13. Ecology

This chapter outlines the potential ecological impacts associated with the construction and operation on the project, including impacts on species and communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) and *Environment, Protection and Biodiversity Conservation Act 1999 (*EPBC Act). The chapter also provides a summary of the *Sydney Light Rail Extension — Stage 1 Ecological Assessment* prepared by Parsons Brinckerhoff and contained as Technical Paper 4 in Volume 2 of this environmental assessment (EA).

DGRs	Where addressed in the EA
Ecology — including but not limited to:	
▪ flora, fauna and habitat, with specific consideration of threatened and vulnerable flora, fauna and populations, including the Long-nosed Bandicoot (*Perameles nasuta*), Eastern Bent-wing bat (*Miniopterus schreibersii oceanensis*) and the Eastern False Pipistrelle Bat (*Falsistrellus tasmaniensis*) and the protection of urban bushland	Section 13.3.4 Section 13.5 Technical Paper 4
▪ vegetation clearing (and resultant foraging, nesting, roosting and habitat loss; and fragmentation, connectivity and edge effects) and operational impacts	Section 13.3.1 Technical Paper 4
▪ ecological surveys commensurate with the biology/ecology of species and the extent of suitable habitat within and adjacent the rail corridor	Section 13.2.1 Technical Paper 4
▪ taking into account of: *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC, 2004).	Section 13.2.1 Technical Paper 4

13.1 Assessment approach

13.1.1 Literature and database review

Available literature was reviewed, including regional assessments as well as ecological surveys of the site, including:

- *Sydney Light Rail — Inner West extension study* (GHD 2010b)
- *Assessment of significance: Rozelle goods line track maintenance and reconstruction* (Biosis Research 2010a).*Preliminary ecological assessment: Sydney Light Rail Extension, Stage 1* (Biosis Research 2010b)
- *GreenWay — Cooks River to Iron Cove. Flora and fauna literature review* (Ward 2010)
- *Cooks River to Iron Cove GreenWay master plan and coordination strategy* (GreenWay Coordination Strategy Working Group 2009)
- *Rozelle Goods Line — rail track maintenance and reconstruction, Review of Environmental Factors* (Transport NSW 2010b)

- *Sydney Light Rail Extension — Stage 1 — Inner West Extension, Preliminary Environmental Assessment* report (Transport NSW 2010c)
- *Light rail and GreenWay integration plan* (Transport NSW 2010a)
- *GreenWay Bushcare management plan, preliminary report* (Ecological 2010)
- *Fauna study, Marrickville LGA* (AMBS 2007)
- *Yuppie bandicoots of inner west Sydney — in hiding or urban renewal?* (Leary et al. unpublished).

Records of threatened species known or predicted to occur within the locality of the study area were obtained from a range of databases, as detailed in Table 13.1. The study area for the purposes of the ecology assessment is defined as the area including and up to 100 metres from the edge of the construction footprint boundary.

Table 13.1 Database searches

Database	Search date	Search area	Source
Threatened species, populations and communities database	9 August 2010	Sydney Metro Catchment Management Area (Pittwater Part B sub catchment)	Department of Environment and Climate Change (2010b)
Atlas of NSW Wildlife	9 August 2010	10 km radius centred on the study area.	Department of Environment Climate Change and Water (2010a).
Protected Matters Search Tool	March 2010	10 km radius centred on the study area.	Department of the Environment, Water, Heritage and the Arts (2010b).

13.1.2 Survey

Previous surveys of the study area have been conducted by Biosis Research (2010a; 2010b). These surveys were conducted in June 2010 and included general habitat surveys, supplementary targeted Long-nosed Bandicoot surveys were undertaken using remote cameras over a two week period (8 to 22 July 2010) in addition to further habitat searches conducted on the 8 and 26 July 2010. The survey found no evidence of the Long-nosed Bandicoot in the study area, with little additional information provided on how Long-nosed Bandicoots use the rail corridor or adjacent lands or how significant the habitat is for the species (Biosis Research 2010a).

The surveys conducted within the study area for this assessment build upon the data collected to provide a more comprehensive ecological assessment.

Site inspections were made on 18 and 24 August and 2 September 2010 to determine the nature and condition of vegetation of the project and the presence of fauna habitats. The location of vegetation and habitats identified during the desktop review was ground truthed. The location of significant habitat features were recorded and mapped, including foraging resources, habitat trees, and vegetation community boundaries.

Particular attention was paid to species of conservation concern identified from the desktop analysis, including threatened and migratory species or locally significant species.
The potential presence of threatened species of animals was determined based on a habitat assessment rather than targeted survey as this is a more conservative approach likely to include species that are difficult to detect.

Areas containing remnant vegetation and dense weed growth were searched for cryptic Threatened species and populations. This included searches for Grey-headed Flying-fox roosts and indirect evidence of Long-nosed Bandicoots. Undersides of bridges were inspected for signs of roosting activity by microchiropteran bats.

Flora and condition of vegetation communities

The floristic diversity and possible presence of threatened species was assessed using random meander surveys in accordance with the *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Working Draft) (Department of Environment and Conservation 2004).

Due to the project's linear nature, random meander surveys were completed along the entire length of the project corridor. Random meander surveys are a variation of the transect type survey and were completed in accordance with the technique described by Cropper (1993), whereby the recorder walks in a random manner throughout the site recording all species observed, boundaries between various vegetation communities and condition of vegetation. The time spent in each vegetation community was generally proportional to the size of the community and its species richness.

The condition of vegetation was assessed through general observation and comparison against this benchmark data as well as using parameters such as intactness, diversity, history of disturbance, weed invasion and health. Three categories (good, moderate, low) were used to describe the condition of the vegetation communities.

Fauna and their habitats

Survey effort considered the methodology detailed in the *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004). However, as much of the study area was already largely disturbed, fauna habitat assessments were completed to assess the likelihood of threatened species of animals occurring in the study area. Habitat assessments included assessing and identifying habitat features, hollow tree surveys, targeted habitat searches and random meanders.

