NSW GOVERNMENT

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 19

Biodiversity

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19 Biodiversity

This chapter provides an assessment of the potential impacts of the project on terrestrial, aquatic and marine biodiversity and identifies measures to address these impacts.

A detailed assessment of terrestrial and aquatic biodiversity has been carried out for the project and is included in Appendix S (Technical working paper: Biodiversity development assessment report). A detailed assessment of marine biodiversity has been carried out for the project and is included in Appendix T (Technical working paper: Marine ecology).

The Secretary's environmental assessment requirements as they relate to biodiversity, and where in the environmental impact statement these have been addressed, are detailed in Table 19-1.

Avoiding or minimising impacts has been a key consideration throughout the design and development process for the Beaches Link and Gore Hill Freeway Connection project. A conservative approach has generally been used in the assessments, with potential impacts presented before implementation of environmental management measures. The environmental management measures proposed to minimise the potential impacts in relation to biodiversity are included in Section 19.6.

Table 19-1 Secretary's environmental assessment requirements – biodiversity

Secretary's requirement	Where addressed in EIS
Biodiversity	
1. Biodiversity impacts related to the proposal are to be assessed in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report (BDAR).	Biodiversity impacts related to the project are provided in **Section 19.5** and documented in **Appendix S** (Technical working paper: Biodiversity development assessment report).
2. The BDAR must include information in the form detailed in the *Biodiversity Conservation Act 2016* (s. 6.12), Biodiversity Conservation Regulation 2017 (s. 6.8) and Biodiversity Assessment Method (BAM) including details of the measures proposed to address the offset obligation as follows: a. the total number and classes of biodiversity credits required to be retired for the developments/project; b. the number of classes of like-for-like biodiversity credits proposed to be retired; c. the number and classes of biodiversity credits proposed to be retired in accordance with the variation rules; d. any proposal to fund a biodiversity conservation action; and	The biodiversity development assessment report is provided in **Appendix S** (Technical working paper: Biodiversity development assessment report).

Secretary's requirement	Where addressed in EIS
e. any proposal to make a payment to the Biodiversity Conservation Fund.	
3. The BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM.	**Section 19.4** describes how the development of the project has avoided and minimised direct and indirect biodiversity impacts with further discussion provided in **Appendix S** (Technical working paper: Biodiversity development assessment report). Further details about route option development are provided in **Chapter 4** (Project development and alternatives). **Section 19.5** provides an assessment of all direct, indirect and prescribed impacts in accordance with the *Biodiversity Assessment Method*. **Section 19.6** provides environmental management measures to further avoid and/or minimise biodiversity impacts and **Section 19.6.1** details the proposed offsets for the project. Further detail is included in **Appendix S** (Technical working paper: Biodiversity development assessment report).
4. If requesting the application of the variation rules, the BDAR must contain details of what reasonable steps have been taken to attempt to obtain the required like-for-like biodiversity credits.	Not applicable.
5. The BDAR must include all spatial data associated with the survey and assessment as per Appendix 11 of the BAM.	Spatial data is provided as part of the **Appendix S** (Technical working paper: Biodiversity development assessment report) submission and *Biodiversity Assessment Method* credit calculator finalisation.
6. The BDAR must be prepared by a person accredited in accordance with the Accreditation scheme for the Application of the Biodiversity Assessment Method Order 2017 under s. 6.10 of the *Biodiversity Conservation Act 2016*.	Details on accreditation in accordance with the Accreditation scheme for the Application of the Biodiversity Assessment Method Order 2017 is provided in **Appendix S** (Technical working paper: Biodiversity development assessment report).
7. In accordance with section 9.1 and 9.2 of the BAM the BDAR must assess all direct and indirect impacts of the proposal on native vegetation, threatened ecological communities and threatened species habitat.	**Section 19.5** provides an assessment of biodiversity impacts related to the project with further details provided in **Appendix S** (Technical working paper: Biodiversity development assessment report).

Secretary's requirement	Where addressed in EIS
8. Impacts on biodiversity values that cannot be assessed using the BAM must also be otherwise assessed. The values include: a. marine mammals; b. wandering seabirds; and c. matters of national significance listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.	**Section 19.5** includes an assessment of impacts on biodiversity values that cannot be assessed using the *Biodiversity Assessment Method*. Further details are provided in **Appendix S** (Technical working paper: Biodiversity development assessment report) and **Appendix T** (Technical working paper: Marine ecology).
9. Species declared as threatened under the *Biodiversity Conservation Act 2016* and recorded recently (since 1990) within approximately 1.5 kilometres of the project's development corridor should be considered as likely to be affected by the proposal.	**Section 19.5** provides an assessment of the impacts to threatened species. Consideration of species recently recorded within 1.5 kilometres of the construction footprint are documented in **Appendix S** (Technical working paper: Biodiversity development assessment report).
10. Identify and assess the impacts of tidal flushing on the crossing of Middle Harbour. This assessment should also include details of any potential sediment accumulation and the impacts this may have on marine populations that dwell on the harbour floor.	**Section 19.5.5** provides an assessment of the impacts of tidal flushing, including low dissolved oxygen and sedimentation on marine populations. This is further discussed in **Appendix T** (Technical working paper: Marine ecology).

19.1 Legislative and policy framework

Chapter 2 (Assessment process) describes the environmental impact assessment and approval process for the project, including relevant NSW and Commonwealth legislation applicable to the project. The key legislative requirements and assessment guidelines specific to biodiversity are outlined below.

19.1.1 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* replaced the *Threatened Species Conservation Act 1995* on 25 August 2017. The *Biodiversity Conservation Act 2016* aims to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. It establishes a framework for assessment and offsetting of biodiversity impacts as well as investment in biodiversity conservation.

The *Biodiversity Assessment Method* (Office of Environment and Heritage (OEH), 2017) is established under section 6.7 of the *Biodiversity Conservation Act 2016*. The purpose of the *Biodiversity Assessment Method* is to assess impacts on threatened species and threatened ecological communities, and their habitats, and the impact on biodiversity values, where required under the *Biodiversity Conservation Act 2016*. The Biodiversity development assessment report provided in Appendix S (Technical working paper: Biodiversity development assessment report) was prepared on the basis of the *Biodiversity Assessment Method* in force before 22 October 2020.

19.1.2 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) includes provisions to protect and manage matters of national environmental significance, including nationally and internationally important flora, fauna, ecological communities and migratory species, defined in the *Environment Protection and Biodiversity Conservation Act 1999* as matters of national environmental significance.

In accordance with sections 67 and 67A of the *Environment Protection and Biodiversity Conservation Act 1999*, any action that has potential to result in an impact on any matters of national environmental significance or on Commonwealth land are considered 'controlled actions' and require a referral to the Australian Government Minister for the Environment for approval. The significance of impacts on matters of national environmental significance is determined in accordance with the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (Department of the Environment, 2013).

19.1.3 Fisheries Management Act 1994

The *Fisheries Management Act 1994* contains provisions for the conservation of fish stocks, key fish habitat, biodiversity, threatened species, populations and ecological communities. The *Fisheries Management Act 1994* regulates the conservation of fish, marine vegetation and some aquatic macroinvertebrates and the development and sharing of fishery resources of NSW for present and future generations. Part 7 of the *Fisheries Management Act 1994* identifies requirements for the protection of aquatic habitats, while Part 7A of the *Fisheries Management Act 1994* lists threatened species, populations and ecological communities and key threatening processes for species, populations and ecological communities in NSW waters. Section 220ZZ of the *Fisheries Management Act 1994* outlines significant impact considerations to threatened species, populations and ecological communities listed under the *Fisheries Management Act 1994*.

19.1.4 Assessment policy and guidelines

A number of assessment guidelines were used to inform the biodiversity assessment, the most relevant of which were:

- *Biodiversity Assessment Method* (OEH, 2017) – for the assessment of impacts on threatened species, threatened ecological communities, and their habitats, and the impact on biodiversity values, where required under the *Biodiversity Conservation Act 2016*
- *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (Department of the Environment, 2013) – for the assessment of significance of impacts on matters of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999*
- *Policy and guidelines for fish habitat conservation and management* (NSW Department of Primary Industries (NSW DPI), 2013) – for the assessment of freshwater and marine biodiversity matters.

Lists of all of the assessment guidelines that were used to inform the biodiversity assessment are provided in Appendix S (Technical working paper: Biodiversity development assessment report) and Appendix T (Technical working paper: Marine ecology).

19.2 Assessment methodology

The biodiversity assessment includes consideration of potential impacts on:

- Terrestrial biodiversity, consistent with the *Biodiversity Assessment Method* (Section 19.2.1)
- Aquatic (freshwater) biodiversity (Section 19.2.2)
- Marine biodiversity (Section 19.2.3).

The key terminology used for the terrestrial, aquatic and marine biodiversity assessments with regard to extent of assessments and identification of impacts is summarised in Table 19-2.

Table 19-2 Biodiversity assessment extent terminology

Term	Definition
Terrestrial biodiversity	
Assessment area	An area within 500 metres of the construction footprint
Construction footprint	The aboveground area to be directly impacted by the project
Terrestrial biodiversity locality	An area within 10 kilometres of the construction footprint
Aquatic biodiversity	
Assessment area	An area within 500 metres of the construction footprint
Construction footprint	The aboveground area to be directly impacted by the project
Aquatic biodiversity study area	An area encompassing the construction footprint and areas immediately adjacent (about 500 metres around the construction footprint)
Marine biodiversity	
Project area	The marine area to be directly impacted by the project
Marine biodiversity study area	Estuarine areas from the highest astronomical tide encompassing the project area and areas nearby from Yeoland Point to Grotto Point
Marine biodiversity study locality	An area within 10 kilometres of the project area (for the purpose of the desktop review)

19.2.1 Terrestrial biodiversity

The assessment of potential impacts on terrestrial biodiversity has been carried out in accordance with the *Biodiversity Assessment Method* (OEH, 2017). The assessment methodology is summarised below, with further detail provided in Appendix S (Technical working paper: Biodiversity development assessment report).

Desktop assessment

A desktop assessment was carried out for the project, including review of information from relevant databases, vegetation maps, topographic maps, aerial photography, reports and published literature.

The following databases were searched on several occasions between June 2016 and April 2020:

- BioNet Atlas of NSW Wildlife
- Environment Protection and Biodiversity Conservation Act 1999 Protected Matters Search Tool
- Threatened species profile search.

The database searches were carried out for the terrestrial biodiversity locality.

The desktop assessment was used to identify threatened species, populations, communities and their habitats with a likelihood of occurrence in areas that may be impacted by the project.

Field surveys

Multiple field surveys were carried out between May 2016 and April 2020, and included:

- Random meander surveys to verify vegetation communities and the condition of vegetation across accessible land within the construction footprint
- Targeted flora and fauna surveys for species identified as having a high or moderate likelihood of occurrence in areas that may be impacted by the project, as identified through the desktop assessment
- Vegetation integrity plots involving quantitative (quadrat/transect) site surveys in accordance with the *Biodiversity Assessment Method*
- Floristic analysis of vegetation plot data to determine vegetation community and plant community types. Native vegetation was classified according to the plant community types in the Vegetation Information System Classification (DPIE (EES), 2020b). Areas of non-PCT vegetation were also identified and mapped.

Further detail on the field surveys between May 2016 and April 2020 is provided in Appendix S (Technical working paper: Biodiversity development assessment report).

Assessment of potential impacts

The potential impacts of the project were assessed against the relevant matters in the *Biodiversity Assessment Method* (OEH, 2017), including:

- Removal of native vegetation and habitat, including direct and indirect impacts on native vegetation and threated flora
- The potential for serious and irreversible impacts on identified threatened species and ecological communities
- The prescribed biodiversity impacts under the *Biodiversity Assessment Method* (OEH, 2017)
- The potential for impacts on relevant matters of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999*.

For the purposes of the assessment, it is assumed that all vegetation within the construction footprint would be removed, except for the Burnt Bridge Creek riparian corridor exclusion zone shown in Figure 19-3.

19.2.2 Aquatic biodiversity

The freshwater aquatic habitat assessment was informed by the results of inspections carried out across five waterways, and associated tributaries, and two waterbodies within the aquatic biodiversity study area:

- Willoughby Creek
- Flat Rock Creek
- Burnt Bridge Creek
- Manly Creek
- Manly Dam
- Trefoil Creek
- Wakehurst Golf Course dam – a dam downstream of the Wakehurst Parkway east construction support site (BL13).

The extent and condition of freshwater habitats within the aquatic biodiversity study area was recorded during the site inspections.

No fish or macroinvertebrate sampling was carried out during the inspections. The likelihood of occurrence of aquatic species has been assessed based on the availability of suitable habitat. Further details of the inspection locations are provided in Annexure D (Freshwater ecology impact assessment) of Appendix S (Technical working paper: Biodiversity development assessment report).

In summary, the aquatic assessment involved the following:

- Identification of the location, extent and condition of waterways potentially impacted by the project
- Assessment of potential impacts to freshwater ecology, including threatened species and ecological communities, and geomorphology due to construction and operation of the project
- Identification of environmental management measures and offsets required to manage potential impacts to aquatic biodiversity.

19.2.3 Marine biodiversity

The assessment methodology for marine biodiversity is summarised below, with further details provided in Appendix T (Technical working paper: Marine ecology).

Desktop assessment

A desktop assessment was carried out for the project, including review of information from relevant databases, aerial photography, reports and published literature.

The following databases were searched:

- BioNet Atlas of NSW Wildlife
- Environment Protection and Biodiversity Conservation Act 1999 Protected Matters Search Tool
- Threatened species profile search
- NSW Department of Planning, Industry and Environment's Fish Communities and Threatened Species Distribution of NSW
- NSW Department of Planning, Industry and Environment's Listed Protected Fish Species website
- NSW Department of Planning, Industry and Environment's Listed Threatened Species, Populations and Ecological Communities website
- National System for the Prevention and Management of Marine Pest Incursions website
- Atlas of Living Australia.

The database searches were carried out for the marine biodiversity study locality.

The desktop assessment was used to identify threatened species, populations, communities and their habitats with a likelihood of occurrence in areas to be impacted by the project.

Field surveys

Preliminary sampling and predictive habitat mapping from aerial photography captured in May 2017 was used to identify areas for field surveys. Sites for field surveys also took into account the outcomes of the desktop assessment, including consideration of relevant species, communities, populations and habitats, and their likelihood of occurrence in areas that may be impacted by the project.

Field surveys were carried out within Middle Harbour in November and December 2017, between Yeoland Point at Castle Cove and Grotto Point at the entrance to Middle Harbour. The field surveys included mapping and confirmation of seagrass, subtidal rocky reef, intertidal rocky reef and deep water soft sediment habitats. Surveys of macroalgae, sessile invertebrate and epibiota coverage and fish numbers, and macroinvertebrate sampling were also carried out in relevant habitats.

Assessment of potential impacts

A risk based approach was applied to the assessment of potential direct and indirect impacts of the project on marine biodiversity, including impacts associated with:

- Removal of habitat
- Turbidity
- Sedimentation
- Mobilisation of contaminants
- Introduction/spread of marine pests
- Altered hydrodynamics
- Underwater noise
- Boat strike to marine mammals and reptiles
- Spill of contaminants.

The assessment considered the sensitivity of key fish habitat types, including Type 1 (highly sensitive), Type 2 (moderately sensitive) and Type 3 (minimally sensitive) habitats.

The likelihood and consequence of direct and indirect impacts on each key fish habitat were evaluated to determine an anticipated level of risk. The levels of risk applied to the assessment are summarised in Table 19-3.

Table 19-3 Risk levels applied to the assessment of potential marine biodiversity impacts

Level of risk	Description
Extreme	The risk is unmanageable and unjustified. Measures to reduce the risk to a lower level are required.
High	The risk is significant and requires substantial measures for risk reduction and/or management.
Medium	The risk may be acceptable and requires routine management measures.
Low	The risk is acceptable and requires either routine management measures or no further measures.

19.3 Existing environment

This section summarises the existing key biodiversity values along and around the project alignment, including:

- Terrestrial flora (Section 19.3.1)
- Terrestrial fauna (Section 19.3.2)
- Aquatic biodiversity (Section 19.3.3)
- Marine biodiversity (Section 19.3.6).

19.3.1 Terrestrial flora

Vegetation communities

Vegetation communities within the construction footprint are summarised in Table 19-4 and shown in Figure 19-1 to Figure 19-5.

The construction footprint of the project overlaps with the construction footprint of the Western Harbour Tunnel and Warringah Upgrade project at Warringah Freeway/Cammeray Golf Course construction support site (BL1). This overlap area was previously assessed as part of the environmental impact statement prepared for the Western Harbour Tunnel and Warringah Upgrade project in 2020. As such, consideration of vegetation within the overlap is not included in the assessment of the Beaches Link and Gore Freeway Connection project.

In addition, the recently completed Northern Beaches Hospital road upgrade project overlaps with the northern extent of the construction footprint. The area of overlap has been heavily modified/cleared due to the construction of the Northern Beaches Hospital road upgrade project. As such, for the purposes of this assessment, all calculations of biodiversity impacts have excluded the area of overlap (see Figure 19-5).

Field surveys carried out for the project identified seven native vegetation communities within the construction footprint, consistent with the following plant community types (PCT):

- PCT 1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion
- PCT 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion
- PCT 1783: Red Bloodwood - Scribbly Gum/Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast
- PCT 1786: Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region
- PCT 1824: Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin
- PCT 1841: Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region
- PCT 1845: Smooth-barked Apple - Red Bloodwood - Blackbutt tall open forest on shale sandstone transition soils in eastern Sydney.

These vegetation communities cover around 15.05 hectares within the construction footprint.

Other vegetation within the construction footprint is also described in Table 19-4 and shown in Figure 19-1 to Figure 19-5 and includes:

- Native revegetation
- Native plantings
- Urban exotic/native
- Weeds and exotics.

This vegetation covers around 6.77 hectares within the construction footprint.

A vegetation exclusion zone is shown on Figure 19-3. This zone was included to reduce the direct impact on the Burnt Bridge Creek riparian corridor and is further discussed in Section 19.4.

Threatened ecological communities

Several patches of the Duffys Forest endangered ecological community (aligned with PCT 1786) have been identified within the construction footprint, as shown in Figure 19-4 and Figure 19-5. This community is listed as endangered under the *Biodiversity Conservation Act 2016*.

The Wakehurst Parkway north construction support site (BL14) would be the same site that was used as the main construction support site for the Northern Beaches Hospital road upgrade project (refer to Figure 19-5). Revegetation works were carried out at this site, including planting with species consistent with the Duffys Forest endangered ecological community within the eastern section of the decommissioned construction support site. During site establishment of the Wakehurst Parkway north construction support site (BL14), this revegetated area would remain fenced off and protected from disturbance. Due to the timing of these recent revegetation works, the current site layout of the Wakehurst Parkway north construction support site (BL14) does not show the revegetation area. During further design development and construction planning, the temporary construction support site layout would be refined to show the revegetation area, and ensure it is avoided and protected during construction.

Table 19-4 Vegetation communities within the construction footprint

Mapped vegetation[1]	Corresponding plant community type (PCT)	Location within the construction footprint	Area within the construction footprint (ha)
Native vegetation community	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion (PCT 1250)	This community occurs on sandy soils influenced by Hawkesbury Sandstone and alluvium geologies. Within the construction footprint, the community was found adjoining the Wakehurst Parkway, within a steep gully forming the head of a tributary of Manly Creek.	0.20
Native vegetation community	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion (PCT 1292)	This community occurs on sandy soils derived from sandstone and alluvium geologies. Within the construction footprint, this community occurs along the Burnt Bridge Creek riparian corridor within Balgowlah Golf Course, and the Kitchener Street construction support site (BL11). Within the construction footprint, this community experiences moderate to high levels of disturbance intersected by walking paths and roads as well being exposed to rubbish, stormwater debris and erosion of substrates and creek banks. It is likely that these factors have contributed to the diversity of exotic plant species recorded within the construction footprint. Weed coverage however is generally restricted to the mid-storey and groundcover with only three exotic canopy trees recorded.	0.88
Native vegetation community	Red Bloodwood - Scribbly Gum/Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast (PCT 1783)	This community occurs along the Wakehurst Parkway on dry sandy soils derived from Hawkesbury sandstone. Along the Wakehurst Parkway the community is subjected to disturbance such as walking paths, edge effects associated with the road and minor weed incursions. This community also occurs within the proposed Wakehurst Parkway east construction support site (BL13).	4.23

Mapped vegetation[1]	Corresponding plant community type (PCT)	Location within the construction footprint	Area within the construction footprint (ha)
Native vegetation community	Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (PCT 1786) (consistent with the Duffys Forest endangered ecological community)	This community occurs on sandy soils derived from sandstone geology and was generally found on the upper slopes supporting a diverse range of small trees, shrubs and ground covers. This community was recorded along the Wakehurst Parkway within the construction footprint and subsequently experiences moderate levels of disturbances in the form of walking paths, edge effects associated with the road and minor weed incursions. This community also occurs within the proposed Wakehurst Parkway south construction support site (BL12).	1.38
Native vegetation community	Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin (PCT 1824)	This community is associated with wetter areas on sandy soils derived from sandstone geology. This community was mapped along the Wakehurst Parkway within the construction footprint, and subsequently experiences moderate levels of disturbance in the form of walking paths, edge effects associated with the road and minor weed incursions. This community also occurs within the proposed Wakehurst Parkway east construction support site (BL13).	6.18
Native vegetation community	Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region (PCT 1841)	This community occurs on sandy soils with slight loam components derived from Hawkesbury sandstone geology. These areas vary in gradient from gentle to steep and were typically situated within proximity to a watercourse. Within the construction footprint, this community was recorded along Burnt Bridge Creek within the Balgowlah Golf Course, within Flat Rock Drive construction support site (BL2) associated with an existing aboveground watercourse and at the Gore Hill Freeway.	1.79

