sands throughout the majority of the Development Envelope. Coffey defined the extent of ASS occurrence within the Development Envelope as:

- Malaga Station to the future Bennett Springs East Station within coffee rock that may be encountered between 1.0 meters below ground level (mbgl) and 2.8 mbgl, dependant on topography. The maximum net acidity recorded was 0.393%S (Figure 25).
- North of Whiteman Park Station to south of Ellenbrook Station within coffee rock that may be encountered between 1.25 mbgl to 2.1 mbgl dependant on topography. The maximum net acidity recorded was 0.073%S (Figure 26).

Coffey also identified that the underlying hydrogeological system has already undergone significant acidification. Groundwater pH indicated acidic to slightly acidic conditions. The presence of elevated concentrations of dissolved aluminium suggests that the system has been influenced by historical acidification due to oxidation of ASS. Groundwater beneath the Marshall Road Paddocks and Drumpellier Drive possessed a low to moderate acid neutralising / buffering capacity. Concentrations of Titratable Alkalinity (TAlk) were generally greater in the vicinity of Ellenbrook and indicate some level of inherent buffering capacity (Coffey 2020).

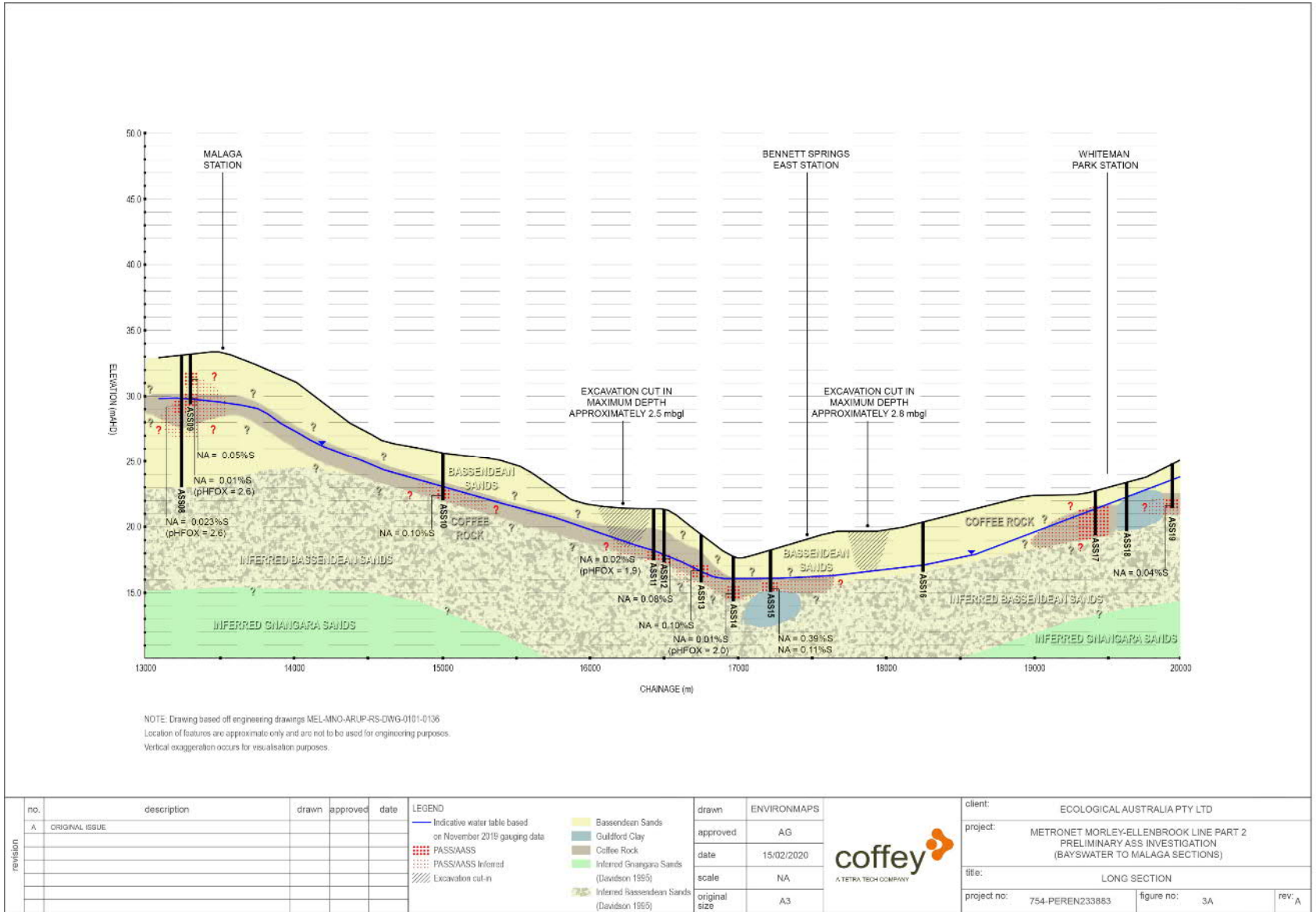


Figure 25: Inferred ASS profile and indicative ASS disturbance based on Concept Design between Malaga Station and the future Bennett Springs East Station

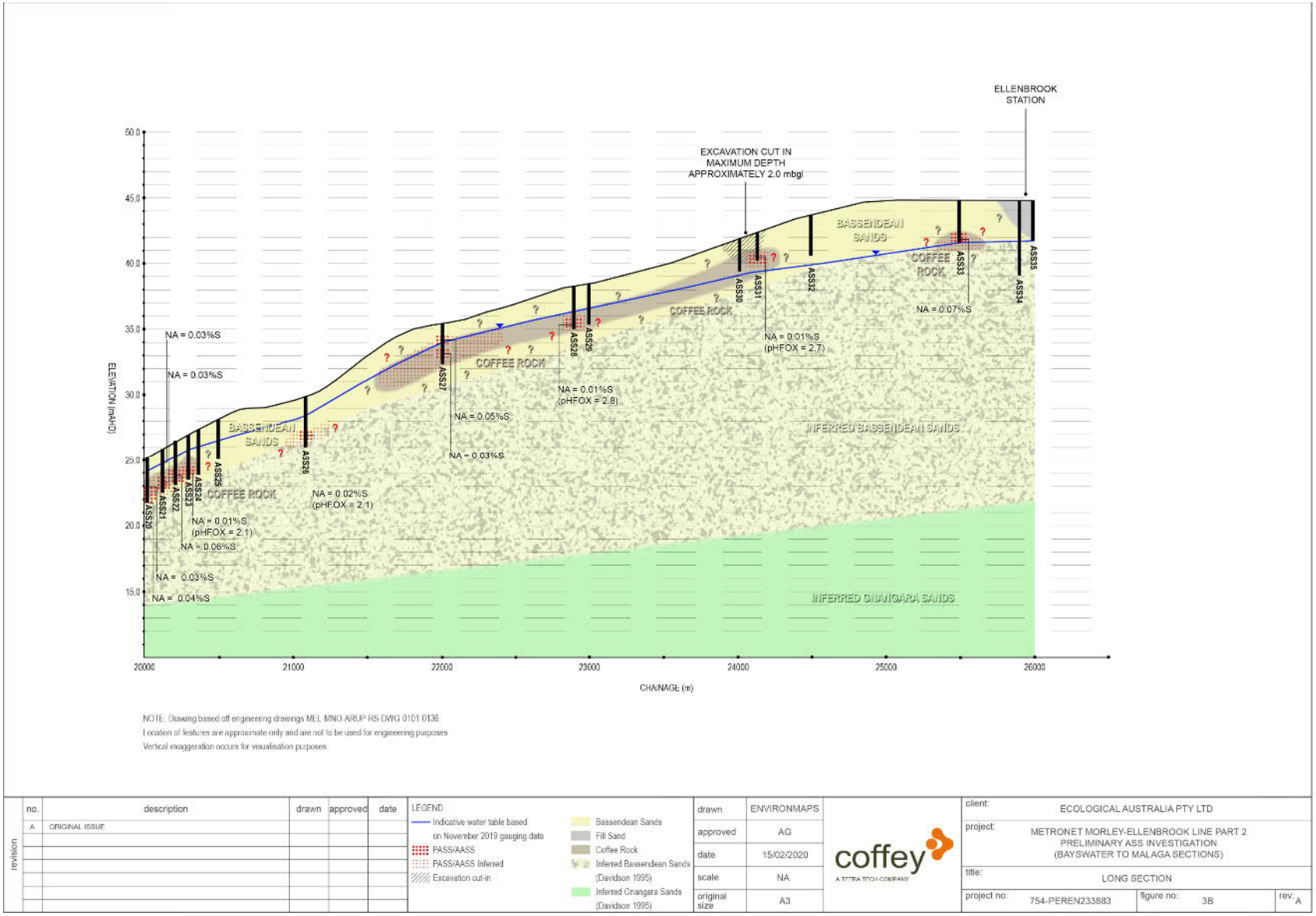


Figure 26**: Inferred ASS profile and indicative ASS disturbance based on Concept Design from North of Whiteman Park Station to south of Ellenbrook Station**

7.4.4. Land use

Land use within the Development Envelope and adjacent areas includes residential, commercial, public open space, road infrastructure, reserve land and bushland (Table 48). Metropolitan Regional Scheme zones are illustrated in Figure 7.

