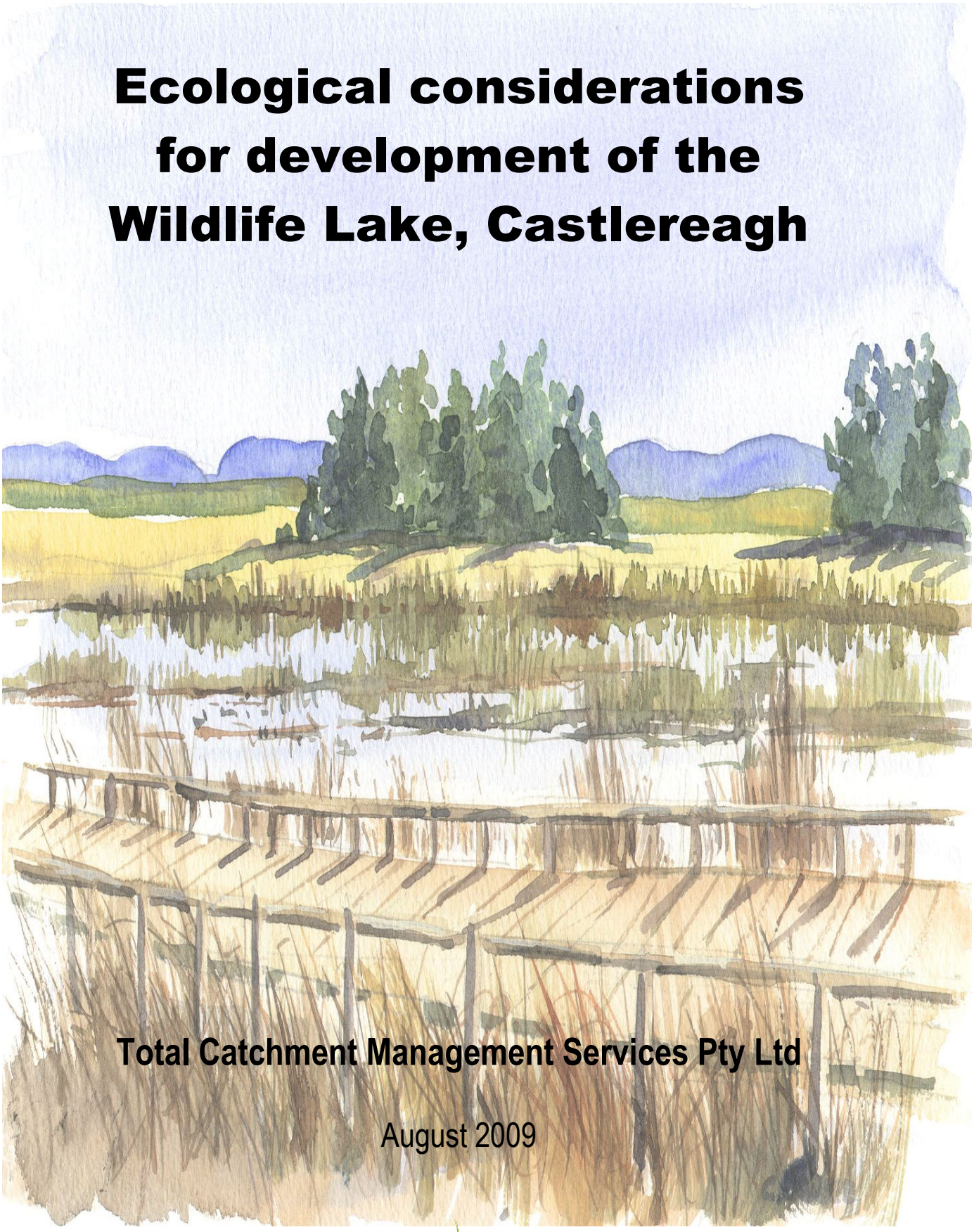
Ecological considerations for development of the Wildlife Lake, Castlereagh



Total Catchment Management Services Pty Ltd

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Ecological considerations for development of the Wildlife Lake

1. Introduction

This report aims to provide ecological information relating to wetland and dryland vegetation communities relevant to the proposed Wildlife Lake to assist Clouston Associates to develop further 'lake edge treatments' and 'kit of parts' management strategies. Government requirements relating to regional and local landscapes together with some more specific requirements relating to the design of landforms, to slopes above and below water and to the aquatic and terrestrial ecosystems to be developed are given in the Deed Schedules (1987), the DA4 Statement of Environmental Effects (SEE) and the DA4 Consent Conditions.

Additional to these are a number of general principles that need to be followed in developing the vegetation communities at Castlereagh and others that need to be met to allow animal populations to colonise, establish and thrive. But basic to all of these is the need to have wetland substrates and dryland soils that are stable, and have, or can develop relatively quickly, physical structure and nutrients available. Soil micro- organisms are increasingly recognised as being important for successful reclamation because of their vital role in nutrient cycling, in plant establishment and growth, geochemical transformations and soil formation. Macro-invertebrates are also an essential component of these systems and of the aquatic and terrestrial food-webs.

The report is based largely on published information. It outlines the main principles to be followed in developing the wildlife lake and its associated aquatic and terrestrial ecosystems and details the attributes that determine a wetland's value to wildlife that can be translated into design principles. Wetland and terrestrial vegetation communities appropriate to the wildlife lake site are outlined briefly with further information provided in appendices. Various practical aspects are considered in the draft Castlereagh Biodiversity and Natural Heritage Conservation Master Plan (TCM Services, 2007). Information on habitats, habitat components, and food requirements has been collated for aquatic and terrestrial invertebrates, and higher animal groups including birds, amphibians, reptiles and mammals. For many higher animal groups water and land areas need to include a number of different spatial scales ranging from 'points' such as a breeding site, to small-area refuges to large-area resources, such as swamps, grassy woodlands and tributary creeks for foraging and feeding. Published information on the size of wet or dry land areas needed for specific groups of animals for various activities are largely lacking. Only where studies of particular species have been undertaken are home ranges and other spatial requirements detailed.

The main currently recorded and, or expected resident vertebrate animal groups are noted, and the potential for national and international migratory bird species to use the habitats developed at Castlereagh is explored. Additionally, the potential for re-introduction of some rare and endangered animals is discussed.

1.1 Government requirements

In considering the design and development of the Wildlife Lake proposed for the northern sector of Castlereagh, the 1987 Deed Schedules and the DA4 Consents and advice provided in the DA4 Statement of Environmental Effects (DA4SEE) need to be taken into account as they provide the regional and local landscape principles to be met. Some more specific requirements relating to the design of landforms, to slopes above and below water and to the aquatic and terrestrial ecosystems to be developed are also given.

1.1.1 The 1987 Deed Schedules

Major Principles for the Penrith Lakes Scheme outlined are as follows:

1. The regional and local landscape context of the scheme shall be considered and where appropriate protected and enhanced.
2. The design and construction of the lakes, landforms and structures and selection and planting of vegetation shall be appropriate to the proposed end uses.
3. The overall landscape theme will, where possible, be based on a landscape that would have occurred had the lakes been formed naturally.
4. The design shall reflect both the overall landscape theme and the recreational strategy (1987 Deed, Sched 8.4 B).

For the Wildlife Lake it is stated that 'The lake will be designed to be visually integrated within the context of the floodplain and river. Land and lake forms shall be designed to be of optimum attractiveness to

wildlife. Facilities shall be provided so that the water level and quality may be managed.' (1987 Deed, Sched 8.4 C2 (b) (vi)).

A series of Specific Principles are also included. It is stated that 'These should be considered in the context of the major principles outlined above...' The specific principle for the Scheme landforms/Lake forms states that '(i) Scheme landforms and lake forms shall be generally of the form of those associated with a river traversing a flood plain. Maximum height of landforms shall be comparable with the levels of existing flood plain and not compete in height with surrounding natural features. (1987 Deed, Sched 8.4 C1).

With regard to bank slopes and underwater slopes the statements are as follows:

> All slopes and embankments shall be designed and constructed in accordance with sound engineering practices. (1987 Deed, Sched 8.3 D2).
>
> Underwater slopes are to vary between 6H: 1V and 10H: 1V depending on location within the scheme area. Such slopes are to commence at 1.5m above water level. After this point the slope may be varied, but to no steeper than 4H: 1V (1987 Deed, Sched 8.3 F4(b)).
>
> A1 - The completed landforms above normal water level shall have an overall slope no steeper than 6H:1V.
>
> A2 - Intermediate slopes steeper than this are permissible provided the overall slope is no greater than 6H:1V (1987 Deed, Sched 8.2 A1 A2).
>
> C1 – A minimum of 100 mm topsoil is to be spread on all the reconstructed landforms which are to be revegetated (1987 Deed Sched 8.2 C1).

With regard to vegetation the following statements are included:

> 'Long term: all lands are to be revegetated to a standard which will support the specified end-use.' (1987 Deed, Sched 8.2 D3).
>
> 'Selection: indigenous native trees and shrubs of the flood plain shall be generally used throughout the scheme to establish a locality character. Theme areas using exotic and/or deciduous trees may be developed in special locations.' (1987 Deed, Sched 8.4 C2 (d) (i)).
>
> 'Water Plants - PLDC will carry out planting of both submergent and emergent varieties of water plants, to provide for the establishment of wildlife habitats on the wildlife lakes, visual variety and amenity. Such planting is to be undertaken at the first filling of any lake.' (1987 Deed, Sched 8.4 C2 (d)(iv)).

With regard to lake waters it is stated that:

> 'The scheme should be designed and constructed to create and maintain a balanced fish community.' (1987 Deed, Sched 7 G1(a)).
>
> 'Sufficient shallows shall be provided in the lakes to develop appropriate habitats for fish community.' 1987 Deed, Sched 7 G2 (c).
>
> 'In the interim lakes, where recruitment facilities are not provided stocking with appropriate fish species shall be undertaken.' (1987 Deed, Sched 7 G2(e)).

The 1987 Deed, Sched 7 G 3 also indicates that 'PLDC should consult with the Fisheries Division of the Department of Agriculture on:

- Design of underwater slopes;
- Water management facilities;
- Rehabilitation proposals for the Nepean River bank;
- Aquatic ecosystem development; and
- Stocking of interim lakes.

The End Water Use for the Wildlife Lake is given as 'Lake water management, wildlife habitat including aquatic and shoreline habitat, scientific and educational, aesthetic value.' (1987 Deed, Sched 7 App A 2).

1.1.2 DA4 Statement of Environmental Effects (SEE)

The DA 4 SEE statements explore further the types of landform proposed: 'The design outcome will provide landforms, which are relatively low in level, in order to harmonise with the character of the surrounding floodplain and to avoid conflict in height with either the Blue Mountains escarpment or the Castlereagh escarpment. The created landforms will reflect natural hill slopes and associated drainage patterns. Terracing will also be incorporated into the site landforms, particularly along lake foreshore areas. In accordance with natural floodplain characteristics, such terraces will vary in width with the potential to introduce a levee bank

character along existing colours, textures and patterns of the landscape. These include gravel and sand, pasture grasses and indigenous native trees and shrubs. (DA4 SEE, p. 72).

The SEE notes also that 'The treed creek north of 'Hadley Park' that contains mainly *Angophora subveltina* will be retained as part of the curtilage around 'Hadley Park'. The vegetation along the creek is a good source of seed of several local tree species and will be useful in revegetating the scheme area.' (DA4 SEE, p. 99) and with regard to ecosystems 'One of the primary targets of current water management is the early establishment of a complete, diverse and well balanced aquatic eco-system.' (DA4 SEE, p.63).

1.1.3 DA4 Consent Conditions

These consent conditions basically reinforce those provided in the 1987 Deed. They include statements relating to bank slopes, design principles for the wildlife lake, selection of plant species and the retention of the Angophora stand north of Hadley Park:

Bank Slope - The completed landforms above normal water level shall have an overall slope no steeper than 6H: 1V. Intermediate slopes steeper than this are permissible provided the overall slope is no greater than 6H:1V. Any departures from the uniform 6H:1V slope are to be specifically justified. (DA4 consent, Cl 16).

[Topsoil] 'A minimum of 100 mm topsoil is to be spread on all the reconstructed landforms which are to be revegetated'. (DA4 consent Cl 19).

[Plant] Selection: indigenous native trees and shrubs of the floodplain shall be generally used throughout the scheme to establish a locality character. Theme areas using exotic and/or deciduous trees may be developed in special locations. (DA4 consent, Cl 22).

[Wildlife Lake Design] 'Within two years of the date of this consent the applicant shall consult with the Hawkesbury - Nepean River Trust and submit to the Department of Urban Affairs and Planning for approval, design principles for the Wildlife Lake that will maximise the wildlife value of the lake. Detailed plans based on the approved principles shall be prepared by the Applicant and submitted to the Department of Urban Affairs and Planning for approval.' (DA4 consent, Cl 15).

[Hadley Park Creek] The treed creek north of Hadley Park is to be retained as part of the curtilage around Hadley Park to permit the retention of a stand of *Angophora subveltina*. (DA4 consent, Cl 41 (iii)).

1.2 Principles relating to plants and animals

Some general principles underlie the development of vegetation communities at Castlereagh and others must be met to allow animal populations to colonise, establish and thrive. In order to establish and 'mimic', as far as possible, the former natural vegetation communities it is essential to:

1. *Use local provenance plant species*: These are best adapted to the soils and climate of the area, most likely to provide the habitat resources that local fauna require and allow normal plant-animal interactions and ecological processes to be restored.

2. *Reflect naturally occurring community composition, floristic diversity and abundance*: The species selected and the numbers of plants used must parallel those that would be found within the different plant communities under natural conditions.

3. *Distribute plant species on the basis of ecological preferences within natural communities:* Landform, micro-topography, environmental, soil gradients, salinity and watertable depth must all be taken into consideration.

4. *Develop full structural complexity, integrity and functionality*: Establish the natural layers in the vegetation (canopy, understorey and ground cover), ensure different age classes are present (seedlings, saplings, mature and aging plants), and that all functional groups are represented (ground cover, shade, litter production, nitrogen fixing, etc.).

For the animals it is essential to:

5**.** *Provide adequate living space:* Home ranges, foraging areas, routes for dispersal, and areas available must all be taken into account. Bigger areas support larger and more diverse animal populations and area to edge ratios need to be kept to a minimum.

6**.** *Create and sustain habitat diversity:* A full range of different environmental niches is required including wet, dry, bare ground, sparse or dense groundcover or understorey, open or closed canopy, cleared, sunny or shady areas, etc.

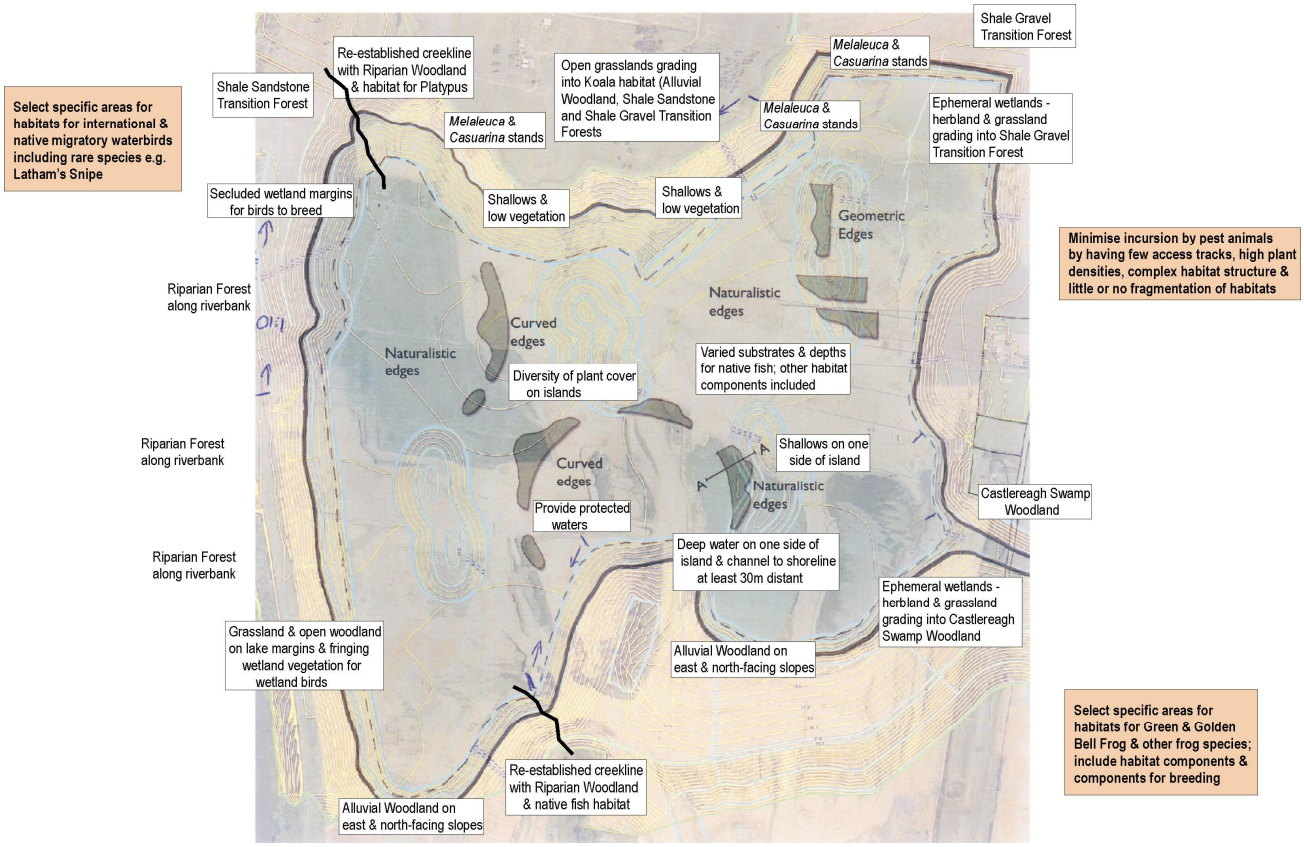
7. *Provide and develop various habitat components:* Initially by provision, and then by managing with nature, a whole range of components need to be introduced and developed, including rocks, leaf litter, ground cover, fallen logs, dead or live trees with hollows, different bark textures, a variety of foliage densities in shrubs, thickets etc.

8. *Ensure food and life cycle resources are available:* Water, soil invertebrates, fungi, surface lichens and mosses, flowering shrubs and trees for nectar, fruit, foraging sites, refuge sites, nesting/breeding sites, etc. are all required.

9. *Provide corridors to allow movement:* Highly mobile species move between multiple habitats and need a connected system of vegetation. Some animals follow flowering or fruiting patterns of plants. Juveniles must be able to disperse from their maternal home range and establish in new areas.

10. *Provide refugia:* For many species, all of the above may be in evidence, however their presence is attributable to a lack of disturbance by humans and/or active protection against effects such as predation and competition from introduced species. These effects may include biological hazards that become significant in small or remnant populations.

Figure 1. Some suggested design features for the wildlife lake



2. Wildlife Lake – designing a wetland of value to wildlife

2.1 Penrith Lakes Water Committee and Expert Panel Reports

A Water Committee and Expert Panel were established to 'review the requirements of the *Penrith Lakes Scheme Water Plan* and *Deed of Agreement* against the existing and proposed works and determine whether the overall objectives of the Plan and Deed will be achieved or whether additional work is required'.