During habitat assessments and random meanders, opportunistic recordings of species were made through incidental sightings, aural recognition of calls and observations of indirect evidence of species' presence (i.e. Long-nosed Bandicoot diggings). This provided supplementary information on faunal species presence.

Spotlighting was used mainly to target the Long-nosed Bandicoot. However, it was also used to locate arboreal, flying, and other ground-dwelling mammals, and nocturnal birds. Spotlighting was used after dusk at four sites (Johnson Park, Hoskins Park, Blackmore Oval and Richard Murden Reserve). The rail corridor was also surveyed by spotlight from the road overpasses at Constitution Road (near the Arlington Stop) and Davis Street (near the Waratah Mills Stop). At least one person hour of survey effort, per site, was completed on foot using two 100 watt vari-beam spotlights.

The speed of the spotlight surveys was about one kilometre an hour. The spotlight surveys were designed to build upon the previous surveys by Biosis Research (2010a) and concentrated on areas that contained suitable habitat for the Long-nosed Bandicoot.

Fauna habitats were assessed generally by examining characteristics, such as the structure and floristics of the canopy, understorey and ground vegetation, the structure and composition of the litter layer, and other habitat attributes important for feeding, roosting and breeding.

The following criteria were used to evaluate habitat values:

- Good: A full range of fauna habitat components are usually present (for example, old growth trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.
- Moderate: Some fauna habitat components are missing (for example, old growth trees and fallen timber), although linkages with other remnant habitats in the landscape are usually intact, but sometimes degraded.
- Poor: Many fauna habitat elements in low quality. Remnants have been lost, including old growth trees (due, for example, to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive past clearing.

13.1.3 Significance assessments

Tests for significance were completed for threatened species, populations or ecological communities considered to have a moderate or higher likelihood of occurrence.

For threatened biodiversity listed under the TSC Act, significance assessment considers the heads of consideration for threatened species assessment, as suggested in the Department of Environment and Conservation/Department of Primary Industries draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation & Department of Primary Industries 2005).

For threatened biodiversity listed under the EPBC Act, significance assessments were completed in accordance with the EPBC Act *Significant Impact Guidelines* (Department of the Environment and Heritage 2006).

Assessments were completed for species, populations or communities listed under both Acts.

13.1.4 Limitations

Varying degrees of non-uniformity of flora and fauna habitats are encountered on all sites. Hence, no sampling technique can entirely eliminate the possibility that a species is present on a site. It should also be recognised that site conditions, including the presence of threatened species, can change with time. However, a precautionary approach was taken and assessments were made based on the presence of suitable habitat and known occurrences of species even if a species was not recorded.

13.2 Existing environment

The study area is highly urbanised and according to available broad scale vegetation mapping (e.g. Tozer et al. 2006) has been cleared of native vegetation. Although the study area is largely cleared of vegetation, it contains bushcare sites that have been revegetated with native plant species, as well as urban gardens, parks, street plantings, and extensive weed infestations. Figures 13.1a to 13.1e describe the vegetation types, including bushcare sites and areas of weed growth. The Pyrmont stabling and maintenance facility provides very poor habitat for fauna and flora.

The highly urbanised inner western suburbs of Sydney provide limited habitat for fauna with the exception of disturbance tolerant species and urban opportunists that are able to exploit these habitats. Interrupted vegetated corridors exist along Whites Creek, Johnston's Creek and Hawthorne Canal, but these contain little native vegetation. Although fragmented, this corridor has been identified as an important urban green corridor. It provides a wildlife corridor and habitat for a range of animals. A total of 115 species of bird, eight species of reptiles, four mammals and four frogs have been recorded within Leichhardt local government area (Leichhardt Council 2009), including threatened species and populations such as the Eastern Bentwing-bat, Pied Oyster Catcher, Grey-headed Flying-fox and an endangered population of Long-nosed Bandicoots.

13.2.1 Vegetation communities and habitats

Bushcare sites

There are six bushcare sites within Hawthorne Canal catchment, three of which are in the disused Rozelle goods line corridor (refer Figures 13.1a to 13.1e). These sites are managed by a local community bushcare group, the Inner West Environment Group (IWEG). Overall, the condition of vegetation and fauna habitats in the bushcare areas was moderate.

Section 4.2.1 of the Technical Paper 4 in Volume 2 provides a more detailed description of each of the bushcare sites.

Parklands, gardens and street plantings

As much of inner western Sydney has been cleared for urban and industrial development, large areas of vegetated land now consist of plantings in the form of parklands, gardens and street trees. While many parts along the project contain plantings, six areas that contain a significant number of plantings were identified (refer Figures 13.1a to 13.1e). Overall, the condition of vegetation and fauna habitats in these areas was low.

Section 4.2.2 of Technical Paper 4 in Volume 2 provides a more detailed description of each of these urban parkland sites.

Weed growth

Large portions of land directly next to and within the rail corridor have been left unmaintained and have consequently developed dense weed infestations. Areas dominated by weed species also included areas of previous landscape plantings that have become overgrown (refer Figures 13.1a to 13.1e). Overall, the condition of vegetation in these areas was low. However, the thick weed growth provides habitat in a moderate condition for fauna groups, including ground dwelling mammals and small birds.

The areas of weed growth within the study area were fairly homogenous in composition. The dense thickets of weeds along the length of the rail line next to the tracks provide suitable habitat for a range of native bird species that rely on dense cover, such as the Superb Fairy-Wren. The area of dense weed growth near the Lewisham West stop, next to the corner of Longport Street and Smith Street, provides breeding habitat for the Australian White Ibis. The dense cover provided by the weed growth is also suitable as sheltering habitat for the Long-nosed Bandicoot and is likely to be a contributing factor to the presence of this species in the study area (Leary et al. unpublished).