Table 48: Land use within the Development Envelope and adjacent land

Location	Land Use
North	
North of Ellenbrook	Predominantly residential land use and then native undeveloped bushland.
East	
Ellenbrook to Gnangara Road	Predominantly residential land use with commercial land use around Ellenbrook.
Gnangara Road intersection to Whiteman Park Station	Residential and agricultural land uses.
Whiteman Park Station to Malaga Station	Predominantly residential land use together with the old RAAF transmission station, which is currently being redeveloped for predominantly residential purposes.
West	
Ellenbrook to Gnangara Road	State Forest.
Gnangara Road intersection to Whiteman Park Station	State Reserve (Whiteman Park).
Whiteman Park Station to Malaga Station	State Reserve (Whiteman Park).
South	
South of Whiteman Park	Predominantly residential with minor agricultural land uses.

7.4.5. Contaminated sites

The PTA commissioned Coffey to conduct a PSI to identify known and suspected contaminated sites within the Development Envelope and determine the potential for environmental impacts due to disturbance of contaminated land during implementation of the Proposal (Appendix M). There are no known contaminated sites within the Development Envelope, however two potentially contaminated sites intersect the Development Envelope (Figure 27). These two sites are known as:

- The former Lexia Liquid Waste Facility (former Lexia Landfill) located on the western margin of the Development Envelope.
- The Swan Valley Egg Farm near the future Bennett Springs East Station in the south.

Contaminated land associated with these sites is either located wholly outside the Development Envelope or has not been substantiated (Table 49). Additional unidentified contamination may also be present throughout the Development Envelope if fly tipping (illegal dumping) has taken place or if existing road infrastructure was constructed using uncontrolled fill (Coffey 2020b). The extent and likelihood of fly tipping and uncontrolled fill material in the Development Envelope is unknown.

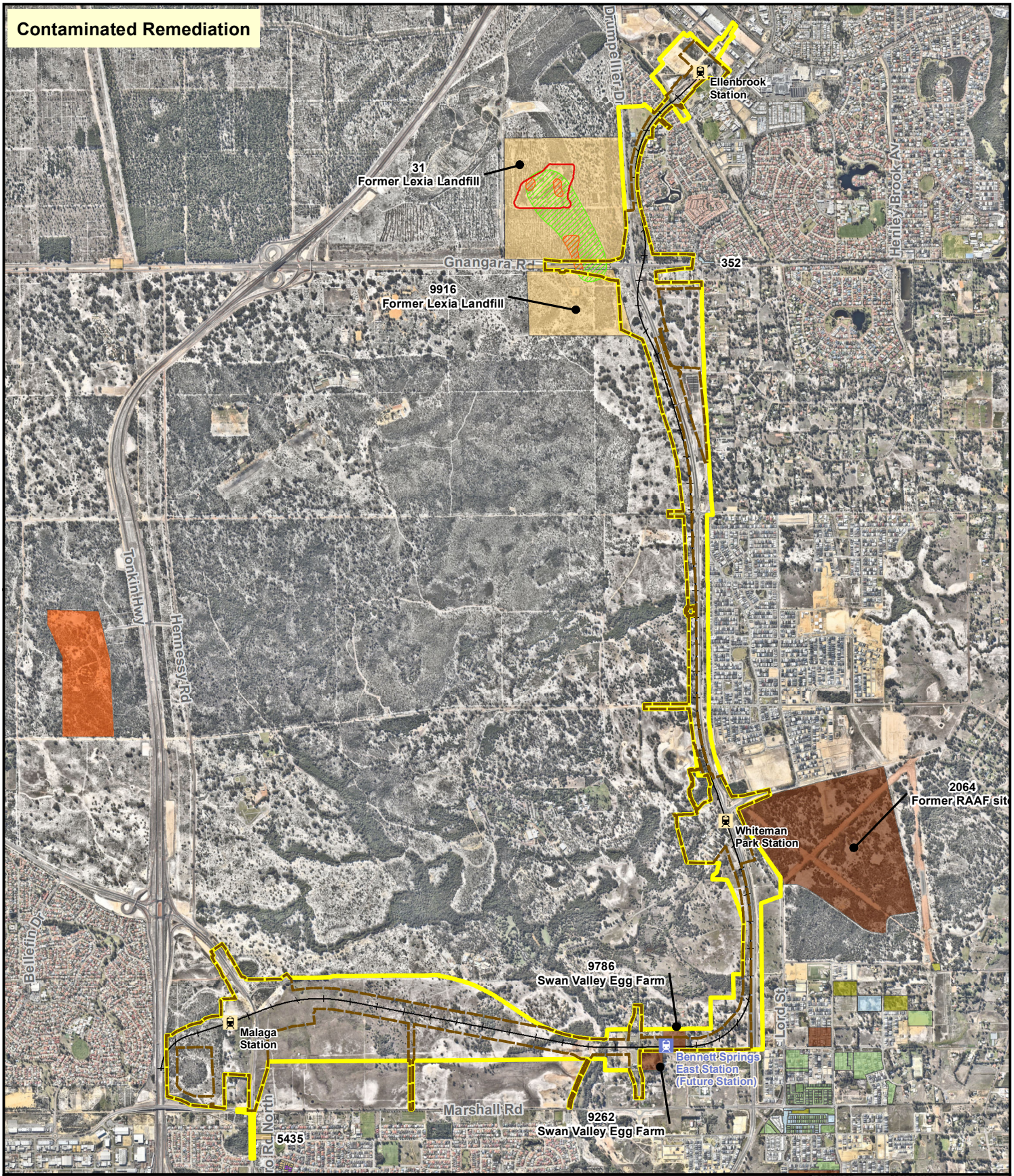
There are also three potentially contaminated sites adjacent to the Development Envelope (within 50 m) (Table 49) as indicated in Figure 27. None of these are classified as contaminated sites by DWER. Contamination has not been substantiated at one of the sites (Site 2064), one site is possibly contaminated – investigation required (Site 5435) and the other site is awaiting classification by DWER (Site 352).

Table 49: Summary of potentially contaminated sites within and adjacent to the Development Envelope

Site	Description
Within the Development Envelope	
Lexia Liquid Waste Disposal Site (Landfill) DWER Site ID 31 and 9916 Gnangara, located within reserve State Forest 65, Lexia WA 6065 (Source site) and Lot 811 on deposited plan 405371 (233 Drumpellier Drive)	**DWER classification:** Potentially contaminated – investigation required **Potential Contamination** Most of this site lies outside the Development Envelope with the exception of a small portion of land near the intersection of Gnangara Road and Drumpellier Drive (Figure 27). The former Lexia Landfill site is only shown to intersect the Development Envelope because DWER have defined the site boundary using lot boundaries based on cadastre data. Contaminated sites investigations conducted by Golder (2015a, 2015b and 2016) have demonstrated that contaminated soils associated with this site are restricted to former grease traps, sludge drying beds, basins and oxygenation lagoons that were located at least 500 m from the Development Envelope boundary (Figure 27). Contaminants detected included hydrocarbons, metals, nutrients, phenols and solvents (Golder 2015b). Although the full extent of soil contamination has not been delineated, soil contamination is understood to be contained within the former infrastructure located outside the Development Envelope. There is a plume of groundwater contamination that extends from the former Lexia Landfill site in a southeast direction towards the Development Envelope (Golder 2016). This plume is understood to intersect the western margin of the Development Envelope near the intersection of Gnangara Road and Drumpellier Drive (Golder 2016) (Figure 27). Groundwater contamination present was investigated by Golder (2016). Analysis of groundwater quality indicated that contamination included elevated concentrations of nutrients (ammonia, nitrate, total oxidised nitrogen, total nitrogen, total phosphorous), E. coli bacteria, metals (chromium, cadmium, copper, nickel, and zinc), Total Recoverable Hydrocarbons (C16-C34 F3), volatile organic compounds (1,4-duchlorobenzene and vinyl chloride), polycyclic aromatic hydrocarbons (Napthalene), organic acids (formic acid and acetic acid) and biological oxygen demand. **Significance to Proposal** Earthworks are to be undertaken in this area to construct a road bridge and underpass at the Gnangara Road and Drumpellier Drive intersection. Potential disturbance of contaminated soil at the Lexia Landfill is considered unlikely due to the 500 m separation distance between the Development Envelope and contaminated soils. Dewatering will be minimal in this area and neither dewatering nor earthworks are expected to intersect the existing contamination plume. Where dewatering is required it is readily manageable using conventional construction practices.