They did not investigate requirements for the Wildlife Lake in detail:

'Currently plans for the wildlife lake are limited. In order to gain the best outcomes for these lakes careful consideration of their end purpose need to be undertaken, taking into account the known biodiversity and ecology of the Penrith area. Whilst it is not expected that these lakes will be created for several years, it is recommended that planning for these lakes, in terms of defining their purpose commences soon to allow sufficient timing for planning and (if required) research.' It was also noted that: 'It is not clear (from the Water Plan for the Lakes) what the intended end use of the wildlife lakes will be other than general statements about providing aquatic and shoreline habitat for a range of species.' and, 'The recreational lakes rely on submerged macrophytes, but the wildlife lake may include emergent macrophytes.'

The Expert Panel recommended that:

'Clear objectives for the wildlife lake should be formalised in terms of intended fauna species (macroinvertebrates, birds, frogs, fish, reptiles, mammals) to be attracted, such that the types of habitat required can be determined. An assessment of macrophytes for the wildlife lakes should take into account the end purpose of the lakes as well as the ecology of the macrophyte species'

A detailed assessment of operational and maintenance procedures was carried out for the development of the aquatic biology in the recreational lakes. This work included consideration of potential and possible methods of recruitment, and identification of appropriate species, of potential problem species and of factors that would affect development and population control. No equivalent work was undertaken for the wildlife lake but it was stressed that determination of the types of habitats required 'will then provide information relevant to the design of the lake (i.e. need for shallow and/or deep areas, islands, sand banks, water levels, water flow, etc), including macrophyte species required.' (Penrith Lakes Water Principles and Water Plan, Peer Review, Stages 1 and 2 Review, May 2005).

2.2 Macrophyte Planning for Lakes

Some preliminary macrophyte planning for the recreational lakes was provided by Biosis in September 2007. They stated that while recommendations for Lake A could also be applied to Lake B the wildlife lake 'will be significantly different due to its fluctuating water levels.' They emphasised the need for adequate areas of macrophytes to ensure water quality is maintained and noted their value also in providing a stable ecological state.

Macrophyte distribution is constrained by light and depth and also affected by substrate type and nutrient availability. The report recommended for Lake A that 30-50% of the total surface area should be made available for submerged macrophytes with water depths in these areas being between two and six metres, depending on water clarity. Submergent species that differ in their depth and light level requirements include *Vallisneria americana*, *Potamogeton crispus*, *P. perfoliatus*, *P. ochratus*, *Hydrilla densa*, *Myriophyllum* spp. and the macro-algae *Chara* and *Nitella*. To establish a diverse community it was considered that three or four submerged species should comprise at least 10 per cent of the total coverage each and at least five species should be established.

Recommendations for emergent macrophytes were that at least 70 per cent of the perimeter should have some cover with water depths to about one metre. Species noted in the figures attached to the report included *Persicaria decipiens* and *Typha* sp.

2.3 What attributes determine a wetland's value to wildlife?

The main attributes determining the value of a wetland to wildlife include its size, habitat diversity, the way in which the habitat components are dispersed within the wetland (interspersion), the form of the margins, the amount of cover to provide shelter, refuges, living and breeding sites provided for wildlife, and the nature of the surrounding dry land.

Wetland size: in general the larger the area of a wetland, the greater is its value as wildlife habitat. A larger wetland can support larger populations of animal species and, because there are usually more habitat types available, a higher diversity of species. A larger wetland is also likely to remain viable during long periods of dry weather.

Habitat diversity: the higher the habitat diversity exhibited by an area, the greater is the diversity of wildlife supported by that area. A wetland exhibiting open water, a variety of vegetation types, a variety of substrates, for example mud and sand, and a variable shoreline will support a greater variety of wildlife than a simple wetland with open water and a few fringing reeds. Variation in water depth is also important because it provides for a wider range of plants and animals than a wetland with no variation in water depth.

Interspersion: a wetland will be more valuable to wildlife if there is maximum variation in the way in which the habitat components are distributed within the wetland. Habitat components, such as reed beds and open water, are of most value if they are scattered throughout the wetland. Value will be gained also by maximising the length of the edge of the habitats.

Margins: the edges of a wetland should be uneven, incorporating peninsulas, embayments and islands. Within the wetland itself the edges of the patches of component habitats, such as reeds and open water, should also be as uneven as possible. Maximising the variation in the character of the margins of the wetland will increase its value to wildlife. The shoreline of the wetland should be very gently sloped and where possible composed of a variety of substrates, such as mud, sand and rock.

Cover: in general, dense vegetation cover is more valuable as roosting, feeding and breeding habitat for wildlife than open cover. But some animals need open areas also and therefore variation in the structure and density of cover will increase value for wildlife. A diversity of wetland plant species forming the vegetation cover is also important.

Sheltering and breeding sites: the presence of particular features will enhance the value of the wetland for some species as sheltering and breeding sites. For example, logs and dead trees in and near the water's edge are used by many species of bird for roosting. Other features preferred or required by some species include rocky outcrops, shallow pools away from the main wetland or the presence of particular food plants. Fish require snags (logs and branches) in the water to shelter and breed.

Upland habitats: the wetland habitat extends beyond the water's edge. The surrounding upland provides habitat for various wetland species at some time in their life cycle, for example, frogs. Also, some waterbirds will forage on grassy areas following heavy rain and many birds associated with the wetland feed on invertebrates that live in nearby vegetation or on the seeds of upland plants. Variation in the type of vegetation surrounding the wetland and of the habitat components required by different animal species will increase value for wildlife. For example, scattered logs and rocks will provide cover for frogs and other species, and a diversity of native plants will provide cover and food for various birds and habitat for their invertebrate prey species.

2.4 Design principles

To maximise the value of a wetland for native wildlife and through that maximise wildlife diversity the following principles need to be applied:

1. Maximise the diversity of the habitats available on the wetland including on the islands.
2. Create islands as secure places for wildlife to escape disturbance from people and predation by introduced mammals. Separate islands from the mainland by a deep channel.
3. Maximise the length and irregularity of the shoreline.
4. Ensure that adequate depths are present so the wetland does not become choked with reeds.
5. Create an irregular bottom to the wetland to provide a variety of water depths as well as habitat variation for aquatic fauna.
6. Create very gentle slopes on the edge of the wetland, except where deep water is needed to discourage reed growth.
7. Provide a diversity of local native wetland plants on the site.
8. Create an area with no public access, as an undisturbed area for wildlife.
9. Create screens of appropriate treed areas to minimise disturbance from adjacent land uses, and or shelter from prevailing winds.

10. Provide a diversity of plant communities on the adjacent upland to extend habitats and habitat components for wetland fauna.

2.5 Possible profiles and habitats from uplands/dry land to lake

Clouston Associates (2009) in their 'Generic wildlife lake edge treatments' indicate four main zones from dry land areas to deep water lake areas, with a range of different slope gradients and water depths, namely:

terrestrial zone – gradients 1:80 to 1:3

ephemeral wetlands – gradients 1:40 to 1:10; water depth 0-500mm

permanent wetlands – gradients 1:20 to 1:6; water depths 500 – 1000mm

deep water lakes – gradients 1:6 to 1:3 (or max angle of repose); water depth 1-10m

Within these zones there can be a variety of different plant communities that would provide a mosaic of animal habitats. Table 1 indicates a possible range.

The aim is to provide a range of habitats including open deep water, protected and enclosed areas of water, islands with plant cover, shallows with emergent reeds and rushes, open sandflats and mudflats, grasslands and other herblands, shrublands, woodlands and forests on the surrounding uplands. Intergrades or ecotones need to be provided between each of the community types to provide a continuum of habitats and corridors for movement of animals.

Table 1. Plant communities to provide faunal habitats within identified landscape zones

Plant community **Zone**	**Terrestrial**	**Ephemeral wetlands**	**Permanent wetlands**	**Deep water lakes**
Riparian Forest				
Alluvial Woodland				
Shale Gravel Transition Forest				
Creeklines and ephemeral drainage lines				
Casuarina stands				
Melaleuca swampland				
Castlereagh Swamp Woodland				
Grasslands				
Herblands				
Sedgelands, Rushlands (aquatic emergents)				
Aquatics – attached and floating				

3. Wetland vegetation communities

In natural wetlands on floodplains there are a variety of different communities present. Some are permanently wet lagoons, other semi-permanent backswamps and others again are seasonally inundated floodways and back channels. These communities carry a variety of different plant species that form clear vegetation zones relating to water depth, the amount of time inundated and substrate type (mud or sandy). Some swamp vegetation communities are predominantly herbaceous whilst others, such as the paperbark and she-oak communities are woody.

In establishing wetlands on quarried land it is essential that ground preparation includes the addition of topsoil and,or organic matter to provide a good rooting medium and nutrients for plants and a substrate and surface for aquatic invertebrates.

3.1 Herbaceous communities

Some 65 species have been recorded as aquatics, emergent semi-aquatics and marginal wetland species (See Appendix 1 Table 1). Most of these species will occur across a number of different substrates as it is the surface water depth that determines their presence and distribution within the wetland.

3.1.1 Open deep water; protected and enclosed areas of water

Some nine species can be expected to occupy the deep water areas of the lake, including two free-floating species (*Azolla filiculoides* var *rubra* and Duckweed, *Lemna disperma*). Two other species, Ribbonweed (*Vallisneria americana*) and Floating Pondweed (*Potamogeton tricarinatus*) are restricted to the deeper waters while the other five species occur also in the shallower, permanent wetland of less than one metre depth: Tall Spikerush (*Eleocharis sphacelata*), Cumbungi (*Typha orientalis*); Common Reed (*Phragmites australis*), *Myriophyllum variifolium*, and Frogsmouth (*Philydrum lanuginosum*). The last three of these are also tolerant of more ephemeral wetland conditions.

The majority of these species provide food for waterfowl including Australian Wood Duck, Australiasian Shoveller, Black Swan, Blue-billed Duck, Freckled Duck, Hardhead, Musk Duck, Pacific Black Duck, Pink-eared Duck, Grey Teal, Stubble Quail and Lathams Snipe amongst others (see Appendix 1, Table 1). Others such as Frogsmouth, Tall Spikerush, Common Reed, and Cumbungi also provide shelter and cover for wildlife. The latter two also play an important part in controlling erosion and preventing wave damage, and also reducing evaporation from the water surface.

Two of the plant species are considered significant in Western Sydney, namely *Azolla filiculoides* var *rubra* and *Myriophyllum variifolium*; if these species can be established they will assist with their conservation.

3.1.2 Shallows with emergent reeds and rushes

In addition to those species discussed above there are 33 species that occupy permanently wet areas and of these the majority (27) also tolerate ephemeral conditions. At least 17 of these species provide food for a variety of waterfowl and taller sedges such as *Juncus usitatus* and Tall Flat-Sedge (*Cyperus exaltatus*) provide good cover and nesting sites. *Haloragis heterophylla* is recorded as food for the Stubble Quail and *Brachycome graminea* as food for both Stubble Quail and Latham's Snipe. One species, *Maundia triglochinoides*, is listed as Vulnerable in Schedule 2 of the TSC Act and 14 others are recorded as significant in Western Sydney (see Appendix 1, Table 1).

3.1.3 Grasslands and herblands - marginal and ephemeral wetlands on sandflats and mudflats

Some 23 species are found only on the damp wetland margins, on lakeside banks and alluvial flats subject to seasonal or occasional inundation, that is, ephemeral wetlands. At least six of these species provide food for waterfowl, and one, Branched Goodenia (*Goodenia paniculata*) is food for the Stubble Quail. Some seven species are recorded as significant in Western Sydney. Included here are the sedges *Cyperus gunnii* and *Fimbristylis velata*, the rush *Juncus remotiflorus*, and the grasses Clustered Lovegrass (*Eragrostis elongata*) and Matt Grass (*Hemathria uncinata*). Forbs include Spreading Sneeze Weed (*Centipeda minima*), and *Gratiola pedunculata*. Again, establishment of these species will assist in their conservation.

3.1.4 Current observations on wetlands

Observations on 31 March 2009 on wetlands at Cranebrook Lakes South and One Tree Lagoon provide information on current species composition in relation to water depth that is useful for planning of further wetland areas by providing a 'reality check' on the species likely to self-establish and thrive. Table 2 summarises the data.

Table 2 Wetland species composition in relation to water depth at Castlereagh*

Species / Depth	0-9cm	10-19cm	20-29cm	30-39cm	40-49cm	50-59cm	60-70cm
Alternanthera denticulata	Yes						
Azolla							Yes
Carex appressa	Yes						
Centella asiatica	Yes						
Cyperus sp.	Yes						
Eleocharis sphacelata			Yes	Yes	Yes	Yes	Yes
Juncus usitatus	Yes	Yes					
Ludwigia peploides			Yes	Yes	Yes	Yes	Yes
Marsilea mutica	Yes						
Myriophyllum papillosum			Yes	Yes	Yes		
Paspalum dilatatum	Yes						
Paspalum distichum	Yes	Yes	Yes	Yes	Yes		
Persicaria decipiens	Yes						
Plantago lanceolata	Yes		Yes		Yes	Yes	
Triglochin procera			Yes	Yes	Yes		
Typha orientalis					Yes		

*Raw data provided by Justin Russell

3.2 Woody wetland communities and intergrades to terrestrial communities

3.2.1 Riparian woodland

This occupies the wettest areas along the watercourses that drain the floodplain, on substrates comprising equal amounts of Holocene alluvium and Wianamatta Shale. The forest canopy can be up to 30m high with a foliage cover of about 30%. The sub-canopy layer is sparse with only about 15% foliage cover, and the shrub layer is virtually absent (5% foliage cover) but there is a dense ground cover with about 60% foliage cover. Tree and shrubs species that are tolerant of waterlogged soils or periodic inundation occur here. They are the paperbark (*Melaleuca*) shrublands and the she-oak (*Casuarina*) stands that often fringe the herbaceous wetland communities or form a mosaic of vegetation that reflects differences in watertable levels or water movement. These and other woody and herbaceous species found on the lowest parts of the floodplain are listed in Appendix 1, Table 2 and their value for wildlife noted.

Abundant species are Swamp Oak (*Casuarina glauca*), Snow in Summer (*Melaleuca linariifolia*), Prickly Paperbark (*Melaleuca styphelioides*) and commonly associated are the shrubs Tick Bush (*Kunzea ambigua*), White Feather Honey-myrtle (*Melaleuca decora*), and the rushes, sedges and grasses Tall Sedge *(Carex appressa)*, Common Rush *(Juncus usitatus)*, Weeping grass (*Microlaena stipoides)* and Basket grass (*Oplismenus aemulus)*. Other trees and shrubs occasionally found on the periodically waterlogged soils include Broad-leaved Apple (*Angophora subvelutina*), River She-oak (*Casuarina cunninghamiana*), Cabbage Gum (*Eucalyptus amplifolia*), Thin-leaved Stringybark (*E. eugenioides*), Forest Red Gum (*E. tereticornis*) and Lemon-scented Tea tree (*Leptospermum polygalifolium*). Some of the wetland herbs noted above are found also as ground cover together with species of *Persicaria* and Maidenhair fern (*Adiantum aethiopicum*).

3.2.2 Castlereagh Swamp Woodland

Patches of this woodland could occur on the eastern and south eastern side of the lake where poorly drained depressions occurred on mixed shale and Tertiary alluvium soils. The canopy of this community reaches 15-20m with about 24% foliage cover. The small tree layer is sparse (about 18% foliage cover) and there is a poorly developed shrub layer (about 6% foliage cover) but much denser and diverse ground layer, averaging about 53% foliage cover. Some 17 trees and small trees, 15 shrubs, four climbers, 23 grasses, 37 other herbs and two ferns are represented within the community. The majority of the species are found also in Riparian Forest and Alluvial Woodland and are not considered further here (see PLFullSpeciesListGenusOrder.xls).

3.2.3 Community Intergrades from Wetland to Dry land

Where the floodplain flats meet the slopes of gentle rises or the lower slopes of the escarpment a lowering in watertable levels will allow other species, tolerant of fluctuating watertables, to grow. The species most commonly found in these drier parts of the continuum from swampland to drier woodland include four *Acacia* species (Sydney Green Wattle, *Acacia parramattensis* is common, Black Wattle, *Acacia decurrens*,

Sickle Wattle, *Acacia falcata* and White Sallow Wattle, *Acacia floribunda* occasional), and also Grey Box (*Eucalyptus moluccana*) and *Phyllanthus gunnii* as well as a number of the tree and shrub species mentioned above. Common grasses include *Austrostipa ramosissima*, *Echinopogon ovatus*, *Entolasia marginata* and *Eragrostis brownii,* and abundant or common herbs include Kidney Weed (*Dichondra repens*), Scour Grass (*Oxalis perennans*) and *Poranthera microphylla*. Four climbers may be present in the woodland with Twining Glycine (*Glycine clandestina*) recorded as common. These and other species are listed in Appendix 1, Table 3.

3.3 Islands with plant cover

Any islands with shallows adjacent will be able to support the full range of plant communities (deep water to ephemeral wetlands) and the dryland surfaces could carry Casuarina and Melaleuca shrublands and woodlands where feasible. Trees and shrubs should be planted to provide shelter from prevailing winds.

Islands provide very valuable wildlife refuges - areas for breeding, roosting and feeding that are free from disturbance and secure from at least some introduced animal predators. Experience elsewhere suggests that to be safe for birds there should be a minimum distance from the island to the shore of 30 metres to prevent predators reaching it, and a relatively deep channel should be provided. Deep water prevents the spread of emergent vegetation and ensures an area of permanent open water is available for diving species. It is also suggested that shelf areas at different depths below the surface are valuable as they provide for different water plants to establish – emergent marginal vegetation at 0.5-1m deep, floating-leaves and submerged plants root on flat areas between 1-3 metres deep (Furness & Lane 1992).

Consideration could be given also to providing shallow areas within the lake, that is ‘submerged islands’, with emergent macrophytes as it has been observed that such habitats currently found in parts of the PLDC quarry site are popular with water birds (J. Russell, pers.comm.).

3.4 Rehabilitated creeklines

The former tributary creeks that crossed the alluvial floodplain would have been meandering streams with slow-moving water, and somewhat ephemeral in nature. Swamp Oak (*Casuarina glauca*) would have bordered them either as pure stands or mixed with Snow in Summer (*Melaleuca linariifolia*). Dense stands of *Phragmites australis* could be present in some of the wettest areas and sedges such as Common Rush (*Juncus usitatus*) on the better drained areas. Also present on the riverbank and floodplain creeklines are Lilly Pily (*Acmena smithii*), Blueberry Ash (*Elaeocarpus reticulatus*) and White River Gum (*Eucalyptus* elata. The grasses *Echinopogon caespitosa*, *Entolasia marginata* and Basket grass (*Oplismenus aemulus*) are common together with *Galium propinquum*, Spiny Mat Rush (*Lomandra longifolia)* and *Wahlenbergia gracilis* as ground cover. Several climbers may be commonly present also (see Appendix 1 Table 4).

4. Dry land (terrestrial) vegetation communities

Some four terrestrial vegetation communities could be represented on the drier slopes surrounding the Wildlife Lake and they would intergrade with the wetland communities described above: Riparian Forest, Alluvial Woodlands (sub-communities of River Flat Eucalypt Forest), Shale Sandstone Transition Forest and Shale Gravel Transition Forest.

4.1 Location, structure and species composition

The location of the communities around the lake and their characteristic structure would be as follows and the number of species represented within each community within each growth form is given in Table 3.