Developed areas

Developed areas along the study area include existing infrastructure (including the Pyrmont stabling and maintenance facility), housing and industrial developments that have removed native vegetation and habitats. These areas generally do not provide habitat for native animals, except those species adapted to exploit urbanised environments. The fauna habitats of the developed areas were in poor condition.

Developed areas are suitable for a range of common native bird species including the Silver Gull, Sulphur-crested Cockatoo, Red Wattlebird, New Holland Honeyeater, Willie Wagtail, Australian Magpie and Noisy Miner. Introduced birds, including the Rock Dove and Common Myna, are also prevalent. Bridges, culverts and buildings also provide potential habitat for microchiropteran bat species, including the threatened Eastern Bentwing-bat which has been identified in previous surveys.

Joins Figure 13.1b

Light rail alignment
City West Link rail corridor tunnel
Local government area boundary
Existing light rail stop
Proposed light rail stops
Construction footprint
Weed growth
Parkland and street plantings

Figure 13.1a Vegetation types

Note: Indicitive only, subject to detail design.

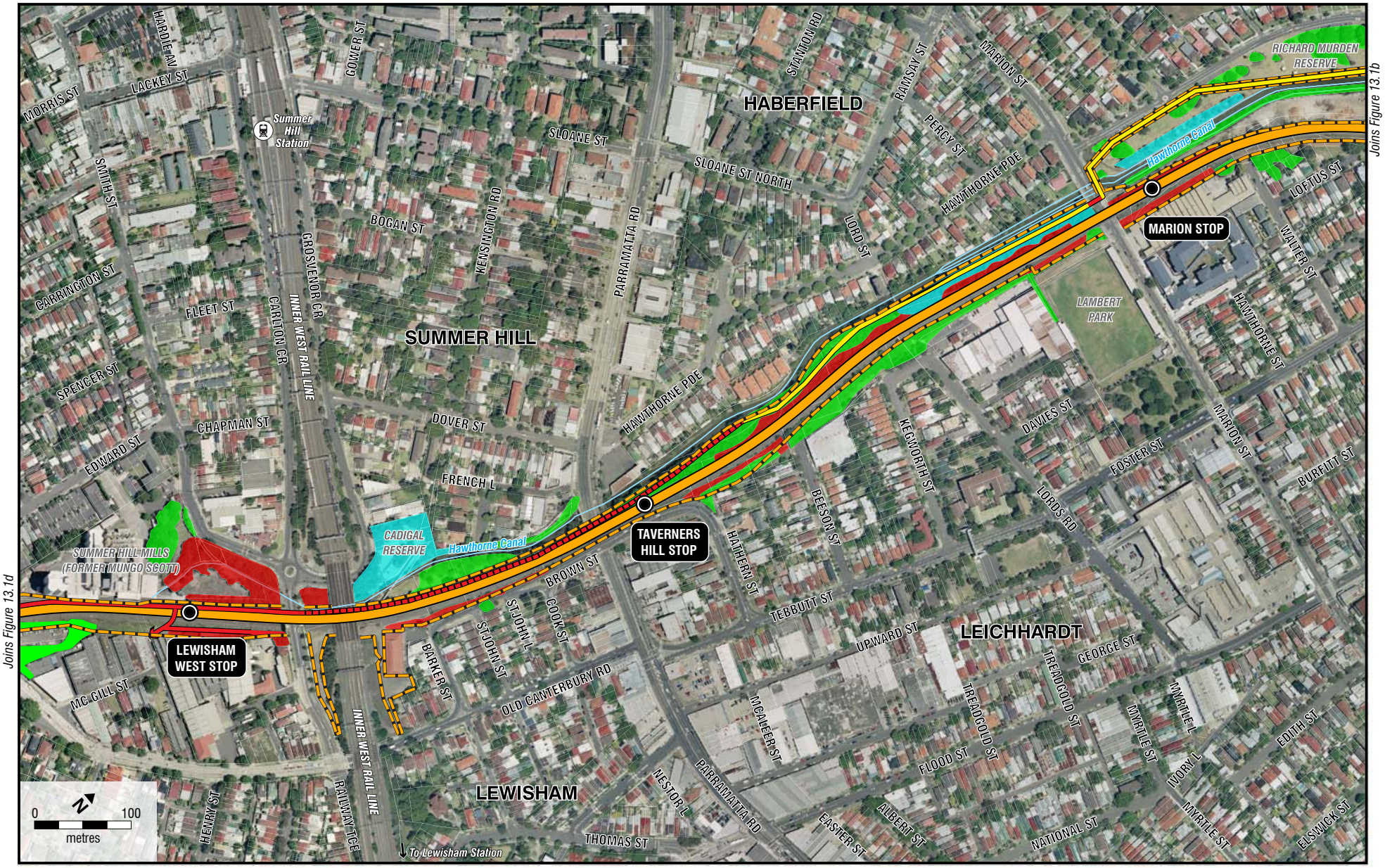
Light rail alignment
Proposed light rail stops
Local government area boundary
Watercourse

Existing GreenWay shared path (upgraded)
New GreenWay on-street cycle path
New GreenWay shared path (at-grade)
New GreenWay shared path (elevated)

Construction footprint
Weed growth
Parkland and street plantings
Bushcare site

Figure 13.1b Vegetation types

Note: Indicitive only, subject to detail design.