Mapped vegetation[1]	Corresponding plant community type (PCT)	Location within the construction footprint	Area within the construction footprint (ha)
Native vegetation community	Smooth-barked Apple - Red Bloodwood - Blackbutt tall open forest on shale sandstone transition soils in eastern Sydney (PCT 1845)	This community occurs on sandy soils derived from sandstone geology and was generally found on the upper slopes supporting a diverse range of small trees, shrubs and ground covers. This community was recorded along the northern section of the Wakehurst Parkway within the construction footprint and subsequently experiences moderate levels of disturbance in the form of walking paths, edge effects associated with the road and minor weed incursions.	0.39
Total area of mapped native vegetation communities (PCTs)			**15.05**
Native revegetation	Assigned to the adjoining Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region (PCT 1841) for the purpose of assessment using the *Biodiversity Assessment Method* credit calculator	This vegetation type is located within Flat Rock Drive construction support site (BL2). The Flat Rock Drive construction support site (BL2) is located within Flat Rock Reserve, a council reserve containing native revegetation. Flat Rock Reserve supported a municipal waste landfill site until 1985. The site was capped with clay in 1998 and has since been progressively revegetated.	1.29
Native plantings	Not consistent with the definition of any plant community type Miscellaneous ecosystems - highly disturbed with no or limited native vegetation	This vegetation association occurs within highly disturbed areas which have been subject to landscaping following development of infrastructure (eg roads, rail, and electricity easements), recreational facilities (eg sports fields, walking tracks), parking areas as well as residential and commercial areas. These landscaped areas have commonly been planted out with native species using horticultural specimens with unknown genetic origins. This vegetation type occurs at Gore Hill Freeway, within the proposed Flat Rock Drive construction support site (BL2), Balgowlah Golf Course construction support site (BL10) and Wakehurst Parkway east construction support site (BL13).	0.36

Mapped vegetation[1]	Corresponding plant community type (PCT)	Location within the construction footprint	Area within the construction footprint (ha)
Urban exotic/native	Not consistent with the definition of any plant community type Miscellaneous ecosystems - highly disturbed with no or limited native vegetation	This vegetation type occurs as garden, park and road verge plantings within existing disturbed areas of the construction footprint. These areas generally contain planted native and exotic horticultural specimens or isolated remnant trees within otherwise planted areas. This vegetation type occurs at Gore Hill Freeway, within the proposed Punch Street construction support site (BL3), Balgowlah Golf Course construction support site (BL10) and Wakehurst Parkway south construction support site (BL12).	4.89
Weeds and exotics	Not consistent with the definition of any plant community type Miscellaneous ecosystems - highly disturbed with no or limited native vegetation	This vegetation type occurs throughout the construction footprint as cleared lands dominated by weeds and/or exotic species. These areas generally occur as exotic grasslands or dense thickets of woody weeds within parks and road verges.	0.23
Total vegetation within construction footprint (including native vegetation communities)			**21.82**

Note 1: Vegetation mapped by project ecologists as part of field surveys for the biodiversity development assessment report

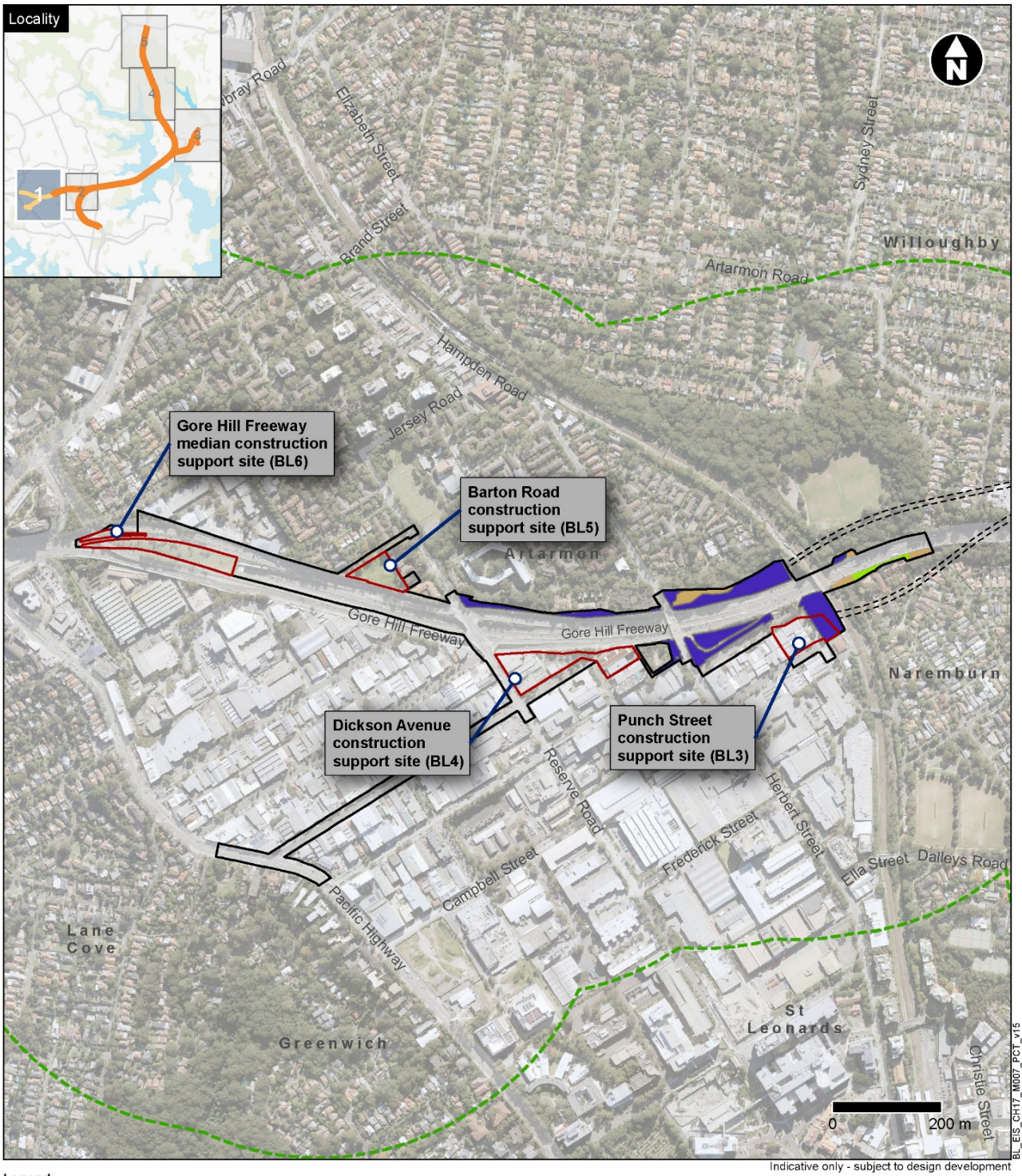


Figure 19-1 Distribution of plant community types and other vegetation (map 1)

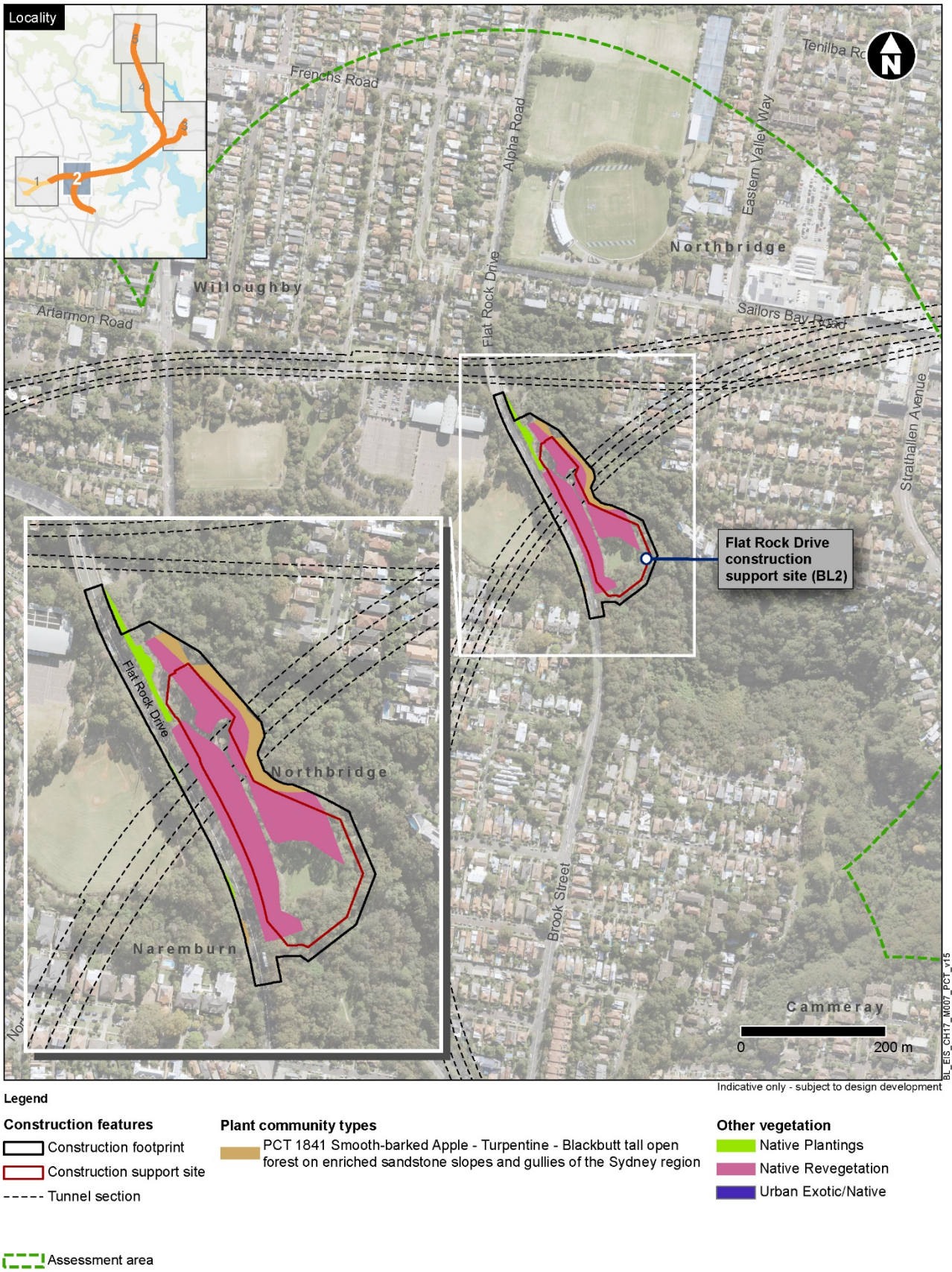


Figure 19-2 Distribution of plant community types and other vegetation (map 2)

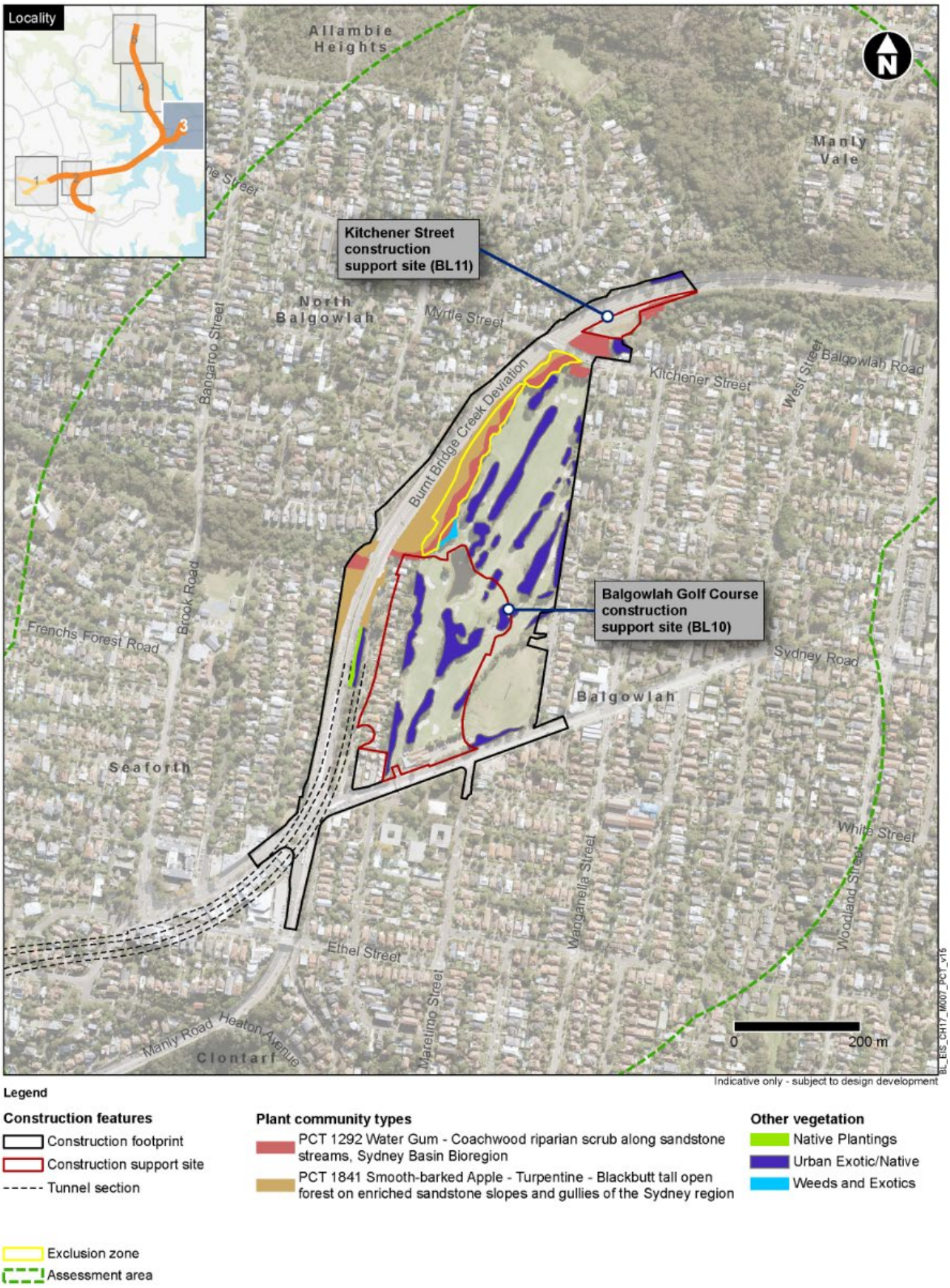


Figure 19-3 Distribution of plant community types and other vegetation (map 3)

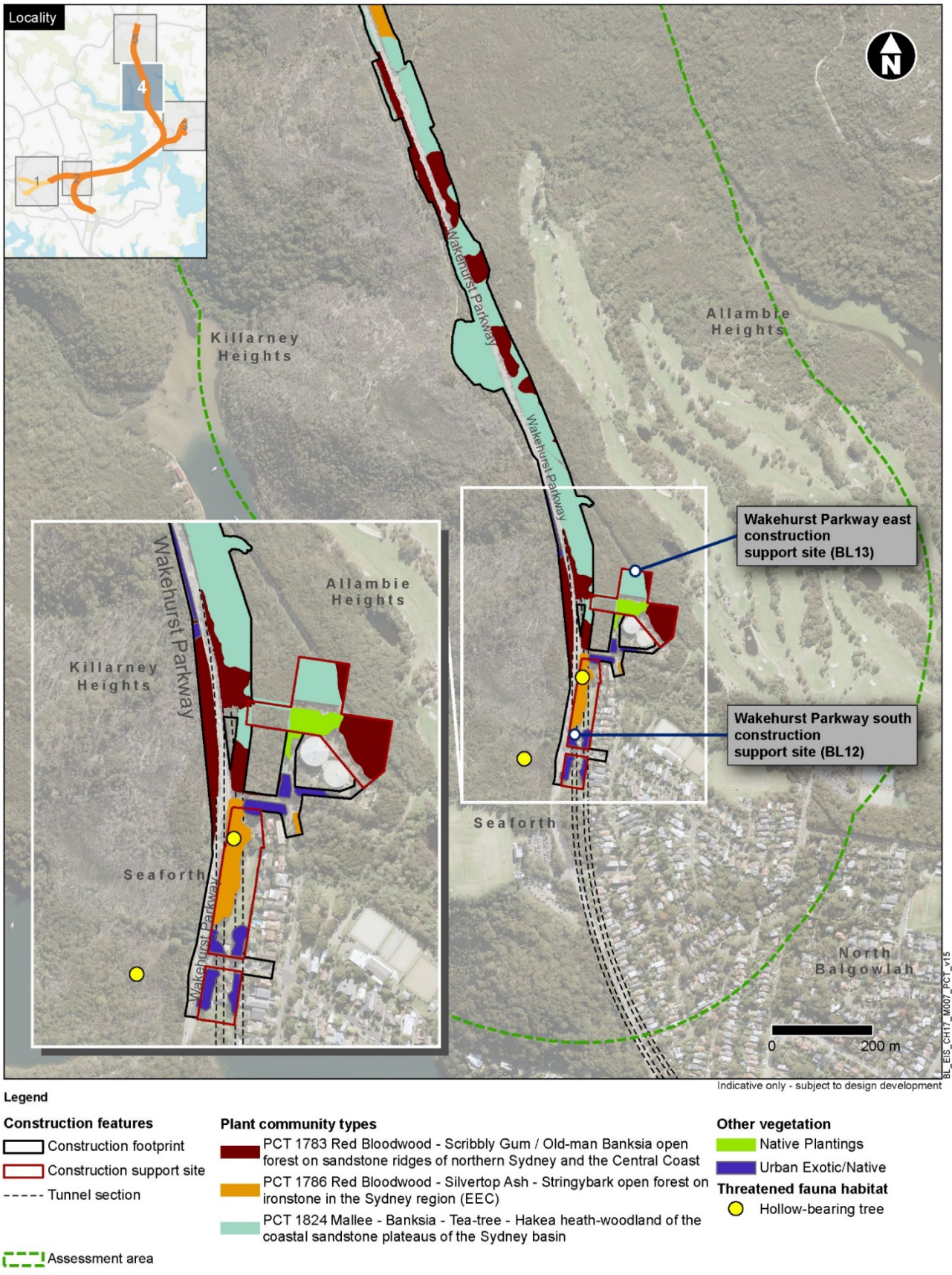
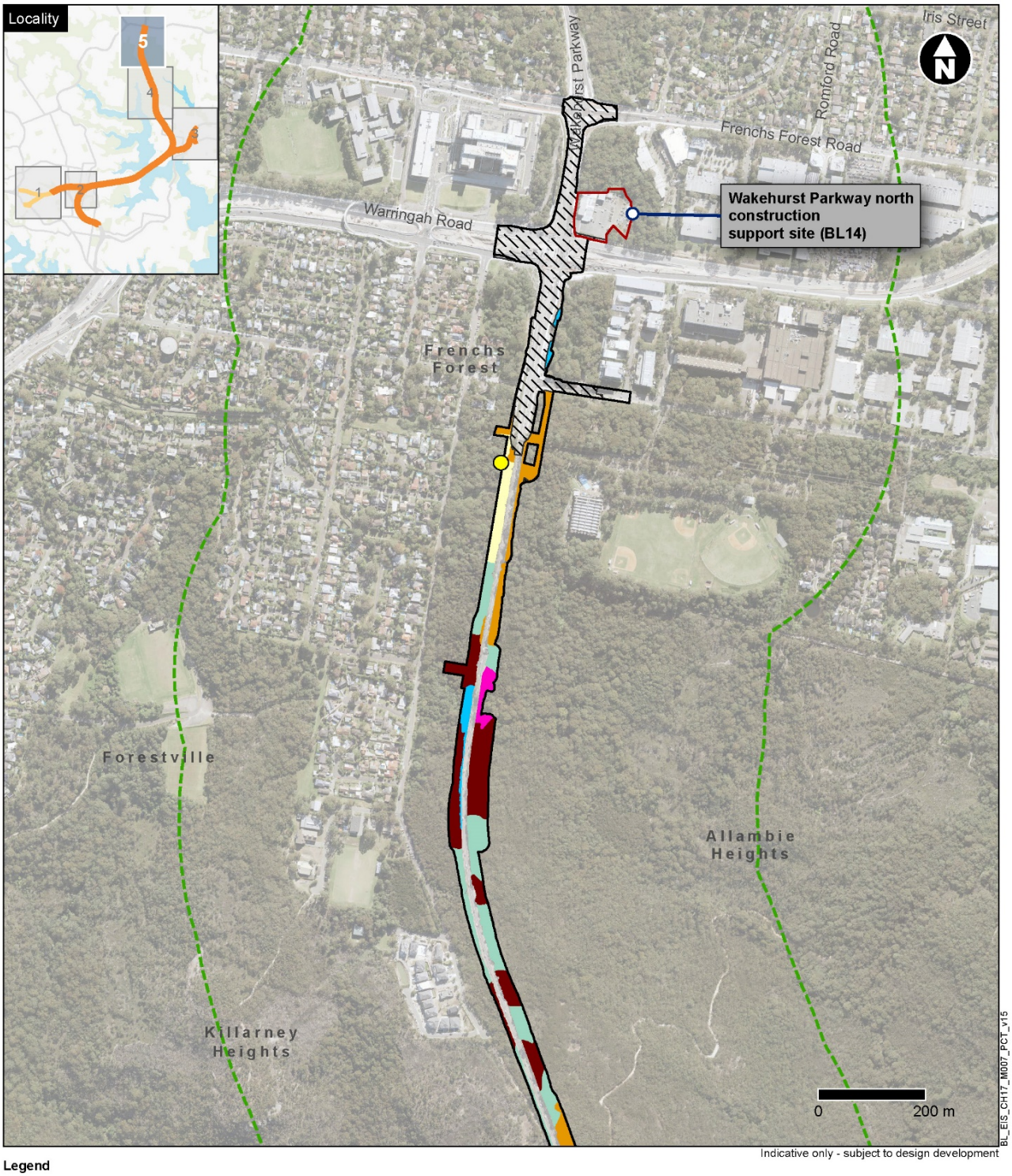


Figure 19-4 Distribution of plant community types and other vegetation (map 4)



Legend

Construction features

- Construction footprint
- Construction support site
- Assessment area
- Area not assessed by the BDAR

Plant community types

- PCT 1250 Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion
- PCT 1783 Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast
- PCT 1786 Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (EEC)
- PCT 1824 Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin
- PCT 1845 Smooth-barked Apple - Red Bloodwood - Blackbutt tall open forest on shale sandstone transition soils in eastern Sydney

Other vegetation

- Weeds and Exotics

Threatened fauna habitat

- Hollow-bearing tree

Figure 19-5 Distribution of plant community types and other vegetation (map 5)

Threatened flora

Field surveys carried out for the project identified two listed threatened flora species within the construction footprint:

- Magenta Lilly Pilly (*Syzygium paniculatum*)
- Netted Bottle Brush (Callistemon linearifolius).