4.1.1 Riparian Forest

Located on the Nepean River banks and immediately adjoining terraces on Holocene alluvium, the forest has a 20-30m high canopy with foliage cover varying between 30 and 70%. A small tree stratum has about 24% foliage cover and the discontinuous shrub layer, averaging about 15% foliage cover, is frequently dense on the levee banks and characterised by a tangle of vines amongst the shrubs. The ground cover varies with moisture levels and banks of ferns, native grasses and many different herbs are also present; average foliage cover is about 46%.

4.1.2 Alluvial Woodland

This would occur on the eastern and northern-facing slopes and terraces on the lake's western and southern side on mixed substrates of Holocene alluvium, Wianamatta Shale, and small amounts of Mittagong Formation, Hawkesbury Sandstone and Tertiary alluvium. The tree canopy is 20-30m high and has a foliage cover of about 23 to 30%. There is a small tree stratum with about 15% foliage cover, a sparse shrub layer (13% average cover) and a dense and diverse ground layer averaging about 61% cover.

4.1.3 Shale Sandstone Transition Forest

Sandstone-tolerant species could occur in the northwest sector of the Wildlife Lake. The forest canopy is 20-30m high with foliage cover 20-25%. Both the small tree stratum and the shrub stratum are sparse, averaging 11-12% foliage cover respectively, and the ground cover is somewhat denser with an average foliage cover of about 34%, and is more diverse in species composition.

4.1.4 Shale Gravel Transition Forest

This could be represented on the north eastern side of the lake. The canopy is 25-35m high with an average foliage cover of 21%. Both the small tree and shrub layers are relatively sparse with about 8% and 14% foliage cover respectively, while the ground cover is both denser (45% foliage cover) and more diverse.

Table 3. Number of plant species in different growth forms within each terrestrial community

Growth Form	Riparian Forest	Alluvial Woodland	Shale Sandstone Transition Forest	Shale Gravel Transition Forest
Trees and small trees	24	35	36	27
Shrubs	23	30	54	52
Climbers	9	21	23	10
Grasses	18	36	46	33
Other herbs	26	73	79	69
Ferns	2	10	6	2
Totals	**102**	**205**	**244**	**193**

The structure of these forests and woodlands provide a range of more or less closed to open habitats for animals with a variety of woody and herbaceous habitat components. The wide variety of growth forms and the numbers of species that could be represented within each community would ensure adequate food and other living resources for animal populations. The individual species composition of these communities is given in various tables in Appendices 4 and 5 of the Castlereagh Biodiversity and Natural Heritage

Conservation Master Plan Draft Report (TCM Services, 2007) and the known wildlife values are given in the associated plant databases (see PLFullSpeciesListGenusOrder.xls and Plant foods of birds.xls), and are not considered further here.

4.2. Developing aquatic and terrestrial ecosystems

With the development of vegetative cover in both wetland and dryland areas it could be expected that many of the soil micro-organisms and invertebrates that assist in the development of soils and play an essential role in the functioning and health of the ecosystems would establish fairly readily and rapidly. But just how quickly the micro-organisms will recolonise will depend on the location of natural recruitment areas and also on the organism's ability to disperse. Key functional groups for the aquatic ecosystems include worms, snails and mussels, small crustaceans, insect larvae, bacteria and fungi, and for the terrestrial ecosystems earthworms, termites, ants, woodlice, millipedes, insect larvae, bacteria, fungi and hexapods. Records of aquatic and terrestrial invertebrate groups with potential to establish at Castlereagh have been collated and information on their habitat requirements, feeding characteristics and predators is summarised in Section 5 of this report with further details provided in the appendices and an excel database currently under development.

Once functioning ecosystems are operating (including all of the various biogeochemical (nutrient) cycles), and enhanced vegetation cover (with diverse structural and floristic elements) is present, it could be expected that macro-invertebrate animal populations (that provide food items for vertebrate animal groups), would establish. A recent review of revegetation and mine site rehabilitation studies noted that 'Many invertebrate orders had similar species richness to surrounding unmined forest within seven years…' while in a study that compared cleared farmland, revegetation sites and remnant forest it was found that 'grasshoppers were much more abundant in cleared farmland than revegetation or remnants; beetles and ants were reasonably abundant in all vegetation types… while 'amphipods were abundant only in vegetation of high floristic diversity (remnant forest, regenerating forest and floristically rich ecological restoration plantings)…'(Salt & Lindenmayer, 2008).

Recolonisation at Castlereagh by the different vertebrate groups of animals can be expected at three phases of vegetation development, namely establishment, intermediate and mature. As the vegetation communities develop there will be an increased diversity of habitats available and the level of resources needed to meet food and nesting or breeding requirements will also increase. Species that are common in nearby natural areas and have the ability to to move across a variety of terrain and environments together with those that are considered to be 'generalist' in their requirements and are adapted to modified environments could be expected to be the first to visit and, or establish. Others requiring more specialised habitats and particular foods and nesting or breeding resources will arrive later or need to be re-introduced. For some species re-introduction will be required so that barriers to their movement, such as roads and areas of cleared land, are overcome.

But it needs to be emphasised that the successful re-establishment of vertebrate animal populations in the newly planted and rehabilitated vegetation will depend largely on the complexity of the vegetation that can be achieved, the diversity of plant species available and the presence of essential habitat components and life-cycle resources.

Information has been collated on the resource needs (habitat preferences, shelter and foraging requirements, foods eaten, nesting and breeding needs) and other characteristics of the main vertebrate faunal groups that have been recorded at Penrith Lakes or from nearby areas, to ensure that the plant communities developed will support the fauna. These data are summarised in the later sections of this report with further details available in the appendices and in excel databases.

Many of the species recorded or expected are considered as 'generalist' species; they have become adapted to modified environments. But they still have a very important role to play in plant-animal interactions and in contributing to the provision of the much-needed natural ecological services that ensure there is clean air, water and other resources available to all.

As well as the 'generalist' species at Castlereagh it will be possible to support more specialist fauna and even contribute to the recovery or enhancement of population measures for endangered or vulnerable species, or those that are regionally significant to western Sydney itself. To do this for some species will require human intervention initially until such time as the natural vegetation has matured and become self-sustaining across the landscape. For a few species, the fragmentation of previously widespread key habitat will necessitate continuing adaptive management support.

5. Invertebrates

5.1 Wetland environments

Invertebrates recorded from the Nepean River including areas below Penrith together with those noted as widespread indicate that at least eight different phyla of invertebrates can be found associated with river waters (Table 4) and also lakes and slow-moving waters (www.mdfrc.org.au). Within these phyla the insects (beetles, bugs, spiders, flies (six orders) and moths) are the best represented followed by crustaceans (four orders).

Table 4. Invertebrate groups recorded from the Nepean River*

Group	Widespread		Nepean River		Nepean below Penrith	
	No families	No. taxa	No. families	No. taxa	No. families	No. taxa
Sponges (Porifera)	1	?	-		-	-
Nematodes (Nematoda)	1	1	-	-	-	-
Proboscis worms (Nemertea)	1	1	-	-	-	-
Flatworms (Platyhelminthes)	1	1	2	2	-	-
Segmented worms (Annelida - Oligochaeta)	1	1	2	4	4	4
Leeches (Annelida - Hirundinea)	2	2	1	2		
Mussels (Mollusca - Bivalvia)	-	-	1	4	-	-
Snails (Mollusca - Gastropoda)	2	2	3	4	3	3
Sandhopper (Crustacea - Amphipods)	-	-	1	1	-	-
Freshwater Shrimps (Crustacea - Malacostraca)	1	1	1	1	1	1
Seed shrimps (Crustacea - Ostracoda)	-	-	1	2	-	-
Water mites (Insecta - Arachnida)	-	-	5	5	2	2
Beetles (Insecta - Coleoptera)	3	3	4	6	3	3
True flies (Insecta - Diptera)	2	6	4	25	2	8
Mayflies (Insecta - Ephemeroptera)	-	-	2	7	1	1
True bugs (Insecta - Hemiptera)	1	1	2	2	2	2
Moths (Insecta - Lepidoptera: Pyralidae/Crambidae)	-	-	1	3	1	5
Alderflies (Insecta - Megaloptera)	-	-	1	1	-	-
Lacewings (Insecta - Neuroptera)	-	-	1	1	-	-
Dragonflies & Damselflies (Insecta - Odonata)	3	4	4	5	4	5
Caddisflies (Insecta - Trichoptera)	1	4	5	13	2	2
Totals	20	27+	41	88	25	36

* Data extracted from Appendix 4 of Jones, H. et al 1997.

5.1.1 Habitats

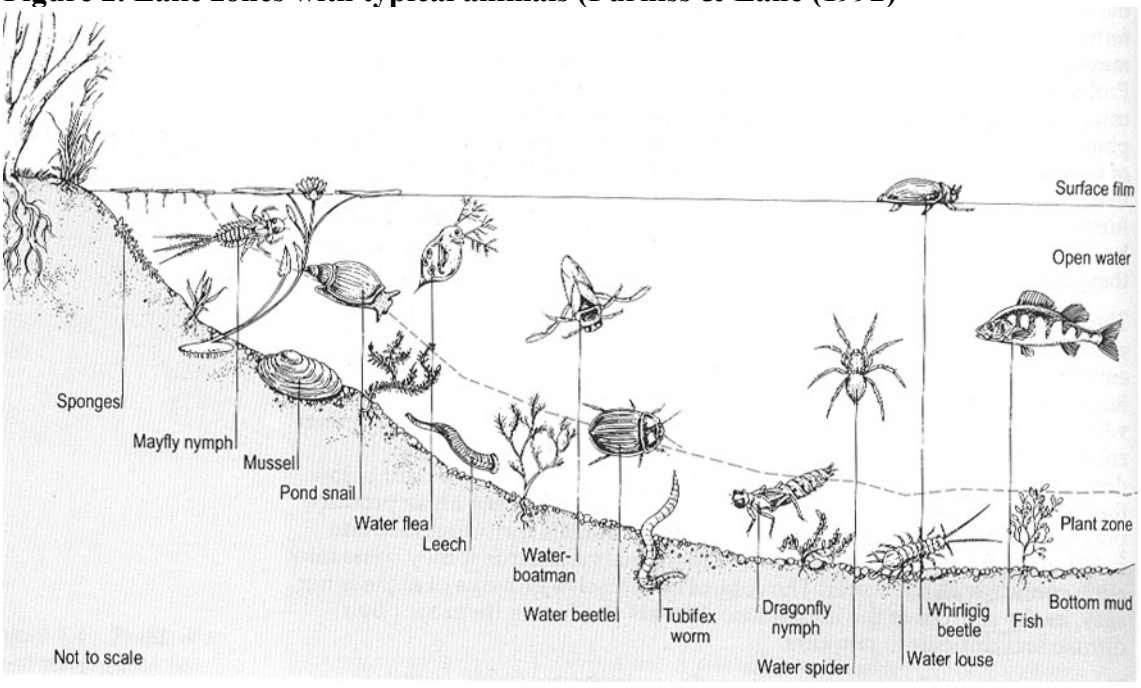
Tables 5 and 6 indicate the preferred habitats of the various groups. More detailed information is provided in an excel database currently under development, based on information available mainly from the Australian Museum, Murray Darling Freshwater Research Centre and NSW Department of Infrastructure, Planning and Natural Resources (Water Bug Survey Bugopedia Factsheets). The range of habitats that need to be developed for use by invertebrates include:

a) open water areas where the water surface can be used by aquatic moths, lacewings, various bugs (water striders, backswimmers, water treaders), beetles (whirligig) and flies, and the water column by most species;
b) benthic sediments and their surfaces: silt, mud, sand and associated leaf packs and organic detritus, that can be used by nematodes, annelids, molluscs, many different crustaceans, water mites and a number of different groups of flies;
c) shallow water areas with leaf litter, rocks and gravel and submerged woody detritus that will provide shelter and living space for sponges, hydra, flatworms, leeches, freshwater snails, crayfish and shrimps, water mites, and flies such as damselflies and dragonflies, alderflies, mayflies, stoneflies and dipterans.
d) Submerged and emergent macrophytes, rocks and detrital leaf packs near the shoreline (and within swamplands) that are favoured by bugs such as the waterboatmen and water scorpions (Hemiptera), whirligig and diving beetles (Coleoptera), water mites (Arachnida), various flies and crustaceans.

Table 5. Aquatic and Riparian Invertebrate Habitats – Rotifers, Sponges, Hydrozoa, Worms, Molluscs, and Crustaceans

Common name (Phylum); Class/Order/ Families	Slow-moving waters (lotic); Fast-flowing (F)	Lakes/Ponds/Dams (Lentic)	Water column	Substratum surface/ leaf packs on substratum	Benthic – within sediments	On/amongst submerged rocks/wood	On macrophytes/Amongst vegetation /on roots (R)	Swamplands	Creeksides and banks	Temporary or ephemeral water bodies
Rotifers (Rotifera)	Yes	Yes	Yes	Yes			Yes			Yes
Sponges (Porifera); Fam. Spongillidae	Yes	Yes				Yes				
Hydra (Cnidaria); Class Hydrozoa	Yes	Yes				Yes				
Roundworms (Nematoda)	Yes	Yes		Yes	Yes					
Proboscis worms (Nemertea)		Yes	Yes				Yes			Yes
Horsehair worms; (Nematomorpha)	Yes	Yes	Yes							
Flatworms (Platyhelminthes)	Yes	Yes	Yes			Yes				
(**Annelida**)										
Segmented Worms; Class Oligochaeta	Yes	Yes	Yes	Yes	Yes			Yes		
Leeches; Class Hirudinea	Yes	Yes	Yes	Yes		Yes	Yes			
(**Mollusca**)										
Freshwater Mussels; Class Bivalvia	Yes	Yes			Yes					Yes
Freshwater Snail; Class Gastropoda	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes
(**Crustacea**)										
Sandhoppers; Amphipoda	Yes	Yes	Yes	Yes	Yes					Yes
Freshwater Crayfish & Shrimps; Decapoda	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Copepods; Copepoda	Yes	Yes	Yes	Yes			Yes			
Freshwater Slater; Order Isopoda	Yes	Yes		Yes	Yes		Yes (R)	Yes	Yes	Yes
Water Fleas; Cladocera	Yes	Yes	Yes	Yes			Yes	Yes		Yes
Clam shrimps; Conchostraca		Yes	Yes	Yes	Yes					Yes
Seed Shrimps; Ostracoda	Yes	Yes	Yes	Yes	Yes		Yes			Yes

Figure 2. Lake zones with typical animals (Furniss & Lane (1992)



Many of the groups found in open water areas are also present in swamplands and, or associated with riparian vegetation along creeklines. Some may also be found within more temporary or ephemeral waters such as seasonal flows along drainage lines, in ditches, rain pools and puddles. Stagnant water and ephemeral pools of water used mainly by mosquitoes, and fly and midge larvae respectively need to be avoided.

Table 6. Aquatic and Riparian Invertebrates: Habitats of Insect Groups

Common name Class/Order/ Families	Slow-moving waters (lotic)/ Fast-flowing (F)	Lakes/Ponds/Dams (Lentic)/Stagnant (S)	Water surface	Water column	Substratum surface/ leaf packs on substratum	Benthic – within sediments	On/amongst submerged rocks/wood	On macrophytes/ Amongst vegetation	Swamplands	Creeksides and banks	Temporary or ephemeral water bodies
Water Mite; Arachnida; Acarina	Yes	Yes				Yes	Yes	Yes	Yes	Yes	Yes
Damsel-& Dragon-flies; Odonata	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	
Mayflies; Ephemeroptera	Yes + F	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stoneflies; Plecoptera	Yes + F	Yes		Yes	Yes		Yes		Yes	Yes	
Caddis-flies; Trichoptera;	Yes + F	Yes		Yes	Yes						
Alder-& Dobson-flies; Megaloptera	Yes	Yes		Yes	Yes	Yes	Yes		Yes	Yes	
Water Beetles; Coleoptera	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Water-bugs; Hemiptera	Yes	Yes	Yes	Yes				Yes	Yes	Yes	Yes
Flies; Diptera	Yes + F	Yes + S	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aquatic Moths; Lepidoptera; Crambidae	Yes	Yes	Yes		Yes		Yes	Yes	Yes	Yes	
Lacewings; Neuroptera	Yes	Yes	Yes		Yes		Yes	Yes		Yes	
Scopion-flies; Mecoptera	Yes	Yes			Yes					Yes	

5.1.2 Food webs

A 'healthy' aquatic ecosystem includes a full range of feeding groups that have been classified as follows (ref. www.mdfrc.org.au/bugguide)

- Shredders – may be herbivores or detritivores feeding on living or decomposing vascular plant tissue respectively
- Filtering collectors – detritivores feeding on suspended decomposing fine particulate organic matter
- Gathering collectors – detritivores that feed on deposited decomposing fine particulate organic matter
- Scrapers – herbivores that feed on biofilms such as periphyton, bacteria and fungi
- Predators and scavengers – are carnivores feeding on living or dead animals respectively
- Macrophyte piercers – herbivores that take up fluids from living vascular plants and algae

Tables 7 and 8 summarise information available on aquatic invertebrate functional feeding groups and preferred foods. Many different invertebrate groups include some species that are known to be detritivores and of particular importance are the annelids, molluscs, crustaceans and dipteran and other groups of flies. They play an essential role in detrital food chains by either shredding or filtering coarse or fine particulate dead plant and animal matter. They increase the surface area available for attack by bacteria and fungi and hence the rate at which decay and decomposition occurs resulting in the recycling of essential elements back into the ecosystem. Bivalve molluscs increase the flux of organic and inorganic matter to waterbody substrates that in turn influence macroinvertebrate assemblages.

Table 7. Aquatic Invertebrates Functional Feeding Groups and Foods –Sponges, Hydrozoa, Worms, Molluscs, and Crustaceans

Common name (Phylum) Class/Order/ Families	Filtering collectors (F) Gathering collectors (G)	Shredders (SH) Scrapers (SC)	Predators (P) Scavengers (S)	Piercers (PI) Parasites (PA)	Detritivores (D) Herbivores (H)	Carnivores (CA) Onmivores (O)	Dead Animal matter (DAM) Animal tissues/ Blood (AT)	Bactera (BA); Al;gae (AL); Fungi (FU)	Organic particulate matter (OPM)	Decaying plant matter (DPM); Plant tissues (PT)	Zooplankton (ZO) Phytoplankton (PHP)	Aquatic Invertebrates (AII); Crustaceans (C); Molluscs(M)	Worms (W); Insect larvae (INL); Bugs (BU); Beetles (BE); Nematodes (NE)
Sponges (Porifera); Spongillidae	F							BA;AL	OPM	DPM			
Hydra (Cnidaria); Hydrozoa			P								ZO		
Roundworms; (Nematoda)			P	PA	D;H	CA;O		BA;FU		PT			
Proboscis worms; (Nemertea)					D	CA						AI	W
Horsehair worms; (Nematomorpha)				PA			AT	BA;AL					
Flatworms; (Platyhelminthes)		SC	P;S			CA;O	DAM					AI;C	INL;NE
Rotifers; (Rotifera)	G		P				DAM		OPM	DPM	ZO;PHP		
(Annelida)													
Segmented Worms; Oligochaeta	G					CA		BA;AL	OPM		PHP		
Leeches; Hirudinea			P	PA			AT					AI;M	W; INL
(Mollusca)													
Freshwater Mussels; Bivalvia	F								OPM		ZO;PHP		
Freshwater Snail; Gastropoda		SC	P; S		H			AL		DPM			
(Crustacea)													
Sandhoppers; Amphipoda	F	SH;SC				O	DAM			DPM		AI	
Freshwater Crayfish & Shrimps; Decapoda	F;G		P		D; H	O	DAM	BA;AL		DPM		AI	
Copepods; Copepoda	F										ZO;PHP		
Freshwater Slater; Isopoda		SH	P	PA	D		DAM; AT			DPM			
Water Fleas; Cladocera		SC						BA;AL		DPM	ZO;PHP		
Clam shrimps; Conchostraca	F					O					ZO;PHP		
Seed Shrimps; Ostracoda	F							AL	OPM				

At the same time other representatives are important in other parts of the aquatic food chain, for example:

- damselflies and dragonflies (Odonata) feed on rotifers, oligochaetes, molluscs, small crustaceans, bugs, beetles, mayflies and chironomid flies and at times tadpoles and small fish but are themselves eaten by spiders, mantids, assassin flies and wasps and also by fish, amphibians, reptiles and birds;
- water beetles (Coleoptera) feed on worms, leeches, molluscs, insects and insect larvae, crustaceans, tadpoles and small fish, but themselves provide food for spiders, wasps, fish, birds, reptiles (Eastern Water Skink) and mammals;
- bugs (Hemiptera) as predators can significantly influence populations of other aquatic insects and even small fish whilst themselves forming a part of fish diet. Encouraging particular groups of bugs, such as the water boatmen, water striders and water treaders could be especially valuable at Penrith Lakes as they feed on mosquito larvae.