- Light rail alignment
- Proposed light rail stops
- Local government area boundary
- Watercourse
- Existing GreenWay shared path (upgraded)
- New GreenWay on-street cycle path
- New GreenWay shared path (at-grade)
- New GreenWay shared path (elevated)
- Construction footprint
- Weed growth
- Parkland and street plantings
- Bushcare site

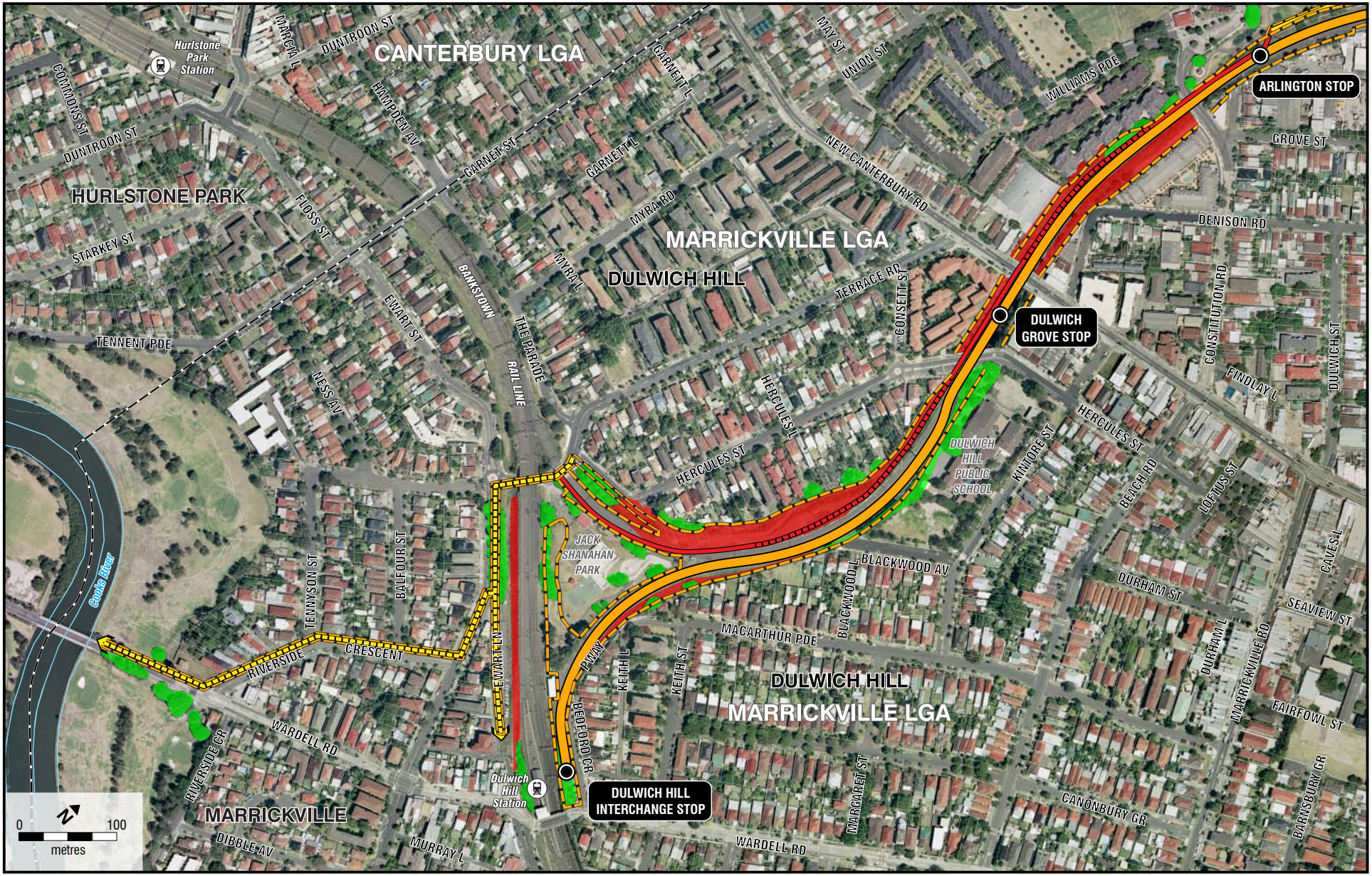
Figure 13.1c Vegetation types

Note: Indicitive only, subject to detail design.

- Light rail alignment
- Proposed light rail stops
- Local government area boundary
- Watercourse
- Existing GreenWay shared path (upgraded)
- New GreenWay on-street cycle path
- New GreenWay shared path (at-grade)
- New GreenWay shared path (elevated)
- Construction footprint
- Weed growth
- Parkland and street plantings
- Bushcare site

Figure 13.1d Vegetation types

Note: Indicitive only, subject to detail design.



Joins Figure 13.1d

Light rail alignment
Proposed light rail stops
Local government area boundary
Watercourse

Existing GreenWay shared path (upgraded)
New GreenWay on-street cycle path
New GreenWay shared path (at-grade)
New GreenWay shared path (elevated)

Construction footprint
Weed growth
Parkland and street plantings
Bushcare site

Figure 13.1e Vegetation types

Note: Indicitive only, subject to detail design.

13.2.2 Species of plant

To obtain an overview of the species present at all locations along the study area, the results of the present survey were combined with those of previous surveys. Overall, 298 species of plants have been recorded within the study area, of which 189 species (63%) were native (refer Technical Paper 4 in Volume 2). No threat-listed species of plant has been recorded in the study area.

The study area traverses three noxious weed control areas: Leichhardt Municipal Council, Marrickville Council and the Council of the Municipality of Ashfield. Of the 109 exotic species of plant recorded, 10 are listed under the *Noxious Weeds Act 1993,* including lantana *Lantana camara* and blackberry *Rubus fruiticosus*, which are listed as weeds of national significance.

13.2.3 Species of animal

Taking into account the results of past biodiversity surveys combined with the survey undertaken for this assessment, 87 species of vertebrate animals have been recorded within the study area, including 74 native species (85%). Birds were the most diverse group of terrestrial fauna recorded in the study area, followed by mammals, reptiles and amphibians. One threatened species, the Grey-headed Flying-fox, was recorded during this survey. Previous surveys have also identified the presence of the Long-nosed Bandicoot, which is listed as an endangered population under the TSC Act within inner western Sydney. Feral and domestic animals, including the European Red Fox and domestic dogs and cats are common along the study area.