Three other threatened flora species, Sunshine Wattle (*Acacia terminalis* subsp. *terminalis*), Glandular Pink-bell (*Tetratheca glandulosa*) and *Epacris purpurascens* var. *purpurascens,* were recorded during the field surveys in proximity to the construction footprint.

In addition, 14 listed threatened species were identified as having moderate likelihood of occurrence within the construction footprint, despite not being identified during field surveys.

Details of these 19 species are provided in Table 19-5, with the locations of species recorded during field surveys for the project shown in Figure 19-6 to Figure 19-11.

Table 19-5 Threatened flora species known or likely to occur in the construction footprint

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Magenta Lilly Pilly (*Syzygium paniculatum*)	Endangered (BC Act) Vulnerable (EPBC Act)	Known to occur in the construction footprint. One in situ remnant individual was recorded next to the construction footprint at the Wakehurst Parkway, located within PCT 1250. The individual is mapped at the edge of the construction footprint, and therefore has been conservatively assessed to be within the construction footprint for the purpose of this assessment. The species is not usually known to be associated with this vegetation type, is considered unlikely to occur at this location and is a widely available and commonly planted horticultural species. However, there is no evidence that this specimen has been planted, and it may be of wild provenance. Eleven planted individuals were recorded at the Burnt Bridge Creek Deviation, only four of which are located within the construction footprint. These planted individuals are not of conservation significance. Two planted individuals were also recorded about 18 metres to the east of the construction footprint at Flat Rock Reserve. Although the reserve has been extensively re-planted, it is possible that these specimens could be of wild provenance.
Netted Bottle Brush (*Callistemon linearifolius*)	Vulnerable (BC Act)	Known to occur in the construction footprint. Four planted individuals were recorded within the construction footprint at the Burnt Bridge Creek Deviation. As they are planted, these individuals are not of conservation significance and are not assessed further under the *Biodiversity Assessment Method*.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Sunshine Wattle (*Acacia terminalis* subsp. *terminalis*)	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. Remnant individuals were recorded in a small fenced area of bushland between the Wakehurst Parkway and the Seaforth Oval car park, associated with PCT 1786, about 145 metres south of the construction footprint. Another five individuals of *Acacia terminalis* subsp. *terminalis* were recorded around 170 metres west of the construction footprint, in vegetation along Burnt Bridge Creek.
Glandular Pink-bell (*Tetratheca glandulosa*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. Recorded in proximity to the construction footprint during field surveys for the project. This species was recorded in bushland next to the Wakehurst Parkway, about 50 metres east of the construction footprint.
Epacris purpurascens var. *purpurascens*	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. Recorded in proximity to the construction footprint during field surveys for the project. This species was recorded to the north of the construction footprint at Artarmon Park, where it occurs in several patches. The closest patch is about 60 metres north of the construction footprint.
Angus's Onion Orchid (*Microtis angusii*)	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species has been previously recorded within proximity to the construction footprint, including recently near Seaforth Oval. Potential habitat for the species is also known to occur within the construction footprint.
Bauer's Midge Orchid (*Genoplesium baueri*)	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Bynoe's Wattle (*Acacia bynoeana*)	Endangered (BC Act) Vulnerable (EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Caley's Grevillea (*Grevillea caleyi*)	Critically endangered (BC Act) Endangered (EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Camfield's Stringybark (*Eucalyptus camfieldii*)	Vulnerable (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the broader terrestrial biodiversity locality.
Hairy Geebung (*Persoonia hirsuta*)	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Haloragodendron lucasii	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Hibbertia puberula	Endangered (BC Act)	Moderate likelihood of occurrence in the construction footprint. Although the species has not been recorded recently within the terrestrial biodiversity locality, potential habitat for the species has been recorded in the terrestrial biodiversity locality.
Lasiopetalum joyceae	Vulnerable (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Leptospermum deanei	Vulnerable (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Pimelea curviflora var. *curviflora*	Vulnerable (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Seaforth Mintbush (*Prostanthera marifolia*)	Critically endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species and potential habitat for the species has been previously recorded within the terrestrial biodiversity locality.
Somersby Mintbush (*Prostanthera junonis*)	Endangered (BC Act and EPBC Act)	Moderate likelihood of occurrence in the construction footprint. The species has been previously recorded in proximity to the construction footprint including along the Wakehurst Parkway, near Seaforth Oval and near the Wakehurst Golf Club. Habitat for the species has also been previously recorded within the terrestrial biodiversity locality.
Scrub Turpentine (*Rhodamnia rubescens*)	Critically endangered (BC Act)	Moderate likelihood of occurrence in the construction footprint. The species has been recorded within the terrestrial biodiversity locality in urban reserves. Marginal habitat occurs in the construction footprint.

Note 1: BC Act refers to *Biodiversity Conservation Act 2016*
EPBC Act refers to *Environment Protection and Biodiversity Conservation Act 1999*

19.3.2 Terrestrial fauna

Terrestrial fauna habitat

Table 19-6 provides a summary of the terrestrial fauna habitat types within and next to the construction footprint, and the known or potential fauna species occurring within those habitats.

The key terrestrial fauna habitat types identified for the project include:

- Vegetated habitats
- Human-made structures and built environments (including existing buildings, culverts and bridges)
- Marine and intertidal habitats. The assessment of marine and intertidal habitats in relation to marine species is discussed in Section 19.3.6.

Table 19-6 Terrestrial fauna habitats

Habitat type	Location	Known or potential fauna species
Vegetated habitats	Large tracts of native vegetation (consisting of plant community types and revegetation areas) occur at Flat Rock Reserve, within and near Flat Rock Drive construction support site (BL2), and in the northern extent of the construction footprint, on either side of the Wakehurst Parkway at the Wakehurst Parkway south construction support site (BL12) and the Wakehurst Parkway east construction support site (BL13).	Vegetated areas within and near Flat Rock Drive construction support site (BL2) and next to the Wakehurst Parkway provide fauna habitat resources for a range of mammals, birds, reptiles and bats, including the following: Flowering plants that offer potential foraging resources to arboreal mammals and birds such as: Noisy Miner (*Manorina melanocephala*); Rainbow Lorikeet (*Trichoglossus moluccanus*); Red Wattlebird (*Anthochaera carunculata*); Ringtail Possum (*Pseudocheirus peregrinus*); Sugar Glider (*Petaurus breviceps*); Grey-headed Flying-fox (*Pteropus poliocephalus*); Powerful Owl (*Ninox strenua*); Eastern Pygmy-possum (*Cercartetus nanus*); and Square-tailed Kite (*Lophoictinia isura*) Intact native vegetation offers foraging habitat to a diversity of microbat species, that may forage above or below the tree canopy for invertebrates Ground layer plants that offer potential sheltering and foraging habitat to reptiles, small mammals, birds and some amphibians such as: Brown Antechinus (*Antechinus stuartii*); Bush Rat (*Rattus fuscipes*); Australian Brush Turkey (*Alectura lathami*); Rosenberg's Goanna (*Varanus rosenbergi*); and Bibron's Toadlet (*Psueudophryne bibronii*) Three hollow-bearing trees located near the Wakehurst Parkway (two within the construction footprint and one outside) offer potential nesting, roosting and sheltering habitat to hollow-dependent birds (such as Rainbow Lorikeet), arboreal mammals (such as Common Brushtail Possum (*Trichosurus vulpecula*)); and hollow-roosting microbats.

Habitat type	Location	Known or potential fauna species
	Urban and landscaped areas throughout the construction footprint including native and exotic vegetation at the following locations within the construction footprint: • Within and next to the Gore Hill Freeway • Balgowlah Golf Course construction support site (BL10) • Kitchener Street construction support site (BL11).	Landscaped areas provide habitat for highly mobile species which are capable of using small, isolated patches of habitat within disturbed urban environments including: Flowering and fruiting plants that offer potential foraging resources to bats, birds and arboreal mammals, such as: Grey-headed Flying-fox, Australian Magpie (*Cracticus tibicen*), Noisy Miner, Rainbow Lorikeet, Grey Butcherbird (*Cracticus torquatus*), Common Brushtail Possum and Ringtail Possum.
	Riparian vegetation associated with Burnt Bridge Creek.	A Grey-headed Flying-fox camp has been identified at a location in the vegetated area between Balgowlah Road and Burnt Bridge Creek Deviation, about 120 metres from the construction footprint.
	Riparian vegetation associated with unnamed ephemeral watercourses within open forest areas next to the Wakehurst Parkway.	Potential sheltering, foraging and breeding habitat for the Red-crowned Toadlet (*Pseudophryne australis*).
	Rocky habitat associated with Hawkesbury sandstone bedrock, boulders, crevices and ledges located within the construction footprint at Flat Rock Reserve, Burnt Bridge Creek and along the Wakehurst Parkway.	Potential sheltering and foraging habitat for: Large-eared Pied Bat (*Chalinolobus dwyeri*), Brown Antechinus; Bush Rat; Red-crowned Toadlet; Rosenberg's Goanna; and Gully Skink (*Saproscincus spectabilis*).
Human-made structures and built environments	Existing culverts, bridges and buildings within the construction footprint.	Potential artificial microbat roosting habitat for: Little Bent-winged Bat (*Miniopterus australis*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Eastern Coastal Free-tailed bat (*Micronomus norfolkensis*), Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*).

Habitat type	Location	Known or potential fauna species
Marine and intertidal habitats	Intertidal sand and mudflats within the construction footprint along the foreshore of Clive Park at Northbridge, Beauty Point at The Spit and Peach Tree Bay at Seaforth.	• Small areas of sand and mudflats provide marginal foraging habitat to threatened shorebird species, where worms, bivalves, crustaceans and other invertebrates occur within soft substrate tidal areas that are exposed during low tide. However, no threatened shorebird species were recorded during targeted surveys, nor were determined as having a high likelihood of occurrence within the construction footprint • No nesting or roosting habitat provided, as these areas are inundated at high tide.
	Intertidal rocky shores along bays and headlands within the construction footprint, including: Peach Tree Bay; Seaforth Bluff; Beauty Point; Quakers Hat; Fig Tree Point; Fig Tree Cove; Clive Park; and Sailors Bay.	• Supports a high abundance of Sydney Rock Oysters (*Saccostrea glomerata*), which offer limited foraging resources for threatened shorebirds. However, no threatened shorebird species were identified during database searches as having a high likelihood of occurrence within the construction footprint • No nesting or roosting opportunities are provided, as these areas are inundated at high tide.
	Open water habitat within Middle Harbour.	• Foraging habitat for a number of threatened bird and bat species that forage for fish or other marine prey species, including: • Little Penguins (*Eudyptula minor*) which have been recorded at several locations within the construction footprint, including at The Spit, Long Bay, Sailors Bay, and in the main channel of Middle Harbour • White-bellied Sea Eagle (*Haliaeetus leucogaster*) due to the presence of preferred prey species (ie fish, turtles and sea snakes) within the construction footprint, as well as potential perching habitat in trees along the foreshore at The Spit, Seaforth and Clontarf • Southern Myotis (*Myotis macropus*) due to the presence of preferred prey species (ie fish) within and near the construction footprint • Not a preferred habitat for wandering seabirds with no wandering seabird species identified as having a high likelihood of occurrence within the construction footprint.

Threatened fauna species and endangered populations

Field surveys carried out for the project identified six listed threatened fauna species, within or next to the construction footprint:

- Grey-headed Flying-fox recorded in a number of locations flying over the construction footprint. In addition, a Grey-headed Flying-fox camp has been identified at a location in the vegetated area between Balgowlah Road and Burnt Bridge Creek Deviation, about 120 metres from the construction footprint
- Rosenberg's Goanna recorded within vegetated areas alongside the Wakehurst Parkway in the construction footprint
- Powerful Owl recorded in bushland off Flat Rock Drive near the Flat Rock Drive construction support site (BL2)
- Large Bent-winged Bat recorded in bushland near the Flat Rock Drive construction support site (BL2)
- Little Bent-winged Bat recorded in bushland near the Flat Rock Drive construction support site (BL2)
- Large-eared Pied Bat recorded about 125 metres from the construction footprint.

Another six listed threatened species were identified as having a high likelihood of occurrence within the construction footprint or assumed to be present, despite not being identified during field surveys. Some species have been identified as a result of recent database searches and surveys carried out for the recently completed Northern Beaches Hospital road upgrade project. These species with a high likelihood of occurrence include:

- Red-crowned Toadlet
- Eastern Pygmy-possum
- Eastern Coastal Free-tailed Bat
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- White-bellied Sea Eagle.

Two threatened fauna species, Southern Brown Bandicoot (*Isoodon obesulus obesulus*) and Southern Myotis, are considered likely to occur in areas next to the construction footprint.

In addition, nine species were identified as having a moderate likelihood of occurrence within the construction footprint, despite not being identified during field surveys. These species were:

- Barking Owl (*Ninox connivens*)
- Eastern Osprey (*Pandion cristatus*)
- Little Lorikeet (*Glossopsitta pusilla*)
- Masked Owl (*Tyto novaehollandiae*)
- Spotted-tailed Quoll (*Dasyurus maculatus*)
- Square-tailed Kite
- Swift Parrot (*Lathamus discolor*)
- Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)
- Brown Treecreeper (*Climacteris picumnus victoriae*).

One endangered population is known to occasionally occur in the construction footprint, being the population of Little Penguins in the Manly Point area, about 5.5 kilometres north-east of the project.

Details of these 23 threatened fauna species and one endangered population are provided in Table 19-7, with the locations of species recorded during field surveys for the project shown in Figure 19-6 to Figure 19-11.

Migratory bird species

As identified above, one migratory bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999*, the White-bellied Sea Eagle, has a high likelihood of occurrence due to potential habitat in Middle Harbour.

Migratory freshwater and marine species, such as whales, turtles and fish, are discussed in Section 19.3.3 and Section 19.3.6 respectively.

Table 19-7 Threatened fauna species known or likely to occur in the construction footprint

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Threatened species		
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Vulnerable (BC Act and EPBC Act)	Known to occur in the construction footprint. This species was recorded in a number of locations flying over the construction footprint. A Grey-headed Flying-fox camp has been identified at a location in the vegetated area between Balgowlah Road and Burnt Bridge Creek Deviation, about 120 metres east of the construction footprint. It is highly likely that the Grey-headed Flying-fox would also use land within the construction footprint and surrounds for foraging.
Rosenberg's Goanna (*Varanus rosenbergi*)	Vulnerable (BC Act)	Known to occur in the construction footprint. This species was recorded during field surveys for the project within vegetated areas next to the Wakehurst Parkway. Vegetation in this area offers potential foraging and nesting habitat for the species due to the presence of preferred prey species including birds, reptiles and small mammals, while the presence of sandstone boulders, slabs and rock crevices offer sheltering habitat to the species. Termite mounds recorded in proximity to the Wakehurst Parkway also offer preferred nesting habitat to the species. Rosenberg's Goanna may also forage for roadkill along the margins of the Wakehurst Parkway, where fauna mortality due to vehicle strike is high.
Powerful Owl (*Ninox strenua*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. The Powerful Owl was recorded during field surveys for the project in bushland off Flat Rock Drive, in proximity to the construction footprint. It has also been previously recorded within vegetated areas next to the Wakehurst Parkway. A hollow-bearing tree, which included one large tree hollow (greater than 0.2 metres diameter), was identified in the northern extent of the construction footprint near the Wakehurst Parkway as offering potential nesting habitat; however, no activity was identified during field surveys. These areas within and next to the construction footprint also offer potential foraging habitat for the Powerful Owl due to the presence of preferred prey species that are known and are likely to inhabit the construction footprint.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was recorded during field surveys for the project in bushland near the Flat Rock Drive construction support site (BL2). Native vegetation throughout the construction footprint, particularly larger tracts of native vegetation within and next to the northern extent of the construction footprint along the Wakehurst Parkway, offers potential foraging habitat to the species. Potential artificial roosting habitat (ie culverts and bridges) is also present throughout the construction footprint; however, targeted surveys within concrete culverts at Artarmon and Balgowlah, and a concrete underground walkway at Willoughby did not detect the presence of any roosting Large Bent-winged Bats. Areas surveyed for the project were not identified to support a maternity cave.
Little Bent-winged Bat (*Miniopterus australis*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was recorded during field surveys for the project in bushland near the Flat Rock Drive construction support site (BL2) and has been previously recorded in the northern extent of the construction footprint, along the Wakehurst Parkway. Native vegetation throughout the construction footprint, particularly larger tracts of native vegetation within and next to the northern extent of the construction footprint along the Wakehurst Parkway offers potential foraging habitat to the species. Potential artificial roosting habitat (ie culverts and bridges) are also present throughout the construction footprint; however, targeted surveys for the project at concrete culverts at Artarmon and Balgowlah, and a concrete underground walkway at Willoughby did not detect the presence of any roosting Little Bent-winged Bats.
Large-eared Pied Bat (*Chalinolobus dwyeri*)	Vulnerable (BC Act and EPBC Act)	High likelihood of occurrence in the construction footprint. This species' echolocation call was recorded at a dam approximately 125 metres from the construction footprint. The species has also been recently recorded in the Wakehurst Parkway east construction support site (BL13). All plant community types in the construction footprint are associated with the Large-eared Pied Bat. It is likely that the species uses native vegetation in the construction footprint for foraging and may be roosting in rocky habitat in proximity to the construction footprint along the Wakehurst Parkway.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Native vegetation throughout the construction footprint, particularly larger tracts of native vegetation within and next to the northern extent of the construction footprint along the Wakehurst Parkway offers potential foraging habitat to the species. Two hollow-bearing trees were identified within the construction footprint in proximity to the Wakehurst Parkway during field surveys for the project, which may provide roosting habitat. Culverts and bridges within the construction footprint also offer potential roosting habitat for the species. However, targeted surveys carried out for the project did not detect the presence of any roosting Eastern Coastal Free-tailed Bats.
Eastern Pygmy-possum (*Cercartetus nanus*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, database searches show that the species has been recently recorded in the Wakehurst Parkway east construction support site (BL13). Potential foraging and sheltering habitat for this species is present in native vegetation within and adjoining the northern extent of the construction footprint next to Wakehurst Parkway. These vegetated habitats support preferred foraging resources, due to the presence of a variety of banksia, eucalypt and bottlebrush species.
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Preferred foraging trees species (*Allocasuarina* and *Casuarina* species) occur within areas of native vegetation within and next to the construction footprint. The species was not observed to use a large tree hollow identified in the northern extent of the construction footprint next to the Wakehurst Parkway during field surveys. This tree hollow is located within an area unlikely to support preferred nesting habitat for the species.
Red-crowned Toadlet (*Pseudophryne australis*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, this species was recorded along the Wakehurst Parkway during investigations for the Northern Beaches Hospital road upgrade project. Riparian vegetation associated with unnamed ephemeral watercourses within open forest areas next to the Wakehurst Parkway offer potential sheltering, foraging and breeding habitat for the species.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Southern Brown Bandicoot (*Isoodon obesulus obesulus*)	Endangered (BC Act and EPBC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, it has previously been recorded in proximity to the construction footprint next to the Wakehurst Parkway. The construction footprint supports potential habitat for the species in native vegetation next to the Wakehurst Parkway.
Southern Myotis (*Myotis macropus*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, potential foraging habitat for this species is present within and next to the construction footprint within Middle Harbour, particularly along sheltered bays such as Sandy Bay and Shell Cove. There is some potential roosting habitat for this species within the construction footprint, due to the presence of human-made structures such as jetties, wharves along the Middle Harbour foreshore, existing culverts, bridges and buildings.
Varied Sittella (*Daphoenositta chrysoptera*)	Vulnerable (BC Act)	High likelihood of occurrence in the construction footprint. The species was not recorded in the construction footprint during field surveys. However, it has previously been recorded in the construction footprint by the Gore Hill Freeway.
White-bellied Sea Eagle (*Haliaeetus leucogaster*)	Vulnerable (BC Act) Migratory (EPBC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, this species has been previously recorded throughout Middle Harbour. Potential foraging habitat for the species is present in Middle Harbour within the construction footprint. Potential perching habitat is also present around Middle Harbour in trees along the foreshore at The Spit, Seaforth and Clontarf.
Barking Owl (*Ninox connivens*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Potential foraging habitat for this species is present within large tracts of native vegetation within and adjoining the northern extent of the construction footprint next to the Wakehurst Parkway. The species was not observed to utilise a large tree hollow identified at this location during field surveys, and the area is unlikely to support preferred nesting habitat for the species.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Eastern Osprey (*Pandion cristatus*)	Vulnerable (BC Act) Migratory (EPBC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Potential foraging habitat for this species is present within Middle Harbour. The areas within and next to the construction footprint are not known to support nesting habitat for the species.
Little Lorikeet (*Glossopsitta pusilla*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Potential foraging habitat for this species is present within landscaped areas throughout the construction footprint. Two hollow-bearing trees were identified within the construction footprint in proximity to the Wakehurst Parkway during field surveys for the project, which may provide roosting habitat.
Masked Owl (*Tyto novaehollandiae*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, potential foraging habitat for this species is present within areas of native vegetation within and next to the construction footprint along the Wakehurst Parkway, due to the presence of prey species. The species was not observed to utilise a large tree hollow identified within this area during field surveys for the project, with the areas within or next to the construction footprint unlikely to support preferred nesting habitat for the species.
Spotted-tailed Quoll (*Dasyurus maculatus*)	Vulnerable (BC Act) Endangered (EPBC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, large tracts of native vegetation within and adjoining the northern extent of the construction footprint next to the Wakehurst Parkway offer potential habitat for the species.
Square-tailed Kite (*Lophoictinia isura*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, potential foraging habitat for this species is present within the areas of native vegetation within and next to the construction footprint along the Wakehurst Parkway.

Species	Conservation significance[1]	Likelihood of occurrence in the construction footprint
Swift Parrot (*Lathamus discolor*)	Endangered (BC Act) Critically Endangered (EPBC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Nectivorous trees within the construction footprint offer marginal foraging habitat to the species; however, the construction footprint does not support preferred habitat for the species.
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Marginal habitat exists along the edge of the Wakehurst Parkway.
Brown Treecreeper (*Climacteris picumnus victoriae*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. Marginal habitat exists along the edge of the Wakehurst Parkway.
Endangered population		
Little Penguin (*Eudyptula minor*)	Endangered population (BC Act) Marine (EPBC Act)	High likelihood of occurrence in the construction footprint. This species was not recorded in the construction footprint during field surveys. However, this species has been previously recorded at several locations within Middle Harbour including at The Spit and Sailors Bay, and in the main channel of Middle Harbour. Potential foraging habitat for the species is present within and next to the construction footprint in Middle Harbour. No nesting habitat is present within the construction footprint, with nesting limited to the Manly area.