Table 8. Aquatic Invertebrates Functional Feeding Groups and Foods: – Insect groups

Common name Class/Order/ Families	Filtering collectors (F) Gathering collectors (G)	Shredders (SH); Scrapers (SC)	Predators (P); Scavengers (S)	Piercers (PI); Parasites (PA)	Detritivores (D); Herbivores (H)	Carnivores(CA); Omnivores(O)	Dead Animal matter (DAM) Animal tissues/ Blood (AT)	Bactera (BA); Al;gae (AL); Fungi (FU)	Organic particulate matter (OPM)	Decaying plant matter (DPM); Plant tissues (PT)	Zooplankton (ZO) Phytoplankton (PHP)	Aquatic Invertebrates (AII); Crustaceans (C); Molluscs(M)	Worms (W); Insect larvae (INL); Bugs (BU); Beetles (BE); Nematodes (NE)	Tadpoles (TA); small Fish (FI)
Water Mite; Arachnida; Acarina			P;S	PA		O	BAM AT	AL; FU		DPM; PT		AI;C	INL;NE	
Damselflies & Dragonflies; Odonata			P			CA						AI;C; M	W;BU; BE	TA; FI
Mayflies; Ephemeroptera	F;G	SH; SC	P		D; H			AL		DPM	ZO; PHP			
Stoneflies; Plecoptera		SH; SC	P		D; H	CA;O		AL		DPM; PT		AI		
Caddis-flies; Trichoptera;	F;G	SH; SC	P			O		AL	OPM	DPM; PT		AI		
Alder-& Dobson-flies; Megaloptera			P									AI		
Water Beetles; Coleoptera	F;G	SH; SC	P	PI		CA;O	DAM	AL;FU	OPM	DPM; PT	PHP	AI;C; M	W;INL	TA; FI
Water-bugs; Hemiptera			P;S			CA	DAM	AL		DPM; PT	ZO	AI; C	INL	FI
Flies; Diptera	F;G	SH;SC	P		D;H	CA	AT	BA;AL ;FU	OPM	DPM; PT	PHP	AI		
Aquatic Moths; Lepidoptera; Crambidae		SH			H			AL		PT	PHP			
Lacewings; Neuroptera			P			CA					ZO	AI		
Scopion-flies; Mecoptera			P			CA						AI	INL	

A wide variety of adult and larval invertebrates (worms, shrimps, insect larvae) are food for platypus, and frogs consume quantities of insects (including mosquitoes) and spiders. Other groups that are significant for both macro-invertebrates and vertebrates include:

- both adult and/or larval stages of Alderflies (Megaloptera), Caddisflies (Trichoptera), Mayflies (Ephemeroptera), Aquatic Moths (Lepidoptera – Crambidae) and Stoneflies (Plectoptera) as important food for fish and the latter also for a number of other aquatic insect larvae;
- bloodworms (non-biting midges, Diptera) as an important source of food for large aquatic insects and fish;
- molluscs as food for turtles and mammals such as the water rat;
- freshwater crayfish and shrimps (Decapoda), often the largest invertebrates in the stream or waterbody, provide food for fish, frogs, reptiles such as turtles and Eastern Water Dragon, birds and platypus.

Figure 3. Aquatic food-web (dashed lines indicate breakdown process)
(Furniss & Lane, 1992)

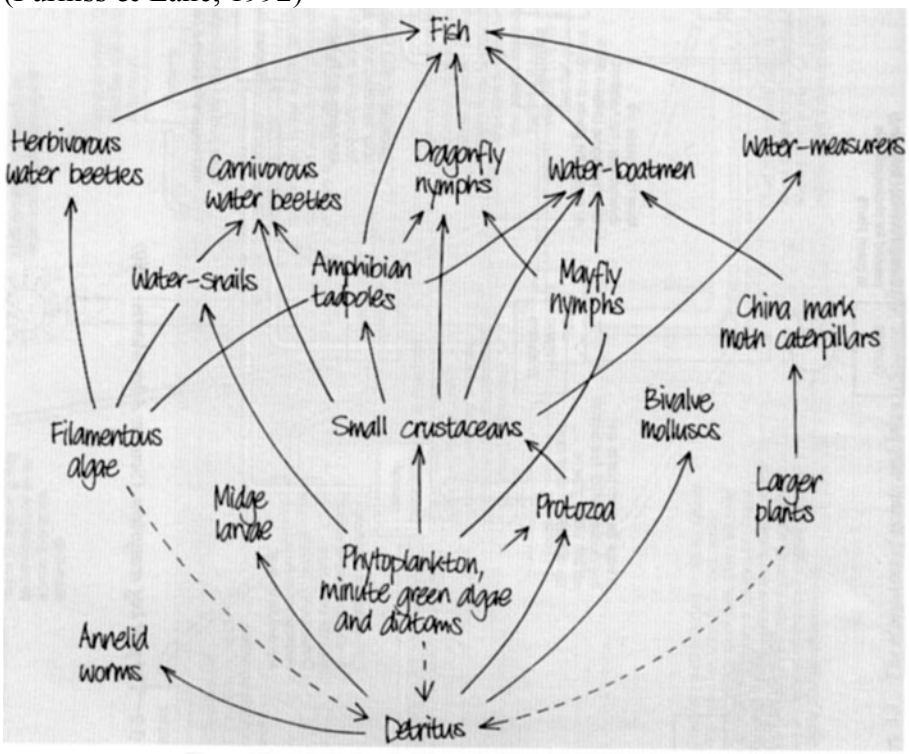
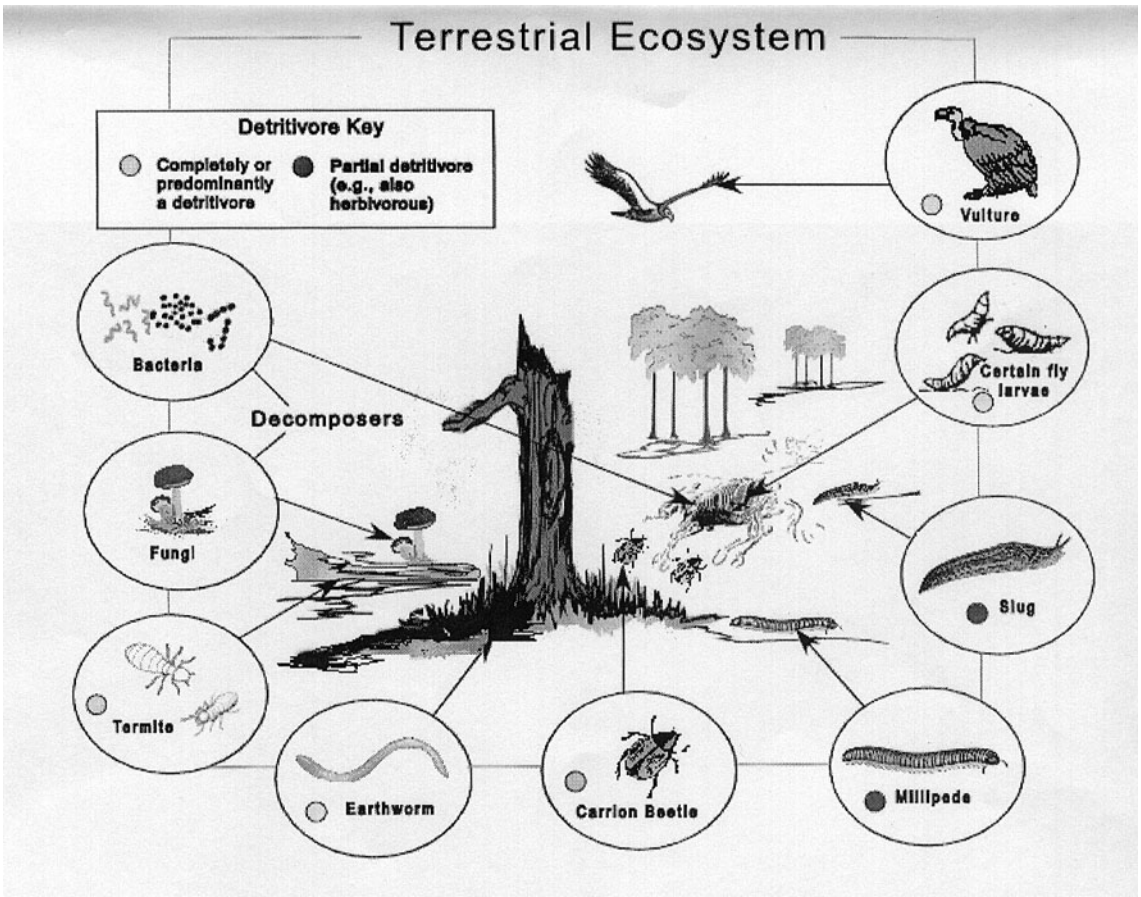


Figure 4. Schematic terrestrial ecosystem (www.princetonecology.org/id33.html)



5.2 Terrestrial environments

The only listing that has been found for Cumberland Plain terrestrial invertebrates is that given for Mt Annan Botanic Gardens (www.rbgsyd.nsw.gov.au) (Table 9; more detail in Appendix 2 Table 1). This covers areas of remnant Cumberland Plain Woodland together with native grassland areas. While this list is not immediately relevant to the plant communities to be re-instated bordering the Wildlife Lake it does relate to communities that are established nearby and therefore can be used as a guide for the invertebrate groups that may be able to colonise the area once the vegetation communities surrounding the wildlife lake are developed. Some 74 families within 18 orders are noted with at least 104 separate genera represented and a further 12 taxa unnamed. Beetles (Coleoptera), bugs (Hemiptera), spiders (Arachnida), moths and butterflies (Lepidoptera) and the ants, bees and wasps (Hymenoptera) are the best represented.

Table 9. Cumberland Plain Woodland – Mt Annan listing of Invertebrates

Phylum/Class/Order	Common Names	No. Families	No. Genera + (unnamed taxa)
Phylum: Crustacea	Crustaceans		
Class: Malacostrata Order: Isopoda	Woodlice, Slaters	1	1
Phylum: Mollusca	Snails and Slugs		
Class: Gastropoda Order: Eupulmonata		4	3 + 1
Phylum: Chelicerata	Spiders and Scorpions		
Class: Arachnida Order: Araneae		8	12
Order: Scorpiones	Scorpions	1	1
Phylum: Mandibulata	Insects and Centipedes		
Class: Insecta Order: Blattodea	Cockroaches	2	3
Order: Coleoptera	Beetles	9	15 + 4
Order: Dermaptera	Giant Earwig	1	1
Order: Diptera	Flies	6	6
Order: Hemiptera	Aphids, Cicadas	12	12 + 1
Order: Isoptera	Termites	--	--
Order: Hymenoptera	Ants, Bees and Wasps	5	12 + 2
Order: Lepidoptera	Moths	10	17 + 3
Order: Lepidoptera	Butterflies	4	9
Order: Mantodea	Praying Mantids	1	1
Order: Neuroptera	Lacewings	1	1
Order: Odonata	Dragonflies and Damselflies	3	3
Order: Orthoptera	Grasshoppers, Crickets	4	4 + 1
Class: Myriapoda Order: Diplopoda	Centipedes & Millipedes	1	1
Order: Polydesmida	Millipede	1	1
Totals 18		**74**	**116**

Invertebrates play essential roles in terrestrial ecosystems by:

- maintaining soil health through recycling processes, and aeration and water cycling;
- assisting in the transformation and dispersal of dead organic matter leading to recycling of nutrients;
- assisting in the propagation of plants though pollination;
- being part of the terrestrial food web;
- controlling populations of insects through predation and parasitism.

5.2.1 Habitats

Table 10 summarises the preferred habitats of the main terrestrial invertebrates based on information available from the Australian Museum and published references (Brunet, 2000; Readers Digest, 2005). The data are very generalised with broad vegetation types only noted (forest, woodlands, grasslands) together with main habitat components.

Table 10. Terrestrial Invertebrate Habitats

Common name	Order	Soil	Riparian areas	Forests, Woodlands	Open Clearings, Grasslands (G)	Tree trunks	Foliage of trees, shrubs, grasses	Under bark (B), rocks(R), logs(L)	Leaf litter	Rotten logs, Decaying plant matter	Ants (A)/ Termites nests	Warm-blooded animals
Springtails	Collembola	Yes	Yes	Yes				B	Yes	Yes	Yes	
Proturans	Protura	Yes		Yes						Yes		
Diplurans	Diplura	Yes		Yes						Yes	Yes	
Bristletails	Archaeognatha			Yes				B	Yes			
Velvet Worms	Onchophora		Yes	Yes					Yes	Yes		
Annelida												
Earthworms	Oligochaeta	Yes		Yes				R, L	Yes			
Crustacea												
Woodlice, Slaters	Isopoda			Yes	Yes			B, R, L			Yes (A)	
Mollusca												
Land snails, slugs	Eupulmonata			Yes		Yes		B, R, L				
Arachnida												
Spiders, scorpions		Yes	Yes	Yes	Yes	Yes	Yes	B, R, L	Yes			
Insecta												
Cockroaches	Blattodea			Yes					Yes	Yes		
Termites	Isoptera	Yes		Yes								
Praying Mantids	Mantodea			Yes		Yes	Yes		Yes			
Earwigs	Dermaptera			Yes				B, R, L				
Crickets, grasshoppers	Orthoptera	Yes		Yes	Yes		Yes	R, L				
Stick,leaf insects	Phasmatodea			Yes			Yes					
Bugs, cicadas	Hemiptera	Yes		Yes		Yes	Yes			Yes		
Lacewings	Neuroptera		Yes	Yes	Yes		Yes	B	Yes			
Beetles and Weevils	Coleoptera	Yes	Yes	Yes		Yes	Yes	B, L	Yes	Yes		Yes
Flies	Diptera	Yes		Yes		Yes	Yes		Yes	Yes		Yes
Moths and Butterflies	Lepidoptera	Yes	Yes	Yes	Yes		Yes	B	Yes	Yes		
Wasps, Ants, Bees	Hymenoptera	Yes	Yes	Yes	Yes	Yes	Yes	B		Yes		
Myriapoda												
Centipedes	Diplopoda	Yes		Yes					Yes	Yes		
Millipedes	Polydesmida	Yes		Yes					Yes	Yes		

The development of habitats and habitat components that enable populations of soil organisms to establish are essential as a first step towards a healthy functioning ecosystem. Basic to this is the need to re-build the soil structure. Natural topsoils are known to be generally rich in bacterial biomass and mycorrhizal fungi but at Castlereagh the soils have been so greatly disturbed over a long period of time that it is considered unlikely that the existing topsoil is suitable for rehabilitation to native vegetation without some form of treatment. The addition of organic matter and soil microbial inoculation may be necessary to enable other micro-organisms to establish. Further consideration of the potential for natural development of soil biota, the key biota to be introduced and their sources, and the role of organic media is provided in a recent report (TCM Services, 2007).

Groups that are particularly important in the soil are the springtails, proturans, diplurans and bristletails as their activities enrich the soil and thus benefit plant growth. Springtails are important also as they have the capacity to disperse spores of mycorrhizal fungi and associated bacteria and hence assist in the establishment of plant-fungal symbioses (http://en.wikipedia.org/wiki/springtail). Earthworms and ants also play a significant role as they mix organic matter with the soil and travel through the soil forming channels and pores, improving its structure, aeration and water-holding capacity. They fragment organic matter and increase the surface area available for colonisation by fungi and bacteria, the organisms responsible for decomposing (oxidising) the compounds within the organic matter to release carbon and energy, and nutrients in mineral form that can be taken up by the plants. Fungal hyphae and the humic compounds

produced by bacteria are important also in increasing soil aggregation that assists in reducing wind erosion of soils.

Cicadas and other bugs (Hemiptera) and some beetles (Coleoptera, family Scarabaeidae in particular) have larval stages that feed on plant roots (eucalypts, banksias and others) and they assist the host plant by forming tunnels and chambers beneath the ground that contribute to the aeration of the soil and allow water to penetrate more deeply. In a natural forest situation, the enormous populations of curl grub larvae, such as those of the flower chafers and Christmas beetles, perform the work necessary to aerate the soil as they feed on plant roots and decaying vegetation, replenishing the rich soil the forest requires for regeneration. Termites have a similarly important role in the regeneration of soil by allowing air and water to reach the deeper layers. Through their industrious nest-building they also provide a wide range of micro-habitats for several other creatures.

Other habitats that are used by a wide variety of terrestrial invertebrates for resting, shelter, feeding and,or breeding include:

the ground surface under rocks, logs and other debris – favoured by woodlice and slaters, slugs and snails, spiders and scorpions and insects such as earwigs, crickets, grasshoppers, beetles and weevils;

- tree trunks and bark – used by snails, spiders and scorpions and many insect groups including mantids, cicadas and other bugs, beetles, lacewings, wasps, ants and bees, some flies and some moths;
- branches, twigs and foliage of trees, shrubs, grasses and other herbs – living space for most groups of insects: mantids, crickets, stick insects, cicadas, bugs, beetles, flies, butterflies and moths amongst others.

5.2.2 Food webs and the role of terrestrial invertebrates

Table 11 summarises information available on terrestrial invertebrate functional feeding groups and preferred foods.

Through their feeding habits macro-invertebrates play a major role in the transformation and dispersal of dead organic matter. For example, the larvae of flies (Diptera) have voracious appetities and so greatly speed up the decomposition of animal carcasses, manure and rotting vegetation, and keep down disease in their natural habitats. The larvae of a number of different species of moth feed on the leaf litter of Myrtaceae, *Acacia* and *Banksia* species; they form silken shelters in the dead leaves, eroding its surface and skeletonising it. They attack the leaves at or just below the surface of the litter where few other organisms feed and prevent the long-term build up of litter. Where present in high numbers (up to 438 larvae per square metre of litter have been recorded in wet and dry sclerophyll forests), they reduce the risk of fire. (Edwards, 2008). Ants help clean up habitats as they consume a wide range of food including dead insects and other dead animal material. Beetles break down unhealthy or dying timber, they consume dead insects, plants and animals, and they bury the excreta of other animals.