13.3 Impacts on biodiversity

13.3.1 Construction impacts

Vegetation clearing

Clearing native and exotic vegetation (land clearing) would be the project's major direct impact on biodiversity in the study area. Clearing native vegetation is known to affect threatened species of flora and fauna and is recognised as a key threatening process under the following final determination titles in the TSC Act and EPBC Act:

- clearing of native vegetation (TSC Act)
- land clearance (EPBC Act).

Under the TSC Act, native vegetation is made up of plant communities, comprising mainly indigenous species. Clearing is defined as the destruction of a sufficient proportion of one or more strata layers within a stand or stands of native vegetation so as to result in the loss, or long-term modification, of the structure, composition and ecological function of a stand or stands (NSW Scientific Committee 2001).

Clearing of vegetation, native and exotic, has many adverse effects on both flora and fauna, including:

- loss of local populations of individual species
- fragmentation of remnants of ecological communities
- reduction in the viability of ecological communities resulting from loss or disruption of ecological functions
- destruction of flora and fauna habitat and associated loss of biological diversity (habitat removal may include removal of hollow bearing trees, loss of leaf litter layer, changes to soil biota)
- soil erosion, increased salinity and loss of productive land
- riparian zone degradation
- increased habitat for invasive species (adapted from NSW National Parks and Wildlife Service 2001; NSW Scientific Committee 2004).

The majority of vegetation removal would be composed of exotic species. Vegetation clearing has been avoided where possible through the selection and design process. Nonetheless, total avoidance of vegetation clearing is not possible and approximately 1.82 ha of vegetation (including approximately 1.7 ha of weeds) would be cleared as a result of the project (refer Table 13.2). This would equate to approximately 8.3% of the vegetated land within the study area (defined as the construction footprint and up to 100 metres surrounding the construction footprint).

Table 13.2 Potential loss of vegetation within the study area

Vegetation type	Extent within study area (ha)	Vegetation clearing (ha)		Total clearing (ha)	Clearing as percentage of existing extent
		Construction compounds and stops	GreenWay shared path		
Bushcare sites	1.4	0.02	0.05	0.07	5%
Planted Trees	12.4	0	0.05	0.05	0.4%
Weed growth	8	1.4	0.3	1.7	21%
Totals	**21.8**	**1.42**	**0.4**	**1.82**	**8.3%**

Note: All areas are approximate.

Removal of fauna habitats

Clearing native and exotic vegetation would result in the removal of fauna habitats. Fauna use elements of this habitat for shelter, to hide from predators, find food, and avoid extreme weather conditions and for breeding. A total of approximately 1.82 ha of broad-scale fauna habitat would be removed, including approximately 1.7 ha of dense weed growth that provides suitable habitat for the Long-nosed Bandicoot and approximately 0.05 ha of foraging habitat for the Grey-headed Flying-fox, Eastern Bentwing-bat, Swift Parrot, and Little Lorikeet (refer Table 13.2).

For the Long-nosed Bandicoot, the dense weed growth within the study area is likely to provide a limited resource. Due to the absence of natural habitats in the study area, the Long-nosed Bandicoot may use the dense weed growth for shelter (Leary et al. unpublished). For the remaining species, the Grey-headed Flying-fox, Eastern Bentwing-bat, Swift Parrot and Little Lorikeet, the habitat within the study area is likely to only provide marginal foraging habitat. Bridges and overpasses in the study area may provide roosting habitat for the Eastern Bentwing-bat.

Habitat fragmentation

Habitat fragmentation is the process of subdividing a continuous habitat into smaller isolated fragments (Andren 1994; Ford et al. 2001) and can have adverse effects on both flora and fauna. The project is estimated to result in the fragmentation of the vegetated areas at each of the stops along the route to varying degrees. Some stops would result in severing the vegetated corridor while others would reduce the overall corridor width.

Habitat fragmentation as a result of the project would occur during construction, however, it would also be an ongoing impact of operating the project.

The fragmentation resulting from the project would be unlikely to have a significant impact on the viability of species that occur within the study area. Plant species remaining in the study area have a high level of resilience to disturbance and would continue to produce viable seed and germinate in the presence of disturbance factors. Animal assemblages are, with the exception of the Long-nosed Bandicoot, dominated by generalist species that are tolerant of a high level of habitat disturbance.

The species most likely to be adversely affected by fragmentation are those that are less mobile, such as the Long-nosed Bandicoot. The project may form a barrier to the movement of this species by breaking up areas of habitat by introducing stops and through the movement of light rail creating a barrier to crossing the tracks. The habitat fragmentation associated with the project is unlikely to affect highly mobile flying species, such as the Grey-headed Flying-fox, Eastern Bentwing-bat, Swift Parrot, and the Little Lorikeet.

Direct mortality to plants and less mobile animals

Fauna injury or death could occur as a result of construction activities, such as:

- vegetation (fauna habitat) clearing
- incidents involving vehicles or plant
- incidental trapping or drowning in trenches or other earthworks.

While some mobile species, such as birds, may be able to move away from the path of clearing, other species that are less mobile, or those that are nocturnal, may find it difficult to move rapidly over large distances.

Fauna injury or death has the greatest potential to occur during the break-out phase of construction when vegetation and habitats are being cleared. The threatened population that could be most affected by the clearing is the Long-nosed Bandicoot.

Proliferation of weeds

The project could disperse weeds into bushcare areas and cleared areas within the study area. The invasion of exotic perennial grasses, such as *Pennisetum clandestinum** and *Eragrostis curvula** which were recorded within the study area, is recognised as a Key Threatening Process under the TSC Act. Several other invasive weeds are listed as a Key Threatened Process under the TSC Act, including *Lantana camara** and *Ipomoea indica** that have been recorded within the study area. Other invasive weeds recorded in the study area include *Ricinus communis**, *Cortaderia selloana**, *Rubus fruticosus** and *Ligustrum** spp.