Note 1: BC Act refers to *Biodiversity Conservation Act 2016*
EPBC Act refers to *Environment Protection and Biodiversity Conservation Act 1999*

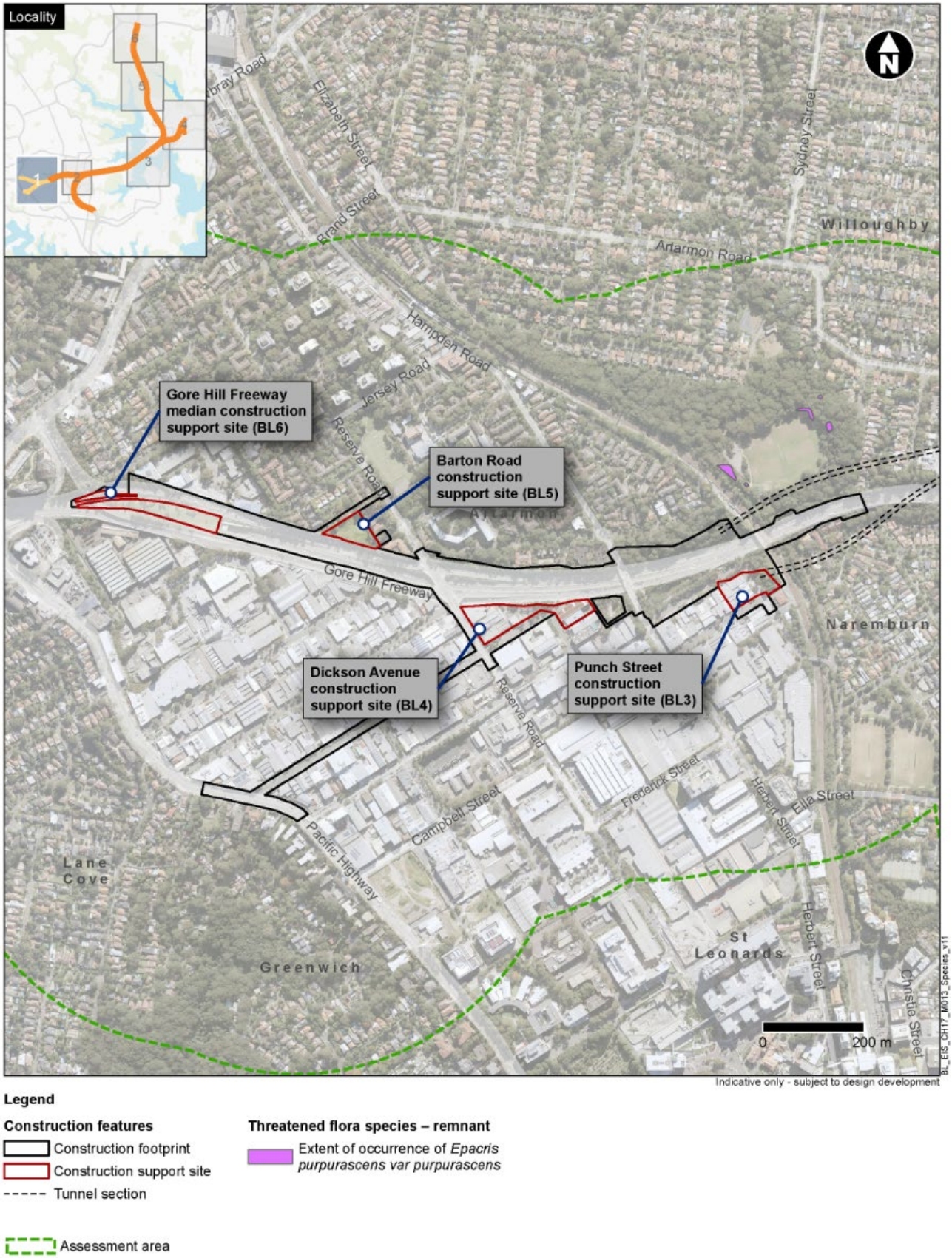


Figure 19-6 Recorded threatened species (map 1)

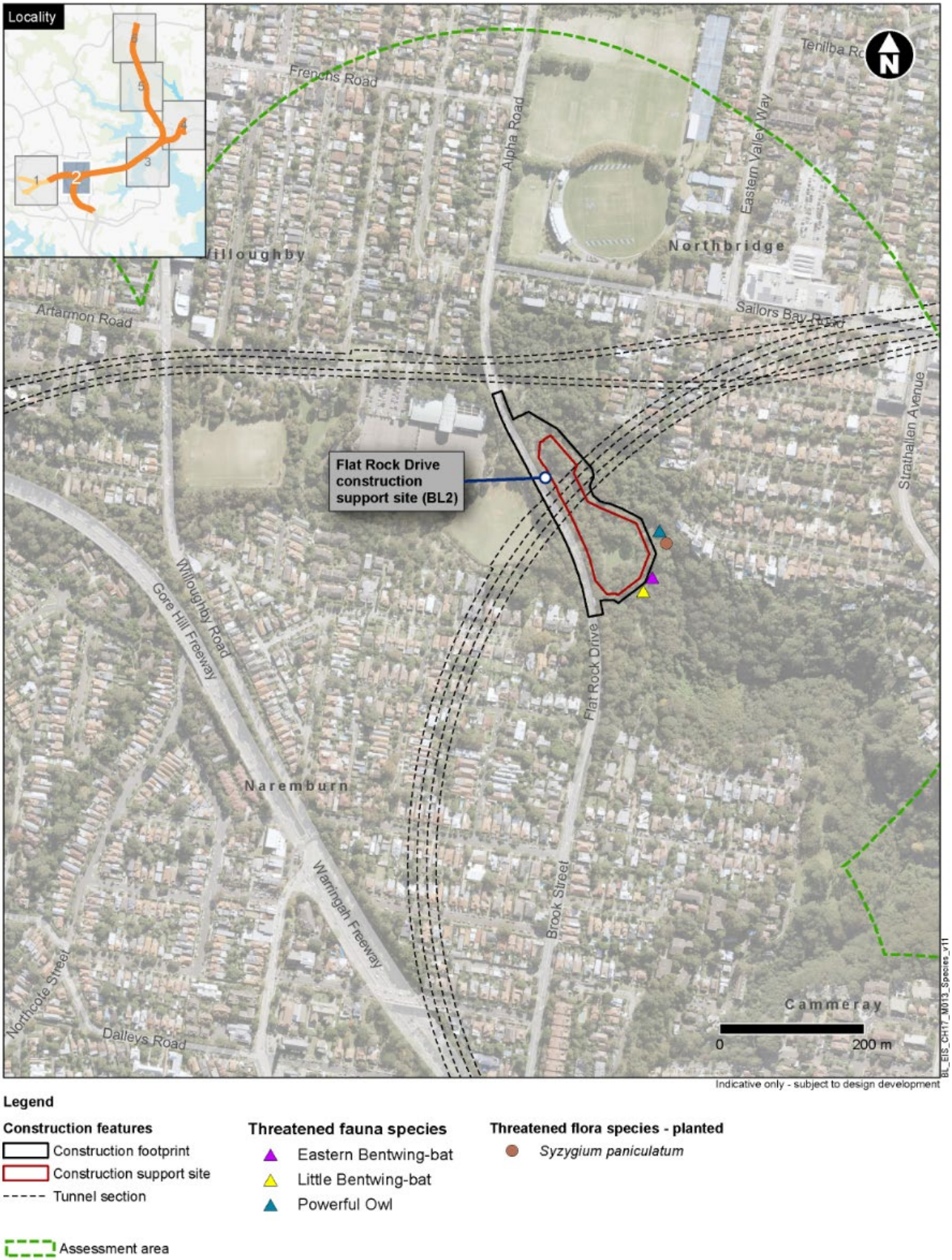
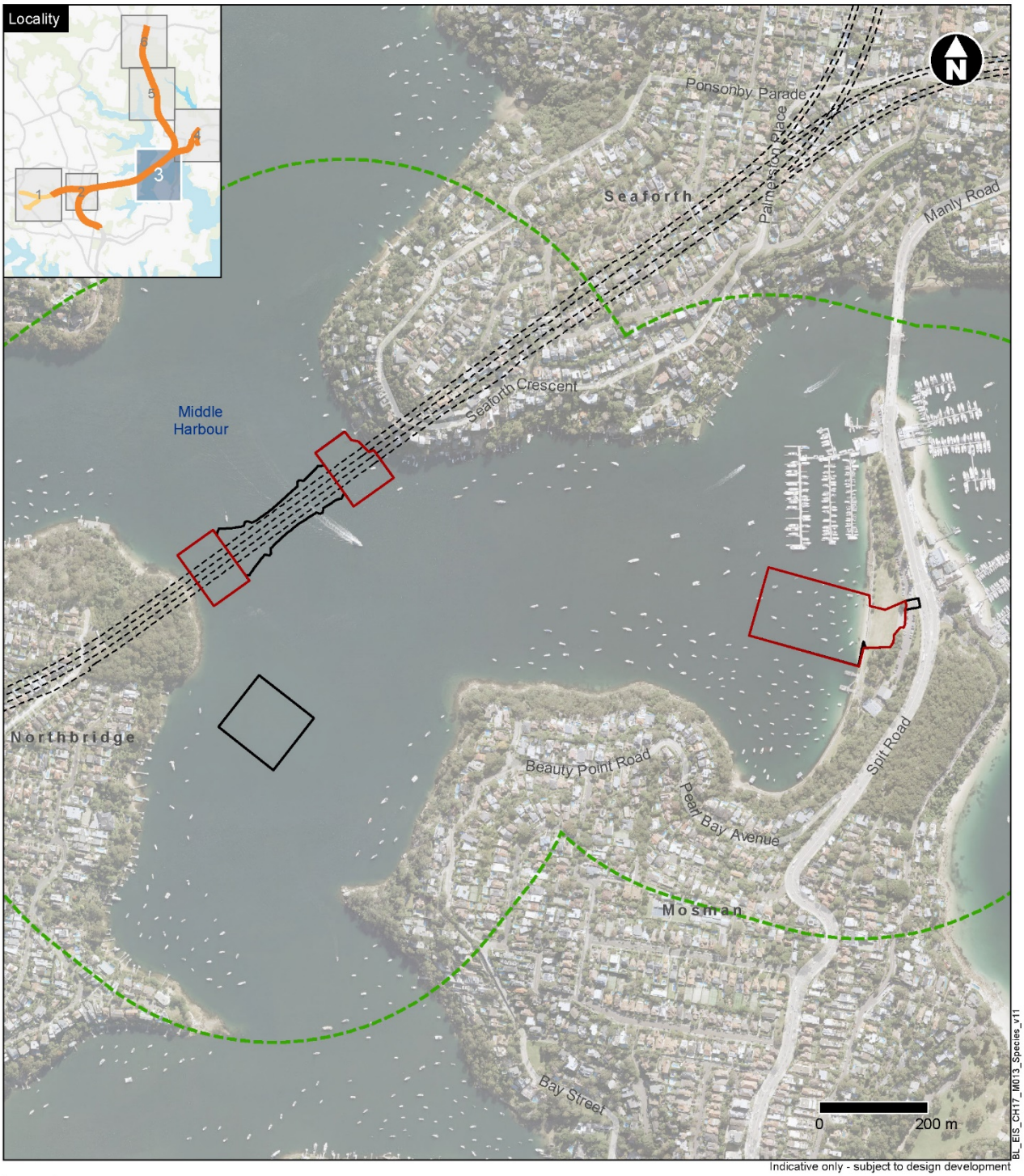


Figure 19-7 Recorded threatened species (map 2)



Legend

Construction features

- Construction footprint
- Construction support site
- ----- Tunnel section

- Assessment area

Figure 19-8 Recorded threatened species (map 3)

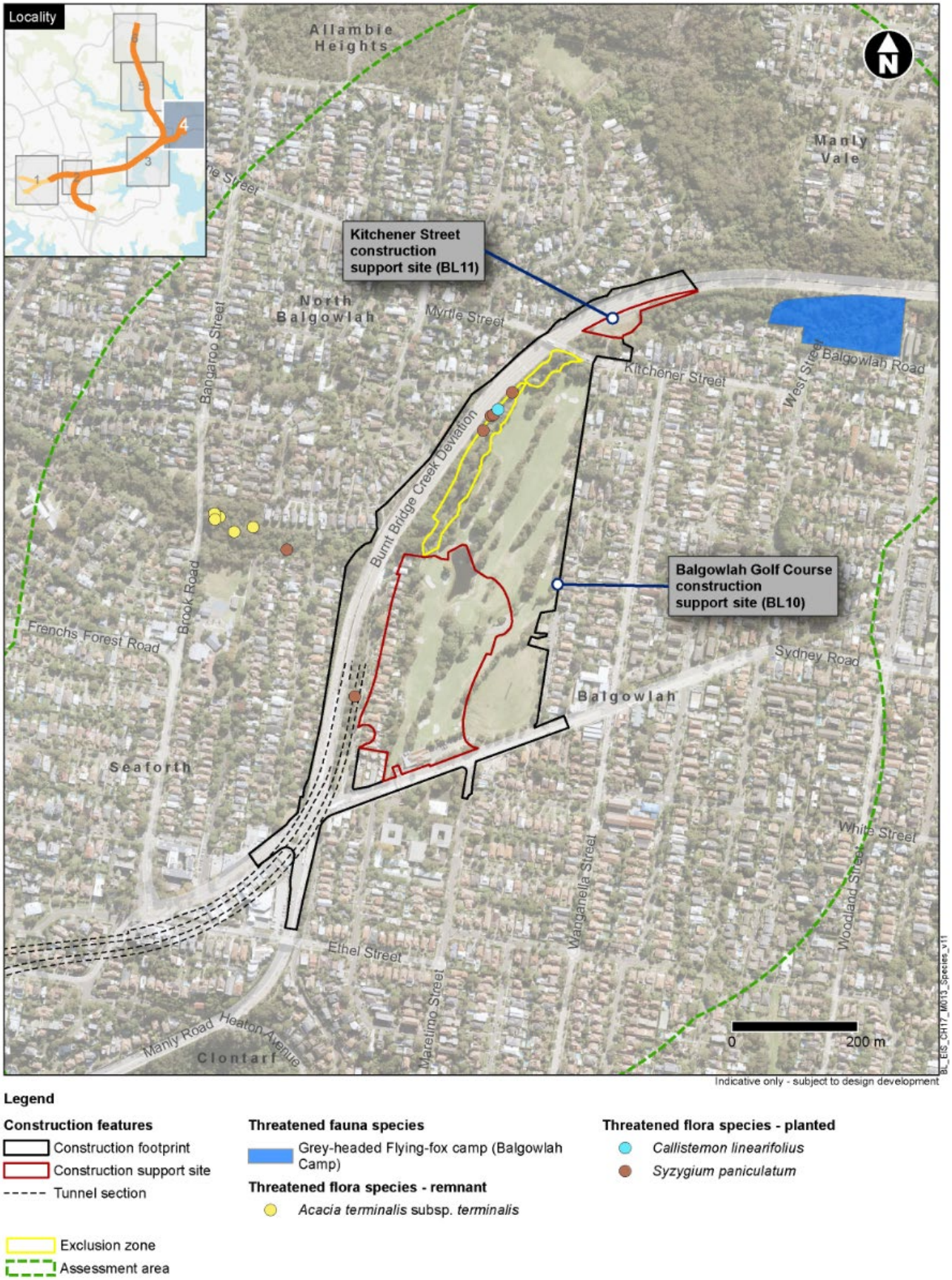


Figure 19-9 Recorded threatened species (map 4)

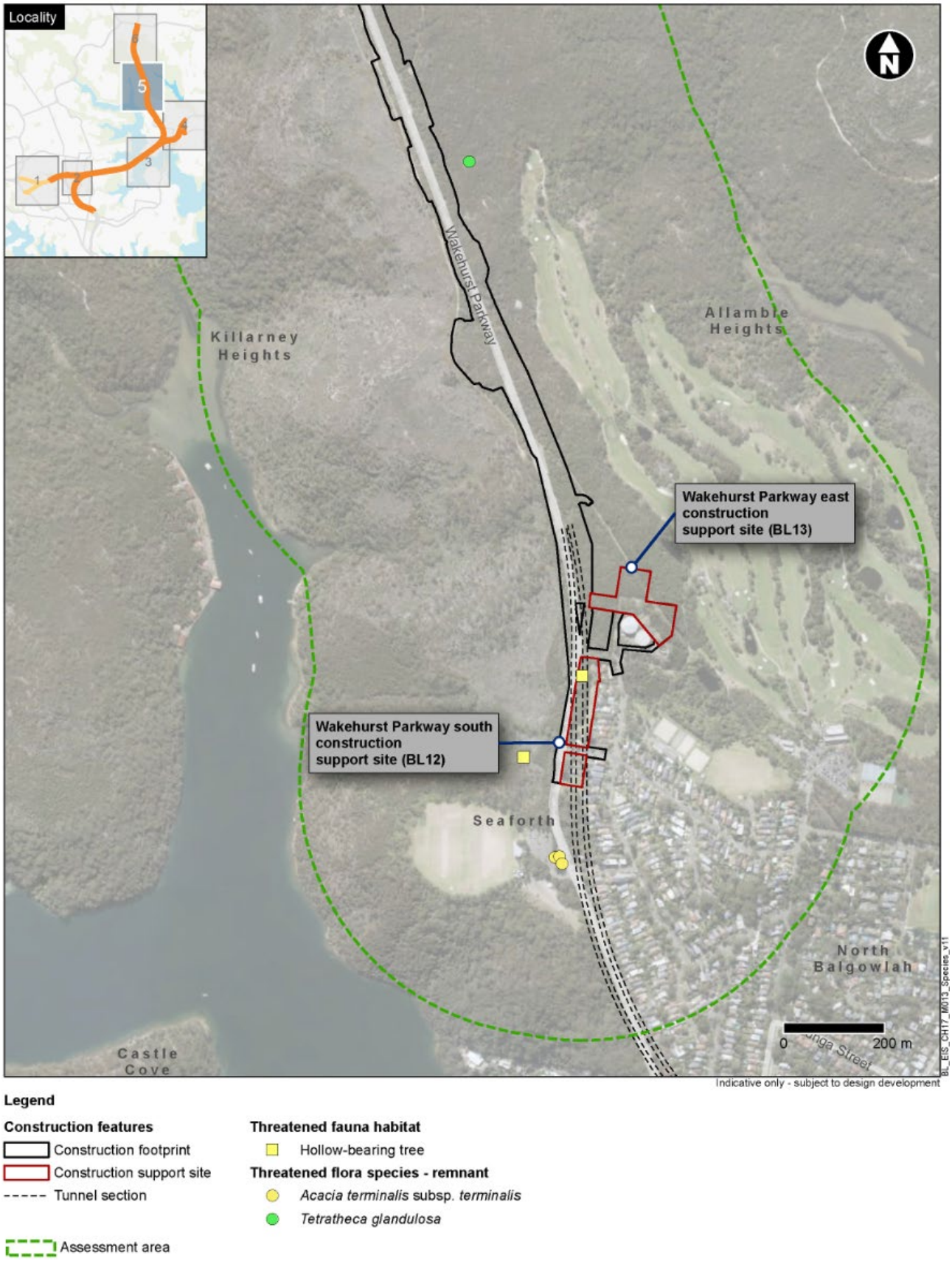


Figure 19-10 Recorded threatened species (map 5)

Figure 19-11 Recorded threatened species (map 6)

19.3.3 Aquatic biodiversity

Aquatic habitat

Table 19-8 provides a summary of the aquatic freshwater habitats associated with the waterways within and downstream of the construction footprint. Key fish habitat classification and whether the waterway is considered a sensitive receiving environment is discussed in Annexure D (Freshwater ecology impact assessment) of Appendix S (Technical working paper: Biodiversity development assessment report).

Manly Dam, Manly Creek and the natural reaches of Flat Rock Creek have been identified as Type 1 highly sensitive key fish habitat and sensitive receiving environments. The classification of waterways regarding their status as sensitive receiving environments is discussed in Chapter 17 (Hydrodynamics and water quality) and summarised in Table 19-8.

The quality of these waterways was also assessed as part of the surface water assessment in Appendix O (Technical working paper: Surface water quality and hydrology), the results of which are provided in Chapter 17 (Hydrodynamics and water quality). In general, the waterways potentially impacted by the project are largely influenced by surrounding urban development with occurrences of contaminants such as suspended sediments, heavy metals and persistent organic pollutants including from stormwater, wastewater overflows and leachate from contaminated lands. Some of these waterways have also been substantially modified from natural channels to artificial, concrete-lined channels to accommodate higher volume and velocity flows from an increase in urban, impervious surfaces.

Although no fish or macroinvertebrate sampling was carried out as part of the aquatic assessment, the waterways in the aquatic biodiversity study area are considered suitable for the majority of common and exotic fish species typically found in waterways in the Sydney region. The most suitable habitat are the natural reaches of these waterways (Manly Dam, Manly Creek and some reaches of Flat Rock Creek).

Common native fish species typically found in waterways in the Sydney region include Short-finned and Long-finned Eels (*Anguilla australis* and *A. reinhardtii*), Common Galaxias (*Galaxias maculatus*), Australian Bass (*Macquaria novemaculeata*) and a number of gudgeon species. Exotic fish species are also widespread across the Sydney region.

Sydney's waterways typically support an array of macroinvertebrates including the Sydney Crayfish (*Euastacus australasiensis*) and the Freshwater Shrimp (*Paratya australiensis*) as well as small insects and freshwater mussels. These species depend on healthy waterways and access to diverse habitats including swamps, floodplains, wetlands, streams and rivers, of which only streams occur within the aquatic biodiversity study area.

The Manly Creek catchment, including the middle and lower reaches of Manly Creek, is home to the only confirmed population of Climbing Galaxias (*Galaxias brevipinnis*) in the Sydney area. Although not a threatened or protected species, the community prepared an action plan for its protection in the Manly Creek catchment (Salkavich et al., 2002). The action plan considers water pollution to be among the threats to this population.