A number of insect groups are important in pollinating native plants: beetles, flies, wasps, bees, thrips, butterflies and moths. Pollen and nectar attract the insects and also scent. For example, moths with a fairly long adult life feed on nectar and pollinate species that have flowers strongly scented at night and nectar flows in the evening. The Rubiaceae, Pittosporaceae, Oleaceae, Solanaceae, Verbenaceae are among the plant families known to be pollinated by moths. Many native flies are also attracted to strong-smelling flowers from which they gain nectar, while butterflies and moths feed on nectar and pollinate mainly sweet-smelling flowers.

A number of insect groups have species that parasitise other insects and hence play a role in controlling the level of insect populations. Tachinid flies perform a highly beneficial role in culling the populations of a wide range of other arthropods, including spiders, on which they deposit their eggs. The larvae hatch and feed on the host's flesh within its body. A number of wasp families are also parasites and their activities reduce populations of spiders, grasshoppers, cicadas, flies, beetles, aphids, moths and butterflies.

Some insect groups include species that are very active predators and can be used as biological control agents. For example, Lacewings feed on lepidopteran eggs and on aphids, scale insects and psyllids thereby reducing populations that are harmful to food plants. Some moth species attack

scale insects and the larvae of others are used to control weeds such as prickly pear. Assassin bugs attack spiders, grasshoppers, flies, ants, bees and larvae of moths and butterflies.

Table 11. Terrestrial Invertebrate Feeding Groups and Foods

Common name	Order	Detritivors (D); Scavengers (S)	Predators (P); Carnivores (C)	Herbivores (H); Omnivores (O)	Piercers (P); Animal tissues/Blood (AT)	Dead animal matter (DAM);	Decaying plant matter (DPM)	Lichens (L); Algae (A); Fungi (F)	Plant saps (PS); Pollen (P); Nectar (N)	Wood (W); Tissues (T);Fruit/Seeds (FR)	Insects (I); Larvae (L); Eggs (E)	Spiders (S)
Springtails	Collembola	D					DPM	L,A,F	P			
Proturans	Protura	D					DPM					
Diplurans	Diplura	D					DPM					
Bristletails	Archaeognatha	D					DPM	L, A				
Velvet Worms	Onchophora		C								I	S
Annelida												
Earthworms		S				DAM	DPM					
Crustacea												
Woodlice, Slaters	Isopoda	D		H, O		DAM	DPM	F		T		
Mollusca												
Land snails, slugs	Eupulmonata	D	P,C	H			DPM	A, F		T, FR		
Arachnida												
Spiders, scorpions			P,C								I	S
Insecta												
Cockroaches	Blattodea	S	C			DAM	DPM					
Termites	Isoptera	D		H			DPM			W		
Praying Mantids	Mantodea		P,C								I	S
Earwigs	Dermaptera	D		O			DPM			T	I,L	
Crickets, grasshoppers	Orthoptera	D	P,C	H		DAM			P		I,L,E	S
Stick,leaf insects	Phasmatodea			H					P			
Bugs, cicadas	Hemiptera				P, AT				P	T, FR	I, L	S
Lacewings	Neuroptera		P,C								I, E	
Beetles and Weevils	Coleoptera	D,S	P,C	H, O	AT	DAM	DPM	F	P,N	W, T	I,L,E	
Flies	Diptera	D,S	P,C	H	AT	DAM	DPM	F	P,N	FR	I,L,E	
Moths and Butterflies	Lepidoptera							L, F	PS,N	W,T,FR	I	
Wasps, Ants, Bees	Hymenoptera	S	P	H		DAM			PS,P,N		I,L	S
Myriapoda												
Centipedes	Diplopoda	D		H			DPM			T		
Millipedes	Polydesmida	D		H			DPM			T		

5.2.3 Predators

Terrestrial invertebrates are an essential part of the food-chain for both other invertebrates and many vertebrate groups. Table 12 lists the main predators of the different macro-invertebrate groups.
Thus while spiders predate on many different insect groups, they are themselves eaten by frogs, lizards and other retiles, birds, predatory marsupial, bats and other mammals. Predatory insects such as assassin flies and mantids take cicadas and other fly species and mantrids also feed on cockroaches, crickets and grasshoppers, moths and butterflies. But these insects and many others similarly form a major part of the diet of frogs, lizards and other reptiles, insectivorous birds, bats and other mammals.

Table 12. Predators of terrestrial invertebrate groups

Common name	Order	Amphibians (A); Reptiles (R)	Birds (B); Mammals (M)	Predatory Marsupials (PM); Bats (BA)	Spiders (S); Ants (A); Centipedes (C); Snails/Slugs (SN)	Beetles (BE); Crickets/ Grasshoppers (CG)	Predatory Flies (F); Predatory Bugs (BU)	Mantids (MA); Wasps (W)	Parasitic Flies (PF); Parasitic Wasps (PW)
Springtails	Collembola	R	B		S, A, C	BE	F, BU		
Proturans	Protura				S, C	BE, CG			
Diplurans	Diplura				A				
Bristletails	Archaeognatha				S, C	BE, CG			
Velvet Worms	Onchophora	R	B, M		S, C				
Annelida									
Earthworms		R	B, M		SN	BE			
Crustacea									
Woodlice, Slaters	Isopoda				S				
Mollusca									
Land snails, slugs	Eupulmonata	A, R	B, M			BE			
Arachnida									
Spiders, scorpions		A, R	B, M	PM, BA	S, C			W	PF, PW
Insecta									
Cockroaches	Blattodea		M		S	CG		MA	
Termites	Isoptera	R	B, M		S, A				
Praying Mantids	Mantodea	R	B, B		S	CG		W	PW
Earwigs	Dermaptera		B	BA	S				PW
Crickets, grasshoppers	Orthoptera	A, R	B	PM, BA	S, A	CG		MA, W	
Stick,leaf insects	Phasmatodea		B		A				PF, PW
Bugs, cicadas	Hemiptera	A, R	B, M	BA	S, A	BE, CG	F	MA, W	PF, PW
Lacewings	Neuroptera				S	CG			
Beetles and Weevils	Coleoptera	R	B, M	BA	S	BE		W	PF, PW
Flies	Diptera	A, R	B	BA	S		F	MA, W	
Moths and Butterflies	Lepidoptera	R	B, M	BA	S, A	BE	BU	MA, W	PF, PW
Wasps, Ants, Bees	Hymenoptera	A,R	M	BA					
Myriapoda									
Centipedes	Diplopoda	A, R			A				
Millipedes	Polydesmida				A				

5.3 An endangered species - Cumberland Land Snail

The Cumberland Land Snail, *Meridolum corneovirens,* is listed as endangered in Schedule 1 of the TSC Act. As far as known the snail is restricted to Cumberland Plain and Castlereagh Woodlands and along the fringes of River-flat Forest especially when this adjoins Cumberland Plain Woodland. Little is known about the species. It can be found under logs, amongst leaf and bark at the base of trees, and sometimes under grass clumps in loose soil. It is active at night, foraging in leaf litter and other debris for fungi. It can burrow into soil to escape dry conditions. Eggs are laid in moist dark areas under logs.

It is vulnerable to impacts from clearing and habitat modification such as weed invasion, removal of ground cover and fire. Management actions are aimed at improving habitat, controlling weed invasion, reducing or stopping removal of ground cover and protecting from fire.

5.4 Management issues

5.4.1 Wetland environments

Water pollution and sediment deposition with associated chemical pollutants are probably the main issues to be addressed in managing the wetland environments. Fluctuations in water depth and the presence of exotic plant species will also impact on aquatic invertebrate populations and might need to be managed.

Reduced water quality, due to an influx of nutrient and toxic chemicals (e.g. from road runoff), or resulting from sediment erosion increasing turbidity, impacts greatly on both species composition and abundance of invertebrates. Groups such as water mites and mayfly larvae that are sensitive to changes in oxygen, chemical pollution and levels of sunlight decline or disappear altogether and thus alter the balance of the whole ecosystem. Inflows of sediment can smother leaf litter packs and woody detritus and levels of oxygen available to invertebrates. The larvae of alderflies, caddisflies, mayflies and stoneflies are all intolerant of low oxygen levels and will be adversely affected.

Changes in water quantity also affect species composition and population levels. Long periods of drought resulting in the drying out of wetland margins and reduced water depths would impact adversely on the invertebrate species that favour marginal wetland habitats and also those present in the upper layers of benthic sediments such as worms, molluscs and crustaceans. Other effects might include declines in the quality of food resources and higher susceptibility to predation by other invertebrates and higher animals.

Changed environmental conditions may also favour growth of exotic weed species that will out-compete the native plants and reduce overall diversity in the wetland.

5.4.2 Terrestrial environments

Lack of adequate vegetative cover over the ground surface and of leaf litter, bark and other debris will affect the soil-dwelling and ground surface invertebrates. Lack of diversity in ground cover, understorey and canopy plant species will impact upon a wide range of macro-invertebrates as resources for resting, shelter, feeding and breeding will be limited. Fragmentation or patchiness of habitats might affect dispersal patterns also. The presence of exotic weed species and competition with exotic invertebrates, for example, native versus introduced earthworms and bees, would affect the composition and population levels of a number of different invertebrate groups.

Fire poses a significant threat to all of the soil organisms and those that play an essential role in the breakdown of leaf litter. Fire destroys the leaf litter habitat, desiccates upper soil levels and kills the micro- and macro-invertebrates present, in particular grasshopper nymphs, beetle larvae and moth larvae. The size of the area burnt also has an effect as re-colonisation of the burnt areas is from refuges is considerable after the fire (Edwards, 2008).

6 Fish and their habitats

A report undertaken by Biosis Research (2006) recommends nine species of native fish for the Wildlife Lake. Table 13 lists the species' habitat requirements and foods used. Some data has been included also from other sources, namely http://en.wikipedia.org/wiki/Australian_bass and http://www.mdbc.gov.au/subs/fish-info/native_info/carpGudgeons.html .

The Biosis report states that structural woody habitat provides high quality natural habitat not only for Australian Bass but also for invertebrates and small fish. Large piles of boulders provide excellent habitat for small fish in the interstitial spaces and it is recommended that interstitial spaces and overhangs should be developed to provide cover for fish species. Habitat structures need to be created in the littoral zones and also on a large scale for bottom habitat.

The natural values of the Wildlife Lake suggest that extensive natural habitat structuring should be provided. Artificial habitats should be avoided in this lake due to its fluctuating water level and natural values. Sandstone boulders in piles, benches and rubble field should be provided. If a sandstone bedrock is available this could be ripped to provided habitat. The majority of the structural woody habitat pieces should be anchored in rock piles, rather than allowing it to drift as this may result in the wood being left on the high watermark and unavailable to fish during low water periods.

Additionally, areas of non-embedded, rounded clean rocks and gravel need to be provided as spawning habitat for Freshwater Catfish. Gravel beds creating interstitial spaces also provides excellent cover for small fish and invertebrates. Macrophytes provide excellent shelter, feeding and breeding habitat for small fish and invertebrates. However, excessive growth density of macrophytes and noxious species such as *Egeria densatta* reduces their value as fish habitat. Submerged reeds, overhanging and trailing riparian vegetation provide shading, shelter and feeding resource for small and large fish. Riparian vegetation is a source of terrestrial food items for fish and organic material for the lakes.

Table 13. Recommended fish species for Castlereagh

Name	Habitat	Food
Macquaria novemaculeata Australian Bass	Larval and juvenile stages – reed beds Juveniles – macrophyte beds Adults - structural woody habitat, boulders and overhangs; often associated with large woody debris	Terrestrial insects, particularly cicadas, aquatic macro-invertebrates,(Trichoptera larvae), crustaceans (freshwater shrimps) and small fish, particularly flathead gudgeon.
Tandanus tandanus Freshwater Catfish	Gravel beds required for spawning sites Prefers sluggish still waters	Molluscs, aquatic invertebrates, fish and crustaceans
Anguilla australis Short-fin Eel	Occupy still and turbid areas in lakes, rivers, creeks and swamps. Adults migrate to the Coral Sea to spawn.	Aquatic invertebrates, fish and crustaceans
Anguilla reinhardtii Long-fin Eel	Prefer flowing or very deep water in creeks, rivers, lakes and swamps Adults migrate to the Coral Sea to spawn.	Aquatic invertebrates, fish and crustaceans
Hypseleotris sp Carp Gudgeon	Found in slow-flowing or still waters, normally associated with macrophyte beds or other aquatic vegetation (including Ribbon Weed, *Vallisneria americana*, and Water Thyme, *Hydrilla verticillata*) Spawning occurs in shallow water and the eggs are deposited on submerged aquatic vegetation or twigs.	Small aquatic invertebrates, ostracods and chironomids
Philypnodon grandiceps Flathead Gudgeon	Slow flowing streams, rivers and lakes; recorded in Ribbon Weed, *Vallisneria americana*, and Water Thyme, *Hydrilla verticillata* habitats	* Aquatic invertebrates and small fish (Biosis).
Retropinna semoni Australian Smelt	Open areas of streams, rivers and lake and also estuaries and wetlands Eggs are laid over vegetation or substrate	* Small aquatic invertebrates (Biosis).
Gobiomorphus australis Striped Gudgeon	Prefers slow turbid creeks wetlands and pools	* Aquatic invertebrates and small fish (Biosis).
Gobiomorphus coxii Cox's Gudgeon	Prefers flowing creeks and rivers Lays eggs on rocks	* Aquatic invertebrates and small fish (Biosis).

7 Birds and their habitats

7.1 Overview

Many different bird species are expected to make use of the various habitat zones of the Wildlife Lake. Waterbirds, including both waders and those species favouring deeper, open waters, are those most likely to be favoured by the proposed environment of the Wildlife Lake. Non-waterbird species will, of course, be found in the riparian and dryland forests adjacent to the Lake.

7.2 Waterbird Species

It has been estimated that 58 waterbird species could eventually occur in the overall Penrith Lakes site as the vegetation proceeds from establishment through to the mature stage of development. Many of these species have either been recorded at the Penrith Lakes site or have been recorded in nearby areas. Others are potentially liable to visit or take up residence as they have been recorded in the wider Cumberland Plain. All of these 58 species could potentially occur in the Wildlife Lake area. Table 14 summarises the range of waterbird species that may occur in the Wildlife Lake and environs.

Table 14. Wildlife Lake waterbird species

Species Type	Recorded at Castlereagh	Additional Species Expected at Castlereagh	Species with Potential to occur at Castlereagh	Total Species
International Migratory Species	1*	1	9	11
Native Visiting Species	3	1	5	9
Native Resident Species	27	5	5	37
Introduced Resident Species	1	0	0	1
Total Species	32	7	19	58

* Cattle Egret – regarded as an introduced species in Australia

Table 15 summarises the distribution of these 58 species across the plant communities and vegetation zones identified in Table 1. Obviously, many species would be found across several plant communities and vegetation zones. The numbers indicated in Table 15 simply record that suitable habitat is likely to exist in the Wildlife Lake environs for that number of the total 58 waterbird species. It does not necessarily follow that all of the bird species indicated in a particular plant community will occur in that community, even if they can be found elsewhere on the Castlereagh site.

Table 15. Numbers of waterbird species across Wildlife Lake zones

Plant Community	Totals	Vegetation Zone			
		Terrestrial	Ephemeral Wetlands	Permanent Wetlands	Deep Water Lakes
Riparian Forest	6	54			
Alluvial Woodland	6				
Shale Gravel Transition Forest	7		54		
Creeklines and Ephemeral Drainage Lines	44				
Casuarina stands	13				
Melaleuca swampland	30				
Castlereagh Swamp Woodland	29				
Grasslands	42				
Herblands	46				
Sedgelands, Rushlands (aquatic emergents)	45			45	
Aquatics – attached and floating	24				24

The full list of waterbird species and the vegetation types in which they occur can be found in Appendix 2, Table 2.

7.2.1 International Migratory Waterbird Species

International Migratory Species are mainly birds that breed in the Northern Hemisphere and migrate to Australia in the warmer months. Those that may occur at Castlereagh are:

- Recorded species: Cattle Egret
- Expected species: Latham's Snipe
- Potential species: Pacific Golden Plover, Whiskered Tern, Sharp-tailed Sandpiper, Curlew Sandpiper, Pectoral Sandpiper, Red-necked Stint, Wood Sandpiper, Common Greenshank, Marsh Sandpiper

Apart from the Curlew Sandpiper all of these are the subjects of international agreements for the conservation of migratory birds (JAMBA, CAMBA, ROKAMBA), but only Latham's Snipe and the Cattle Egret have been recorded in sufficient numbers on the Cumberland Plain to be confidently anticipated to visit Castlereagh.

Latham's Snipe inhabits permanent and ephemeral wetlands. 'They usually occur in open, freshwater wetlands that have some form of shelter (usually low and dense vegetation) nearby (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies, flooded meadows, seasonal or semi-permanent swamps, or open waters) but various other freshwater habitats can be used including bogs, waterholes, billabongs, lagoons, lakes, creek or river margins, river pools and floodplains.' Latham's Snipe feeds 'on seeds and other plant material (mainly from species in families such as Cyperaceae, Poaceae, Juncaceae, Polygonaceae, Ranunculaceae and Fabaceae), and on invertebrates including insects (mainly flies and beetles), earthworms and spiders and occasionally molluscs, isopods and centipedes. The composition of the diet can vary somewhat over the duration of the species' stay in Australia, but no clear patterns have been determined. Latham's Snipe forage during the day or at night' (See Department of Environment, Water, Heritage and the Arts: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?showprofile=Y&taxon_id=863.

The Cattle Egret is in a different category than the other species that are the subject of international agreements in that it has taken up permanent residence in Australia in relatively recent times, apparently from both deliberate introductions and natural migration from Asia. It breeds in northern Australia and Asia and tends to migrate to southern areas during the warmer months.

7.2.2 Native Visiting Waterbird Species

The following nine species may occur at Castlereagh:

- Recorded species: Freckled Duck, Australian Spotted Crake, Hardhead
- Expected species: White-necked Heron
- Potential species: Glossy Ibis, Pink-eared Duck, Baillon's Crake, Red-kneed Dotterel, Australian Reed-Warbler

Of these, the Freckled Duck is listed as Vulnerable in the Threatened Species Conservation Act (NSW 1995). The species breeds in the Murray-Darling River system and disperses to other areas in south-eastern and south-western Australia during dry periods. 'It prefers permanent fresh water swamps and creeks with heavy growth of cumbungi (bullrushes), lignum or tea-tree' The Freckled Duck 'feeds at dawn and dusk and at night on algae, seeds and vegetative parts of aquatic grasses and sedges and small invertebrates'. See species profile at the Department of Environment and Conservation –NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10771)

Plants used by the Freckled Duck include *Azolla* sp., *Eleocharis* sp., *Myriophyllum* sp., Marsileaceae (seedheads), *Paspalum distichum*, *Schoenoplectus validus, Cyperus* sp., *Cyperus pilosus* and *Carex* sp.