Site	Description
Swan Valley Egg Farm DWER Site ID 9786 and 9262 Bennett Springs, located at 53 Cheltenham Street, Lot 607 on Plan 3698	**DWER classification:** Report not substantiated **Potential Contamination:** The Swan Valley Egg Farm was reported to DWER as a potentially contaminated site in 2016 because fill sand was imported to the site from an unknown source that was suspected of containing fragments of asbestos containing material (ACM) that has the potential to pose a risk to human health (Coffey 2020b). Following a site inspection by the Department of Environment Regulation (DER) in 2016, it was found the fill material consisted of small pieces of building rubble including cement sheeting. Only two fragments of ACM were identified with the rest of the cement sheeting determined not to contain asbestos. The Department of Health (DoH) concluded in 2016 that ACM was not present at levels that posed an unacceptable risk to human health in accordance with the "Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia, (DoH 2009). DER agreed with the DoH conclusions. Since ACM materials were not found at levels deemed to pose a risk to human health, ACM at this site is not expected to pose a significant risk. Due to historical use for intensive agriculture, there is potential for contaminated soil and groundwater to be present (Coffey, 2020b). Chemicals of potential concern at the Swan Valley Egg Farm may include carbamates, organochlorine pesticides, organophosphate pesticides, herbicides, insecticides, aldrin, dieldrin, nitrates, salinity, metals, nutrients, toxaphene and ammonia. **Significance to Proposal:** Earthworks to be undertaken in this area are likely to be at grade or on fill. This site is not expected to pose a significant risk to the environment, however further testing may be required to determine if any contamination is present.
Adjacent to the Development Envelope	
DWER Site ID 5435 Lot 106 Bennett Spring Drive, Bennett Springs Abuts the Development Envelope east of Beechboro Road	**DWER classification:** Possibly contaminated – investigation required **Potential Contamination:** No information is available on potential contamination at this site. This is a site that is known to DWER but is currently not listed as a contaminated site. **Significance to Proposal:** This site is located outside the Development Envelope and as such no earthworks are proposed within the site and therefore none of the potentially contaminated soils would be disturbed. It is unknown if groundwater contamination exists at the site. However, dewatering is not required in the vicinity of this site. The nearest dewatering will be conducted at the Tonkin Highway dive structure, which is located approximately one kilometre northwest of Site 5435. The PTA commissioned Golder (2020c) to assess potential groundwater drawdown at the Tonkin Highway dive structure. Results of Golder's investigation show that without management groundwater drawdown would extend to approximately 1.3 km from the dive structure. However, with the implementation of the proposed mitigation measures (e.g. reinjection of dewatering effluent) this cone of depression would be significantly reduced and the dewatering proposed would avoid interactions within groundwater underlying Site 5435. With implementation of the proposed mitigation measures, the proposed dewatering is unlikely to result in migration of unidentified groundwater contamination and therefore the Proposal is not expected to draw contaminated groundwater into the Development Envelope or result in significant impacts to land or soils.

Site	Description
Former RAAF transmission station **DWER Site ID** **2064** **Brabham, Lots 352 – 355 Murray Road, Lot 10 Woolcott Avenue and Lot 822 Youle-Dean Road.** **Abuts the Development Envelope east of Whiteman Park Station.**	**DWER classification:** Report not substantiated Report not substantiated **Potential Contamination:** This is a site that is known to DWER but is currently not listed as a contaminated site. A PSI conducted at this site identified ACM stockpiles from fly-tipping and / or historical land use. Some minor soil contamination from hydrocarbons may be present, as evidenced by some staining near drums on the site. Residual pesticide contamination may also be present at an old caretaker's residence on the site. However, concentrations of analytes in soil samples were generally below screening criteria and potential contamination is not substantiated. The potential for groundwater contamination has not been investigated. The results of the PSI for the site did not present evidence that suggests significant groundwater contamination is likely, although it could not be discounted. **Significance of Proposal:** This site is located outside the Development Envelope and as such no earthworks are proposed within the site and any potentially contaminated soils present will be avoided. It is unknown if groundwater contamination exists at the site. If significant groundwater contamination is present, then dewatering at Whiteman Park Station could potentially cause migration of contaminants. However, given the likely short duration of any dewatering for construction purposes, it is unlikely that this will occur.
DWER Site ID **352** **Public open space adjacent to roundabout at the intersection of Gnangara Road and Pinaster Parade. Located approximately 50 m east of the Development Envelope.**	**DWER classification:** Awaiting Classification **Potential Contamination:** No information is available on potential contamination at this site. This is a site that is known to DWER and is currently awaiting classification but is not listed as a contaminated site. **Significance of Proposal:** This site is located outside the Development Envelope and as such no earthworks are proposed within the site and any unidentified contaminated soils present will be avoided. It is unknown if groundwater contamination exists at the site, however significant dewatering is not expected to be required near this site.



METRONET | Malaga to Ellenbrook Rail Works - Environmental Review Document
Figure 27 **Contaminated Sites**

Public Transport Authority

Legend

- Development Envelope
- Indicative Footprint
- Proposed Railway Station
- Proposed Railway Station (Future)
- Indicative Railway Alignment

Lexia Site

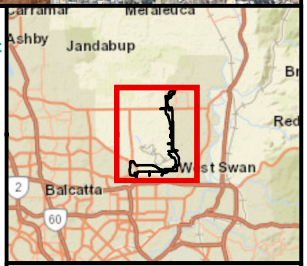
- Approximate Extent of Soil Contamination at Former Lexia Landfill Site

Groundwater Contamination Plume from The Former Lexia Landfill Site

- Nutrient and Pathogen Plume
- Organic Contaminant Plume

Classification

- Contaminated - remediation required
- Contaminated - restricted use
- Report not substantiated
- Possible Contamination - awaiting classification
- Possibly Contaminated - investigation required
- Remediated for restricted use
- Decontaminated



Date Printed: 13/06/2020
Created By: D.Whiteley
Approved by: C.Baxter

Scale: 1:40,500 @A4
Coordinate System: GDA 1994 MGA Zone 50

0 200 400 600 m

N

Document Path: Y:\ENVIRONMENTAL\Sam\04_MorleyEllenbrookLink\02_MXDs\MAPS_001_200\PTA-GIS-MEL-0134_A4P_v1.mxd
Base Data: Nearmap 2019, Landgate 2019, Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

7.5. Potential impacts to terrestrial environmental quality

The potential impacts to Terrestrial Environmental Quality from construction and operation of the Proposal in the Development Envelope are summarised in Table 50.

Table 50: Potential construction and operational impacts to terrestrial environmental quality

Proposal Stage	Impact Type	Aspect (Activities)	Potential Impacts
Construction	Direct	• Excavation of soils from railway construction. • Disturbance of soils from construction of railway and hardstand areas. • Temporary groundwater abstraction for construction water supply and temporary dewatering for construction purposes. • Discharge of dewatering effluent. • Storage and handling of chemicals.	• Excavation of ASS resulting in contamination of soils and groundwater. • Disturbance of known or suspected contaminated sites resulting in contamination of soils. • Contamination of soils from stockpiling activities. • Leaks and spills from storage and handling of fuels and chemicals resulting in contamination of soils. • Contamination from the release of waste products (including dewatering effluent). • Localised and temporary dewatering of ASS resulting in contamination. • Dewatering near known or suspected contaminated sites resulting in the spread of contamination.
	Indirect	• Alteration of landscape from construction of railway. • Discharge of dewatering effluent.	• Loss of biodiversity in groundwater dependent ecosystems. • Impacts to groundwater users caused by groundwater contamination.
Operation	Direct	• Operation and maintenance of a railway.	• Contamination of soils from fuel and chemical storage leaks. • Contamination of soils from the release of waste products (including sewage). • Accidental spillage or leaks from electrical substation.
	Indirect		• No potential indirect impacts are considered likely

7.6. Assessment of impacts to terrestrial environmental quality

7.6.1. Excavation of ASS

In anoxic conditions, ASS does not pose a significant risk to the environment, but when ASS are disturbed there is potential for iron sulfides in the soils to react with oxygen and produce sulfuric acid (DER 2015a). This can acidify the landscape and result in mobilisation of contaminants (commonly iron, aluminium and other metals) that can be transported to waterways, wetlands and groundwater.