Within the eastern side of the Burnt Bridge Creek catchment is the Balgowlah Golf Course stormwater harvesting dam which was completed in 2013. The dam is a four megalitre pond/dam with a maximum nominal water depth of 2.5 metres which is used irrigate the Balgowlah Golf Course. However, given its recent construction and disconnection with natural watercourses, the Balgowlah Golf Course stormwater harvesting dam is unlikely to provide potential habitat for native fish.

Threatened ecological communities, species and endangered populations

No threatened freshwater fauna, flora species or ecological communities or endangered populations listed under the *Fisheries Management Act 1994* and/or the *Environment Protection and Biodiversity Conservation Act 1999* have been identified as likely to occur within the aquatic biodiversity study area.

Freshwater migratory species

No freshwater migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* are considered likely to occur within the aquatic biodiversity study area.

Table 19-8 Aquatic freshwater habitats

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
Willoughby Creek at Cammeray, located about 60 metres east of the Cammeray Golf Course construction support site (BL1)	• The area of the creek next to Primrose Park tennis courts was identified as a semi-natural waterway, partially modified to accept stormwater discharge. Around 10 metres downstream of the survey location, the creek contains entrenched bedrock and a concrete-lined channel. A natural bedrock/boulder waterfall and a shallow plunge pool is located around 50 metres upstream of the survey location • Banks in the upstream section of the creek are vegetated by dense tree cover and shrubs with a groundcover consisting primarily of ferns. Walking tracks and tennis courts are present on the south east bank, and on the opposite bank the riparian vegetation corridor is around 70 metres wide and continuous. Further downstream, the riparian corridor includes Primrose Park sporting fields • Moderate condition riparian vegetation including commonly occurring native tree species are present within remnant riparian vegetation, such as Black Wattle (*Callicoma serratifolia*), Coachwood (*Ceratopetalum apetalum*), Blueberry Ash (*Elaeocarpus reticulatus*) and Cheese Tree (*Glochidion ferdinandi*) • Localised infestations of Large Leaf Privet (*Ligustrum lucidum*) and Lantana (*Lantana camara*) are also known to occur • This riparian vegetation provides shade and potentially other ecological functions (eg a source of food and habitat, in the form of wood debris, for aquatic biota). No instream vegetation or woody debris were identified within the section of the creek inspected. Some rocky features are present.	Type 3 minimally sensitive key fish habitat Class 3 minimal key fish habitat for fish passage.	No

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
Flat Rock Creek at Naremburn, located directly east of, and within Flat Rock Drive construction support site (BL2) and above the ramp tunnel alignment at Artarmon (from Gore Hill Freeway Connection). Further detail on Flat Rock Creek illustrating the various linings is provided in Figure 17-2 of Chapter 17 (Hydrodynamics and water quality).	• The upper reaches of Flat Rock Creek in Artarmon consist of a covered concrete lined drain and vegetated floodway associated with the Artarmon Reserve detention basin. The creek is a concrete lined channel as it crosses the Gore Hill Freeway for the first time and continues in an open lined channel as it meanders east and crosses back under the Gore Hill Freeway. The creek is installed within an underground box culvert between Willoughby Road, Willoughby and 150 metres east of Flat Rock Drive, Northbridge.	Not key fish habitat.	No
	• Flat Rock Creek was identified as freshwater upstream of its confluence with Quarry Creek • 150 metres east of Flat Rock Drive and upstream of Quarry Creek, the channel consists of a steep gorge with natural bedrock and large boulders. Dense riparian vegetation encroached on the channel is likely due to frequent low flow conditions in the main channel. Riparian vegetation consists of native, tall, woody trees, dense shrubs and groundcover. In the upper reaches, instream woody debris (less than three metres long) provides aquatic habitat.	Type 1 highly sensitive key fish habitat Class 2 moderate key fish habitat for fish passage.	Yes
	• Flat Rock Creek was identified as estuarine downstream of the confluence with Quarry Creek • Downstream of Quarry Creek, the channel is subjected to stormwater discharge with evidence of channel and bank erosion a likely result of high flow events. The south bank consists of dense native and exotic, overhanging riparian vegetation. Fish habitat includes some undercut banks with potential to provide refuge as well as large woody debris (greater than three metres long) and dense instream patches of Common Reed (*Phragmites australis*) present in some sections.	Type 1 highly sensitive key fish habitat Class 1 major key fish habitat for fish passage.	Yes

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
Existing aboveground watercourse within the northern extent of Flat Rock Reserve in the Flat Rock Drive construction support site (BL2)	• This watercourse drains through a 0.40 metre underground pipe at the Small Street roundabout, but also receives catchment runoff from the escarpment which forms the north eastern bank. This escarpment bank is steep, ranging between three and 10 metres along the watercourse and is generally comprised of sandstone • The natural channel bed is generally bedrock with a layer of sediment and detritus and colonised by exotic grasses and forbs where there is no flow. Concrete or rock is laid on the channel bed in sections exposed to higher flow velocities. Channel banks are steep, and the watercourse width ranges between two and 10 metres. Riffles and pools were also observed • Dense native and exotic riparian vegetation occurs along both banks. The escarpment is well vegetated with a mix of native and exotic woody trees, ferns with a dense midstorey and groundcover.	Not key fish habitat.	No
Burnt Bridge Creek at North Balgowlah, located next to the following temporary construction support sites: Balgowlah Golf Course construction support site (BL10) Kitchener Street construction support site (BL11). Further detail on Burnt Bridge Creek illustrating the various linings is provided in Figure 17-3 of Chapter 17 (Hydrodynamics and water quality).	• The upstream reach of Burnt Bridge Creek, located upstream of the existing Burnt Bridge Creek Deviation culverts, is mostly a natural channel with rocky outcrops and low levels of sedimentation over bedrock. Culvert crossings act as potential barriers to fish passage during low flows. Exotic Parrots Feather plants (*Myriophyllum aquaticum*) and native eels (*Anguilla* spp.) were observed in the deeper pools. Emergent woody debris along the banks have potential to provide habitat for freshwater fish and invertebrates during high flows. The channel receives substantial shading from the native riparian overstorey of She-oaks (*Casuarina* spp.). However, the width of the riparian corridor is limited by residences and landscaped gardens, and exotic vegetation was prevalent in the understorey. There is also a large trunk sewer line installed along the creek alignment which would indicate substantial disturbance during its installation	Type 2 moderately sensitive key fish habitat Class 2 moderate key fish habitat for fish passage.	No

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
	• To the east of the existing Burnt Bridge Creek Deviation culverts, the downstream reach of Burnt Bridge Creek is a wider channel with modified bedrock and sections of concrete and boulder retaining walls through the golf course with the trunk sewer line noted above installed along the length of the creek in the golf course area. This section of the watercourse is known to experience hazardous flooding velocities (up to five to eight metres per second). A weir has created a deeper pool where organic debris has accumulated and exotic macrophytes have established. A thin corridor of native riparian vegetation is located next to the channel, some of which overhangs instream and provides shading along sections of the reach • Further downstream, the Kitchener Street bridge spans the width of the channel along this reach with two large box culverts perched over bedrock. Flows are restricted to partially connected pools. Erosion and bank undercutting were observed along this reach. The width of riparian corridor along this reach is limited by nearby residences and Burnt Bridge Creek Deviation. The riparian corridor provides moderate shading over the channel, with small woody debris instream.		
Manly Creek (also known as Curl Curl Creek), located about 300 metres east of the northern extent of the construction footprint	• The substratum of Manly Creek comprises mostly sandstone bedrock, boulders and cobbles and is inundated by a series of connected pools, runs and riffles with some unconsolidated materials accumulated in the pools • The banks are low and large snags and boulders provide potential fish habitat at this location • The riparian corridor consists of woody vegetation.	Type 1 highly sensitive key fish habitat Class 1 major key fish habitat for fish passage.	Yes

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
Manly Dam located to the east of the construction footprint	• Manly Dam contains large areas of emergent, native/exotic aquatic macrophytes including native sedges (*Eleocharis* spp.) and the exotic Yellow Waterlily (*Nymphaea mexicana*) • The dam supports an extensive wetland community, and is located within 100 metres of areas of Coastal Sandstone Gully Forest groundwater dependent ecosystem and Coastal Upland Damp Heath Swamp endangered ecological community • Shallow wetland areas scattered around the dam foreshore support native and exotic emergent macrophytes that offer potential habitat for Common Eastern Froglet (*Crinia signifera*), Eastern Dwarf Tree Frog (*Litoria fallax*) and Eastern Banjo Frog (*Limnodynastes dumerilii*) • Deeper parts of the dam support Eastern Long-necked Turtles (*Chelodina longicollis*), Australian Bass (*Macquaria novemaculeata*) and Silver Perch (*Bidyanus bidyanus*).	Type 1 highly sensitive key fish habitat Class 1 sensitive key fish habitat for fish passage.	Yes
Trefoil Creek, located about 300 metres north of the northern extent of the construction footprint	• Trefoil Creek is a narrow (less than one metre wide), natural, ephemeral channel located within a steep gully characterised by small, disconnected pools with a sandy silt substratum overlaying bedrock. Accumulated debris and log jams are common along the reach and likely to be mobilised during high flows • Riparian vegetation comprises dense, overhanging native and exotic vegetation providing substantial riparian shading over ephemeral and disconnected pools.	Type 2 moderately sensitive key fish habitat Class 3 minimal key fish habitat for fish passage.	Yes

Location	Habitat features	Key fish habitat classification	Sensitive receiving environment
Unnamed small, ephemeral watercourses located within the construction footprint next to the Wakehurst Parkway	• Riparian vegetation includes Sydney Peppermint – Smooth-barked Apple – Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, offering habitat to locally occurring amphibian, reptile and mammal species, due to the diversity of fauna habitat features available (ie rocks and logs, well-developed leaf litter and intact native vegetation) • Standing pools and riffles with an ephemeral flow varying in width and depth are likely to provide sheltering, foraging and breeding habitat for numerous species of amphibian, reptile, mammal, invertebrate and bird including threatened species such as Red-crowned Toadlet given the presence of substantial fauna habitat (ie logs, leaf litter, rock).	Type 3 minimally sensitive key fish habitat Class 3 minimal key fish habitat for fish passage.	No
Wakehurst Golf Course dam, located about 100 metres north-east of the Wakehurst Parkway east construction support site (BL13)	• This dam is a freshwater lagoon, bound by sandstone escarpment to the west and levee banks to its north, east and south and nested within the bushland reserve between the Wakehurst Parkway and Wakehurst Golf Course • Riparian vegetation includes mostly dense, native vegetation with some exotic understorey • Some fringing areas of native emergent macrophytes (*Eleocharis* spp.) and filamentous green algae were recorded • A vegetated drainage line discharges into the dam. Upstream sections were vegetated with shrubs, ferns, grasses and forbs or layered with detritus. No instream macrophytes were observed although moss was observed in some sections.	Not key fish habitat.	No

19.3.4 Groundwater dependent ecosystems

A search of the *National Atlas of Groundwater Dependent Ecosystems* (BOM, 2018) did not identify any groundwater dependent ecosystems within the construction footprint. However, three areas of groundwater dependent ecosystems may rely on subsurface groundwater associated with local waterways within, or close to the construction footprint. These groundwater dependent ecosystems are outlined in Table 19-9 and shown on Figure 19-12.

No high priority groundwater dependent ecosystems (as defined by the Department of Planning, Industry and Environment (Water)) would be located within or next to the construction footprint.

Table 19-9 Groundwater dependent ecosystems mapped by BOM (2018) in proximity to the project

Location of mapped groundwater dependent ecosystem	Distance from the project	Mapped ecosystems
Upper reaches of Flat Rock Creek at Munro Park – moderate to high potential for terrestrial groundwater dependent ecosystem	About 280 metres south-east of the tunnel alignment and the Flat Rock Drive construction support site (BL2)	Coastal Sandstone Gully Forest Sandstone Riparian Scrub Coastal Sand Forest
Bates Creek – moderate to high potential for terrestrial groundwater dependent ecosystem	About 550 metres west of the Wakehurst Parkway surface road works	Estuarine Mangrove Forest Seagrass Meadow Coastal Sandstone Gully Forest
Manly Dam Reserve – moderate potential for terrestrial groundwater dependent ecosystem	About 650 metres east of the Wakehurst Parkway surface road works	Coastal Sandstone Gully Forest Coastal Sandstone Plateau Heath

Coastal Upland Swamp in the Sydney Basin Bioregion, listed as Endangered under the *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999*, is mapped near the construction footprint. While it is not mapped as a groundwater dependent ecosystem within the *National Atlas of Groundwater Dependent Ecosystems* (BOM, 2018), this threatened ecological community may also be sensitive to changes to groundwater flows. A review of the regional vegetation mapping by OEH (2016), as well as ground truthing, identified that the closest areas of Coastal Upland Swamp to the construction footprint are two patches 95 metres west of the Wakehurst Parkway in Garigal National Park and one small patch north of Bantry Bay Oval, about 135 metres to the south-east of the construction footprint. The extent of groundwater dependence of both of these areas of Coastal Upland Swamp, or their connectivity to other areas of groundwater, is not known.

19.3.5 Wetlands and conservation areas

No wetlands listed under the State Environmental Planning Policy (Coastal Management) 2018 are located within the aquatic biodiversity study area. There are no wetlands of international importance within the construction footprint. Therefore, impacts to wetlands and conservation areas are not assessed further.

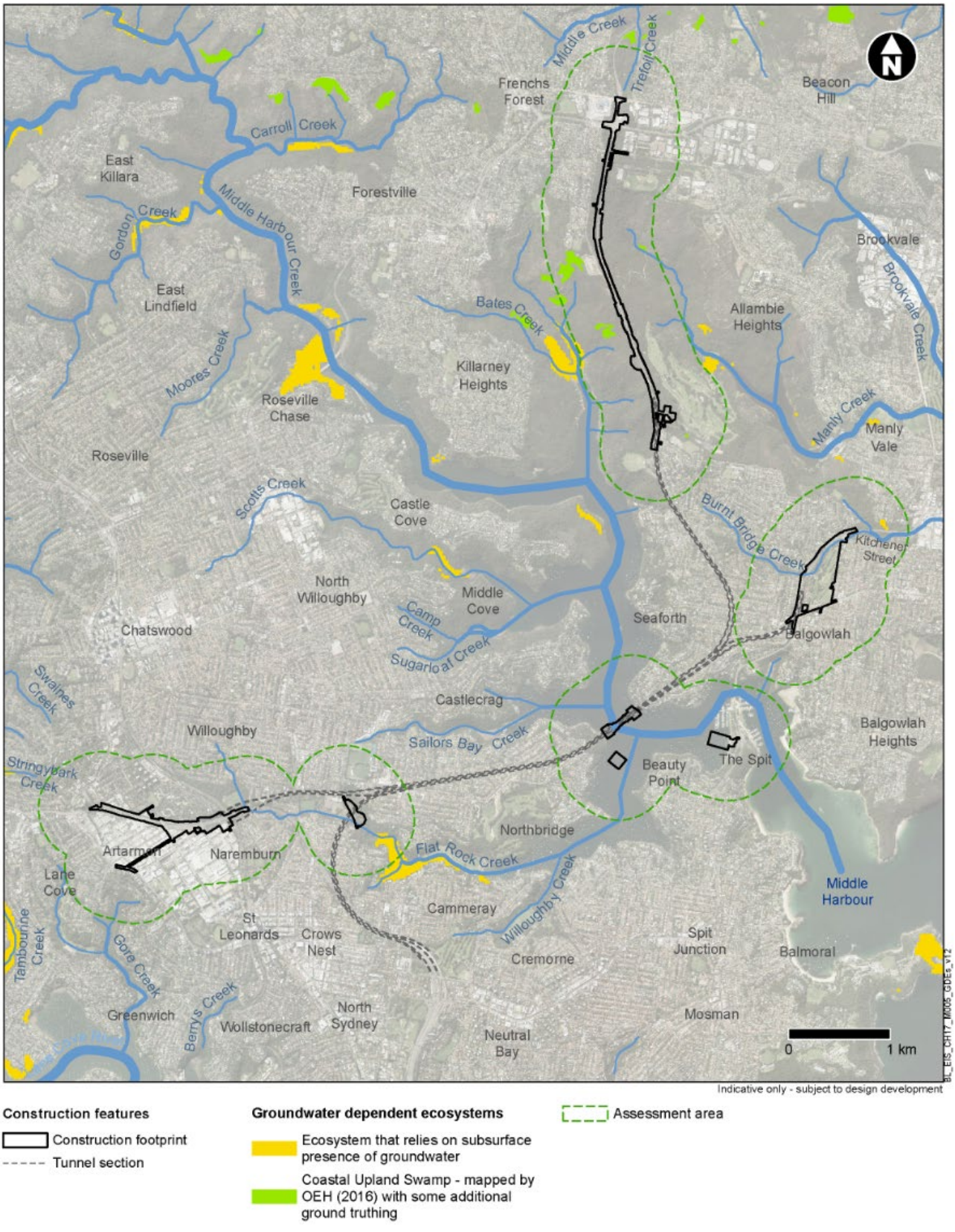


Figure 19-12 Distribution of groundwater dependent ecosystems

19.3.6 Marine biodiversity

Marine habitats

Eight marine habitat types were identified within the marine biodiversity study area and are shown in Figure 19-13. The habitats and relevant key fish habitat classifications as defined in the *Policy and guidelines for fish habitat conservation and management* (NSW DPI, 2013) are summarised in Table 19-10.

No critical habitats listed on State or Commonwealth registers of critical habitat occur within the marine biodiversity study locality.

Table 19-10 Marine habitats within the marine biodiversity study area

Key fish habitat classification	Marine habitat
Highly sensitive key fish habitat (Type 1)	Seagrass
	Saltmarsh
	Subtidal rocky reef
Moderately sensitive key fish habitat (Type 2)	Intertidal rocky shore
	Mangrove
	Intertidal sand and mudflat
Minimally sensitive key fish habitat (Type 3)	Deepwater soft sediment
	Open water

Two natural sills occur within the harbour at The Spit and Grotto Point. These natural sills in some circumstances could interact with hydrology, resulting in natural situations arising where dissolved oxygen levels in the bottom layers at the sills is reduced. Based on average annual rainfall patterns, the conditions leading to dissolved oxygen depletion near the bed of the harbour are likely to occur naturally a few times per year, particularly during the warmer late summer and autumn period.

The occurrence of these events may result in mortality to some benthic (bottom dwelling) infauna (animals which live in the sediments on the floor of a waterbody) and epifauna (animals living on the surface of the bed of a harbour or riverbed) within the deepest parts of Middle Harbour. However, fish and sharks would be able to avoid these environments and any impacts that would otherwise result from these naturally occurring events. Although there would be some naturally occurring mortality of benthic fauna associated with these events, recolonisation would typically occur through natural processes, with these communities likely to be resilient to these types of disturbances.

Threatened marine ecological communities, species and endangered populations

Saltmarsh and seagrass (*Posidonia australis)* meadow communities occur within the marine biodiversity study area. These two marine threatened ecological communities are listed under the *Fisheries Management Act 1994* and the *Environment Protection and Biodiversity Conservation Act 1999* (refer to Table 19-11).

Although the Subtropical and temperate coastal saltmarsh community occurs within and around Middle Harbour, it has not been identified in the project area.

The fragmented patches of seagrass within the marine biodiversity study area at Explosives Reserve, Castlecrag, Clive Park, Beauty Point, Seaforth and Brady Point do not meet the condition thresholds to be considered part of the *Posidonia australis* meadows of the Manning-Hawkesbury ecoregion listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999*. The seagrass patches are, however, consistent with the *Posidonia australis* endangered population listed under the *Fisheries Management Act 1994*.

Table 19-11 Threatened marine ecological communities in the marine biodiversity study area

Marine ecological community	Conservation significance[1]
Seagrass (*Posidonia australis*)	Endangered population (FM Act) Endangered (EPBC Act)
Subtropical and temperate coastal saltmarsh	Protected (FM Act) Vulnerable (EPBC Act)

1. FM Act = *Fisheries Management Act 1994*
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

Two listed marine fish species were identified as having a high likelihood of occurrence within the project area, Black Rockcod (*Epinephelus daemelii*) and White's Seahorse (*Hippocampus whitei*). These species have a high likelihood of occurrence due to the presence of suitable habitat within the project area. In addition, nine listed marine species were identified as having a moderate likelihood of occurrence within the project area.

White's Seahorse is listed as endangered under the *Fisheries Management Act 1994* and has been nominated for threat-listing under the *Environment Protection and Biodiversity Conservation Act 1999*. A preliminary assessment of significance under the *Environment Protection and Biodiversity Conservation Act 1999* has been carried out for White's Seahorse for completeness.

Details of the 11 listed marine species likely to occur within the project area are provided in Table 19-12.

Fauna passage is not currently affected by the natural sills within the harbour, with fish, sharks, marine mammals and marine turtles able to transit through these shallow waters to deeper waters upstream, including areas within and surrounding the project area.

Migratory marine species

No migratory marine species listed under the *Environment Protection and Biodiversity Conservation Act 1999* have high or moderate likelihood of occurrence in the marine biodiversity study area.

Table 19-12 Threatened marine species known or likely to occur in the project area

Species	Conservation significance[1]	Likelihood of occurrence in the project area
Black Rockcod (*Epinephelus daemelii*)	Vulnerable (FM Act) Vulnerable (EPBC Act)	High likelihood of occurrence in the project area. Suitable habitat for this species is present within the project area. Suitable habitat for this species within the project area includes medium to high relief subtidal rocky reef areas, which are present along the shorelines of Middle Harbour.
White's Seahorse (*Hippocampus whitei*)	Endangered (FM Act) Nominated for threat-listing, marine (EPBC Act)	High likelihood of occurrence in the project area. Suitable habitat for this species is present within the project area, including low, medium and high relief subtidal rocky reef areas and *Halophila*, *Zostera* and *Posidonia* seagrass meadows.
New Zealand Fur-seal (*Arctocephalus forsteri*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the project area. Foraging habitat and suitable rest areas are present within the project area.
Australian Fur-seal (*Arctocephalus pusillus doriferus*)	Vulnerable (BC Act)	Moderate likelihood of occurrence in the project area. Foraging habitat and suitable rest areas are present within the project area.
Loggerhead Turtle (*Caretta caretta*)	Endangered (BC Act) Endangered, migratory, marine (EPBC Act)	Moderate likelihood of occurrence in the project area. This species has been anecdotally recorded within the marine biodiversity study area; however high-quality preferred habitat for this species is not present within the project area.
Green Turtle (*Chelonia mydas*)	Vulnerable (BC Act) Vulnerable, migratory, marine (EPBC Act)	Moderate likelihood of occurrence in the project area. This species has been anecdotally recorded within the marine biodiversity study area, however high-quality preferred habitat for this species is not present within the project area.
Leatherback Turtle (*Dermochelys coriacea*)	Endangered (BC Act) Endangered, migratory, marine (EPBC Act)	Moderate likelihood of occurrence in the project area. This species has been anecdotally recorded within the marine biodiversity study area; however high-quality preferred habitat for this species is not present within the project area.