7.2.3 Native Resident Waterbird Species

With this group of birds consideration needs to be given not only to their foraging and roosting needs but also to their breeding requirements. For example, species such as ducks and swans are often seen diving in deeper waters but will nest in secluded wetland margins or even in the hollows of trees away from water. The following species may occur at Castlereagh:

- Recorded: species: Great Crested Grebe, Australasian Grebe, Australian Darter, Australian Pelican, Great Cormorant, Little Pied Cormorant, Little Black Cormorant, Pied Cormorant, Great Egret, Little Egret, White-faced Heron, Royal Spoonbill, Australian White Ibis, Straw-necked Ibis, Chestnut Teal, Grey Teal, Australasian Shoveler, Pacific Black Duck, Australian Wood Duck, Black Swan, Eurasian Coot, Dusky , Moorhen, Purple Swamphen, Black-fronted Dotterel, Silver Gull, Black-winged Stilt , Masked Lapwing

- Expected species: Hoary-headed Grebe, Intermediate Egret, Yellow-billed Spoonbill, Buff-banded Rail, Spotless Crake
- Potential species: Nankeen Night Heron, Musk Duck, Red-capped Plover, Golden-headed Cisticola, Little Grassbird

All but five of this group have been recorded at Castlereagh or in nearby areas and could be confidently expected to populate the Wildlife Lake environs. The other (potential) species do not appear to have special habitat needs, beyond those of other similar species in this group.

7.2.4 Introduced Resident Waterbird Species

The Mallard is the only species in this category. It is now widespread in eastern New South Wales. The male and female are distinctly different and females and can be difficult to distinguish from the native Pacific Black Duck.

7.3 Non-Waterbird Species

It has been estimated that 145 non-waterbird species could eventually occur in the overall Penrith Lakes site as the vegetation proceeds from establishment through to the mature stage of development. Many of these species have either been recorded at the Penrith Lakes site or have been recorded in nearby areas. Others are potentially liable to visit or take up residence as they have been recorded in the wider Cumberland Plain. Of the total of 145 species, 142 could potentially occur in the Wildlife Lake area. The three that are not anticipated in the Wildlife Lake area are all introduced species which are usually found in more developed, built-up areas. Table 15 summarises the range of non-waterbird species that may occur in the Wildlife Lake and environs.

Table 15. Wildlife Lake non-waterbird species

Species Type	Recorded at Castlereagh	Additional Species Expected at Castlereagh	Species with Potential to occur at Castlereagh	Total Species
International Migratory Species	0	1	0	1
Native Visiting Species	12	9	13	34
Native Resident Species	51	27	22	100
Introduced Resident Species	2	4	1	7
Total Species	65	41	36	142

Table 16 summarises the distribution of these 142 species across the plant communities and vegetation zones identified in Table 1.

Table 16. Numbers of non-waterbird species across Wildlife Lake zones

Plant Community	Totals	Vegetation Zone			
		Terrestrial	Ephemeral Wetlands	Permanent Wetlands	Deep Water Lakes
Riparian Forest	113	142			
Alluvial Woodland	123				
Shale Gravel Transition Forest	123		137		
Creeklines and Ephemeral Drainage Lines	52				
Casuarina stands	46				
Melaleuca swampland	56				
Castlereagh Swamp Woodland	124				
Grasslands	49				
Herblands	25				
Sedgelands, Rushlands (aquatic emergents)	4			4	
Aquatics – attached and floating	0				0

Obviously, many species would be found across several plant communities and vegetation zones and, not surprisingly, the majority of species would be found in the forest and woodland zones on the fringes of the Wildlife Lake. Four species are listed as occurring in the permanent wetlands – these are birds that hunt for

insects on the wing by flying at low altitudes over open vegetation (White-throated Needletail, Fairy and Tree Martins, Welcome Swallow).

The numbers indicated in Table 16 simply record that suitable habitat is likely to exist in the Wildlife Lake environs for that number of the 145 non-waterbird species that may eventually be found at the overall Castlereagh site. It does not necessarily follow that all of the bird species indicated in a particular plant community will occur in that community, even if they can be found elsewhere on the Castlereagh site.

The full list of non-waterbird species and the vegetation types in which they occur can be found in Appendix 2, Table 2.

7.3.1 International Migratory Non-Waterbird Species

The only International Migratory Species that may occur at Castlereagh in the non-waterbird category is the White-throated Needletail. This species is listed under the JAMBA, CAMBA and ROKAMBA agreements. It breeds in Siberia, Mongolia and Japan and migrates to Australia between October and May. The birds spend most of their non-breeding time on the wing, flying over most habitats from as low as 1 metre to over 1,000 metres above the surface, seeking various types of insects (See Department of Environment, Water, Heritage and the Arts: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682).

The White-throated Needletail is widespread over much of eastern and south-eastern Australia. It has been recorded on the Cumberland Plain and can be expected at Castlereagh.

7.3.2 Native Visiting Non-Waterbird Species

The following 34 species may occur at Castlereagh:

- Recorded species: Stubble Quail, Horsfields Bronze-cuckoo, Shining Bronze-cuckoo, Brush Cuckoo, Common Koel (Asian Koel), Channel-billed Cuckoo, Rainbow Bee-eater, Fairy Martin, Cicadabird, Rufous Whistler, Noisy Friarbird, Regent Honeyeater
- Expected species: Musk Lorikeet, Dollarbird, Sacred Kingfisher, Tree Martin, Scarlet Honeyeater, White-throated Gerygone, Leaden Flycatcher, Rufous Fantail, Dusky Woodswallow
- Potential species: Spotted Harrier, Bar-shouldered Dove, Little Lorikeet, Swift Parrot, Pallid Cuckoo, White-winged Triller, Scarlet Robin, Fuscous Honeyeater, Black-chinned Honeyeater, Satin Flycatcher, White-browed Woodswallow, Brown Songlark, Rufous Songlark

Of these, the Swift Parrot and the Regent Honeyeater are both listed as Endangered in the Threatened Species Conservation Act (NSW 1995).

The Swift Parrot migrates from Tasmania to the mainland during the winter/autumn months to feed mostly on winter flowering eucalypts, as well as those that are commonly infested with lerps. It has been recorded in the Castlereagh Nature Reserve.

Favoured feed trees for the Swift Parrot include species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Bloodwood (*C. gummifera*), Mugga Ironbark (*E. sideroxylon*), White Box (*E. albens*), Grey Box (*E. microcarpa*), Grey Box (*E. moluccana*) and Blackbutt (*E. pilularis*). Birds are reported to return to some foraging sites on a cyclic basis depending on food availability. See species profile at the Department of Environment and Conservation –NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10455 0.

The Regent Honeyeater has declined due to destruction of habitat and there are few significant breeding sites remaining, one of which is in the Capertee Valley, about 100 km north-west of Castlereagh. These birds favour open forest and woodland and are nomadic, tending to move around in response to the flowering of their favoured feed trees. They feed on the nectar of eucalypts and other nectar producing plants as well as on insects and spiders.

Key eucalypt species include Mugga Ironbark, Yellow Box (*Eucalyptus melliodora)*, Blakely's Red Gum (*Eucalyptus blakelyi)*, White Box and Swamp Mahogany. The birds also utilise : *E. microcarpa, E. punctata, E. polyanthemos, E. mollucana, Corymbia robusta, E. crebra, E. caleyi, Corymbia maculata, E.mckieana, E. macrorhyncha, E. laevopinea*, and *Angophora floribunda*. See species profile at the Department of Environment and Conservation –NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10841)

7.3.3 Native Resident Non-Waterbird Species

The following 100 species may occur at Castlereagh:

- Recorded species: Brown Goshawk, Swamp Harrier, Black-shouldered Kite, White-bellied Sea Eagle, Nankeen Kestrel, Australian Hobby (Little Falcon), Brown Quail, Peaceful Dove, Crested Pigeon, Sulphur-crested Cockatoo, Galah, Little Corella, Yellow-tailed Black-cockatoo, Crimson Rosella, Eastern Rosella, Red-rumped Parrot (Grass Parrot), Fan-tailed Cuckoo, Southern Boobook, Barn Owl, Tawny Frogmouth, Azure Kingfisher, Laughing Kookaburra, Superb Lyrebird, Welcome Swallow, Black-faced Cuckoo-shrike, Grey Shrike-thrush, Eastern Yellow Robin, Superb Fairy-wren, Eastern Spinebill, Little Wattlebird, Yellow-faced Honeyeater, White-plumed Honeyeater, Noisy Miner, Bell Miner, Lewin's Honeyeater, Mistletoe Bird, Yellow Thornbill, Spotted Pardalote, Striated Pardalote, White-browed Scrubwren, Chestnut-breasted Mannikin, Red-browed Finch (Red-browed firetail), Double-barred Finch, Zebra Finch, Magpie-lark (Pee wee), Grey Fantail, Willie Wagtail, Grey Butcherbird, Australian Magpie, Pied Currawong, Australian Raven
- Expected species: Collared Sparrowhawk, Wedge-tailed Eagle, Whistling Kite, Brown Falcon, Common Bronzewing, Australian King Parrot, Rainbow Lorikeet, Richard's Pipit (Australian Pipit), White-bellied Cuckoo-shrike, Crested Shrike-tit, Golden Whistler, Rose Robin, Eastern Whipbird, Variegated Fairy-wren, White-throated Treecreeper, Red Wattlebird, Brown-headed Honeyeater, White-naped Honeyeater, New Holland Honeyeater, Yellow-rumped Thornbill, Striated Thornbill, Olive-backed Oriole, Restless Flycatcher, Satin Bowerbird, White-winged Chough, Apostlebird, Silvereye
- Potential species: Grey Goshawk, Pacific Baza, Little Eagle, Square-tailed Kite, Peregrine Falcon, Painted Button-quail, Wonga Pigeon, Brown Cuckoo-Dove, Long-billed Corella, Gang-gang Cockatoo, Glossy Black-cockatoo, Australian Owlet-nightjar, Jacky Winter, Varied Sittella, White-eared Honeyeater, Yellow-tufted Honeyeater, White-cheeked Honeyeater, Brown Thornbill, Buff-rumped Thornbill, Speckled Warbler, Brown Gerygone, Weebill

Of these, the Square-tailed Kite, Gang-gang Cockatoo and Glossy Black-cockatoo are listed as Vulnerable in the Threatened Species Conservation Act (NSW 1995).

The Square-tailed Kite is found in a variety of timbered habitats including dry woodlands and open forests and is commonly associated with forests dominated by Woollybutt (*Eucalyptus longifolia)*, Spotted Gum (*Corymbia maculata*) or Peppermint Gum (*Eucalyptus dives*). It shows a particular preference for timbered watercourses. See species profile at the Department of Environment and Conservation –NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10495)

The Glossy Black Cockatoo has a patchy distribution along the Great Dividing Range and east coast of New South Wales being a rare visitor to most parts of its range but locally common in some areas. It appears to feed exclusively on casuarina seeds and occurs in open forest and woodlands in which stands of she-oak species occur, particularly Black She-oak (*Allocasuarina littoralis*), Forest She-oak (*A. torulosa*) or Drooping She-oak (*A. verticillata*). See species profile at the Department of Environment and Conservation – NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10140).

The numbers of the Gang-gang Cockatoo in New South Wales have declined markedly in recent years. In summer, it is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, it may be found at lower altitudes in drier and more open eucalypt forests and woodlands, and often found in urban areas. The Gang-gang Cockatoo feeds on seeds of native shrubs and trees, including eucalyptus, acacias and cypress pine, but it also takes seeds of introduced species such as Hawthorn and conifers. See species profile at the Department of Environment and Conservation – NSW (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10975)

7.3.4 Introduced Resident Non-Waterbird Species

There are seven introduce species that could occur in the Wildlife Lake environs:

- Recorded species: Rock Dove (Feral Pigeon), Spotted Turtle-dove
- Expected species: Skylark, Common Myna (Indian Myna), Common Starling, Common Blackbird
- Potential species: Nutmeg Mannikin

7.4 General Habitat Needs of Birds

The following is a brief outline of the various habitats preferred by groups of birds that may occur in the Wildlife lake environs. The groupings follow the English nomenclature convention adopted by the Australian Museum.

7.4.1 Waterbirds

Grebes

The Great Crested Grebe and Hoary-headed Grebe both favour large open water bodies, while the Australasian Grebe is found in freshwater ponds and smaller waterways. They dive for fish and aquatic insects and also forage on the water surface for the latter.

Pelicans and Allies

Cormorants, Darters and Pelicans all frequent wetlands, riverine waterways and estuaries. They feed on fish supplemented by crustaceans, aquatic insects and frogs and sometimes molluscs. The Darter also eats some plant matter. Pelicans can become quite tame and accept food handouts from humans. Cormorants and Pelicans nest in colonies on islands or secluded shores, building large stick nests in trees over water or on the ground. The Darter is less colonial, nesting in trees standing in water.

Herons, Storks and Ibis

The habitats favoured by Herons and Egrets include shallow flowing water, flooded pastures, tree-lined wetlands and swamps. Food comprises a variety of invertebrates (grasshoppers and other insects, crustaceans, molluscs) and also fish, frogs, lizards and some small mammals. Herons and egrets breed mainly in colonies with other waterbirds; they build stick nests over the water or in trees and shrubs near or over the water.

Habitat preferences of Ibis and Spoonbills include shallow fresh water lagoons and swamps, wet grasslands, pastures and croplands in some cases. Food items comprise fish, crustaceans, aquatic insects and their larvae, and in some cases also molluscs and terrestrial invertebrates and frogs, small reptiles and mammals (Straw-necked Ibis). The Australian White Ibis is a noted scavenger of food scraps in parks and recreation areas and populations have increased significantly in the past two decades. Spoonbills and Ibis nest in colonies, in trees over water or among reed beds over water.

Waterfowl

This group includes ducks, geese and swans. Some species in this group favour large deep water lakes with dense reed beds (e.g. Hardhead, Musk Duck, Black Swan) whilst other prefer shallower lakes and swamps and even urban ponds or wet grasslands (e.g. Pacific Black Duck, Australian Wood Duck, Mallard). Many of the ducks are dabblers, feeding on the surface of shallow water or upending to feed from the bottom, whilst others dive for their food. Their food varies from mainly vegetarian (swamp and dryland plants and seeds) to more omnivorous, with insects and their larvae, crustaceans, molluscs and small fish being eaten also. Nests vary from scrapes in the ground in long grass or rushes, to platforms of floating reeds and grasses, or tree hollows or rock crevices can be used. In some species breeding is triggered by rising water levels or flooding.

Rails, Cranes and Bustards

This group includes Moorhens, Swamphens, Rails, Crakes and Coots. They are birds of wetlands: lagoons, swamps and streams, with the Crakes in particular being found in dense swamp vegetation, as they are secretive in habit. Foods comprise aquatic plants, grasses, seeds and fruits together with a variety of molluscs, crustaceans, insects and some small vertebrates in some cases (fish, frogs). Nests are well-hidden, built from grasses, reeds and aquatic plants.

Shorebirds and Gulls

In addition to Gulls, this group includes Plovers, Dotterals, Terns, Sandpipers, Snipe, Stints, Greenshanks and Stilts. The habitats favoured by this group of birds are quite varied. Most inhabit shallow margins of lakes, rivers, swamps and beaches. Some, such as the Masked lapwing, are also common in pastures, playing fields and parklands. Their foods include a variety of insects, small crustaceans, spiders, fish, seeds, grasses. The Silver Gull is a noted scavenger of food scraps. The nests of this group often consist of a scrape in the ground which may be lined with plant material and is sometimes surrounded by sticks, stones or litter. The nest may be located in the shelter of a small plant but some species (e.g. Masked Lapwing) build nests well removed from cover.

Old World Warblers

This group includes several birds which inhabit wetlands and others that are terrestrial species. Species that can be regarded as inhabitants of wetlands are the Australian Reed warbler, the Little Grassbird and the Golden-headed Cisticola. These birds inhabit dense reeds and other vegetation around wetlands and

sometimes irrigated pastures. All feed mainly on insects but also grass seeds. The nests of these species are constructed on the ground among dense reeds or long grass.

7.4.2 Non-Waterbirds

Fowl-like Birds

Within this group, the Stubble Quail and Brown Quail are the only two species likely to be seen at Castlereagh. They are ground-dwellers, living in dense grass often near water and feed on seeds, green shoots and sometimes also insects. The nests consist of a scrape in the ground lined with grass and hidden in thick cover.

Diurnal Birds of Prey

The hawks, kites and eagles recorded, expected or with the potential to occur at Castlereagh vary in their habitat requirements. Some live along rivers and wetlands whilst others prefer forest and woodland habitats and others again more open country or lightly wooded areas. In contrast, open country is the preferred habitat for all four members of the Falcon family that may occur at Castlereagh.

Most species feed on birds, mammals (including rabbits, wallabies and rodents), reptiles, frogs and large insects. Some, such as the Swamp Harrier and White-bellied Sea Eagle, take fish, turtles and water-birds also. Road kills provide food for some. Most build stick nests high above the ground and both the Nankeen Kestrel and the Peregrine Falcon have been known to use buildings. One species, the Swamp Harrier, nests on the ground or builds a platform of sticks and vegetation on the water.

Button Quails

The Painted Button Quail is the only species in this group likely to be seen at Castlereagh. It lives in open scrublands and dry forests with coarse grass understorey, on rocky hillsides. Food is sought in leaf litter and consists of various seeds, insects and plant material. This bird nests on the ground at base of grass tussock or shrub.

Pigeons and Doves

Doves and Pigeons feed on the ground on seeds of grasses, sedges and other herbs and some will also eat small insects, they need to drink frequently. The two introduced species frequent city parks and gardens whilst the other species, whilst foraging in urban areas, prefer to live in grassy woodlands on the edges of denser forests near water. Nests are usually a thin platform of twigs placed in dense shrubs or tree forks in natural areas or in gardens, accessible ledges of buildings or roof spaces are used also.

Cockatoos, Parrots and Lorikeets

Of the seven species of Cockatoos that may occur at Castlereagh, two are abundant around urban areas (Sulphur-crested Cockatoo, Galah) although their natural habitats are timbered. The Little Corella frequents grasslands near water and has benefited from clearance and agriculture as has the Long-billed Corella, a species occurring naturally in southern parts of Australia but which is expanding its range north and living in urban parks also. The Yellow-tailed Black Cockatoo favours woodland and pine plantations, the Glossy Black-Cockatoo frequents woodland dominated by *Casuarina* and *Allocasuarina* species and the Gang-gang Cockatoo favours forests and woodlands.

Most Cockatoos feed on seeds of grasses and grain crops supplemented with bulbs, roots, fruits and nuts or seeds of native trees and pinecones (Sulphur-crested Cockatoos and Yellow-tailed Cockatoo respectively). The Glossy Black-Cockatoo feeds mainly on seeds of *Casuarina* and *Allocasuarina* species and needs mature stands of these trees as immature and/or scattered trees do not yield enough food. Nests of all these cockatoos are built in tree hollows, lined with wood chips and leaves.

Natural habitats for the parrot species are rainforest, wet or dry sclerophyll forests and woodlands (Australian King Parrot, Little Lorikeet, Musk Lorikeet, Crimson Rosella, Rainbow Lorikeet, Swift Parrot) or more open woodlands and grasslands (Eastern Rosella, Red-rumped Parrot). Most species frequent urban parks and gardens and the Eastern Rosella also frequents orchards and agricultural grain-growing areas. Foods include seeds, fruits, flowers, pollen, nectar, insects and their larvae. Nests are built in tree hollows. Eastern Rosellas will sometimes use nest-boxes or other artificial sites.