Excavation and dewatering of ASS will not be required throughout most of the Footprint because the Proposal has been designed predominantly at or above grade and excavations will remain above the ASS.

Where disturbance of ASS is unavoidable the risk of direct impacts is considered low because net acidity of soils within the Development Envelope is generally below or only marginally above DWER ASS criteria of 0.03 %S (71% of samples had a net acidity at or below 0.05 %S) (Coffey 2020a) and only small volumes of ASS is likely to be disturbed. Total volumes of ASS requiring disturbance will be determined upon completion of the detailed design. However, based on the Concept Design the inferred disturbance of ASS is estimated to be 25,000 m^3 and is considered manageable with the implementation of standard ASS management practices in accordance with DWER guidelines (DER, 2015b).

An ASS Management Plan (ASSMP) will be prepared and implemented in accordance with DWER ASS guidelines (DER 2015a and 2015b) to ensure impacts from ASS disturbance are avoided. A framework for ASS management considerations to be included in the ASSMP is provided in the ASSMS for the Proposal (Appendix W). Key management strategies to be implemented include minimising disturbance of ASS, stockpile management protocols, and treatment of excavated ASS to neutralise acidity. Specific management requirements will be informed by the detailed design and defined in a detailed ASS Management Plan.

The preliminary ASS investigation did not determine potential for ASS below 9 mbgl. However, there are only a few locations within the Development Envelope where there is the potential to excavate below 9 mbgl at the base of the deepest excavations required for:

- The dive structure at Tonkin Highway.
- At train stations (for lift pits, services, pile caps etc.).
- Footings and abutments of major structures.
- Bridges required to cross Bennett Brook and Gnangara Road.

The final depths of these excavations will be determined as part of detailed designs to be completed by the PTA's Construction Contractor. The maximum depth of excavation is expected to take place at the Tonkin Highway dive structure, where the maximum depth of excavation is expected to be approximately 9 mbgl. The other deep excavations listed above are expected to be much shallower. For example, the Gnangara Road underpass is expected to have a maximum depth of approximately 4 mbgl. The maximum depth of groundwater drawdown is expected to be an additional 1 m below this.

Given that ASS identified by Coffey were limited to coffee rock at shallow depths from 1.0 to 2.8 mbgl and deeper soil profiles generally did not contain ASS, the risk of disturbance to ASS in deeper soils is expected to be low. If excavation is required below 9 mbgl then additional ASS investigations will be conducted to inform ASS management at these depths. If this cannot be practicably achieved, then as a precaution soils associated with coffee rock encountered at these depths will be managed as ASS.

Given the risk of direct impacts is low, it is unlikely that the proposed excavation of ASS would result in indirect impacts to other environmental values. However, if ASS disturbance did cause significant contamination of soil and groundwater then local vegetation communities could also be impacted. This may result in the loss of biodiversity. GDEs would be the most prone to impacts because these communities are reliant on local groundwater quality. Potential GDEs that may be impacted within the Development Envelope comprise mostly of wetlands that may be dependent on groundwater and Banksia woodlands that may intercept the shallow water table.

There are several of these adjacent to the deeper excavations proposed, including:

- REW UFI 15752 palusplain adjacent to Malaga Station and the Bennett Brook bridge.
- REW UFI 15757 adjacent to the Tonkin Highway dive structure.
- CCW UFI 15259, the Bennett Brook floodplain located adjacent to the proposed bridge.
- CCW UFI 8728 adjacent to the proposed bridge crossing Bennett Brook.
- REW UFI 8806 palusplain adjacent to Whiteman Park Station.
- REW UFI 8678 sumpland adjacent to Whiteman Park Station.
- Banksia Woodlands TEC adjacent to Malaga Station.
- Banksia Woodlands TEC adjacent to the intersection of Gnangara Drive and Drumpellier Drive.

If excavation of ASS causes significant groundwater contamination, there is also the potential for groundwater users downgradient of the Development Envelope to be impacted. It is expected that potential impacts to groundwater users will be avoided through the implementation of the ASS mitigation measures outlined above, which will prevent significant changes to water quality (e.g. treatment of PASS prior to reuse). Additional mitigations will also be implemented to prevent impacts to groundwater quality caused by dewatering ASS. These are discussed in Section 7.6.6.

The potential for cumulative impacts from ASS disturbance for this Proposal have also been considered. Most of the Development Envelope is undeveloped and it is therefore unlikely that significant oxidation of ASS has occurred as a result of urban land use. ASS management to be implemented during the Proposal is considered adequate to prevent significant changes to groundwater and soil quality caused by excavation of ASS. Consequently, the Proposal is considered unlikely to exacerbate deterioration of water quality in the underlying groundwater aquifer or cause changes to soil quality that would affect future land use.

ASS are commonly disturbed as a result of civil construction on the Swan Coastal Plain, which do not typically result in significant impacts to the environment when ASS are managed in accordance with DWER ASS guidelines (DER, 2015b). This Proposal will manage potential disturbance of ASS in accordance with DWER guidance using the key mitigation measures referenced above and a project specific ASSMP. Consequently, it is unlikely that the proposed ASS disturbance would result in significant impacts to the quality of soils or land.

7.6.2. Soil disturbance at contaminated sites

Known and suspected contaminated sites within the Development Envelope were identified during the PSI conducted for the Proposal by Coffey (2020b). Results of the PSI indicated there are no instances of soil contamination known to exist within the Development Envelope. Potential soil contamination is limited to a 2.7 ha area (0.5% of the Development Envelope) at the Swan Valley Egg Farm (Sites 9786 and 9262), unidentified areas throughout the Development Envelope where uncontrolled fill may have been used in construction of existing road infrastructure, or where fly tipping may have taken place (Coffey, 2020b). Given the limited amount of soil contamination present, it is considered unlikely that the Proposal would result in direct impacts to soil quality or land use as caused by disturbance of in situ contaminants.

The nearest confirmed instance of soil contamination is located at the former Lexia Landfill site. A small portion of this site is located within the Development Envelope, near the intersection of Gnangara Road and Drumpellier Drive. The extent of soil contamination at the former Lexia Landfill is restricted to the footprint of former grease traps, sludge drying beds, basins and oxygenation lagoons located approximately 500 m northwest of the Development Envelope boundary (Figure 27). The risk of accidental disturbance of contaminated soil at the former Lexia Landfill site is considered low because these soils are located away from major access routes to the Development Envelope and there is an adequate (500 m) separation distance from proposed earthworks.

Other sources of potentially contaminated soils that may be used for the Proposal include fill materials that will be imported for use in construction. To prevent contamination from imported materials, all fill materials used for the Proposal will be verified as suitable for specified construction purposes. Disturbance of uncontrolled fill or other unidentified contaminated soils already in situ will be managed using an Unexpected Finds Procedure that will be used to identify, risk assess and manage potentially contaminated soils. With the implementation of these mitigation measures the risk of contamination from uncontrolled fill is considered low.

In the unlikely event that earthworks cause significant impacts to soil and water quality, GDEs could also be impacted if contaminants are spread by earthmoving, seepage or runoff. Construction activities at the Swan Valley Egg Farm presents the highest risk of disturbing unidentified soil contamination. The Swan Valley Egg Farm lies within MUW palusplain UFI 15511. If during works in this area, potentially contaminated soils are allowed to be discharged in runoff, then contamination may be mobilised west towards Bennett Brook. Contaminants introduced to Bennett Brook could then affect the associated wetlands that include the Bennett Brook CCW floodplain UFI 15259, CCW palusplain UFI 8728 and REW palusplain UFI 15752.

The risk of impacts to these sensitive receptors is considered to be low as runoff will be managed in accordance with relevant DWER guidelines that will ensure stormwater is managed appropriately. Where sedimentation is excessive, controls will be implemented to manage sediment and solute loads before being released.

Potential direct and indirect impacts associated with the movement of contaminated soil are considered preventable using the proposed construction methods. The primary controls for achieving this will be early identification of soil contamination using an Unexpected Finds Protocol and prevention of the spread of contamination through strict stockpile management measures, which include limiting height of stockpiles and containment of contaminated stockpile runoff.

7.6.3. Contamination from stockpiling activities

Inappropriate stockpiling and handling of materials during construction could directly impact the quality of soil, surface water and groundwater within the Development Envelope and adjacent land by causing contamination from:

- Mobilisation of contaminants from direct contact with contaminated soils that are disturbed and transported during construction.
- Mobilisation of sediments in fugitive dust and runoff that can cause sedimentation of water sources and mobilise contaminants in soils.
- Mobilisation of contaminants in leachate from stockpiles transported by runoff and seepage.