Species	Conservation significance[1]	Likelihood of occurrence in the project area
Hawksbill Turtle (*Eretmochelys imbricata*)	Vulnerable, migratory, marine (EPBC Act)	Moderate likelihood of occurrence in the project area. This species has been anecdotally recorded within the marine biodiversity study area; however high-quality preferred habitat for this species is not present within the project area.
Flatback Turtle (*Natator depressus*)	Vulnerable, migratory, marine (EPBC Act)	Moderate likelihood of occurrence in the project area. This species has been anecdotally recorded within the marine biodiversity study area; however high-quality preferred habitat for this species is not present within the project area.
Grey Nurse Shark (*Carcharias Taurus*)	Critically endangered (FM Act) Critically endangered (EPBC Act)	Moderate likelihood of occurrence in the project area. Foraging habitat for this species is present within the project area.
White Shark (*Carcharodon carcharias*)	Vulnerable (FM Act) Vulnerable, migratory (EPBC Act)	Moderate likelihood of occurrence in the project area. Foraging habitat for this species is present within the project area.

Note 1: FM Act refers to *Fisheries Management Act 1994*
BC Act refers to *Biodiversity Conservation Act 2016*
EPBC Act refers to *Environment Protection and Biodiversity Conservation Act 1999*

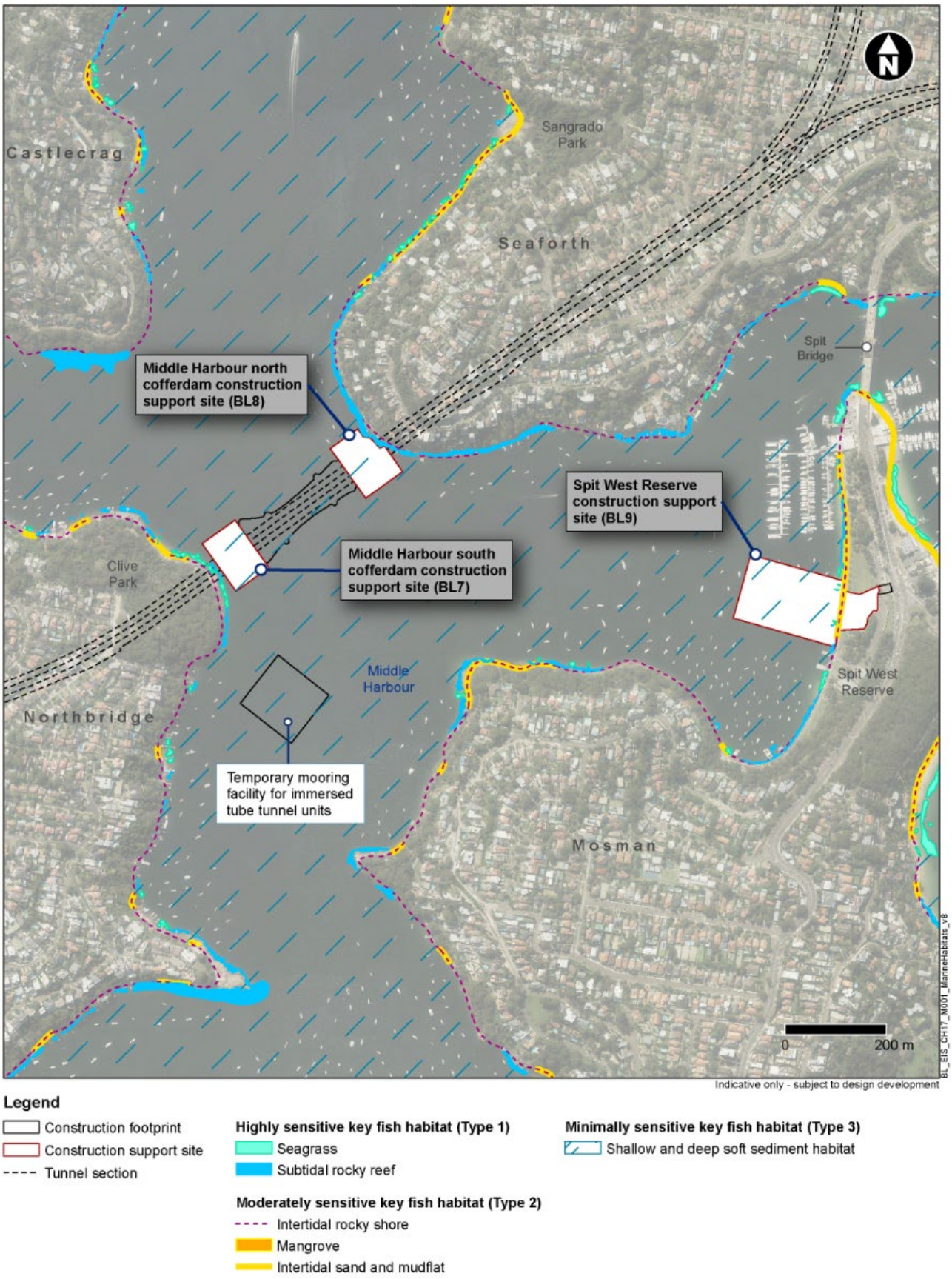


Figure 19-13 Marine habitats within the marine biodiversity study area

19.4 Avoidance and minimisation

Based on the outcomes of the desktop assessment and field surveys, opportunities to avoid or minimise biodiversity impacts were considered as part of the project design development process. Chapter 4 (Project development and alternatives) describes the alternatives that were considered as part of the project development process and explains the selection of the preferred corridor and design.

Five corridor alternatives were considered for the project; four of these included upgrading the Wakehurst Parkway, where there is the potential for greater biodiversity impacts compared to the remainder of the project. The five corridors were evaluated by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors to identify the solution that best balanced technical, community and environmental outcomes while meeting the transport objectives.

The project largely avoids surface impacts to terrestrial biodiversity values by tunnelling, and the preferred corridor avoids impacts associated with other options to the areas around Parriwi Park and Fisher Bay Bushland Reserve, where threatened species have been recorded.

Throughout the refinement of the preferred corridor design, a number of elements have been included to avoid and minimise impacts on biodiversity during construction and in operation of the project, including:

- The Flat Rock Drive construction support site (BL2) was chosen to be located in an area of Flat Rock Reserve which was previously used as a landfill site until 1985. This area contains mostly native revegetation, avoiding impact to surrounding remnant vegetation. Refer to Section 3 of Appendix S (Technical working paper: Biodiversity development assessment report) for further details
- The preferred design for the connection to and from the Burnt Bridge Creek Deviation and surface road works at Balgowlah have reduced impacts to Burnt Bridge Creek to the east and west of Burnt Bridge Creek Deviation, including potentially reduced impact on mature trees in the golf course compared to other options. Furthermore, direct impact of the Burnt Bridge Creek riparian corridor has been reduced by establishing an exclusion zone around riparian native vegetation adjoining the creek
- The preferred design for the connection to Sydney Road from the Burnt Bridge Creek Deviation avoids the need to demolish and replace the Kitchener Street bridge which reduces potential noise impacts and duration of impacts to the Grey-headed Flying-fox camp at Balgowlah compared to other options
- Impacts to terrestrial fauna connectivity have been minimised by providing a number of dedicated fauna crossings spanning the Wakehurst Parkway that would provide fauna connectivity between Garigal National Park to the west and Manly Dam Reserve to the east. Fauna fencing would be provided for the length of the Wakehurst Parkway to reduce the risk of vehicle strike and fauna mortality, and guide fauna towards crossing structures
- Impacts to the Duffys Forest endangered ecological community have been avoided as far as possible by optimising the location of the tunnel portals and permanent tunnel support facilities
- Tunnelling has largely avoided impacts to areas supporting groundwater dependent ecosystems, apart from some vegetation at Flat Rock Creek/Quarry Creek that would be subject to potential water table drawdown impacts
- The project design and construction works have been developed to largely avoid direct impacts to seagrass and other sensitive marine habitat areas in Middle Harbour
- The construction methodology for the crossing of Middle Harbour and immersed tube tunnel alignment have been designed to reduce the construction footprint and avoid dredging of the sandbar at the entrance to Middle Harbour or dredging in the vicinity of the Spit West Reserve construction support site (BL9). The sandbar is considered one of the more sensitive marine habitat areas within Middle Harbour.

Further discussion on the avoidance and minimisation of biodiversity impacts is included in Section 4 of Appendix S (Technical working paper: Biodiversity development assessment report).

19.5 Assessment of potential impacts

This section assesses the potential impacts during construction and operation of the project on:

- Terrestrial flora, including removal of vegetation and loss of threatened flora species, edge effects, spread of weeds and pathogens (Section 19.5.1)
- Terrestrial fauna, including potential removal or degradation of fauna habitat, fauna injury and mortality, noise, vibration, dust and light spill impacts (Section 19.5.2)
- Aquatic biodiversity, including potential loss of aquatic habitat and water quality impacts (Section 19.5.3)
- Groundwater dependent ecosystems, including groundwater drawdown impacts (Section 19.5.4)
- Marine biodiversity, including potential loss of marine habitat, marine water quality impacts, and underwater noise impacts (Section 19.5.5).

Vegetation removal including the clearing of fauna habitat would be further minimised during further design development and detailed construction planning, where feasible and reasonable. Appendix W (Technical working paper: Arboricultural impact assessment) provides a preliminary assessment of trees that could be retained subject to further design development and construction planning.

In addition, the final layout of the new and improved open space and recreation facilities at Balgowlah, including the retention and/or removal of trees, would be subject to the outcome of the dedicated community consultation process. This consultation would be jointly led by Transport for NSW and Northern Beaches Council and would be separate to the consultation for the Beaches Link environmental impact statement. This process would start after the environmental impact statement public exhibition period and well in advance of construction starting. Further information on the new and improved open space and recreation facilities at Balgowlah is included in Section 5.2.1.3 of Chapter 5 (Project description).

19.5.1 Assessment of potential impacts to terrestrial flora

Removal of native vegetation

Construction of the project would require removal of about 15.44 hectares of native vegetation and native revegetation (refer to Table 19-13). This includes around 1.38 hectares of Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (PCT 1786), located along the Wakehurst Parkway at Frenchs Forest (refer to Figure 19-4 and Figure 19-5), which is consistent with the Duffys Forest endangered ecological community listed under the *Biodiversity Conservation Act 2016*.

As described in Section 19.4, to reduce impacts on native vegetation, an exclusion zone is proposed to be established around riparian vegetation adjoining Burnt Bridge Creek adjacent to the surface road works at Balgowlah where reasonable and feasible. The exclusion zone would be about 0.90 hectares in area and would contains 0.48 hectares of PCT 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion and 0.42 hectares of PCT 1841: Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region.

Biodiversity offsets would be provided for these impacts, as outlined in Section 19.6.1.

During further design development and construction planning, vegetation removal would be further minimised where feasible and reasonable. Refer to environmental management measures in Table 19-18.

Table 19-13 Vegetation to be removed as part of the project

Plant community type (PCT)	Condition	Area removed (ha)
PCT 1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	Moderate/ good	0.20
PCT 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Moderate/ good	0.40
PCT 1783: Red Bloodwood - Scribbly Gum/Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast	Moderate/ good	4.23
PCT 1786: Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (consistent with the Duffys Forest endangered ecological community)	Moderate/ good – Good	1.01
PCT 1786: Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (consistent with the Duffys Forest endangered ecological community)	Moderate/ good – Moderate	0.37
PCT 1824: Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	Moderate/ good	6.18
PCT 1841: Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region	Moderate/ good	1.37
PCT 1845: Smooth-barked Apple - Red Bloodwood - Blackbutt tall open forest on shale sandstone transition soils in eastern Sydney	Moderate/ good	0.39
Native revegetation	Highly disturbed	1.29
Total		**15.44**

Removal of threatened flora species

Potential impacts to threatened flora species as a result of the project are summarised in Table 19-14, including impacts to both native remnant and planted individuals of Magenta Lilly Pilly (*Syzygium paniculatum*) and planted individuals of Netted Bottle Brush (*Callistemon linearifolius*). These impacts are indicative based on the current level of design development and would be confirmed during further design development.

Table 19-14 Summary of threatened flora species impacts

Species	Conservation significance	Habitat or individuals to be impacted
Magenta Lilly Pilly (*Syzygium paniculatum*)	Endangered (BC Act) Vulnerable (EPBC Act)	One remnant individual and up to four planted individuals
Netted Bottle Brush (*Callistemon linearifolius*)	Vulnerable (BC Act)	Up to four planted individuals

The project would not have a significant impact on any of these threatened flora species based on the very low numbers of remnant individuals to be removed, and the fact that other individuals are planted. Biodiversity offsets would be provided for the impacted remnant individual, as outlined in Section 19.6.1. Offsets are not required for planted individuals impacted by the project, as these are not considered to be of conservation significance.

Edge effects on native vegetation

The project would result in indirect impacts to some areas of native vegetation adjoining the construction footprint, mainly due to fragmentation of vegetation and creation of new edges, which may result in edge effects. However, most of the construction footprint adjoins small, fragmented areas of vegetation within urban areas. This vegetation is often already situated adjacent to an existing cleared edge, such as a road, and is subject to ongoing disturbance and edge effects.

The assessment of potential edge effects found:

- A total of 0.23 hectares of native vegetation would be subject to increased edge effects to the extent they would become unviable due to the small size and isolation of the remaining patches
- A total of 8.20 hectares of native vegetation would be subject to increased edge effects as a result of the project due to the creation of one or more new edges within previously unfragmented vegetation. These new edges could be subject to degradation by the establishment and spread of weeds, enriched runoff from road pavement and dumping of rubbish. However, the project would include the provision of drainage infrastructure that would appropriately manage surface water flows. Fauna fencing to be installed along the Wakehurst Parkway would likely prevent the dumping of rubbish along the roadside.

Of the 8.43 hectares of native vegetation subject to edge effects, about 1.36 hectares meets the criteria for Duffys Forest endangered ecological community. There are no areas of indirect impact that meet the criteria for any *Environment Protection and Biodiversity Conservation Act 1999* listed threatened ecological community.

Invasion and spread of weeds, pathogens and disease

An increase in the movement of people, vehicles, machinery, vegetation waste and soil during and following construction activities may facilitate the introduction or spread of exotic grasses and other weed species. Areas along the Wakehurst Parkway would be particularly susceptible to weed establishment due to earthworks being carried out to widen the road. Areas around the Flat Rock Drive construction support site (BL2) would also be potentially highly susceptible to weed establishment from construction works.

In addition, the soil-borne pathogen *Phytophthora cinnamomi* (Phytophthora) is known to occur within the construction footprint. This pathogen is associated with damage and death to native plants. Construction of the project has the potential to increase the spread of this pathogen which could be dispersed by vehicles, animals, walkers and the movement of soil, or over large distances in flowing water, such as storm runoff.

Management measures would be implemented where feasible and reasonable to minimise the risk of introduction and spread of weeds and pathogens during construction of the project (refer to Section 19.6).

19.5.2 Assessment of potential impacts to terrestrial fauna

Removal of fauna habitat

Table 19-15 provides a summary of the potential impacts to terrestrial fauna habitats and associated threatened species for the following habitat types:

- Vegetated habitats
- Human-made structures and built environments (including existing culverts, bridges and buildings)
- Marine and intertidal habitats. The assessment of potential impacts to marine species is discussed in Section 19.5.5.

Vegetated habitats that would be removed are primarily located next to the Wakehurst Parkway, within the Flat Rock Drive construction support site (BL2), Balgowlah Golf Course construction support site (BL10), Wakehurst Parkway south construction support site (BL12) and Wakehurst Parkway east construction support site (BL13).

The removal of flowering and fruiting trees, shrubs and ground layer vegetation, and rocky habitat would result in the loss of potential foraging and sheltering habitat to a number of threatened fauna species known or considered likely to occur in the construction footprint. However, these impacts would be negligible since the habitat to be removed does not comprise a significant proportion of habitat available to species in the surrounding terrestrial biodiversity locality or wider bioregion.

Two hollow-bearing trees would also be removed as part of construction works along the Wakehurst Parkway. One has a hollow diameter of 0.10 to 0.15 metres, and the other has a hollow diameter more than 0.20 metres.

The realignment and upgrade of the Wakehurst Parkway would increase existing fragmentation of the nearby vegetation, which would potentially adversely affect the movement patterns of a number of threatened terrestrial fauna species known or likely to occur in the area such as Rosenberg's Goanna, Eastern Pygmy-possum, Red-crowned Toadlet and Southern Brown Bandicoot. Fauna exclusion fencing, fauna underpasses and rope crossings would be upgraded/replaced or constructed as part of the realignment and upgrade of the Wakehurst Parkway to facilitate the safe crossing of fauna beneath or over the road. The proposed fauna exclusion fencing along both the eastern and western edge of the realigned and upgraded Wakehurst Parkway, would prevent fauna from accessing the road and being subjected to vehicle strike. Therefore, impacts due to increased habitat fragmentation as a result of the project would be minimised. Locations of the upgraded/replaced or new fauna underpasses and rope crossings is provided in Chapter 5 (Project description).

Direct impacts to human-made structures and the built environment would be limited to the alteration of existing bridges and culverts at the surface connections at Artarmon, surface road works at Balgowlah and the realignment and upgrade of the Wakehurst Parkway, which offer limited and marginal potential roosting habitat for some bat species. These species include the Large Bent-winged Bat, Little Bent-winged Bat, and Southern Myotis. These works would be temporary and are unlikely to adversely impact such species.

No marine or intertidal habitats that provide potential habitat for terrestrial fauna would be directly impacted by the project.

Table 19-15 Potential impacts to threatened fauna habitats and associated threatened species

Habitat type	Known or potential threatened fauna species	Potential impacts
Vegetated habitats	• Grey-headed Flying-fox • Powerful Owl • Rosenberg's Goanna • Large Bent-winged Bat • Eastern Coastal Free-tailed Bat • Large-eared Pied Bat • Eastern Pygmy-possum • Spotted-tailed Quoll • Southern Brown Bandicoot • Glossy Black-Cockatoo • Little Bent-winged Bat • Red-crowned Toadlet • Barking Owl • Little Lorikeet • Masked Owl • Square-tailed Kite • Swift Parrot • Varied Sittella • Dusky Woodswallow • Brown Treecreeper.	• Impacts to fauna due to the loss of potential foraging and sheltering habitat associated with vegetation or rocky habitat features to be removed, including Rosenberg's Goanna, Eastern Pygmy-possum, Large-eared Pied Bat and Red-crowned Toadlet. However, the habitat does not comprise a substantial portion of foraging habitat available in the surrounding terrestrial biodiversity locality or wider bioregion. Habitat removal would also be further minimised where feasible and reasonable. Further environmental management measures to minimise this impact are provided in Section 19.6 • The realignment and upgrade of the Wakehurst Parkway would increase existing fragmentation of the nearby vegetation. However, mitigation measures such as fauna exclusion fencing, fauna underpasses and rope crossings would be implemented to minimise impacts • Potential edge effects to vegetated habitats next to the Wakehurst Parkway are not expected to result in any associated habitat impacts, including downstream riparian areas which provide potential sheltering, foraging and breeding habitat for the Red-crowned Toadlet.
Human-made structures and built environments	• Large Bent-winged Bat • Little Bent-winged Bat • Eastern Coastal Free-tailed Bat • Yellow-bellied Sheathtail-bat • Greater Broad-nosed Bat • Southern Myotis	• Direct impacts would be limited to the alteration of existing bridges and culverts at Artarmon, Balgowlah and the Wakehurst Parkway which offer limited and marginal potential roosting habitat and is unlikely to adversely impact threatened bat species.

Habitat type	Known or potential threatened fauna species	Potential impacts
Marine and intertidal habitats	• Southern Myotis • White-bellied Sea Eagle • Eastern Osprey • Little Penguin	• Construction activities within Middle Harbour have the potential to decrease the surrounding water quality and impact the occurrence and behaviour of fish and other prey for threatened fauna species. However, these impacts would be temporary and localised and species would be able to forage in other parts of the harbour.

Fauna injury and mortality

Terrestrial fauna injury or mortality may occur during vegetation clearing activities (particularly during the felling of trees) or may result from collisions with work vehicles or plant, or accidental entrapment in plant, trenches or other works. Vehicle strike, particularly where construction vehicles would be in operation near tracts of fauna habitat along the Wakehurst Parkway, would not only directly impact the fauna species killed or injured, but would potentially impact predatory species likely to feed on the roadkill. For example, Rosenberg's Goanna has been known to feed on roadkill, and was recorded along the Wakehurst Parkway during field surveys carried out in 2017. Threatened fauna species with a high likelihood or known occurrence in the construction footprint could be subject to injury and mortality.

The majority of fauna species recorded within the construction footprint are highly mobile bird and mammal species that are likely to be able to move away from vegetation clearing and other construction activities quite readily. Fauna species susceptible to injury or mortality include less mobile species such as amphibians, reptiles, invertebrates and juvenile/nesting birds/mammals and small mammals. Threatened fauna species at highest risk of injury or mortality include:

- Red-crowned Toadlet
- Eastern Pygmy-possum
- Rosenberg's Goanna.

Marine fauna injury or mortality may occur during construction of the crossing of Middle Harbour or could result from collisions with watercraft or barges carrying out construction within Middle Harbour. This could include the threatened Little Penguin; however, this species typically forages in shallow waters at the shoreline, which the project largely avoids. Middle Harbour is subject to high levels of water traffic and the species may be adapted to avoiding water vessels. Notwithstanding, an observer qualified to spot Little Penguins would be used during marine construction activities. A stop-work procedure would also be developed by a suitably qualified and experienced ecologist and implemented upon evidence of any Little Penguin in the proximity of the works area.

Noise, vibration, dust and light spill impacts

Construction activities would result in localised and temporary noise and vibration impacts; however, as most construction areas occur in highly urbanised areas that are subject to ambient noise, any increase in noise and vibration is not expected to have a significant impact on terrestrial fauna.