Cuckoos and Coucals

The Common Koel, the Fan-tailed Cuckoo, Horsfield's Bronze-cuckoo, the Pallid Cuckoo and the Channel-billed Cuckoo can be found in cleared/ modified areas such as orchards, parks and gardens in suburban areas,

and are found naturally in open forests and woodlands. The Shining Bronze-Cuckoo and the Brush Cuckoo, on the other hand, occur in dense closed canopy sclerophyll and rainforest. Most species feed on insects and their larvae, but two, Common Koel and Channel-billed Cuckoo are fruit eaters. Both these species over winter in New Guinea and adjacent islands and move back to Australia to breed. All species are nest parasites, laying eggs in the nests of other birds such as flycatchers, fairy-wrens, scrubwrens and thornbills.

Owls

The two owls recorded at Castlereagh occupy areas of open forest, woodland, farmlands and leafy suburbs. Their food is mainly insects but also small birds and mammals. These species need tree hollows for nesting but may use caves or undisturbed buildings.

Nightjars and Relatives

The Tawny Frogmouth occurs in forests and woodlands and near water courses (tree-lined). It feeds on insects and small vertebrates at night. During the day it perches on branches, remaining motionless and adopting a very effective camouflage that has the appearance of a broken tree limb. Its nest is a loose arrangement of sticks in a tree fork.

The Australian Owlet-nightjar occurs in forests and woodlands and near water courses (tree-lined) and feeds on insects at night. It nests in tree hollows or rock crevices.

Swifts

The White-throated Needletail arrives in Australia from its northern hemisphere breeding grounds in October and leaves in autumn or winter. It roosts at night in wooded country, feeding on the wing during the day, taking flying insects such as flies, beetles, ants and termites.

Kingfishers and Allies

Always close to water, the Azure Kingfisher perches in shady overhanging trees on creeks, rivers and lakes. It dives into the water to take aquatic insects and other aquatic invertebrates, small fish, crustaceans and sometimes frogs. It nests at the end of a tunnel (50-130 cm long) excavated into the riverbank.

Kookaburras are found in most wooded areas as well as in parks and suburban gardens. They feed on insects, worms, crustaceans and small snakes, frogs, birds and mammals. The Sacred Kingfisher lives in open eucalypt forests, *Melaleuca* forests and woodlands. It spends the winter in the north and moves south to breed in the spring and feeds mainly on the land. Both the Laughing Kookaburra and Sacred Kingfisher build nests in tree hollows or in burrows excavated in termite mounds.

The Rainbow Bee-eater over-winters in the north and then returns south to summer breeding areas. It is found in open forests and woodlands and cleared areas near water, in orchards and vineyards. It feeds on insects and may build its nesting tunnels in quarries, cuttings and mines.

The Dollarbird migrates to Australia from New Guinea in spring to breed, returning north in autumn. It inhabits open woodlands and feeds on insects. It requires mature, hollow-bearing trees for nesting.

Lyrebirds

The Superb Lyrebird is a ground-dwelling species that prefers moist forests and woodlands, it has a home-range about 10 km in diameter. Superb Lyrebirds feed on insects, worms and occasionally seeds found in leaf litter. They roost in trees at night, and build a stick nest on the ground or in tree stumps.

Larks

The introduced Skylark is the only member of this group likely to occur at Castlereagh. It is a bird of grasslands and open woodlands and it also inhabits agricultural areas where cereal crops are grown. The birds feed on seeds, leaves and insects. The nest is a slight depression scraped in the ground, hidden within long grasses and constructed of dried grass.

Swallows and Martins

These birds frequent many different habitats, both wooded and more open and often near water. They feed on a wide variety of insects, usually in large flocks. Their nests are built from mud and vegetation. and they all use human-built structures such as rock walls and buildings as nesting sites - as well as more natural sites - tree holes, cliff holes and caves.

Pipits and Wagtails

Richard's Pipit is found in open grassland areas favouring bare ground with patches of cover. Richard's Pipit feeds on the ground on insects and their larvae and also seeds. The nest is built of grasses in a depression in the ground near shelters such as grass tussocks, a large stone or piece of wood. This is the only member of this group likely to occur at Castlereagh.

Cuckoo-shrikes and Trillers

The Black-faced Cuckoo-shrike is common in woodland, gardens and urban parks and the White-bellied Cuckoo-shrikes may also occur in suburban areas although their natural habitat is open forest, woodland and wooded riverbanks. The Cicadabird favours dense forests and swamps while the White-winged Triller inhabits open forests, woodlands and riparian areas in semi-arid districts. All feed on insects and their larvae, fruit and seeds. They build their nests (twigs bound with cobwebs) in tree forks.

Bulbuls

The introduced Red-whiskered Bulbul has been recorded at Castlereagh and is the only member of this group that is likely to occur at Penrith Lakes. It is a common bird in urban areas in parks and gardens but, like the European Goldfinch, it is considered unlikely to be found in the Wildlife Lake area.

Whistlers and Shrike-thrushes

The species in this group are found naturally in open forests and woodlands but they also frequent parks and gardens and wooded watercourses. They feed on insects and their larvae and occasionally berries. The Grey Shrike-thrush also preys on small vertebrates (nestlings and eggs of small birds, small lizards and mammals). Nests are built in tree forks or canopy of tall shrubs, or in tree stumps, tree holes or rock ledges (Grey Shrike-thrush).

Australasian Robins

This group (which includes the Jacky Winter) feeds on insects and a number of them are migratory, moving to more open areas in winter from open forests and woodlands. The Rose Robin is sometimes seen in gardens when migrating from wet forest or rainforest habitats. It is sensitive to habitat fragmentation and loss of understorey shrubs. Robins build cup-shaped nests of bark fibre, sticks and vegetation in tree forks.

Whipbirds and Quail-thrushes

The Eastern Whipbird is the only member of this group likely to occur at Castlereagh. It favours wet habitats such as rainforest margins and wet sclerophyll forests. It feeds on the ground on insects and other small invertebrates and need dense ground cover for shelter whilst foraging. It builds its nests in dense vegetation near the ground.

Fairy-wrens

Superb Fairy-wrens are found naturally in most habitats with low dense shrubs that provide shelter. The Variegated Fairy-wren is found in forest, woodland and shrub land habitats. Food for both species consists of insects and other small arthropods. The Variegated Fairy-wren also feeds on various seeds. Nests are built mainly of grasses, bark-fibre and cobwebs in low shrubs.

Sittellas

The Varied Sittella is the only member of this group likely to occur at Castlereagh. It lives in eucalypt forests and woodlands favouring rough-barked trees (ironbarks, stringy-barks) or mature trees with hollows or dead branches. It feeds on insects from the trunks and branches of trees. The small nest is cone-shaped and located in tree forks.

Treecreepers

The White-throated Treecreeper is the only member of this group likely to be found at Castlereagh. It favours open forests, woodlands and rainforests and feeds on insects (mainly ants). The nest is built in a in a tree hollow lined with bark, grasses and hair.

Honeyeaters

Included in this group are Spinebills, Wattlebirds, Minors, Noisy Friarbird and Honeyeaters. All make use of parks and gardens and remnant bushland with large trees and many different shrubs. Naturally most reside in forests and woodlands near water. Some, such as the Little Wattlebird favour drier heaths with tall stands of

banksias while the Bell Miner lives in the canopy of tall forests with a dense shrub layer while many of the honeyeaters prefer more open forests and woodlands with sparse understorey and near water.

Their food is predominantly nectar and insects (and their products, such as lerps and honeydew), but some also eat seeds and fruit (Red Wattlebird, Little Wattlebird, Noisy Miner, White-plumed Honeyeater, Lewin's Honeyeater). The main plants used include eucalypts, banksias, grevilleas, *Hakea*, epacrids, acacias, casuarinas, *Callistemon, Melaleuca*, turpentines and mistletoes. The Yellow-faced Honeyeater also uses areas of dense Blackberry and Scotch Broom. Most are aggressive when feeding and drive off smaller birds.

Nests are normally slung in outer tree and shrub branches within thick foliage, sometimes over water.

Flowerpeckers

The Mistletoe Bird occurs in a variety of habitats wherever mistletoe occurs and feeds almost exclusively on their fruits, thereby assisting in spreading the seed. It also eats other berries and insects. Its nest is suspended from twigs in the outer foliage of trees or shrubs. No other members of this group are anticipated to occur at Castlereagh.

Pardalotes, Gerygones, Scrubwrens and Thornbills

The natural habitat for this group varies from forests and woodlands with well-developed understorey to wooded watercourses to more open grassy woodlands and edge habitats. Some favour the older more established urban areas (Yellow Thornbill, Striated Thornbill) with many eucalypts (Spotted Pardalote), or dense shrubs and plenty of ground cover (Brown Thornbill), or combinations of bushy growth and open areas (Yellow-rumped Thornbill).

Food comprises insects, seeds, nectar and fruit; for some, scale insects are a staple (e.g. Striated Thronbill, Spotted Pardalote). Some forage on the ground amongst litter and grass while most feed amongst leaves and foliage at shrub level. Nests are mostly slung from tree branches in outer foliage but the White-browed Scrubwren nests in dense undergrowth near the ground and the Pardalotes nest within tunnels in an earth bank beside creeks or cliffs.

Finches

The introduced European Goldfinch has been recorded at Castlereagh and is the only member of this group that is likely to occur at Penrith Lakes. It is often associated with human settlements and is considered unlikely to be found in the Wildlife Lake area.

House Sparrows and Grass Finches

The native species in this group live in a variety of habitats that include grasslands as they feed on half-ripe grass seeds and insects. The Double-barred Finch and Red-browed Finch prefer open grassy areas surrounded by dense shrubbery – they nest in dense foliage. The Chestnut-breasted Mannikin prefers to live in dense long grass and reed beds in swampy areas and the Zebra Finch favours grassy woodlands. All finches are always near water as they need to drink often.

This group also includes two introduced species, the Nutmeg Mannikin and the House Sparrow. The former occupies grassland areas and may potentially be seen at Castlereagh. The Hose sparrow is always associated with human settlements and, while it is likely to occur at the Penrith Lakes site, it is unlikely to be seen in the Wildlife Lake area.

Monarchs, Fantails, Magpielarks and Drongos

These birds can be found in a range of habitats. The Magpie Lark and Willie Wagtail are common inhabitants of gardens and parks, the Grey Fantail and Restless Flycatcher are seen in open areas, farmland, gardens and open forests, the Leaden Flycatcher and Satin Flycatcher prefer tall to medium open forest while the Rufous Fantail lives in dense rainforest or open forests and woodlands often along watercourses. All but the Magpie Lark and Willie Wagtail tend to migrate north in winter, although non-breeding and young Magpie Larks may also be migratory. They all feed on insects caught on the wing, foraged for in foliage or hunted on the ground. Their nests are usually placed in tree forks, often near water, or man-made structures may be used (Magpie Lark, Willie Wagtail).

Orioles

The Olive-backed Oriole is the only member of this group likely to occur at Castlereagh. It lives in rainforest and wet sclerophyll forests and feeds on fruits and insects. Nests are attached by their rim to a tree branch or fork in the outer foliage of a shrub.

Bowerbirds

The Satin Bowerbird is the only member of this group likely to occur at Castlereagh. It favours the edges of rainforest and wet sclerophyll forests and feeds mostly on fruit supplemented with leaves, flowers, nectar and insects. It also frequents parks and gardens and will construct bowers in secluded areas of gardens. The male makes a well decorated bower to attract females. The nest is built in a tree or bush.

Mudnest Builders

The White-winged Chough is found in open forests and woodlands in wetter areas where leaf litter is abundant and mud, for nest-building. It feeds on the ground on insects and their larvae and other invertebrates and takes some seeds also. Apostlebirds are found mainly inland in open dry forests but also in farmlands, on roadsides and in orchards, always near water. Both species build nests comprising a large bowl of mud built on a horizontal tree branch.

Woodswallows, Magpies, Butcherbirds and Currawongs

These birds occupy a range of habitats including rainforest margins, forest, woodland, open country including farmlands and along roadsides. The Australian Magpie and Pied Currawong are commonly observed in parklands and gardens. Their natural diet comprises insects and their larvae (Magpie, Woodswallows), small animals, fruits and seeds (Butcherbird, Currawong). The Woodswallows also feed on nectar. Nests are placed in tree forks up to 20m above ground and, in the case of the Dusky Woodswallow, in a stump hollow or fence post.

Ravens and Crows

The Australian Raven is found in woodlands, along wooded watercourses and in open pastures. It feeds mainly on insects and also carrion, supplemented with grains and fruit. It builds a large stick nest in a tree fork.

White-eyes

The Silvereye is the only member of this group likely to occur at Castlereagh. It is common in most wooded habitats and frequents parks and gardens. The birds feed on insects as well as fruit and nectar.The nest is a small, cup-shaped structure comprised of grasses and other plant material and placed in a tree fork about 5 metres from the ground.

Old World Warblers

As mentioned in Section 4.4.1, this group includes several birds which inhabit wetlands and others that are terrestrial species. Terrestrial species that may be seen at Castlereagh are the Brown Songlark and the Rufous Songlark. Both prefer open grasslands, including pastures and grassy scrub and feed mainly on insects, but also grass seeds. The nests of these species are constructed on the ground in a clump of thick grass or other low vegetation.

Starlings

The two members of this group that are likely to be seen in the Wildlife Lake area are the introduced Common Starling and Common (or Indian) Myna. Both are now very common in urban and rural areas and are pest species in market gardens and orchards where they damage crops. They eat insects and scavenge for fruit and vegetables. The Starling and Myna build nests in buildings and tree hollows using materials such as leaves, grasses and refuse. Both species also compete vigorously for nesting sites with native birds.

Thrushes and Old World Flycatchers

The introduced Common Blackbird is the only member of this group likely to occur at Castlereagh. It is common in urban and semi rural areas and could occur in the Wildlife Lake area. It eats insects as well as seeds and fruit and forages on the ground by turning over leaf litter. The bird builds a cup-shaped nest of dried grasses in a tree or shrubby vegetation. It will also use tree hollows.

8. Frogs and their habitats

8.1 Overview

Some 18 species of frogs have been recorded at Penrith Lakes including 10 Tree frogs (family Hylidae) and eight Ground-dwelling frogs (family Myobatrachidae). All are found in wetland areas or along creeks and rivers and need water bodies for breeding purposes

Australian Museum specialists note 'Our knowledge of the general biology of frogs in New South Wales and elsewhere in Australia is poor. Descriptions of habitats are vague and imprecise at best and non-existent at worst. Information concerning the diet of adult frogs is almost non-existent. There is no published information regarding the natural diets of tadpoles.' Knowledge of frog population biology and community biology is also largely lacking. In regard to the latter they state: 'We know that some sites have more co-occurring frog species than others, but we do not understand why this should be so. This means that we cannot accurately predict which species will be present at particular sites.'

'Our strategies for conserving frogs and stopping their declines are currently restricted to simple protection of habitat. If we know that a particular frog species occurs in an area and we know what habitats it uses within this area, then we may simplistically attempt to conserve the species in the area by avoiding or preventing disturbance of these habitats through human activities. We may similarly hope to achieve recovery of a threatened species simply by stopping human disturbance of habitats used by the species.' (amonline.net.au/terrestrial_ecology/research/ecology_frogs.htm)

8.2 General habitat needs

Habitat and resource needs are summarised in Table 17 and more details are given in Appendix 2, Table 3.

Table 17. Frogs - Main habitats, habitat components and breeding habitat components

	Tree Frogs	Ground-dwelling frogs
Main Habitats		
Shallow lakes and lagoons	Yes	
Creeks – slow flowing, rocky	Yes	Yes
Bush-lined watercourses and seepages	Yes	Yes
Swamps – emergent rushes, sedges, grasses, other herbs	Yes	Yes
Swamp margins – herblands wetting and drying		Yes
Grassland seasonally flooded		Yes
Grasslands drier	Yes	Yes
Swamp woodlands – *Melaleuca*	Yes	
Forests – riparian and moist	Yes	Yes
Forests – drier	Yes	Yes
Woodlands – alluvial, moist	Yes	Yes
Woodlands – drier		Yes
Forest clearings		Yes
Urban areas	Yes	
Habitat Components		
Emergent rocks and stones in creeks	Yes	
Leaf litter and ground debris	Yes	Yes
Loose soil		Yes
Rock crevices	Yes	
Flat rocks - exfoliations	Yes	
Tree hollows or cracks	Yes	
Loose bark	Yes	
Fallen timber	Yes	Yes
Emergent reeds and rushes	Yes	
Swamp vegetation	Yes	Yes
Habitat Components for Breeding		
Rocks and pebbles	Yes	
Leaf mould		Yes
Soil burrow		Yes
Shallow water	Yes	Yes
Floating and submerged vegetation	Yes	Yes

Tree frogs are found along watercourses in forests and woodlands, and also often in or near swamps (including Paperbark Swamps (*Melaleuca*), ponds and dams. Some species are mainly arboreal, sheltering in tree cracks, tree hollows and beneath bark, whilst others use ground shelter such as rocks or fallen trees, large boulders in flowing water, or reeds in water. They forage in swamp reeds, other low vegetation and leaf litter for food. At breeding times eggs are deposited as water surface foams or on vegetation in or under water, or adhere to rocks in quiet backwaters.

The ground-dwelling frogs occupy mainly stream edges in forests and woodlands but also in swamps, ponds, and flooded grasslands on river flats. They shelter in vegetation at the edge of water, below logs near ponds, in leaf litter or in burrows and forage mainly in open areas. Eggs are deposited in foam nests amongst vegetation beside still or gently flowing water, or in burrows in stream banks, or in some cases on submerged vegetation.

The diet of the tree frogs may include a wide variety of invertebrates such as mosquitoes, moths, flies, and cockroaches and some will even take small vertebrates such as mice, birds, snakes and other frogs. Ground-dwelling frogs have been recorded as feeding on spiders, centipedes, other insects and small crustaceans.

8.3 Likelihood of establishment

Amongst the Tree Frogs it is considered that only one species, the Eastern Dwarf Tree Frog, could establish early but most of the others require denser and more complex vegetation (intermediate stage of development) and one, Lesueuer's Tree Frog, requires mature vegetation. It is considered unlikely that the Blue Mountains Tree Frog would establish at Castlereagh as it occurs only in specific habitats the Blue Mountains.

Two of the Ground-dwelling Frogs could establish at the earliest stage of vegetation development, namely the Common Eastern Froglet and the Brown-striped Frog, whilst the two toadlets could become established once the vegetation is more complex. It is considered that assistance to re-enter would be required by both the Eastern Banjo Frog and the Spotted Grass Frog once vegetation is relatively complex (intermediate stage). Two other species are considered to be unlikely to establish as their current distribution is well outside the Castlereagh and western Sydney environs.

8.4 Endangered and vulnerable species

Three species can be considered for re-introduction: the Green and Golden Bell Frog (*Litoria aurea*), listed as endangered under the NSW TSC Act Schedule1 and as vulnerable under the Commonwealth EPBC Act; the Red Crowned Toadlet (listed as Vulnerable in Schedule 2 of the TSC Act); and the Giant Burrowing Frog (*Heleioporus australiacus*) also listed as Vulnerable in Schedule 2 of the TSC Act and in the EPBC Act. Of these only the Green and Golden Bell Frog is likely to be successfully re-introduced as the highly specialised sandstone habitats of the other two species do not occur within the Castlereagh lands.