Potential contamination can indirectly impact the environment as a result of contaminated soils being transported off site due to inadequately controlled runoff or groundwater infiltration.

The PTA considers the stockpile management practices that will be implemented for the Proposal will be adequate to prevent significant direct and indirect impacts. These practices will include, where practicable:

- segregating stockpiles of known or suspected contaminated soils (including potential ASS)
- collection of leachate from potentially contaminated stockpiles
- bunding and covering stockpiles of contaminated materials during excessive rainfall
- stockpiling potentially acid generating materials such as excavated PASS on a limestone pad
- treating PASS stockpiles with neutralising materials in a timely manner.

Details of where stormwater runoff will accumulate and how it will be discharged will be identified during the Proposal's detailed design phase. Stormwater within the Footprint will be intercepted to manage sediment and solute loads before being released outside the Footprint in accordance with relevant DWER guidelines.

Once stockpiling and storage of contaminated spoil is complete, the stockpiling area will be appropriately decommissioned. Decommissioning of the stockpiling area will include the remediation and validation of the ground surface (as required) and be in accordance with the applicable regulations and guidelines. Given that no contaminated soils are known to occur within the Footprint, it is unlikely that remediation of the ground surface will be required. If remediation is required, appropriate methods will be applied, commensurate with achieving final land use outcomes.

Potential contamination from stockpiling activities is considered unlikely because proposed mitigation measures will contain potentially contaminated materials and eliminate pathways for transporting potential contaminants to sensitive environmental receptors.

7.6.4. Release of waste products

The Proposal is expected to generate a variety of waste streams that could result in contamination of soils if not managed and disposed of in a controlled manner. Waste streams to be generated by the Proposal are expected to include:

- Inert waste – packaging and construction materials such as scrap metal, timber and concrete. These materials are typically benign. This waste stream is expected to be limited to construction activities.
- Domestic and putrescible waste – small volumes of domestic and putrescible waste (small quantities of food scraps) will be generated. During construction this will be produced by construction workers and will mostly be generated at the site office and crib huts. Domestic waste will continue to be produced in minor volumes during operations within stations and associated infrastructure. This will primarily be produced by public transport users and from the PTA's operating workforce.
- Sewage – during construction, small volumes of sewage will be generated by the workforce and contained within mobile ablutions (e.g. portaloos) in the Development Envelope. For rail operations, permanent ablutions will be established at stations to dispose of sewage produced by public transport users and PTA workers.
- Hazardous materials and dangerous goods – small quantities of paints, waste oils and lubricants may be generated by the operation and maintenance of equipment, vehicles and machinery. This will continue during operations, but in lower volumes.

Small volumes of waste will be generated during construction throughout the entire Development Envelope. This waste will be collected and secured at source, and then be transported to a centralised location, where it will be segregated if not already and stored prior to collection. Waste streams will generally be benign and produced in small volumes, consequently the risk of waste products entering the environment and causing significant soil contamination is low. However, there is potential for soil and water quality to be directly impacted if wastes are released to the environment via uncontrolled discharges. This may also cause indirect impacts to other environmental factors, resulting in loss of biodiversity in GDEs and wetlands. However, the waste management measures proposed are considered adequate for preventing a significant release to the environment because they require all waste to be contained and disposed of in a controlled manner.

Other materials that will be released to the environment in large volumes include imported fill materials. The quality of these materials will also be verified prior to use to ensure they are suitable for the proposed use. This is considered an appropriate measure to prevent the risk of contamination to the environment.

All other wastes generated by the Proposal will be produced in small volumes and any potential release to the environment is likely to be localised and not significant.

Waste streams associated with the Proposal are consistent with typical construction activities and the management and disposal for all wastes will be strictly controlled, with most waste streams being collected for disposal and transferred to offsite licensed landfill facilities. Consequently, it is unlikely that waste generated for the Proposal will result in significant direct or indirect impacts to the environment.

7.6.5. Chemical spills and leaks

Inappropriate storage of chemicals associated with construction activities can lead to accidental leaks and spills, which may contaminate soil, land and water, adversely impacting the value of soils, and soils important for maintaining drinking water quality. Accidental discharge of chemicals can also contaminate surface water and groundwater resources if contaminants directly flow into surface waters or are transported via runoff or infiltrate into groundwater (seepage) Most of the chemicals required for the Proposal will be stored and handled in low volumes and therefore significant impacts from accidental spills and leaks are considered unlikely. However, given the Development Envelope includes Public Drinking Water Source Areas (PDWSA) (e.g. is located within a PDWSA and the Gnangara Underground Water Pollution Control Area (UWPCA) the potential for accidental chemical discharge into the environment will need to be well managed. Accidental chemical discharges may also impact sensitive ecological receptors such as GDEs and TECs and all chemical discharges will be contained and managed appropriately.

Impacts to the environment will be mitigated by storing larger volumes of chemicals such as fuels away from PDWSAs and managing all chemical discharges using a Spill Response Framework and Procedure, which ensures spills are prevented, contained and remediated in a timely manner. Controls for managing potential spills and leaks focus on prevention of spills by minimising volumes of chemicals stored on site and maintaining chemical storage in accordance with AS1940. Storage methods will include separation, segregation and secondary containment. Hazardous materials and other chemicals required for the Proposal are likely to include oils, lubricants, degreasers, paints and substances needed for the maintenance and operation of equipment. Bulk storage of hydrocarbons (e.g. fuels) may also be required. Chemicals will be stored in bunded, self-contained storage areas located away from areas of known environmental values including wetlands, GDEs and TECs . Hydrocarbons including fuels will be stored in accordance with Australian Standard 1940 (AS:1940). No bulk storage of fuel will occur within the PDWSA.

Most chemicals on site will be stored in small quantities and the largest likely spill or leak is expected to be minor (i.e. typically less than 50 L) because most chemicals will be stored in drums of this volume. The exception to this is fuel storage, which is expected to require a 50,000 L fuel tank. Fuel will be bunded and stored in a centralised location away from PDSWAs and areas of known environmental values. Where required, a refuelling trailer or service vehicles will be used to refuel vehicles and machinery within designated areas within the Development Envelope. The refuelling trailer will be operated in accordance with AS1940 to make sure chemicals are adequately contained. Where practicable, re-fuelling will take place at the centralised fuel tank. However, in some instances mobile refuelling may be required. When this is required additional controls will be implemented such as the use of drip trays to capture incidental spills during fuel transfer. Where practicable, re-fuelling within PDSWAs will be avoided. Potential contamination caused by spills and leaks or other releases of contaminants would be localised and temporary, and the mitigation measures will ensure all sources of contamination will be contained and accidental discharges are remediated in a timely manner. Consequently, contamination from accidental release to the environment is not considered a significant risk to the environment.

Based on the small volumes of chemicals being used and the management methods to be implemented, the likelihood of indirect impacts to environmental values is considered low. However, if a major spill did occur (e.g. large spill during refilling the bulk fuel storage tank) then there is potential for impacts to other environmental factors such as loss of biodiversity in wetlands and other potential GDEs. To mitigate this risk, bulk fuel storage will be bunded and limited to a centralised construction area away from PDWSAs and areas of known environmental values.

The PTA considers the potential release of contaminants into the environment can be minimised by adhering to the PTA Spill Response Framework and Procedure, which ensures spills are prevented, contained and remediated in a timely manner. Hazardous materials and other chemical use required for the Proposal is consistent with typical construction activities and the proposed uses during construction and operations are not considered likely to result in significant impacts to the quality of soils or land. With implementation of the proposed mitigation, the maximum plausible spill or leak would be small (typically less than 50 L) and is unlikely to result in significant environmental harm. Consequently, it is unlikely that the Proposal will result in significant direct or indirect impacts to the environment as a result of uncontrolled discharges.

7.6.6. Dewatering impacts to ASS

Groundwater drawdown required for construction can directly impact the environment by causing oxidation of ASS, resulting in contamination of soil and groundwater. Where ground or surface water dependant ecosystems, such as wetlands occur, changes to soil and water quality can result in loss of biodiversity. Most of the proposed construction works have been designed at or above grade to avoid disturbance of ASS.

Temporary water abstraction will be required from construction sites that extend below groundwater level. Based on preliminary designs, temporary dewatering may be required at the following sites:

- At all train stations during the construction of deep infrastructure e.g. lift pits, underground services and pile caps.
- At the dive structure proposed to pass under the Tonkin Highway west of the proposed Malaga Station.
- During installation of foundations for major structures such as bridges and abutments at Beechboro Road, Bennett Brook, Whiteman Park and Gnangara Road.
- During the installation and/or relocation of underground services.