The most likely causes of weed dispersal associated with the project would include earthworks, movement of soil and attachment of seed (and other propagules) to vehicles and machinery.

However, as existing disturbed vegetation within the study area has considerable weed growth already, the overall extent of weed invasion into the study area is not likely to increase significantly.

Noise and other human disturbance

Construction activities would be likely to increase noise levels, and general disturbance would be associated with the presence of humans within the study area. Increased noise levels could be a cause of disturbance for native animals, particularly Long-nosed Bandicoots, resulting in displacement of individuals out of the affected area, disturbance to foraging patterns and disturbance to breeding cycles.

The majority of the species of the animals observed, or likely to occur, within the study area were generalist species that are known to be accustomed to residential and industrial noises.

13.3.2 Operational impacts

Noise

The main potential operational impact of the project on biodiversity would be noise disturbance from light rail operations. However, the introduction of light rail noise would not be a significant contribution to the post-construction noise levels in the study area. The majority of the species likely to occur within the study area are species that would be accustomed to residential and industrial noises. Considering the previous operation of the rail line as a freight corridor, there has historically been considerable noise sources in the study area. The only threatened biodiversity likely to be affected by light rail noise is the inner western Sydney population of the endangered Long-nosed Bandicoot, and the Eastern Bentwing-bat if it is roosting in any bridges or culverts near the track. However, due to the noisy nature of the urban environment in which these species exist, a significant impact would not be likely.

Light

Studies relating to the effect of light pollution on fauna have indicated light pollution from a variety of sources can trigger behavioural and physiological responses, including (but not limited to):

- an extension of daylight or twilight foraging behaviour into the night-time environment, sometimes referred to as the 'night light niche' where reptiles, microchiropteran bats, and some diurnal birds will forage for insects under artificial lighting (Schwartz & Henderson 1991)
- a disruption of seasonal day length cues which trigger critical behaviours (Longcore & Rich 2004)
- a disruption to predator-prey relationships (Longcore & Rich 2004).

The project would introduce a new source of light into the study area. The immediate area around the stops and along the length of the GreenWay shared path would be subject to lighting essentially creating permanent 'daylight' conditions. Lighting for the GreenWay shared path would be based on pole-mounted fixtures at a spacing of 20 metres. Lighting on the path may operate up to 10 pm. Low level lighting (bollard or similar) would be used in some parts of the path, including near bushcare areas. Lighting design would seek to minimise light spill impacts and would be finalised during detailed design.

The light rail vehicles would also provide an intermittent source of light as they move along the track at night. The light rail vehicles are expected to run until 11 pm Monday to Thursday and 12.30 am Friday to Saturday.

Light pollution could affect nocturnal fauna by interrupting their life cycle in any one of the ways outlined above. Due to the sustained nature of the lighting around the stops and the frequency of light rail services, it is unlikely that animals would habituate to the light disturbance and an impact in the area of lighting is likely. This may be important for nocturnal species, including the Long-nosed Bandicoot. Some positive impacts for microchiropteran bat species may occur due to increased prey (insect) abundance and availability around lighting sources.

Light rail collision with fauna

International studies have shown that dead carcasses attract scavengers on rail tracks, which can increase the collision of raptors with trains (Krone et al. 2000). Other studies have focused on the impacts of train collision with local populations of large mammals (Wells et al. 1999). However, there are no data available on the mortality rates of Australian fauna due to train collision and it is difficult to predict the extent of impacts associated with increased movements.

The effect of train traffic mortality on fauna populations is often difficult to measure as factors, such as area, quality and spatial configuration of the habitat along rail lines, also play a role (Catharinus et al. 2006). Data sets on wildlife mortalities from trains are difficult to obtain because of the relative inaccessibility of railway lines; the lack of experienced individuals to observe, identify, and record railway kills; and the inherent difficulty of identifying and investigating railway wildlife (Wells et al. 1999).

The project would result in frequent light rail movements and is likely to result in some level of collision with native fauna, including possibly the endangered Long-nosed Bandicoot population, throughout the length of the line as a consequence. Areas where there are likely to be higher chances of collision include where the route traverses through areas of dense weed growth that provide habitat for ground dwelling mammals.

Barrier effects

The creation and continued effects of barriers associated with the project would persist throughout the construction and operational phases. Barriers, both physical and biological, would be created and maintained as part of the proposal. Rail lines can act as a barrier through either increased mortality or avoidance (Catharinus et al. 2006; Wells et al. 1999). The local habitat corridor that occurs along the edges of the rail line would not be significantly affected as the project would occur on the existing rail tracks. Stops may provide a new barrier to animal movement due to clearing vegetation and constructing platforms; however, revegetation and landscaping would serve to reconnect the corridor.

Barrier effects are likely to be the most significant in areas where the study area traverses the larger patches of vegetation. This is particularly the case for ground-dwelling species, including reptiles, amphibians and the threatened Long-nosed Bandicoot population that may be affected by the light rail movements. Local populations of mobile faunal species, including birds and bats, are unlikely to be significantly disrupted by barrier effects of the project.

Changed hydrology/surface run-off

Changed hydrology can alter ecosystems, including vegetation communities and fauna habitats. Run-off could also have a negative effect on the ecology of flora and fauna in nearby habitats. Alterations to hydrological regimes would mainly be associated with the construction phase. There may be some minor changes to surface run-off/infiltration with the introduction of sealed surfaces, including stops, access paths and the GreenWay shared path. However, the long-term concentration of flows would be similar to current levels. As such, it is anticipated that changed hydrology would not affect local populations of flora and fauna during operation.

Improved hydrology through applying water sensitive urban design (WSUD) may provide a positive impact to the ecology of plants and animals in nearby habitats.

13.3.3 Cumulative and consequential impacts

The potential biodiversity impacts of the project have been considered. The incremental effects of multiple sources of impact (past, present and future) are referred to as cumulative impacts and provide an opportunity to consider the project in a strategic context. This is necessary so that the impacts associated with the project and other activities in the region are examined collectively.