Realignment and upgrade of the Wakehurst Parkway may indirectly affect threatened fauna species that have been previously recorded in nearby native vegetation, including:

- Red-crowned Toadlet
- Eastern Pygmy-possum
- Large Bent-winged Bat
- Little Bent-winged Bat
- Large-eared Pied Bat
- Grey-headed Flying-fox
- Powerful Owl
- Eastern Coastal Free-tailed Bat
- Southern Myotis
- Rosenberg's Goanna
- Glossy Black-Cockatoo.

Construction activities including the realignment and upgrade of the Wakehurst Parkway around the cut and cover and trough structures of the ramp tunnels and widening of the Wakehurst Parkway, and establishment and operation of temporary construction support sites, could result in noise, vibration, light spill and dust impacts on nearby habitat throughout the duration of construction. Excavation along the Wakehurst Parkway is required (eg at cuttings) and would require the use of rock hammers. Controlled blasting has also been identified as an opportunity in a few selected locations to minimise the duration of excavation. Areas likely to require controlled blasting would be confirmed during further design development and construction planning, and would be managed in accordance with requirements in Appendix G (Technical working paper: Noise and vibration).

Fauna can be sensitive to elevated noise, changing their behaviour and impacting their physiology. Rock hammering and blasting have potential to impact fauna inhabiting vegetation and rock habitat next to the Wakehurst Parkway. Fauna may initially desert the immediate area at the start of excavation activities due to increased noise and vibration levels. Native vegetation and rocky habitats in the adjacent Garigal National Park and Manly Dam Reserve would provide refuge for any displaced individuals with mobility. Fauna could then gradually reinhabit, potentially developing a tolerance to the high noise levels during construction. However, due to the extent of adjoining habitat, the initial displacement from the immediate area could become permanent. For less mobile species or breeding individuals, the effects of the high noise levels may be more acute.

There is potential for indirect impacts to Large-eared Pied Bat habitat areas more than 100 metres from the construction footprint due to noise and vibration, light and dust. The works in the vicinity of potential roost and foraging habitat would be minimised by implementing environmental management measures included in Section 19.6. While there is the potential for impacts from controlled blasting to Large-eared Pied Bat habitat areas, this method would minimise the duration of excavation, which would reduce the exposure to other indirect impacts such as light and dust.

Potential typical noise impacts to the Grey-headed Flying-fox camp are expected to be similar to or less than existing background noise levels at this location during most construction activities. The background noise levels are currently dominated by road traffic noise from the Burnt Bridge Creek Deviation. Some noise generating construction activities are predicted in worst case to exceed existing day time road traffic noise levels on the Burnt Bridge Creek Deviation. These activities include surface works on Burnt Bridge Creek Deviation and oversized deliveries associated with the Kitchener Street construction support site (BL11) and would likely be short term in duration.

Grey-headed Flying-foxes occupying the Balgowlah camp appear to be accustomed to background traffic noise and have persisted at the camp despite regular maintenance of the gross pollutant trap by Northern Beaches Council directly near core roosting habitat. Accordingly, typical noise levels of key noise-generating construction activities during the day are not anticipated to adversely impact the Grey-headed Flying-fox camp. Some noise-generating construction activities would result in worst case noise levels that would exceed existing day time road traffic noise levels on Burnt Bridge Creek Deviation. However, reasonable and feasible noise management measures would be implemented when construction activities are occurring near the Grey-headed Flying-fox camp, as outlined in Section 19.6.

Grey-headed Flying-foxes may not be sensitive to construction noise at night time (ie related to construction activities proposed to occur outside of standard construction hours), as most individuals would be engaging in nocturnal foraging activities throughout the surrounding locality.

Construction activities in Middle Harbour resulting in impulsive or continuous underwater noise may lead to changed behaviour of the Little Penguin. The species may avoid foraging in areas subjected to continuous or high levels of sound. Sudden or high levels of sound may have the potential to result in hearing loss or damage to auditory tissues in the Little Penguin. The potential for an impact to occur and the scale or nature of impact would depend on an individual penguin's proximity to construction activities, lessening as distance from construction activities increases. Given the level of construction activity proposed in the harbour, it is expected that individuals of the species would avoid the area reducing the risk of hearing loss and/or auditory damage occurring. Notwithstanding, an observer qualified to spot Little Penguins would be used during marine

construction activities. A stop-work procedure would also be developed by a suitably qualified and experienced ecologist and implemented upon evidence of any Little Penguin in the proximity of the works area.

Water quality impacts on terrestrial fauna

Runoff from the Wakehurst Parkway during construction and operation of the project has the potential to result in soil erosion and sedimentation impacts downstream if not appropriately managed. This may impact the potential sheltering, foraging and breeding habitat of the Red-crowned Toadlet. The project would include the provision of temporary and permanent water quality control measures along the Wakehurst Parkway, including new or modified drainage and water quality basins. As discussed further in Section 19.5.3, the results of water quality modelling indicates that during operation, the project would not decrease the water quality of nearby ephemeral and unnamed freshwater waterways at the Wakehurst Parkway (refer to Appendix O (Technical working paper: Surface water quality and hydrology) for further details).

Given that potential construction impacts on Red-crowned Toadlet habitat would be managed by the implementation of standard environmental management measures as outlined in Chapter 16 (Geology, soils and groundwater) and Chapter 17 (Hydrodynamics and water quality) and that water quality of the Red-crowned Toadlet habitat is unlikely to decrease during operation of the project, adverse impacts on potential Red-crowned Toadlet habitat are unlikely.

Construction works within Middle Harbour have the potential to result in water quality impacts (eg during piling and dredging activities) which could result in potential adverse impacts to foraging habitat for threatened fauna species such as the Little Penguin and White-bellied Sea Eagle. However, the selected methodology for the project has considered dredging methods and controls to limit the potential for turbidity impacts and mobilisation of sediment, to minimise the impact on the surrounding marine environment. This includes, but is not limited to, the installation of floating silt curtains and the use of a closed environmental clamshell bucket for dredging the upper layers of sediment to minimise the spread of excavated material into the water column. Accordingly, any potential increase in turbidity and sedimentation of marine waters near construction activities would be likely minimal, localised and temporary.

19.5.3 Assessment of potential impacts to aquatic biodiversity

Loss of aquatic habitat

Instream works would be required along an existing aboveground watercourse within Flat Rock Reserve and Burnt Bridge Creek.

The existing aboveground watercourse within Flat Rock Reserve would be diverted for around 100 metres through a newly constructed culvert at the north eastern perimeter of the Flat Rock Drive construction support site (BL2). Aquatic habitat impacts associated with these drainage works are anticipated to be minor.

Burnt Bridge Creek would undergo localised adjustment to facilitate an extension of the existing box culvert crossing of the Burnt Bridge Creek Deviation further into Balgowlah Golf Course. Scour protection would also be installed at the downstream limit of the culvert works. This may result in the loss of some small invertebrates as well as some instream habitat, including instream macrophytes and some unconsolidated sediments. However, the instream works are anticipated to have a minimal and localised impact to instream freshwater habitats.

A small area of riparian vegetation would be removed for the localised adjustment and drainage works at Burnt Bridge Creek. This has the potential to impact bank stability and surface water quality if not appropriately managed. Riparian vegetation directly affected during construction would be restored where practicable in accordance with the environmental management measures included in Section 19.6 and Chapter 22 (Urban design and visual amenity), to ensure that impacts to downstream aquatic habitats are minimised.

Due to the instream works within Burnt Bridge Creek there would be a net loss of about 60 square metres of Type 2 moderately sensitive key fish habitat. Offsets for aquatic habitat are discussed in Section 19.6.1.

The instream works would be carried out during low flows with fish passage to be maintained throughout the works. Where practical, native freshwater fauna, including fish and crayfish, would be relocated to a similar habitat along the same waterway prior to the start of the instream works. The adjusted Burnt Bridge Creek would be designed to be a low flow channel which maintains connectivity during low flows, and to promote fish passage. Therefore, significant or long-term impacts to freshwater ecology are not expected as a result of the project.

The project would also impact the Balgowlah Golf Course stormwater harvesting dam as part of constructing the new access road between Sydney Road and Burnt Bridge Creek Deviation. The Balgowlah Golf Course stormwater harvesting dam would initially be retained and maintained for construction water and for irrigation of Balgowlah Oval by Northern Beaches Council. As construction progresses, the stormwater harvesting dam would be dewatered and filled in. As discussed in Section 19.3.3, the stormwater harvesting dam is unlikely to provide habitat for native fish. Notwithstanding, dewatering procedures would be implemented in the event that native aquatic fauna are encountered to ensure any potential impacts are minimised.

Hydrological impacts

During construction and operation, there would be potential that baseflow reductions to Flat Rock Creek, Quarry Creek and Burnt Bridge Creek could affect surface environmental water availability and flows to these waterways. Estimates for maximum baseflow reduction include:

- A 20 per cent reduction in baseflow at the end of construction and 39 per cent after 100 years of operation at Flat Rock Creek
- A 23 per cent reduction in baseflow at the end of construction and 69 per cent after 100 years of operation at Quarry Creek
- A 79 per cent reduction in baseflow at the end of construction and 96 per cent after 100 years of operation at Burnt Bridge Creek.

During construction, baseflows would not be reduced completely and given the changes to baseflows during the construction period would be expected to be within natural ranges, there would be minor impacts only to aquatic biodiversity. Further, it is expected that the additional creek flows from treated water from the construction wastewater treatment plants could partially feed the surrounding groundwater system.

Reductions to baseflows during operation could be considered significant, in particular for Burnt Bridge Creek and Quarry Creek. However, they are unlikely to result in a complete loss of aquatic habitat. Pools would be retained in these waterways and there would still be high flows immediately after rainfall events. Between rainfall events there would still be some (low) flow along the waterways. Outside of the pool areas, substantially reduced flows between rainfall events would be expected to alter assemblages of freshwater biota in these creeks to generally include only those species that are most tolerant to low flows. Potential operational impacts to reductions in baseflows at Flat Rock Creek are likely to be offset by discharges to the creek from the Gore Hill Freeway operational wastewater treatment plant.

While the potential impacts to baseflow reductions may be overestimated due to conservative modelling, additional monitoring of surface water flows and groundwater levels in the vicinity of Flat Rock Creek, Quarry Creek and Burnt Bridge Creek would be carried out to support a refined assessment of impacts and develop suitable design mitigation measures during further design development. Refer to Chapter 16 (Geology, soils and groundwater) and Chapter 17 (Hydrodynamics and water quality) for further discussion on baseflow reductions and environmental management measures to manage potential impacts.

Water quality impacts on aquatic biodiversity

Construction activities and temporary construction support sites in the vicinity of waterways could result in potential soil erosion, siltation and off-site movement of eroded sediments by stormwater into downstream waterways, accidental fuel and chemical spills, as well as potential changes to water quality and flow in nearby waterways if not appropriately managed. Impacts from construction activities, including wastewater treatment and discharge, are discussed in Chapter 17 (Hydrodynamics and water quality).

Potential impacts of construction activities on water quality would be managed by the implementation of standard environmental management measures as outlined in Chapter 17 (Hydrodynamics and water quality), including erosion and sediment controls for all work sites and surface work areas. With the implementation of appropriate measures during construction, impacts to water quality would be temporary and manageable. Water treatment devices, such as construction sediment basins, would be provided to manage sediment-laden runoff from disturbed areas during construction.

During operation, there would be an increase in impervious surfaces as a result of the project, which would result in an increased volume of runoff with the potential for increased scouring, erosion and sedimentation in downstream waterways. Runoff may also transport increased sediment loads and nutrients such as nitrogen and phosphorus to these waterways. The project would include the provision of water quality control measures during operation, including new and modified drainage infrastructure along the Gore Hill Freeway, Burnt Bridge Creek Deviation, Wakehurst Parkway and on surrounding roads directly affected by the project. In addition, new or modified permanent water quality basins would be provided at:

- Gore Hill Freeway – extension of the existing water quality basin at Punch Street
- Burnt Bridge Creek Deviation – within the new and improved open space and recreation facilities (subject to further consultation)
- Wakehurst Parkway – a new water quality basin to the west of the widened Wakehurst Parkway, adjacent to Garigal National Park and three new water quality basins to the east of the widened Wakehurst Parkway about 800 metres to 900 metres south of the intersection with Warringah Road.

Groundwater captured in the tunnels would be treated to comply with (ANZECC/ARMCANZ, 2000) and ANZG (2018) guidelines and spill controls and water quality monitoring would be implemented to manage operational impacts on ambient water quality within the receiving waterways. For locations where stormwater would be discharged (ie Gore Hill Freeway, Balgowlah and the Wakehurst Parkway), water quality treatment to meet existing conditions would be provided, at a minimum, such that impacts on surface water quality would be minimal.

Due to the presence of sensitive receiving environments along the Wakehurst Parkway, there is potential for impacts on aquatic biodiversity due to reduced water quality during operation. In particular, the population of Climbing Galaxias has been noted as being is susceptible to water pollution. However, MUSIC model results for the Wakehurst Parkway stormwater catchments presented in in Appendix O (Technical working paper: Surface water quality and hydrology) show that during operation, the project would result in an overall beneficial water quality outcome with a reduction in annual suspended solid and phosphorous loads, but an increase in total annual nitrogen loading of 188 kilograms per year for the overall combined Wakehurst Parkway catchments.

Based on these results, it was concluded that the operation of the project at the Wakehurst Parkway would not decrease the water quality of nearby ephemeral and unnamed freshwater waterways, nor Garigal National Park drainage lines, Bantry Bay, Manly Dam or Manly Creek.

With the implementation of appropriate management measures (refer to Chapter 17 (Hydrodynamics and water quality)), the likelihood of impacts to aquatic biodiversity as a result of the project would be low.

19.5.4 Impacts to groundwater dependent ecosystems

No direct impacts on groundwater dependent ecosystems would occur as a result of the project. Some areas of Coastal Sandstone Gully Forest, Sandstone Riparian Scrub and Coastal Sand Forest adjoining Flat Rock Creek would be subject to impacts from groundwater drawdown, with groundwater drawdown impacts of up to four metres predicted by 2028 and 11 metres by 2128. The level of groundwater dependency of this vegetation is unknown; however, it is likely that it is able to draw on surface water in Flat Rock Creek and soil moisture to prevent drying out of the community, except in dry periods where there is no recharge from rainfall or surface runoff. Groundwater drawdown as a result of the project may contribute to trees dying or becoming stressed during periods of prolonged drought.

Appendix N (Technical working paper: Groundwater) details that the maximum predicted baseflow impact to Flat Rock Creek after 100 years of operation of the project is a reduction of 84.7 kilolitres per day, equating to a flow reduction of 39 per cent. The maximum predicted baseflow impacts to Quarry Creek after 100 years of operation would be a reduction of 11.4 kilolitres per day, equating to a flow reduction of 69 per cent. Operational wastewater treatment plant discharges to Flat Rock Creek could offset this impact.

It is noted that groundwater modelling provides a conservative assessment which excludes the designed tunnel linings. Additional modelling carried was carried out for a scenario in which the section of tunnel beneath Flat Rock Creek is lined. With the linings assumed, the predicted water table drawdown after 100 years of operation was predicted to be up to eight metres less than the drawdown predicted without the lining, demonstrating that implementation of tunnel lining would help mitigate potential groundwater drawdown impacts and that potential baseflow impacts would be lower than predicted (refer to Chapter 16 (Geology, soils and groundwater) and Appendix N (Technical working paper: Groundwater)).

Coastal Upland Swamp may also be sensitive to changes to groundwater flows, and two areas mapped as Coastal Upland Swamp may be impacted by groundwater drawdown as a result of the project. The extent of groundwater dependence of both of these areas of Coastal Upland Swamp, or their connectivity to other areas of groundwater, is not known and therefore the impacts from groundwater drawdown are uncertain.

The closest mapped patch of Coastal Upland Swamp is located about 95 metres to the west of the Wakehurst Parkway in Garigal National Park. Groundwater drawdown is predicted to be less than one metre (by 2028 and 2128). It is unlikely that groundwater drawdown of less than one metre would result in impacts to most of the area of this Coastal Upland Swamp; it is possible that some areas at the upslope edges of the patches could be affected in the event of prolonged low rainfall periods.

Another small (0.07 hectare) area of Coastal Upland Swamp was identified north of Bantry Bay Oval, about 135 metres south-east of the construction footprint, with predicted groundwater drawdown of less than one metre by 2028 and 2128 (see Appendix N (Technical working paper: Groundwater)). Due to its small size, urbanised context and modified floristics, including numerous weedy exotic species, impacts to this area of Coastal Upland Swamps are not considered to be significant.

Appropriate environmental management measures would be implemented to manage potential drawdown impacts to groundwater dependent ecosystems and baseflow reduction impacts (refer to Chapter 16 (Geology, soils and groundwater)).

19.5.5 Assessment of potential impacts to marine biodiversity

Impacts to key fish habitat

A risk assessment relating to the potential hazards to Type 1, 2 and 3 key fish habitats within the marine biodiversity study area is summarised in Table 19-16, including the removal of habitat, altered hydrodynamics, elevated turbidity and sedimentation from dredging, mobilisation of contaminants, introduction of marine pests and underwater noise from dredging and piling.

Removal of medium/high relief rocky reef habitat would occur during the installation of the Middle Harbour north cofferdam (BL8). This has the potential to provide habitat for Black Rockcod and White's Seahorse. As the removal of this habitat would be limited to less than 0.01 hectares, impacts would be small relative to the extent of the habitats in Middle Harbour so as to not compromise the functionality, long-term connectivity or viability of habitats, or ecological processes beyond the affected areas. No offsets would be required as this area of rocky reef would be reinstated after construction and there would therefore be no net loss of habitat.

Dredging for the installation of the immersed tube tunnels would result in the removal of about 3.50 hectares of deep water soft sediment habitat. This would include an unavoidable loss of about 1.41 hectares of deep water soft sediment habitat where the immersed tube tunnel units at the crossing would be placed. However, the hard surfaces of the immersed tube tunnels would be colonised through natural processes of recruitment and immigration by sessile invertebrates and some algae and provide habitat for some fish. The immersed tube tunnels would provide more surface area than the deep water soft sediment habitat it would replace, such that there would be no net loss to key fish habitat.

There is also potential for scour from vessel movements and shading from construction infrastructure to result in the removal of seagrass habitat near the Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams and Spit West Reserve construction support site (BL9). With appropriate management of construction activities, including vessel movements, direct impacts to seagrass habitats would be minimal.

Alteration of hydrodynamics associated with the construction and operation of the immersed tube tunnels, including cofferdams, silt curtains and temporary wharves would impact currents around Type 1 key fish habitats and the flushing of deep water environments. Modelling of temporary changes to current speeds carried out for the project construction phase indicated that while the temporary changes would be relatively large in some locations at some parts of the tidal cycle, substantial impacts are not expected for the key fish habitats within the marine biodiversity study area. These habitats, including Type 1 seagrass and rocky reef habitats, thrive in many other parts of the marine biodiversity study area where natural currents are within the expected modified range. The temporary changes in hydrodynamics are not expected to impact deep water habitats.

Permanent alteration of hydrodynamics would occur due to the installation of the immersed tube tunnel, which would create a sill-like feature of about 9.2 metres high above the bed of the harbour at the deepest part of the Middle Harbour crossing location. The presence of the additional sill has the potential to impact on water quality within the marine biodiversity study area by reducing natural flushing of upstream environments, which could result in increased residence times of the deeper waters upstream of the sill from 1.6 days to 2.4 days. Longer residence time of the deeper waters could promote conditions more favourable to the depletion of dissolved oxygen in the bottom boundary layer and may lead to longer periods of low dissolved oxygen concentrations in the near-bed waters upstream of the. When dissolved oxygen concentrations are reduced there may be mortality to some benthic infauna and epifauna in soft sediment habitat in the deepest parts of the harbour, but fish and sharks would generally be able to avoid these bottom layers. It would be expected that recolonisation of affected deep water soft sediment habitat would occur through natural processes of recruitment of planktonic larvae and from movement of fauna from shallower unaffected areas of soft sediment.

Based on average annual rainfall patterns, the conditions leading to dissolved oxygen depletion to about 50 per cent saturation concentrations are likely to naturally occur a few times per year, particularly during the warmer late summer and autumn period. Due to the presence of existing low dissolved oxygen events, deep water communities are expected to be resilient to similar disturbances and would be able to rapidly recolonise following episodes of altered hydrodynamics. While the project would potentially result in low dissolved oxygen events lasting slightly longer at a slightly lower dissolved oxygen concentration than the present system, as currently occurs, any depletion of dissolved oxygen in deeper waters would be rapidly mixed vertically resulting in the project having a negligible effect on dissolved oxygen in surface waters and nearshore environments in which Type 1 and Type 2 key fish habitats are located.

The sill created by the immersed tube tunnels would likely increase the rate of siltation in the deepest water upstream of the crossing by three to four millimetres per decade. This rate is within the range of sedimentation rates within Sydney Harbour and forms a negligible contribution to overall sedimentation. Investigations of the existing water quality variability carried out for the project indicated that while the operation of the project has the potential to impact on the hydrodynamics for deep water habitats, the conditions would be similar to the existing disturbances caused by the two other natural sills within Middle Harbour (refer to Section 19.3.6).

Turbidity and sedimentation caused by dredging during the construction of the project has the potential to impact on about 0.02 hectares of medium relief subtidal rocky reef habitat around the Middle Harbour north cofferdam (BL8). Turbidity and sedimentation from dredging operations also has the potential to impact on seagrass and rocky reef habitats in the vicinity of the Middle Harbour south cofferdam (BL7) and Spit West Reserve construction support site (BL9). The modelling of the predicted sedimentation load carried out for the project indicated that the project is unlikely to substantially impact these habitats. Temporary increases in turbidity during construction may result in temporary shifts in the composition of fish communities. However, changes in fish community compositions would be expected to be within the natural variability observed within the marine biodiversity study area. Impacts associated with turbidity and sedimentation would be temporary and limited to the construction phase of the project and would not adversely impact the broader ecological functioning of marine communities.