The actual dewatering rates and volumes required for dewatering will be determined once the design and construction methods have been finalised. Golder (2020a) estimated that dewatering will be required for between 6 and 12 months at the Tonkin Highway dive structure, for about one month at bridges, and intermittently over a couple of months for the railway stations.

It is unlikely that localised groundwater abstraction at water supply bores will result in oxidation of a significant volume of ASS because ASS within the Development Envelope are located at depths below this drawdown radius (in coffee rock at 1.0 to 2.1 mbgl). Based on the analysis conducted by Golder (2020a), drawdown-related impacts from water supply abstraction can be managed by carefully locating and operating bores within the Development Envelope while monitoring drawdowns nearby to ensure the expected outcomes are achieved. The water table is expected to recover shortly after abstraction ceases and/or after one wet season of recharge. Consequently, potential groundwater drawdown for water supply is considered unlikely to result in significant oxidation of ASS and is not expected to cause contamination of soils or groundwater.

A conceptual model illustrating the dewatering and reinjection processes for the Tonkin Highway dive structure is shown on Figure 46. This model illustrates several important dewatering related features:

- Dewatering will need to occur within the structure and extend at least one metre below the floor to provide safe and dry working conditions. This could be achieved using dewatering bores and/or sumps.
- The walls required to stabilise the dive structure during construction may or may not intersect clayey deposits of the Guildford Formation because it is discontinuous across the site. If not, groundwater in the Bassendean Sand will flow into the base of the excavation. If the walls do intersect Guildford Formation, inflow rates are expected to be smaller.
- Once pumped from the structure, groundwater will be returned to the Bassendean Sand to balance out the drawdown from dewatering. This could be achieved using re-injection bores and/or sumps.
- Groundwater in the Gnangara Sand and Ascot Formation may flow upwards to the dewatered structure at a rate that is dependent on the presence of and hydraulic properties of the Guildford Formation.

Using the mitigations identified above, the PTA is confident that dewatering can be successfully managed such that the extent of drawdown is adequately managed to ensure no project attributable impacts to sensitive receptors within or outside the Development Envelope, including potential GDEs such as wetlands and TECs. Once dewatering ceases, it is expected the water table will fully recover within one wet season of recharge given the net take of groundwater will have been small.

As mentioned in Section 7.6.1 inferred disturbance of ASS for the Proposal is estimated to be 25,000 m^3. Since any dewatering of ASS will be localised and generally confined to the immediate vicinity of deep excavations, it is considered unlikely that a significant amount of ASS will be oxidised. Given that most of the soils within the Development Envelope have a net acidity that is below or marginally above the DWER ASS criteria, unavoidable ASS disturbance is expected to be manageable through implementation of the ASS guidelines (DER, 2015b) and is not likely to cause a significant amount of acidification or leaching of contaminants. The Proposal is therefore not expected to cause significant contamination of soils or water.

Potential impacts from discharge of dewatering effluent have also been considered. Groundwater within the region has been historically acidified by water table declines that have resulted in the oxidation of ASS (Shand et al. 2018). This was supported by groundwater sampling and analysis conducted by Coffey (2020a) that indicated groundwater beneath the Development Envelope contains concentrations of total titratable acidity (TTA) at 50 – 210 mg/L, which exceeds the DWER ASS criteria for TTA of 40 mg/L. It is therefore possible that discharge of acidic dewatering effluent could acidify surface soil and cause localised contamination if not managed appropriately.

Waste materials and dewatering effluent will only be released to the environment if an assessment has been undertaken which confirms that the release will not pose an unacceptable risk to human health or the environment. For dewatering effluent this assessment will include consideration of DWER ASS criteria.

- Management strategies proposed to manage potential impacts from dewatering ASS are outlined in the ASSMS. The key mitigation will be to minimise dewatering and groundwater drawdown where practicable. Where dewatering is unavoidable, dewatering effluent will be managed in accordance with DWER ASS guidelines, where required dewatering effluent will be treated to manage potential acidity (DER, 2015b). Dewatering of ASS is considered manageable through the implementation of regulatory guidelines and the implementation of an ASSMP. Given that the proposed dewatering is unlikely to result in significant contamination from ASS disturbance, the PTA considers the Proposal unlikely to indirectly impact other environmental factors. However, it is recognised that if dewatering of ASS does cause contamination then there is potential for indirect impacts to vegetation, flora and fauna, including loss of biodiversity in GDEs including wetlands. In the unlikely event of ASS contamination, there are several potential GDEs near the proposed dewatering areas that could be indirectly impacted.

Potential impacts to these sensitive ecological receptors will be managed through implementation of the ASSMP and management measures for groundwater drawdown administered in the TECMP (Appendix X), which include minimising groundwater drawdown, recharge such as through infiltration basins, trenches and/ or reinjection wells within the Development Envelope, and re-use of excess abstracted dewater where practicable.

The potential for cumulative impacts from dewatering ASS has been considered in the design of the Proposal, and in the management and mitigation measures described in the ASSMS. Most of the Development Envelope is not yet developed and it is unlikely that significant oxidation of ASS has occurred as a result of urban land use. However, regionally there has been some acidification of groundwater, which has been attributed to oxidation of ASS caused by a declining water table. The ASS management that will be implemented during the Proposal is considered adequate to prevent significant environmental impacts from disturbance of ASS. Consequently, the Proposal is considered unlikely to significantly contribute to impacts from oxidation of ASS.

Proposed dewatering of ASS is considered to have a low risk of causing direct and indirect impacts to the soil quality due to the low net acidity of soils present and the small volume of ASS that will require dewatering. With the implementation of the proposed management measures, dewatering will avoid most ASS in the Development Envelope. The ASS that is dewatered will be excavated and treated to neutralise acidity. Consequently, the PTA considers it unlikely that the proposed dewatering of ASS would cause significant direct or indirect impacts to the quality of land or soil within the Development Envelope or adjacent land.

7.6.7. Contamination from groundwater drawdown

Potential interactions with existing groundwater contamination have been considered in hydrogeological investigations commissioned for the Proposal by the PTA, which determined that with implementation of conventional management measures, groundwater drawdown can avoid spreading existing contamination and prevent drawing contaminated groundwater further into the Development Envelope (Golder, 2020a and 2020b).

Groundwater contamination within the Development Envelope is understood to be limited to one site on the western margin of the Development Envelope at the former Lexia Landfill site (Figure 27) (Coffey, 2020b). Contamination at the former Lexia Landfill site was previously investigated by Golder (2015a 2015b and 2016), who reported a groundwater contamination plume that starts at former landfill infrastructure about 500 m west of the Development Envelope and extends in a south-east direction along the western margin of the Development Envelope (Golder 2016) (Figure 27). This contamination plume is believed to enter the Development Envelope near the intersection of Gnangara Road and Drumpellier Drive.

Construction works proposed near the groundwater contamination plume will involve earthworks and dewatering to construct a new road bridge and underpass at the Gnangara Road and Drumpellier Drive intersection. The PTA commissioned Golder (2020b) to do further investigations to determine whether the proposed dewatering is likely to spread the existing contamination, such as drawing the plume further into the Development Envelope. Golder (2020b) considered two scenarios:

1. Dewatering without any return of the abstracted groundwater i.e. a ‘do-nothing’ scenario.
2. The abstracted groundwater is actively managed e.g. infiltration or reinjection to reduce extent of groundwater level drawdown.

Results of analysis conducted by Golder (2020b) show the dewatering can be conducted without impacting the existing groundwater contamination (Figure 47). In the ‘do-nothing’ scenario, drawdown is predicted to reach 1 m at the underpass and extend radially outwards by approximately 190 to 280 m. If all the abstracted groundwater is actively managed on the western side of the structure, the size of the drawdown cone would be significantly reduced. Drawdown of up to 0.25 m is predicted to extend radially from a range between 30 m and 60 m from dewatered sites.

There is a potential contaminated site (Site ID 5435) located outside the Development Envelope about one kilometre south-east of the dive structure at Tonkin Highway (Figure 27). It is unknown whether groundwater contamination exists at Site 5435. Golder also investigated groundwater drawdown in this part of the Development Envelope. Simulations conducted by Golder (2020a) show that for the ‘do-nothing’’ scenario, drawdown is predicted to reach 4 m at the dive structure and extend radially outwards by approximately 1.3 km (Figure 46). Similarly, to the Gnangara Road underpass, with active management such as through groundwater recharge, the size of the drawdown would be significantly reduced. Consequently, even though the status of groundwater contamination at Site 5435 is unknown, with active groundwater drawdown management the Proposal is unlikely to affect groundwater at this site and is not expected to result in the spread of potential contamination present.