The project is located in a highly modified landscape dominated by high-density urban and industrial development in which the remaining areas of vegetation and associated habitat are highly fragmented and isolated. This existing landscape is not expected to change significantly in the near future due to the highly developed nature of inner western Sydney limiting development potential. Therefore, impacts to existing biodiversity from future development in the locality are likely to be limited.

13.3.4 Species specific impacts

Table 13.3 summarises the specific impacts likely to affect each of the endangered populations and threatened species recorded or likely to occur in the study area. The location of each threatened species recorded in the study area and the extent of suitable habitat is provided in the threatened species profiles supporting the impact assessments (refer Technical Paper 4 in Volume 2).

The project would have direct impacts on habitat for threatened species as a result of vegetation clearing. Assessments of the significance of these impacts are provided in Section 8 and Appendix D of Technical Paper 4 in Volume 2.

Table 13.3 Potential impacts on threatened biodiversity

Species or community	Status		Direct and indirect impacts across the study area
	TSC Act[1]	EPBC Act[2]	
Long-nosed Bandicoot, inner western Sydney population	E2	-	Loss of approximately 1.7 ha of potential sheltering, foraging and breeding habitat[3].
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	Loss of 0.05 ha of foraging habitat.
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	Loss of 0.05 ha of foraging habitat. Disturbance to bridges.
Swift parrot (*Lathamus discolor*)	E	E	Loss of 0.05 ha of foraging habitat.
Little lorikeet (*Glossopsitta pusilla*)	V	-	Loss of 0.05 ha of foraging habitat.

1. Conservation status as listed under the TSC Act. E = endangered. V = vulnerable, E2 = endangered population.
2. National conservation status as listed under the EPBC Act. V = Vulnerable E = Endangered.
3. No bandicoots were recorded in during the studies associated with the project, but have been recorded in similar habitat (i.e. disturbed and modified vegetation) in the past.

The potential impact of the project on the Eastern False Pipistrelle Bat was also considered as part of the EA. No suitable habitat has been identified near to the project area which is considered suitable to support the Eastern False Pipistrelle Bat.

13.3.5 Positive impacts to biodiversity

The project would provide for additional bushcare sites and vegetation remediation areas to provide for existing biodiversity and promote an increase in local habitat for fauna. The GreenWay would be an example of an almost continuous vegetated corridor in the highly urbanised environment of inner western Sydney and would be an important landscape link to disperse fauna and flora. Consequently, the contribution of the project to the creation and functioning of the GreenWay can be seen as a positive biodiversity impact.

Positive impacts to waterways, particularly Hawthorne Canal, from WSUD may occur, as the impact of rapid urban stormwater passage and pollutants would be reduced and result in benefits to water quality and habitats.

13.4 Management of impacts

Management of the mitigation process

Before construction, detailed flora and fauna mitigation measures would be developed and presented as part of a flora and fauna management plan (FFMP) relating to the project's construction and operation. The plan would address:

- staff and contractor inductions, in particular the location of sensitive biodiversity and roles and responsibilities relating to protection of all native biodiversity
- vegetation clearing protocols, including pre-clearing surveys and fauna salvage/translocation
- rehabilitation and restitution of adjoining habitat
- weed control.

The plan would include the following clear objectives and actions for the project:

- limiting the clearing of vegetation to that required to construct the project
- minimising human interferences to flora and fauna
- minimising impact to Threatened species, populations and communities
- minimising impacts to aquatic habitats and species
- the management of vegetation and habitats surrounding the construction footprint including control of weeds
- the actions to use to rehabilitate affected areas, including revegetating areas for conservation purposes
- flora and fauna monitoring at regular intervals.

Mitigation measures

The general principle to minimise impacts to biodiversity should, in order of consideration, try to:

- avoid impacts on habitat, through the planning process
- minimise impacts on habitat, through the planning process
- mitigate impacts on habitat, though using a range of mitigation measures.

The avoidance of impacts can best be achieved through the planning and route selection process. The project largely follows the predefined route of the disused Rozelle goods line corridor and therefore opportunities to reposition the light rail route were not available. A number of possible stop locations and construction compounds were examined for impacts on the environment and other factors (for example, economic and social considerations). The proposed stops and construction areas that best fit the environmental, social and economic criteria were then chosen. The route selection for the GreenWay shared path has been chosen to minimise impacts on existing vegetation where possible and provide for bushcare areas.

Minimising impacts involves reducing the loss of habitat or significant species as far as practicable. The proposed stops and construction compounds are generally loosely defined within the broad corridor. Through detailed surveys within these corridors, it is usually possible to fine-tune the final locations and the width of the footprint to minimise loss of important vegetation communities or habitats and avoid significant plant species or habitat features. The final alignment and construction footprints are also subject to engineering constraints and safety standards.

Residual impacts that cannot be avoided or minimised are mitigated wherever possible. Depending on vegetation and project type, mitigation measures generally employed during construction can include the following:

- fauna exclusion fencing
- landscaping and revegetation
- site rehabilitation.

Table 13.4 outlines further mitigation measures.

Table 13.4 Proposed mitigation measures

Impact	Mitigation
Vegetation and habitat loss	▪ Limit disturbance of vegetation to the minimum necessary for all construction. ▪ Clearly mark the limits of clearing and install fencing around the areas not be cleared before construction activities start to avoid unnecessary vegetation and habitat removal. ▪ An ecologist would inspect all vegetation to be cleared for Long-nosed Bandicoots before disturbance; any that were found during the pre-clearing surveys would be relocated (if caught) to an appropriate location within the rail corridor that would not be cleared. ▪ An ecologist would conduct pre-clearing inspections of any bridges and tunnels for the presence of microchiropteran bat species. Any bats found roosting in the bridges or tunnels would be relocated and excluded from roosting in the structures until works have finished. Restrict equipment storage and stockpiling of resources to designated areas in cleared land. ▪ Cleared land would be revegetated as soon as practicable after completion of works to reinstate native vegetation and provide habitat for fauna.