Underwater noise would be caused by dredging and piling during the construction of the project in Middle Harbour. Construction related underwater noise may be impulsive or continuous and has the potential to impact fish and shark species within the marine biodiversity study area, including in seagrass, rocky reef, deep water and open water habitats. Potential impacts may include physical or behavioural impacts to marine species, such as temporary impacts to hearing or organs, changes to foraging behaviour, and changes in the distribution of marine species to avoid underwater noise generated by the project. Modelling carried out for the project indicated that underwater noise impacts would be largely limited to the immediate location of piling and dredging activities, but may extend to about 300 metres from the noise source, with the potential to impact up to 0.09 hectares of seagrass habitat, 1.54 hectares of rocky reef habitat, and 128.73 hectares of deep water and open water habitat. As different species have different tolerance thresholds to underwater noise, there would be a range of potential responses to these impacts. It is expected that any impacts to marine species would not affect the broader ecological functioning or viability of local populations due to the temporary nature of underwater noise impacts, with any changes in species assemblages recovered through natural processes of recruitment and immigration.

Piling methods proposed are similar to methods used currently throughout Sydney Harbour for ongoing wharf upgrades and other marine infrastructure construction and maintenance work, and potential impacts would be managed through well-established marine industry methodologies.

Overall, the impacts on key fish habitats during construction and operation of the project are not considered to be significant and would be adequately managed by the measures identified in Section 19.6.

Table 19-16 Risk assessment for key fish habitats

Hazard	Highly sensitive key fish habitat (Type 1)			Moderately sensitive key fish habitat (Type 2)			Minimally sensitive key fish habitat (Type 3)	
	Seagrass	Saltmarsh	Subtidal rocky reef	Intertidal rocky shore	Mangrove	Intertidal sand and mudflat	Deepwater soft sediment	Open water
Removal of habitat	High	Moderate	Moderate	Moderate	Moderate	Moderate	High	High
Turbidity	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Sedimentation	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	N/A
Mobilisation of contaminants	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Low
Introduction/spread of marine pests	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate
Altered hydrodynamics	Moderate	Low	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Underwater noise	Moderate	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
Boat strike to marine mammals and reptiles	Moderate	N/A	Moderate	N/A	N/A	N/A	Moderate	Moderate
Spill of contaminants	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Impacts to marine threatened species and ecological communities

A risk assessment relating to the potential hazards to threatened species and ecological communities within the marine biodiversity study area is summarised in Table 19-17.

Threatened or protected species, populations or endangered ecological communities listed under the *Fisheries Management Act 1994*, *Biodiversity Conservation Act 2016* or *Environment Protection and Biodiversity Conservation Act 1999* that are most likely to be affected by the project are those that would reside, forage or transit through habitat that would be affected during construction activities. This includes the Black Rockcod and White's Seahorse because of their potential to reside in high and medium relief rocky reef, although only a few individuals of these species would occur in the small areas of these habitats where individuals would potentially be harmed.

Some marine mammals, marine turtles and sharks could also occur in the project area because of their potential to either forage on or transit through seagrass, rocky reef or deep water soft sediment habitats, but their potential to occur in the small parts of these habitats where species could be harmed by the project would be low given that these habitats are generally considered suboptimal for these species. As marine mammals and marine turtles can be observed above the water, impacts due to boat strikes to marine mammals and turtles would be manageable.

As the potential for impacts during the construction phase of the project would be largely limited to the temporary disturbance of individuals of marine species, the potential for significant impacts to any threatened species would be minor and would not affect the viability of local populations of listed species. Notwithstanding, as a safeguard for White's Seahorse that may occur within affected areas, pre-construction surveys of potentially affected areas would be carried out by suitably qualified and experienced marine ecologists to search for and relocate White's Seahorse individuals (and other Syngnathids) to nearby unaffected habitat.

During operation of the project, the sill formed by the immersed tube tunnels would be steeper than the natural sills that occur within Middle Harbour (refer to Section 19.3.6). However, the tunnels would be confined to much deeper waters than the natural sills. As such, it is considered that the additional sill created by the tunnel structure would not be an impediment to fish passage during operation.

In summary, the project is not expected to have a significant impact on any marine threatened species, populations or endangered ecological communities.

Table 19-17 Risk assessment for threatened marine species and ecological communities

Hazard	Threatened marine species (grouped)			
	Fish (specifically Black Rockcod and White's Seahorse)	Mammals	Reptiles	Sharks
Removal of habitat	Moderate	Moderate	Moderate	Moderate
Turbidity	Moderate	Moderate	Moderate	Moderate
Sedimentation	Moderate	N/A	Moderate	Moderate
Mobilisation of contaminants	Moderate	Low	Low	Low
Introduction/spread of marine pests	Moderate	N/A	Low	Low
Altered hydrodynamics	Moderate	Moderate	Moderate	Moderate
Underwater noise	Moderate	Moderate	Moderate	Moderate
Boat strike to marine mammals and reptiles	N/A	Moderate	Moderate	N/A
Spill of contaminants	Moderate	Low	Low	Low

19.5.6 Matters of national environmental significance

Matters of national environmental significance were considered for the assessments carried out as part of Appendix S (Technical working paper: Biodiversity development assessment report) and Appendix T (Technical working paper: Marine ecology).

Threatened species and ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* that are known or considered highly likely to occur in the construction footprint and project area/marine biodiversity study area include:

- *Syzygium paniculatum*
- Large-eared Pied Bat
- Grey-headed Flying-fox
- White-bellied Sea Eagle
- Subtropical and temperate coastal saltmarsh
- *Posidonia australis* seagrass meadows of the Manning-Hawkesbury ecoregion
- Black Rockcod
- White's Seahorse.

The Significant Impact Assessments completed for these matters of national environmental significance concluded that the project would not have a significant impact on these species. As such, the project does not require referral to the Australian Government Minister for the Environment.

An additional Matter of National Environmental Significance, Coastal Upland Swamps in the Sydney Basin Bioregion, does not occur within the construction footprint but may be impacted by groundwater drawdown as a result of the project. The Significant Impact Assessment for Coastal Upland Swamps in the Sydney Basin Bioregion concluded that the project would not have a significant impact on this threatened ecological community. As such, the project does not require referral to the Australian Government Minister for the Environment.

19.6 Environmental management measures

Environmental management measures relating to biodiversity impacts are outlined in Table 19-18.

The required biodiversity offsets for the project are outlined in Section 19.6.1 below.

Additional measures relevant to the management of biodiversity impacts are also outlined in other chapters of the environmental impact statement, including:

- Chapter 10 (Construction noise and vibration)
- Chapter 16 (Geology, soils and groundwater)
- Chapter 17 (Hydrodynamics and water quality)
- Chapter 22 (Urban design and visual amenity).

Table 19-18 Environmental management measures –biodiversity

Ref	Phase	Impact	Environmental management measure	Location
B1	Design	Removal of native vegetation and threatened species habitat	The area required and layout of Flat Rock Drive construction support site (BL2) will be refined during further design development and construction planning to avoid direct impacts on PCT 1841, where feasible and reasonable.	BL
B2	Design	Injury and mortality of fauna	Connectivity measures will be designed during further design development in accordance with the *Wildlife Connectivity Guidelines: Managing wildlife connectivity of road projects* (Draft) (Roads and Maritime, 2011c) and consider measures to facilitate the crossing of native fauna species including the Eastern Pygmy-possum, Red-crowned Toadlet, Southern Brown Bandicoot and Rosenberg's Goanna. Maintenance requirements for underpasses and rope crossings will be developed during further design development and incorporated into an Operational Environmental Management Plan or existing Environmental Management System as relevant.	BL
B3	Design	Injury and mortality of fauna	Fauna exclusion fencing would be designed to exclude small fauna species from the road corridor such as Eastern Pygmy-possum and will be installed for the full extent of the Wakehurst Parkway within the construction footprint. The design specifications of the fauna exclusion fence will be developed during further design development including the need for access gates to manage any fauna on the roadside of the fauna exclusion fence based on best available knowledge from other Transport for NSW projects.	BL

Ref	Phase	Impact	Environmental management measure	Location
B4	Design and operation	Noise, vibration and light impacts	Artificial light impacts on native fauna in the operational phase of the project will be minimised where feasible and reasonable through further design development, where the project adjoins tracts of fauna habitat (eg along the Wakehurst Parkway) consistent with the requirements of *Australian Standards and Guidelines 4282 – 2019 Control of the obtrusive effects of outdoor lighting*.	BL/GHF
B5	Pre-construction	Impacts to marine species	Pre-construction surveys of potentially affected marine habitat areas will be carried out as close as practicable to 24 hours prior to commencement of works by suitably qualified and experienced marine ecologists to search for White's Seahorses (and other Syngnathids) and relocate them to nearby habitat.	BL
B6	Pre-construction	Removal of native vegetation and threatened species habitat	Vegetation removal including the clearing of native vegetation and fauna habitat will be further minimised during further design development and construction planning, where feasible and reasonable.	BL/GHF
B7	Pre-construction and construction	Impacts on the Large-eared Pied Bat	Activity-specific controls will be developed to manage impacts from high noise and vibration generating activities (eg controlled blasting and rock hammering) on Large-eared Pied Bat along the Wakehurst Parkway. The controls will be prepared by a suitably qualified and experienced microbat specialist and implemented during surface road works as required.	BL
B8	Pre-construction	Impact to aquatic environments	Any dewatering activities will be undertaken in accordance with the *Technical Guideline: Environmental Management of Construction Site Dewatering* (RTA, 2011), in a manner that prevents pollution of waters. Dewatering of the stormwater harvesting dam at Balgowlah Golf Course will be carried out with consideration of native fauna and appropriate measures will be implemented to relocate native aquatic fauna as required.	BL/GHF

Ref	Phase	Impact	Environmental management measure	Location
B9	Pre-construction and construction	Underwater noise impacts to marine species	Prior to commencement of impact piling appropriate management measures to minimise noise impacts on fish and aquatic organisms will be developed by a suitably qualified and experienced marine ecologist and implemented during impact piling works. The measures will include investigation and contingency actions should distressed or dead fish be observed within or adjacent to the construction footprint during piling works.	BL
B10	Construction	Removal of native vegetation and threatened species habitat	Vegetation removal along the Wakehurst Parkway will be timed to avoid the winter breeding period for the Eastern Pygmy-possum (May to July), where feasible and reasonable.	BL
B11	Construction	Removal of native vegetation and threatened species habitat	Vegetation removal will be carried out in accordance with *Guide 4: Clearing of vegetation and removal of bushrock of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF
B12	Construction	Removal of native vegetation and threatened species habitat	The unexpected species find procedure included in *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011) will be followed if threatened ecological communities, flora or fauna species, not assessed in the biodiversity development assessment report, are identified in the construction footprint.	BL/GHF
B13	Construction	Removal of native vegetation and threatened species habitat	Vegetation will be re-established within the construction footprint, where feasible, in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF
B14	Construction	Removal of native vegetation and threatened species habitat	Pre-clearing surveys for threatened fauna species will be carried out in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011). This will include inspections of hollows and dead timber for Eastern Pygmy-possum.	BL/GHF

Ref	Phase	Impact	Environmental management measure	Location
B15	Construction	Removal of threatened flora species	Prior to clearing, the location of the individual of *Syzygium paniculatum* next to the Wakehurst Parkway will be confirmed. If the individual is outside the construction footprint, but in close proximity to the boundary, the need for a site-specific exclusion zone will be investigated to minimise potential indirect impacts. Should the individual be within the construction footprint, further design investigation will be carried out to determine if impacts can be avoided where reasonable and feasible.	BL
B16	Construction	Removal of threatened flora species	Pre-clearing surveys for threatened flora species will be carried out in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF
B17	Construction	Noise, vibration and light impacts	Mitigation measures such as quieter construction methods or the use of temporary noise barriers in close proximity to the construction activities will be used wherever feasible and reasonable to minimise noise impacts to the Grey-headed Flying-fox camp. For the Kitchener Street construction support site (BL11), the arrangement of the site layout should maximise acoustic shielding (ie locations of site sheds, offices and fixed structures) to minimise noise impacts from within the site to the direction of the Grey-headed Flying-fox camp.	BL
B18	Construction	Noise, vibration and light impacts	Where feasible and reasonable, noise intensive works with the potential of impacting the Grey-headed Flying-fox camp (ie demolition involving rock hammering or resurfacing works) should be programmed to avoid September to February.	BL

Ref	Phase	Impact	Environmental management measure	Location
B19	Construction	Noise, vibration and light impacts	A person experienced in flying-fox behaviour (ie able to identify each stage of the reproductive cycle, ABLV-vaccinated and trained to rescue flying-foxes if required) will monitor disturbance levels within the Grey-headed Flying-fox camp at Balgowlah during construction activities that result in noise levels at the camp that exceed the pre-construction ambient noise levels. Monitoring would occur at representative periods (eg fortnightly) while pups are being carried (August-February).	BL
B20	Construction	Noise, vibration and light impacts	Adaptive management measures to minimise impacts on Grey-headed Flying-foxes will be developed in consultation with Department of Planning, Industry and Environment (Environment, Energy and Science) and an appropriately qualified expert in Grey-headed Flying-fox biology and behaviour, if Grey-headed Flying-fox behaviour during monitoring suggests that disturbance levels are high.	BL
B21	Construction	Noise, vibration and light impacts on fauna	Controlled blasting, rock hammering and other potential high noise generating activities along the Wakehurst Parkway will be managed to minimise noise and vibration levels to adjacent fauna habitat where practicable, including but not limited to: • Use of noise suppression devices on plant and equipment in accordance with the manufacturer's specifications • Regularly maintain plant and equipment to minimise noise levels when in use • Substituting plant or processes to reduce noise.	BL
B22	Construction	Injury and mortality of fauna	Fauna will be managed in accordance with *Guide 9: Fauna handling of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF

Ref	Phase	Impact	Environmental management measure	Location
B23	Construction	Injury and mortality of fauna	Pre-clearing surveys for non-threatened fauna species will be carried out in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011). Surveys will also include human made structures that have been identified as potentially providing habitat for microbats and are subject to demolition or modification.	BL/GHF
B24	Construction	Injury and mortality of fauna	An observer qualified to spot Little Penguins will be used during marine construction activities. A stop-work procedure will be developed by a suitably qualified and experienced ecologist and implemented upon evidence of the species in the proximity of the works area.	BL
B25	Construction	Invasion and spread of weeds, pests, pathogens and disease	Weed species will be managed in accordance with *Guide 6: Weed management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF
B26	Construction	Invasion and spread of weeds, pests, pathogens and disease	Pathogens will be managed in accordance with *Guide 2: Exclusion zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011).	BL/GHF
B27	Construction	Removal of aquatic habitat	Aquatic habitats will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA, 2011) and the *Policy and guidelines for fish habitat conservation and management* (NSW DPI, 2013). This will include flow and sufficient fish passage to be maintained similar to current conditions during instream works where reasonable and feasible.	BL/GHF
B28	Construction	Impacts to marine vegetation and sensitive habitat	Transit routes for vessels entering and departing from construction support sites will be marked out with consideration for propeller wash and distances to sensitive marine habitats.	BL

Ref	Phase	Impact	Environmental management measure	Location
B29	Construction	Impacts to marine vegetation and sensitive habitat	Exclusion zones will be implemented to avoid disturbance to sensitive marine habitats not proposed to be directly impacted by the project. These include any intertidal sand and mudflats, intertidal rocky shore, subtidal rocky reef and seagrass habitats with potential to occur within or next to transit routes and vessel movements. Routine inspections and maintenance of exclusion measures will be carried out.	BL
B30	Construction	Impacts to marine vegetation and sensitive habitat	Scour protection measures including possible velocity reduction from wastewater treatment plant discharge will be implemented where reasonable and feasible to avoid scour impacts on the marine environment.	BL
B31	Construction	Impacts to marine vegetation and sensitive habitat	To minimise the potential impact of turbidity (suspended sediment) on sensitive marine vegetation and habitats silt curtains will be installed around seagrass patches and subtidal rocky reef contained within the Zone of Influence as described in the Appendix T (Technical working paper: Marine ecology).	BL
B32	Construction	Impacts to marine vegetation and sensitive habitat	Silt curtains will be monitored for effectiveness particularly following inclement weather and maintenance carried out when required. Records of monitoring and maintenance will be kept.	BL
B33	Construction	Impacts to marine vegetation and sensitive habitat	To avoid direct damage to seagrass and subtidal rocky reef from silt curtain movement, there will be a suitable buffer distance between marine habitat and the silt curtain to account for curtain movement due to tides and currents and to prevent shading of the marine vegetation from the silt curtain. The silt curtain will be anchored to bare sediment where practicable to avoid movement.	BL
B34	Construction	Impacts to marine vegetation and sensitive habitat	Subtidal rocky reef habitat removed along the shoreline at the Middle Harbour north cofferdam (BL8) and intertidal rocky shore, sand and mudflat habitats removed at the Spit West Reserve construction support site (BL9) will be rehabilitated and restored as close as possible to pre-construction conditions where feasible and reasonable.	BL

Ref	Phase	Impact	Environmental management measure	Location
B35	Construction	Invasion and spread of marine pests, pathogens and disease	Locally sourced vessels and equipment will be used where feasible and reasonable. Any vessels sourced internationally will be inspected for potential marine pests prior to departing from their previous port. Construction contractors will need to demonstrate that due diligence has been taken to avoid introducing marine pests, pathogens or disease from internationally sourced vessels and/or construction equipment prior to departure.	BL
B36	Construction	Invasion and spread of marine pests, pathogens and disease	A targeted survey will be conducted of the dredge footprint to locate any areas of the marine algal pest *Caulerpa taxifolia*. If *Caulerpa taxifolia* is identified within the dredging footprint, surface sediments from these areas will be disposed of onshore rather than in the marine environment.	BL
B37	Construction	Impacts to marine species	A stop work procedure will be developed in accordance with the recommendations in Appendix T (Technical working paper: Marine ecology) to mitigate potential impacts to marine mammals and reptiles within the vicinity of impact piling works.	BL
B38	Construction	Impacts to marine species	Salvage of live fish and other native marine organisms (eg large, mobile macroinvertebrates) will occur during cofferdam dewatering and will be carried out by suitably qualified and experienced marine ecologists. All salvaged organisms will be immediately relocated to similar habitat nearby.	BL

19.6.1 Biodiversity offsets

The required ecosystem credits for the project in relation to native vegetation to be removed (direct impacts) is summarised in Table 19-19.

Offsets for indirect impacts are in addition to *Biodiversity Assessment Method* credit obligations and are at the discretion of the Minister for Planning and Public Spaces (DPIE, 2019). For indirect impacts resulting in isolated patches, offsets were calculated by reducing vegetation integrity values for these areas to zero, effectively treating these areas as direct impacts. The potential required ecosystem credits for indirect impacts from the project in relation to native vegetation is summarised in Table 19-20.

Species credits would be required as part of the biodiversity offsets for the project, as outlined below. Species that require species credits are listed in the Threatened Biodiversity Data Collection (DPIE (EES), 2020a). Offsets are identified and a preliminary strategy is provided in Appendix S (Technical working paper: Biodiversity development assessment report).

Offsets required for the potential threatened species impacted by the project that require species credits are summarised in Table 19-21.

The *Policy and guidelines for fish habitat conservation and management* (NSW DPI, 2013) specify that significant environmental impacts (direct and indirect) are to be offset by environmental compensation on a minimum 2:1 basis for all key fish habitat lost. A greater compensation ratio may be considered if offsets cannot be sourced in the vicinity of the impact or are not of the same habitat type as that impacted.

The project would potentially impact about 15 metres of Burnt Bridge Creek as a result of the culvert extension works and scour protection. Assuming an average bed width of about four metres in the affected area, this would equate to about 60 square metres of Type 2 key fish habitat. According to the *Policy and guidelines for fish habitat conservation and management* (NSW DPI, 2013) this would result in an offset requirement of about $6900. Final offset calculations would be carried out following further design development. Refer to Annexure D (Freshwater ecology impact assessment) of Appendix S (Technical working paper: Biodiversity development assessment report) for further discussion on aquatic offsets.

Table 19-19 Native vegetation offsets – ecosystem credits (direct impacts)

Zone	Plant community type (PCT) name	Area impacted (ha)	Ecosystem credits required
1250 Moderate/ Good	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	0.20	6
1292 Moderate/ Good	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	0.40	10
1783 Moderate/ Good	Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast	4.23	100
1786 Moderate/ Good - Good	Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (Duffys Forest endangered ecological community)	1.01	35
1786 Moderate/ Good - Moderate		0.37	7
1824 Moderate/ Good	Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	6.18	154
1841 Moderate/ Good	Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region	1.37	39
1841 Revegetation		1.29	21
1845 Moderate/ Good	Smooth-barked Apple - Red Bloodwood - Blackbutt tall open forest on shale sandstone transition soils in eastern Sydney	0.39	19
Total ecosystem credits required			**391**

Table 19-20 Native vegetation offsets – ecosystem credits (indirect impacts)

Zone	PCT name	Area impacted (ha)	Ecosystem credits required
Isolated patches			
1783 Moderate/ Good	Red Bloodwood - Scribbly Gum/Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast	0.05	1
1786 Moderate/ Good - Good	Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (Duffys Forest endangered ecological community)	0.17	6
1824 Moderate/ Good	Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	0.01	1
New edges			
1250 Moderate/ Good	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	0.22	1
1783 Moderate/ Good	Red Bloodwood - Scribbly Gum/Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast	2.59	12
1786 Moderate/ Good - Good	Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region (Duffys Forest endangered ecological community)	1.19	8
1824 Moderate/ Good	Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	4.20	21
Total ecosystem credits required			**50**

Table 19-21 Threatened species offsets – species credits

Species	Vegetation zone name	Individuals/ Area (ha)	Species credits
Magenta Lilly Pilly (*Syzygium paniculatum*)	1250_Mod_Good	1 individual	2
Red-crowned Toadlet (*Pseudophryne australis*)	1250_Mod_Good 1783_Mod_Good 1824_Mod_Good	0.98 ha	24
Eastern Pygmy-possum (*Cercartetus nanus*)	1250_Mod_Good 1783_Mod_Good 1786_Mod_Good-Good 1786_Mod_Good-Moderate 1824_Mod_Good 1845_Mod_Good	12.38 ha	403
Large-eared Pied-bat (*Chalinolobus dwyeri*)	1250_Mod_Good 1292_Mod_Good 1783_Mod_Good 1786_Mod_Good-Good 1786_Mod_Good-Moderate 1824_Mod_Good 1841_Mod_Good 1845_Mod_Good	13.68 ha	670
Total species credits required			**1099**

The impacts of a development and gains in biodiversity values at biodiversity stewardship sites are measured in biodiversity credits.