The predictive results show that natural groundwater flows can be retained where the aquifer is contaminated at Gnangara Road, and the Proposal is unlikely to draw contaminated groundwater further into the Development Envelope. Golder (2020b) concluded that management measures can be put in place to undertake construction dewatering within all areas of the Development Envelope. The proposed management approach to reduce off-site depth and extent of groundwater drawdown would include:

- Minimising the duration of dewatering.
- Use of construction methods and engineering design that will minimise impact to sensitive environmental receptors within and outside the Development Envelope. Specific construction methods will be determined in the detailed railway design.
- Infiltrate or recharge as much abstracted groundwater as possible back into the aquifer to reduce net groundwater abstraction. The use of infiltration basins/trenches and recharge wells are used throughout the Perth metropolitan area.
- Management of dewatering using a Proposal specific DMP. Management measures proposed for dewatering are also outlined in the TECMP (Appendix X).

Similar dewatering and groundwater reinjection methods have been successfully implemented on recent projects delivered by the PTA such as the Thornlie-Cockburn Link and Forrestfield Airport Link.

Based on the above results, the PTA is confident that the Proposal is unlikely to spread existing groundwater contamination and considers this management approach can successfully manage other potential impacts such as dewatering of ASS at other dewatering sites.

Golder (2020b) indicated that groundwater abstraction near the former Lexia Landfill site would be manageable using the management protocols for groundwater abstraction described above and in accordance with regulatory guidelines. Dewatering design and other management strategies can be implemented to minimise the risk of abstraction and spread of groundwater contamination. These Management measures are further detailed in the TECMP (Appendix X) and CEMP (Appendix U) and include minimising groundwater drawdown through established construction methods based on the dewatering requirements (i.e. depth and duration), groundwater recharge using abstracted groundwater and re-use of excess dewater effluent where practicable.

Given that groundwater abstraction for the Proposal will be managed to avoid abstraction of contaminated groundwater at the former Lexia Landfill facility and minimise changes to natural groundwater flow, it is unlikely that the Proposal would result in significant changes to soil quality or land use.

7.6.8. Rail maintenance and operation

Rail operations and maintenance activities have the potential to cause localised release of small volumes of chemicals to the environment caused by:

- Metals contamination from railcar breaking mechanisms and grinding for railway track maintenance that may result in contamination of soils.
- Leaks and spills from hydrocarbons and other chemicals such as oil leaks from transformers, hydraulic fluid and lubricating oils.
- Accumulation of low concentrations of contaminants such as sediments, hydrocarbons and metals, from use of hardstand infrastructure such as roads and carparks at train stations.
- Application or spills of herbicides during weed control activities resulting in contamination.
- Use of firefighting equipment/chemicals for electrical fires resulting in contamination of soils.

None of these contamination sources are likely to occur in volumes sufficient to cause significant impacts to soil quality. Ongoing release of contaminants such as metals from railcar operations will be minimised through regular maintenance of equipment and infrastructure in accordance with the manufacturer's specifications. Spills and leaks will be managed through the implementation of a spill response procedure that will ensure all spills are contained and remediated in a timely manner.

Operation of station facilities will generate a variety of waste streams that could potentially cause soil contamination if disposed in an uncontrolled manner resulting in release to the environment. Potential waste streams during rail operations include sewage and grey water from permanent ablutions installed at train stations, and domestic and putrescible waste generated by public transport users and workers. These facilities will be connected to the Water Corporation sewer and therefore uncontrolled release of sewage to the environment is not considered a likely risk. Station facilities will also include dedicated bins for disposal of domestic waste produced by public transport users and PTA workers. It is therefore considered unlikely that waste disposal would result in contamination of land.

After the implementation of proposed mitigation measures, potential discharges of contaminants into the environment as a result of rail operations are expected to be minor and not sufficient to cause significant contamination. If contamination did occur, it would be localised to the rail corridor. Given the nature and scale of potential contamination, it is unlikely that significant indirect impacts to the environment would occur.

Potential impacts from the operation of the railway are likely to be limited to releases of small volumes of contaminants, minor and accidental spills and leaks that are unlikely to be sufficient to cause contamination. With implementation of the proposed mitigation measures it is unlikely that any of these potential sources of contamination would result in significant harm to the environment.

7.7. Mitigation

Table 51 demonstrates how the PTA has applied the EPA's mitigation hierarchy of avoid, minimise and rehabilitate during Proposal design to address key potential impacts to Terrestrial Environmental Quality. These mitigation measures have also been incorporated into the CEMP (Appendix U), TECMP (Appendix X) and ASSMS (Appendix W) where appropriate.

Table 51: Summary of Environmental Impacts and mitigation hierarchy for terrestrial environmental quality