Impact	Mitigation
Fragmentation and connectivity	▪ Connectivity would be maintained through revegetating the GreenWay with native species of local provenance. ▪ All areas used for construction compounds would be returned to original condition or revegetated with native plant species, depending upon their location and future planned use of the site.
Mortality	▪ To minimise the likelihood of fauna injury or death when clearing vegetation, measures identified in this table would be developed and presented as part of the FFMP. ▪ A vegetation clearing protocol would be developed and put in place. The protocol would include: ‣ all areas of potential Long-nosed Bandicoot habitat in the area to be cleared would be identified (by survey) and marked ‣ marked habitat areas would be disturbed by a person before clearing to encourage animals to disperse into adjacent habitat ‣ after disturbance the habitat may be cleared ‣ all contractors would have the contact numbers of wildlife rescue groups should animals be injured during clearing.
Weeds	▪ Weed management actions would be developed to manage weeds during the construction phase. This would specifically include the management of weeds listed under the *Noxious Weeds Act 1993.* ▪ Vegetation to be cleared would not be stockpiled on site and would be disposed of immediately offsite at a suitable waste facility licensed to accept green waste. ▪ Vehicles and other equipment used in clearing within the construction zone and general construction equipment are to be cleaned so they are completely free of soil, seeds and plant material before entering and leaving the site to prevent the introduction and spread of exotic plant species and pathogens. ▪ A weed control program would be developed in consultation with IWEG and local councils. The weed control program would aim to manage weed infestations and prevent weed encroachment into bushcare sites. ▪ Competitive planting with native species should be used to decrease the prevalence of weeds within the rail corridor. ▪ All landscape plantings are to be of locally indigenous native species to prevent future weed invasion.
Noise impacts on fauna	▪ None required. The impact of construction noise to fauna would be minimal in this highly urbanised landscape.
Altered hydrology	▪ Detailed design of pavements, other hard surfaces and drainage infrastructure would consider WSUD to avoid contaminated run-off into vegetated areas.
Cumulative impacts	▪ The project is in a highly disturbed landscape that possesses little natural vegetation or habitats. The revegetation proposed for the project would seek to reverse the cumulative impacts that have occurred within the locality.
Key Threatening Processes	▪ Weed control would be used throughout the corridor to reduce the potential for weed species establishing and spreading.

Impact	Mitigation
Positive impacts	▪ Revegetation of areas impacted during construction, where appropriate, would enhance the functioning of the GreenWay as a wildlife corridor and improve its value as habitat for native fauna. ▪ Providing new bushcare sites would be a positive impact for biodiversity and the community. ▪ The project would seek to mitigate habitat compartmentalisation through providing bushcare and vegetated areas as part of the GreenWay.

Compensatory measures

It should be recognised the success of compensatory biodiversity measures largely relies on the time lag between habitat loss and replacement of resources. To minimise the time lag between any vegetation removal and revegetation works, where practical, revegetation would take place before construction in areas where works would not be carried out.

Existing bushcare sites that may be lost to the project would be offset through establishing new bushcare sites, as outlined in the *GreenWay Bushcare Management Plan* (IWEG 2010a). Future bushcare sites have been identified (refer Figures 1a to 1f) and occupy an area of approximately 1.7 ha of land. The detailed design process, undertaken with Transport NSW and the IWEG, would further refine the locations and areas of the future bushcare sites.

13.5 Significance of impacts

One State and Commonwealth listed threatened species, the Grey-headed Flying-fox (listed as vulnerable under the TSC Act and EPBC Act), was recorded along the project during the survey. Additionally, previous biodiversity surveys within the study area have recorded the Inner Western Sydney population of endangered Long-nosed Bandicoot and the vulnerable Eastern Bentwing-bat, both listed under the TSC Act, as present. As such, significance assessments have been prepared for these species and population in accordance with the heads of consideration for threatened species assessment as suggested in the Department of Environment and Conservation/Department of Primary Industries draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation & Department of Primary Industries 2005). An assessment has been prepared in accordance with *EPBC Act — Principal Significant Impact Guidelines 1.1. Matters of National Environmental Significance* under the EPBC Act for the Grey-headed Flying-fox. Significance assessments have also been prepared for the Swift Parrot and Little Lorikeet as they are considered to have a moderate likelihood of occurrence within the study area (refer the Ecological Assessment, Technical Paper 4, Volume 2).

Although a small amount of habitat removal may occur due to the project, it is unlikely to result in a significant impact to the endangered Long-nosed Bandicoot population or threatened species listed under the TSC Act as the project would not:

- affect current disturbance regimes
- significantly affect habitat connectivity
- affect critical habitat.

For the threatened species listed under the EPBC Act, the Grey-headed Flying-fox and Swift Parrot, the project is unlikely to result in a significant impact as it would not:

- lead to a long-term decrease in the size of a population of the species
- reduce the area of occupancy of the species
- fragment an existing population into two or more populations
- adversely affect habitat critical to the survival of the species
- disrupt the breeding cycle of a population
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat
- introduce disease that may cause the species to decline
- interfere with the recovery of the species.

A summary of likely impacts to threatened biodiversity is provided in Table 13.5.

Table 13.5 Summary of likely impacts to threatened biodiversity

Threatened biodiversity		TSC Act[1]	EPBC Act[2]	Significant impact
Scientific name	**Common name**			
Endangered populations				
Perameles nasuta — Inner Western Sydney population	Long-nosed Bandicoot, inner western Sydney population	E2	-	No
Fauna				
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	No
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-	No
Lathamus discolor	Swift parrot	E	E	No
Glossopsitta pusilla	Little lorikeet	V	-	No

Notes:

1) TSC Act — E = Endangered V = Vulnerable E2= Endangered Population

2) EPBC Act — E = Endangered V = Vulnerable