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Contamination of soil from excavation of ASS.	Potential for disturbance of ASS during construction is not considered likely to cause significant acidification of soil due to the application of the proposed mitigation measures that include the implementation of an ASSMP prepared in accordance with DWER ASS guidelines (DER, 2015a and 2015b).	*Avoid* • The railway has been designed to minimise the locations and extent of dewatering required during construction. *Minimise* • Where practicable, additional ASS investigations will be conducted to identify ASS that need to be managed in excavations deeper than 9 mbgl. If this cannot be practicably achieved, then as a precaution, soils associated with coffee rock encountered at these depths will be managed as ASS. • An ASSMP will be prepared by the PTA. The ASSMP will comply with DWER guidelines for management of ASS (DER 2015b). • The PTA will minimise impacts from storing or releasing dewatering effluent and a Dewatering Management Plan will be prepared for dewatering and abstraction licensing. *Rehabilitate* • If contamination attributable to ASS disturbance is detected, remediation will be in accordance with the ASSMP. • Upon completion of works, any treatment pad areas and dewatering ponds will be appropriately decommissioned, comprising validation, and if required remediation, of the ground surface where the infrastructure was located.
Disturbance of known or suspected contaminated sites resulting in contamination of soils.	Potential for disturbance of contaminated soils within known or suspected contaminated sites is considered unlikely because there are no known instances of soil contamination within the Development Envelope and the proposed mitigation measures allow for identification, risk assessment and management of unidentified soil contamination during construction.	*Avoid* • The Proposal was designed to avoid existing soil contamination, which was identified in the PSI. • Fill will be verified as suitable for the intended use. Imported fill will be managed using a material tracking system. *Minimise* • A PSI has been conducted to identify potential contamination within the Development Envelope.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
		• Detailed Site Investigations (DSI) will be conducted within the Development Envelope to identify excavation sites that have the potential to intersect any contaminated (or suspected contaminated) soils or groundwater. • An Unexpected Finds Protocol will be implemented to provide a process for managing potential contaminated soil encountered during construction that were not previously identified. • Potentially contaminated material will be tested and if unable to be reused or remediated for reuse will be disposed of at an appropriately licenced facility. • Material of unknown contamination status that is awaiting sampling will be bunded and kept separate from other material until the material has been sampled and classified. • Appropriate management of excavated soil in accordance with the CEMP, such as limiting height of stockpiles, bunding of limestone pads and installation of leachate collection systems to contain potentially contaminated stockpile runoff. • Maintain appropriate soil moisture content to reduce dust emissions (particularly during handling). *Rehabilitate* • Upon completion of works, any stockpile or treatment pad areas will be appropriately decommissioned, comprising validation, and if required remediation of the ground surface where the treatment pad and associated infrastructure was located.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Contamination from stockpiling activities.	Potential contamination from stockpiling activities is considered unlikely because proposed mitigation measures will contain potentially contaminated materials and eliminate pathways for transporting potential contaminants to sensitive environmental receptors.	*Minimise* • Material of unknown contamination status that is awaiting sampling will be bunded and kept separate from other material until it has been sampled and classified. • Appropriate management of excavated soil in accordance with the CEMP, such as limiting height of stockpiles, bunding of limestone pads and installation of leachate collection systems to contain potentially contaminated stockpile runoff. • Segregate clean and contaminated excavated soil (where practicable). • Maintain a register of stockpile locations, the origin, relevant sample locations and results and transport details for offsite disposal. • Restrict the maximum height of a stockpile to be generally less than 3 metres and/or lower than the boundary fence. • Sampling of material to be conducted in accordance with relevant guidelines and classification to be derived from appropriate assessment criteria for reuse potential. • Maintain appropriate soil moisture content to reduce dust emissions (particularly during handing). *Rehabilitate* • Upon completion of works, any stockpile or treatment pad areas will be appropriately decommissioned, comprising validation, and if required remediation of the ground surface where the treatment pad and associated infrastructure was located.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Contamination of soils from the release of waste products (including dewatering effluent).	Waste streams associated with the Proposal are consistent with typical construction activities and the management and disposal for all wastes will be strictly controlled, with most waste streams being collected for disposal at licensed landfill facilities offsite. Consequently, it is unlikely that the Proposal will result in significant direct or indirect impacts to the environment.	*Avoid* • Avoid importation and use of contaminated fill during the Proposal. If material is to be imported, it is to be verified as suitable for the intended use. *Minimise* • Wastes will be appropriately contained (with bins, skips, etc.) and segregated for collection by waste contractors licensed for the classes of waste. • Putrescible wastes will be contained in bins with secure lids so that animals are not encouraged to forage. • Contaminated or hazardous wastes will be kept in secondary containment. • Unexpected Finds Protocol requires daily visual monitoring during construction to ensure any potential source of contamination is identified and managed. • The management of wastes will be tracked through implementation of a waste register including waste locations, origin and transport details for offsite disposal. • The Unexpected Finds Protocol detailed in the CEMP will be implemented to manage any pre-existing waste (i.e. uncontrolled wastes / fly tipping) encountered during construction. • Minimise potential for contamination of land and water from release of acidic dewatering effluent by testing and treatment of dewatering effluent to ensure it meets DWER ASS criteria prior to being released to the environment. Potential acidity in dewatering effluent will be managed in accordance with an ASSMP. *Rehabilitate:* • Upon completion of construction, wastes generated by the Proposal will be appropriately removed or disposed of, and if required remediation of the ground surface will be implemented as required.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Contamination of soils from fuel and chemical storage leaks.	With implementation of the proposed mitigation measures, the maximum plausible spill or leak would be small (typically less than 50 L) and is unlikely to result in significant impacts to the environment.	*Avoid* • Where practicable the Proposal has been designed to avoid disturbance of known or potentially contaminated sites. *Minimise* • Chemicals will be stored in bunded, self contained storage areas for tools, chemicals and equipment. • Hydrocarbons such as fuels will be stored in accordance with Australian Standard AS 1940. • Weekly inspections of hazardous materials storage, handling and disposal to assess compliance • Inspect spill containment compounds for presence of spills or contaminated rainwater, as soon as practicable after any significant rainfall event and following tank refuelling • There will be no bulk storage of fuel within Priority 1 PDWSAs. • Chemical storage areas will be bunded to ensure that pollutants are not washed into adjacent areas during rainfall events. *Rehabilitate* • Uncontrolled release of chemicals (accidental leaks or spills) will be attended to immediately via the use of an onsite spill response protocol. Any contaminated soil will be contained, and appropriately remediated or disposed. • Upon completion of construction, wastes generated by the Proposal will be appropriately removed or disposed of, and if required remediation of the ground surface will be implemented as required.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Localised and temporary dewatering of ASS resulting in contamination	Due to the low net acidity of soils present and the small volume of ASS that will require dewatering, and with the implementation of mitigation measures, it is unlikely that proposed dewatering of ASS would result in significant acidification or contamination of soils or groundwater.	*Avoid* • The Proposal is designed to avoid dewatering where practicable. • Where practicable, additional ASS investigations will be conducted to identify ASS that need to be managed where dewatering is needed deeper than 9 mbgl. *Minimise* • An ASS Management Plan ASSMP will be implemented by the PTA. The ASSMP will comply with DWER guidelines for management of ASS (DER 2015b). • Management of dewatering and groundwater abstraction will be in accordance with the TECMP and ASSMP and include minimisation of dewatering and management of groundwater drawdown through recharge and reuse of abstracted groundwater.
Drawing in of contaminated groundwater.	Contaminated groundwater within the Development Envelope is limited to a plume of groundwater contamination from the former Lexia Landfill site on the western margin of the Development Envelope. Given that groundwater abstraction for the Proposal will be designed to avoid abstraction of contaminated groundwater at the former Lexia Landfill site and will minimise changes to natural groundwater flow, it is unlikely that the Proposal would draw contaminated groundwater into the Development Envelope.	*Avoid* • The Proposal is designed to avoid dewatering where practicable. • Dewatering to be managed in accordance with TECMP. Drawdown will be actively managed as required at the dive structure in Malaga and Gnangara Road underpass to avoid interactions with contaminated and potentially contaminated groundwater. *Minimise* • Minimisation of dewatering and management of groundwater drawdown through recharge and reuse of abstracted groundwater.

Potential Impact	Assessment of Impacts	Mitigation Hierarchy
Contamination from rail operations and maintenance	Potential impacts from the operation of the railway are likely to be limited to releases of small volumes of contaminants, minor and accidental spills and leaks that are unlikely to be of sufficient volume to cause contamination. With implementation of the proposed mitigation measures it is unlikely that any of these potential sources of contamination would result in significant harm to the environment.	*Avoid* • Wastes will be appropriately contained (with bins, skips, etc.) and segregated for collection by waste contractors licensed for the specified classes of waste. • Avoid importation and use of contaminated material. If material is to be imported, it is to be verified as suitable for the intended use. Imported fill will be managed using a material tracking system. • Permanent ablutions to be connected to the Water Corporation sewer to avoid accidental sewage discharges to the environment. *Minimise* • Maintenance activities with potential to cause contamination such as weed spraying will be minimised as much as practicable. • Hazardous materials will be stored and handled in accordance with Australian Standard 1940. • Infrastructure and equipment will be maintained to manufacturer's specifications. *Rehabilitate* • Uncontrolled release of chemicals (accidental leaks or spills) will be attended to immediately via the use of an onsite spill response procedure. Any contaminated soil will be contained and appropriately remediated or disposed. • Rail infrastructure will be regularly inspected. Any evidence of potential contamination will be reported to DWER and remediated.

7.8. Residual impacts

7.8.1. Residual impacts

With the implementation of the mitigation measures outlined in Section 7.7, the PTA is confident that all direct and indirect construction and operational related impacts can be managed so that adverse impacts on terrestrial environmental quality can be avoided and there are no residual impacts as a result of the Proposal.

7.8.2. Significant residual impacts

There are no significant residual impacts to Terrestrial Environmental Quality as a result of the Proposal.

7.8.3. Predicted outcome

The PTA considers the Proposal can be managed to prevent significant impacts to the quality of land and soils and therefore protect values associated with terrestrial environmental quality. This will be achieved through completion of comprehensive baseline studies, optimisation of the Footprint to avoid ASS and existing contamination, and implementation of stringent management measures administered through the CEMP (Appendix U), ASSMP (Appendix W) and TECMP (Appendix X).

The Terrestrial Environmental Quality environmental factor can be managed during the construction and operation of the Proposal, and the EPA's objective of maintaining the quality of land and soils will be met.

8. Inland waters

This chapter describes the values of inland waters potentially impacted by the Proposal, considers the various construction and operational related activities that could either directly or indirectly impact inland waters, assesses those impacts and determines that there are some significant residual impacts to geomorphic wetlands. The assessment considered the regional context of inland waters including the extent, condition and values of geomorphic wetlands across the SCP.

The PTA is confident that with the implementation of the proposed mitigation and management measures that are summarised in this ERD and have been incorporated into the CEMP (Appendix U), TECMP (Appendix X) and the commitment to offset the significant residual impacts to clearing the three CCWs and one REW (Appendix T), the Proposal will meet the EPA's objective to protect inland waters.

8.1. EPA objective

To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

8.2. Policy and guidance

Key EPA policy and guidance is listed below.

- Environmental Factor Guideline: Inland Waters (EPA 2018c).

8.3. Other policy and guidance

Additional policy and guidance on which this ERD is based is provided below.

- Statement of Planning Policy 2.2 Gnangara Groundwater Protection (WAPC 2005).
- Statement of Planning Policy No. 2.7 Public Drinking Water Source Policy (WAPC 2003).
- State Planning Policy 2.9 Water Resources (WAPC 2006).
- Environmental Water Provisions Policy for Western Australia (Water and Rivers Commission 2000).
- Wetlands Conservation Policy for Western Australia (Government of Western Australia 1997).
- A Guide to Managing and Restoring Wetlands in Western Australia (DEC 2012d).
- Geomorphic Wetlands Swan Coastal Plain Dataset (DBCA 2020).
- Water Quality Protection Note 10, *Contaminant Spills Emergency Response* (DoW 2006).
- Water Quality Protection Note 25: Land Use Compatibility Tables for Public Drinking Water Source Areas (DoW 2016).
- Water Quality Protection Note 56: Tanks for Fuel and Chemical Storage Near Sensitive Water Resources (DWER 2018).
- Water Quality Protection Note 83, Infrastructure Corridors Near Sensitive Water Resources (DoW 2007).
- Western Australian Environmental Offsets Policy (Government of Western Australia 2011b).