8.4.1 Green and Golden Bell Frog (*Litoria aurea*)

The endangered status of the Green and Golden Bell Frog means that it is unlikely to re-colonise at Castlereagh without assistance. The species is capable of breeding successfully in disturbed/created habitat areas as well as its more natural breeding areas such as in lagoons, billabongs and depressions adjacent to or in slow flowing/intermittent watercourses. The spawn and tadpoles may be eaten by introduced fish such as *Gambusia* and Carp (as is the case with most other frog species). However it may be possible to re-introduce populations to Castlereagh if suitable habitat can be developed and threats like the Plague Minnow (*Gambusia holbrooki*) are eradicated or successfully managed. Foraging habitat needs include non invasive emergent plants such as *Eleocharis* and other reeds and rushes on the margins of its swamp and lagoon habitat. Shelter habitat can be provided using accumulations of small to medium boulders and ground timbers/logs. Additional terrestrial foraging areas can be provided with grassy areas containing tussock forming vegetation species such as *Lomandra ssp* and *Gahnia ssp*.

Green and Golden Bell Frogs still persist in Western Sydney at Riverstone, Mt Druitt and St Marys with possible other sightings at Prospect and Bents Basin. Reintroduction efforts would ideally make use of one of these nearby sources with stocks to be increased in a rigorously controlled breeding program and maintained free of disease. Frog chytrid disease has been listed as a Key Threatening Process (KTP) at both state and national level.

The Australian Museum specialists state that although the Green and Golden Bell Frog is the most studied Australian frog, knowledge about it 'is severely limited. While we know, for example, that they are capable of moving distances of 10 km or more, we have little idea concerning typical patterns of movement. We know that they can live over ten years in captivity but have no information concerning typical rates of

survival or longevity. We do not know what factors determine distribution or abundance, nor how such factors might operate.' …. conservation and recovery are problematic. We know that the species can thrive in some completely artificial sites and we should be able to develop and enhance habitat for the species, if we could create the right conditions. We have also been able to evaluate some aspects of habitat that affect the frog. Nonetheless, however, our ability to design new habitat for the species cannot be considered good, as we have not so far succeeded in introducing the species into any new sites.' (amonline.net.au/terrestrial_ecology/research/ecology_frogs.htm)

9. Aquatic and dry land reptiles

9.1 Overview

Current knowledge indicates some 30 species of reptiles could be expected to live at Castlereagh. Groups represented in wetland and upland/dryland areas include:

Wetlands (no. species)
- Turtles (2)
- Dragons (1)
- Snakes (6)
- Legless Lizards (1)
- Skinks (1)

Drylands (no. species)
- Dragons (2)
- Snakes (6)
- Gekkos (2)
- Legless Lizards (1)
- Skinks (7)
- Monitors (1)

None of the reptiles are listed as endangered or vulnerable under NSW or Commonwealth legislation. It is considered that the Heath Monitor (*Varanus rosenbergi*), listed as vulnerable in the NSW TSC Act Schedule 2 and recorded from the Blue Mountains escarpment to the west, might cross the Nepean River to forage at Castlereagh if suitable foraging habitat became available but it is unlikely to colonise.

9.2 General habitat and resource needs of wetland species

The main wetland habitats, habitat components and breeding habitat components for the different groups of reptiles are given in Table 18 and their foods in Table 19. More details are provided in Appendix 2, Table 4.

Table 8. Reptiles - Main wetland habitats, habitat components and breeding habitat components

Reptile Group	Turtles	Snakes	Skinks	Lizards	Dragons
Main Habitats					
Shallow lakes and lagoons	Yes		Yes		
Creeks – slow flowing	Yes				
Bush-lined watercourses and seepages		Yes	Yes		Yes
Swamps – emergent rushes, sedges, grasses, other herbs		Yes	Yes		
Shrubby thickets adjoining swamps or watercourses, seasonally flooded		Yes			
Swamp woodlands – Melaleuca, Casuarina				Yes	
Grasslands			Yes		
Forests – riparian and moist		Yes	Yes		
Woodlands – alluvial, moist		Yes	Yes		Yes
Artificial rocky structures such as weirs, gabions, retaining walls					Yes
Habitat Components					
Emergent logs in shallow water	Yes				
Shallowing vegetated banks	Yes		Yes		
Leaf litter	Yes	Yes	Yes	Yes	Yes
Loose soil	Yes		Yes		
Deep soil cracks		Yes			
Deep rock crevices		Yes	Yes		
Flat rocks - exfoliations		Yes	Yes	Yes	
Tree hollows		Yes	Yes		Yes
Logs and hollow logs		Yes	Yes	Yes	
Fallen timber		Yes	Yes	Yes	Yes
Disused animal burrows		Yes	Yes		
Dense matted vegetation		Yes	Yes		
Habitat Components for Breeding					
Soil nesting chamber, bank burrow, deep soil or soil hole	Yes	Yes	Yes		Yes
Large rock slabs or deep rock crevices		Yes	Yes	Yes	
Hollow tree stumps		Yes			

Two species of turtle have been recorded at Castlereagh. Turtles occupy permanent and ephemeral watercourses, lagoons and swamps. In drought times the Eastern Snake-necked Turtle shelters in mud, under litter or loose soil. Its food includes aquatic vegetation, aquatic insects, fish, crustaceans, molluscs, frogs and tadpoles. Eggs are laid in a soil chamber.

The Eastern Water Dragon is found naturally in bush-lined watercourses and seepages, and forages in trees or shrubs near or over water. It also colonises artificial rocky structures at the water's edge. It feeds on insects including cicadas, spiders, grubs, small lizards, yabbies, fish, flowers and fallen fruits (figs and lilly pillies). Eggs are laid in chambered bank burrow.

Six snakes favour wetland habitats. They shelter in tree hollows and crevices, fallen and hollow logs, in rock crevices or beneath rocks, and in dense vegetation, disused animal burrows, and deep soil cracks. They feed on frogs, tadpoles, and fish (including eels), other reptiles (skinks, geckos, dragons, lizards and lizard eggs, snakes) and also occasionally small mammals and nesting birds. They feed on frogs, tadpoles, and fish (including eels), other reptiles (skinks, geckos, dragons, lizards and lizard eggs, snakes) and also occasionally small mammals and nesting birds. Eggs are laid in communal nests in deep soil, rock crevices, under large rock slabs or hollow stumps.

Amongst the Skinks only the Eastern Water Skink occupies permanent watercourses, lakes and swamps and swamp margins where fallen timber or rocky outcrops are present. It shelters in burrows, holes, crevices amongst rocks, in banks, and under embedded fallen timber. Beetles, especially water beetles, aquatic larvae, spiders, snails, tadpoles, smaller lizards and native fruits and berries are its food.

The Scaly-foot Lizard inhabits tea-tree swamps as well as forests and woodlands. It shelters and nests under logs and rocks. It feeds on spiders, insects, fruits of prostrate shrubs, and *Kunzea* species.

Table19. Foods of wetland reptiles

Foods	Turtles	Dragons	Snakes	Skinks	Lizards
Plants					
Aquatic vegetation	Yes				
Flowers		Yes			
Fruits (figs, lilly pillies, etc)		Yes		Yes	Yes
Ants (pupae, larvae, eggs)				Yes	
Aquatic insects and larvae	Yes			Yes	
Beetles				Yes	
Cicadas		Yes			
Crustaceans	Yes				
Yabbies		Yes			
Fish	Yes	Yes	Yes		
Eels			Yes		
Frogs	Yes		Yes		
Tadpoles	Yes		Yes	Yes	
Insects		Yes		Yes	Yes
Snails				Yes	
Snakes			Yes		
Small lizards		Yes	Yes	Yes	
Lizard eggs			Yes		
Skinks, Dragons, Geckos			Yes		
Small mammals (Rats, Bandicoots, Possums, small wallabies)			Yes		
Birds			Yes		
Spiders		Yes		Yes	Yes
Centipedes				Yes	
Grubs, Bugs, and Caterpillars		Yes			
Flies				Yes	
Amphipods				Yes	

9.3 General habitat and resource needs of dry land species

Dryland areas are the favoured habitats of most skinks, monitors and geckos but are also occupied by two species of dragons, a number of different snakes and one species of legless lizard. Table 20 indicates their main preferences and needs and Table 21 their foods.

Table 20. Reptiles - Main dryland habitats, habitat components and breeding habitat components

Reptile Group	Snakes	Monitors	Geckos	Skinks	Lizards	Dragons
Main Habitats						
Bush-lined watercourses and seepages	Yes	Yes				Yes
Swamp margins – herblands wetting and drying				Yes		
Forests – drier	Yes			Yes		Yes
Woodlands – alluvial, moist	Yes			Yes		Yes
Woodlands – drier	Yes			Yes		Yes
Forest clearings						Yes
Forest patches in cleared lands	Yes			Yes		
Rocky ridges or slopes with shrubby vegetation	Yes		Yes	Yes		Yes
Rock outcrops or outliers	Yes		Yes	Yes		
Habitat Components						
Shallowing vegetated banks				Yes		
Leaf litter	Yes			Yes	Yes	Yes
Deep rock crevices	Yes		Yes	Yes		
Flat rocks - exfoliations	Yes	Yes	Yes	Yes	Yes	
Tree hollows/crevices	Yes	Yes		Yes		Yes
Loose bark				Yes		Yes
Fallen timber	Yes	Yes	Yes	Yes	Yes	Yes
Disused animal burrows	Yes		Yes	Yes		
Dense undergrowth				Yes	Yes	Yes
Dense matted vegetation	Yes			Yes		
Habitat Components for Breeding						
Soil nesting chamber, bank burrow, deep soil or soil hole	Yes		Yes	Yes		Yes
Large rock slabs or deep rock crevices	Yes			Yes	Yes	
Rotted tree trunks				Yes		
Well-embedded rocks or logs	Yes		Yes		Yes	

The Bearded Dragon and the Jacky Lizard occupy dry forests, woodlands and open woodland and rocky ridges and slopes with scrub (Jacky Lizard). They shelter in hollows, in dense undergrowth and litter under bushes, fallen timber or bark. They feed on beetles, ants, spiders, other insects, small lizards (Bearded Dragon), and flowers, near-ground fruits and green shoots.

The terrestrial snakes occupy forests, woodlands, shrublands, tree-lined watercourses, rocky outcrops are favoured. They shelter under fallen timber or flat rocks, in rock crevices or loose bank, in tree hollows and large hollow logs, under densely matted vegetation and deep leaf litter, in disused animal burrows and deep soil cracks. Eggs are laid under well-embedded rocks or logs. Foodstuffs vary with different groups - Diamond Python hatchings feed mostly on lizards while adults prey on small to medium sized mammals – rats, bandicoots, possums, small wallabies, fruit bats and birds. Many other snakes feed on skinks, dragons, lizards and lizard eggs, blind snakes, frogs and adults may feed also on small birds, mammals and occasionally frogs. The Blind Snake lives mainly on the pupae, larvae and eggs of ants supplemented with worms and leeches.

The geckos require rock outcrops and rocky country with sparse vegetation. They shelter in rock crevices, under exfoliations, fallen timber or in soil burrows and feed on spiders and other insects. They nest in soil under rocks or in rock crevices.

The dryland skinks occupy a variety of forests and woodlands, often living on the margins or edges of clearings, and in shrublands. Some need dense low ground vegetation, whilst others inhabit rock faces, tree hollows or fallen timber. Many use burrows in banks, under flat rocks or exfoliations, or well-embedded

fallen timber for shelter. Deep leaf litter, bark, or the base of large tussock-forming grasses are also used in this way. Food for many includes spiders, other insects and insect larvae, for others also small reptiles, frogs and tadpoles, and for a number also plant material: fruit, flowers and soft leaves and shoots. Nests are made in rock crevices, hollow logs, or burrows under rocks, logs or matted vegetation.

The Lace Monitor usually lives in rainforest and sclerophyll forest and shelters in tree hollows or in shallow burrows under fallen trees or large rocks. Its diet includes small reptiles, small mammals, insects, spiders and carrion.

Burton's Snake-lizard inhabits low dense bushes and shelters under fallen logs, in leaf litter or in trees and rocks. Communal nests are under logs or rocks on soil. Skinks, other legless lizards, geckos and dragons form its food.

Table 21. Foods of dryland reptiles

Foods	Dragons	Snakes	Monitors	Geckos	Skinks	Lizards
Plants						
Flowers	Yes				Yes	
Fruits (figs, lilly pillies, etc)	Yes				Yes	
Plant food – green shoots	Yes				Yes	
Animals						
Ants (pupae, larvae, eggs)	Yes					
Beetles	Yes					
Cockroaches				Yes		
Fresh carrion			Yes			
Frogs		Yes			Yes	
Tadpoles					Yes	
Insects	Yes		Yes	Yes	Yes	
Lizards	Yes	Yes	Yes			
Legless lizards						Yes
Lizard eggs		Yes				
Skinks, Dragons		Yes				Yes
Geckos						Yes
Blind snakes		Yes				
Small mammals		Yes	Yes			
Rats, Bandicoots, Possums, Small wallabies		Yes				
Fruit Bats		Yes				
Birds		Yes				
Worms		Yes				
Leeches		Yes				
Spiders	Yes		Yes	Yes	Yes	
Scorpions				Yes		
Grubs, Bugs, and Caterpillars			Yes			

9.4 Likelihood of establishment

9.4.1 Wetland species

The Eastern Snake-necked Turtle could be expected to visit and re-colonise at Castlereagh during the earliest establishment phase of the vegetation. Less common is the Macquarie Turtle, but it may colonise following flood events once mature vegetation is present. It is considered that only the Eastern Water Skink is likely to establish in the earliest stages of vegetation development while the Eastern Water Dragon and at least four of the snakes could become established once more complex vegetation is available (during the intermediate phase). The yellow-faced Whip Snake would require mature vegetation. Both the Eastern Tiger Snake and the Scaly-foot Lizard are probably no longer in the area and would require re-introduction if desired.

9.4.2 Dry land species

Only the Grass Skink is considered to be likely to establish during the early development of the vegetation. The Bearded Dragon, the Diamond Python and Blind Snake, and at least three other Skinks could be expected to establish when the vegetation is relatively complex, at an intermediate phase of development.

Three other snakes and two skinks may establish at the mature vegetation phase. It is considered that the Lace Monitor could readily migrate to the site from the west by fording the river and also from any residual stock east of the site. The size of the area would be sufficient to sustain the Lace Monitor but its large territory and ranging disposition often results in road mortality. Of the Gecko species known from the area only the Stone Gecko is considered likely to re-colonise naturally once mature vegetation is available. The Common Death Adder and Burton's Snake-lizard have both probably disappeared from the region and would require re-introduction if desired. The spectacular Underwoods Gecko has probably disappeared from nearby areas but could possibly be re-established through assisted reintroduction.

9.5 Management issues

The main threats to reptiles at Castlereagh and elsewhere are loss of habitat through clearing of land, predation by cats, dogs and foxes, and road traffic. The Bearded Dragon, while somewhat tolerant of man-made disturbances is nevertheless severely impacted by road mortality and predation by cats, dogs and foxes. Jacky Lizards are particularly susceptible to clearing of understorey and heath, fire and predation by cats.

10. Mammals

10.1 Overview

Some 11 native mammal species have been recorded at Penrith Lakes; they include marsupials such as gliders, possums and wallabies, and placental mammals including three groups of bats and the water rat. A further 17 species that could also be expected as they have been recorded from nearby localities include monotremes such as the platypus and echidna, marsupials such as antichinus, bandicoots and wombats as well as additional species of gliders, and placental mammals including additional species of bats and rats. Included are five species of bats that are listed as vulnerable under the NSW TSC Act Schedule 2; one of these is also listed under the Commonwealth EPBC Act.

10.2 General habitat and resource needs of wetland mammals

Of the species considered only the Water Rat, Swamp Rat and Platypus are linked mainly to wetland habitats; their habitats, habitat components and breeding habitat components are given in Table 22 and their food resources in Table 23.

Table 22. Wetland mammals – habitats, habitat components and breeding habitat components

	Swamp Wallabies	Rats	Platypus
Main Habitats			
Shallow lakes and lagoons			Yes
Creeks - fast-flowing			Yes
Swamps – emergent rushes, sedges, grasses, other herbs	Yes		
Shrubby thickets adjoining swamps or watercourses	Yes	Yes	
Forests – riparian and moist	Yes	Yes	
Woodlands – alluvial, moist	Yes		
Habitat Components			
Vegetated banks			Yes
Dense undergrowth		Yes	
Dense grass and ferns/groundcover	Yes	Yes	
Habitat Components for Breeding			
Bank burrow, deep soil or soil hole		Yes	Yes
Tussock grasses		Yes	

The Swamp Wallaby can be found in wet areas in open forest and dense swampy woodland vegetation. They shelter in areas of dense grass or ferns. As herbivores they feed on both grasses, bracken fern and shrubs; a coarse browse of shrubs is preferred.

The Water Rat occurs in permanent fresh or brackish water, in slow-moving streams, lakes, swamps, and farm dams. It forages close to the shoreline in shallow water up to 2 m in depth. It wades through shallow water in search of aquatic prey, and dives in areas of greater depth. Prey is often taken to a favourite feeding platform such as a log, rock, or stump located close to the water. The Water Rat is largely carnivorous - crustaceans, aquatic insects, and fish form the bulk of its diet. Among insects, water beetles and water bugs are of primary importance, and nymphs of damselflies and dragonflies can be seasonally important. Birds, mammals, frogs, reptiles, mussels, spiders, and plants are also occasionally taken, with plants more commonly consumed in winter or during periods of limited resources. Nests are built at the end of bank burrows or occasionally in logs. (www.anbg.gov.au/cpbr/WfHC/Hydromys-chrysogaster/index.html)

The Swamp Rat lives in riverside swamps and on the drier adjacent flats. It moves through tunnels made in dense grass or sedge and nests in burrows, or in tussock grasses where the ground is waterlogged. Grasses and sedges supplemented by insects are its diet.

Platypus are semi-aquatic inhabiting freshwater streams, lakes, dams, creeks and rivers. They prefer steep-sided well-vegetated banks and shallow channels. They construct shelter burrows that are up to two metres long just above water level in bank of river or stream; they have a submerged entrance often under a tangle of tree roots. Nesting burrows are between five metres and 20m long with more than one entrance and

plugged with earth at intervals; they are often up to 80cm above the waterline. They nest in the end chamber of damp herbage. They spend up to 12 hours a day in water - mainly at night and sift bottom silt or gravel for food - a wide variety of adult and larval invertebrates including shrimps, mayfly, caddisfly and other fly larvae, and molluscs; also small vertebrates, fish and frogs.
(www.vic.waterwatch.org.au/file/inform/NCCMA)

Table 23. Foods of wetland mammals

Foods	Swamp Wallabies	Rats	Platypus
Plants			
Ferns	Yes		
Fruits and seeds		Yes	
Grasses	Yes	Yes	
Fungi		Yes	
Sedges and rushes		Yes	
Shrubs	Yes		
Animals			
Aquatic insects		Yes	
Crustaceans		Yes	
Fish		Yes	Yes
Fresh carrion		Yes	
Frogs		Yes	Yes
Insects		Yes	
Invertebrates			Yes
Larval invertebrates (worms, shrimps, insect larvae)			Yes
Lizards		Yes	Yes
Mussels and other molluscs		Yes	
Small mammals		Yes	
Small vertebrates			Yes
Water birds		Yes	

10.3 Dry land mammals

The majority of the mammals recorded at Penrith Lakes or from nearby areas are found in dry land habitats. The main habitats, habitat components and breeding habitat components for the different groups are given in Table 24 and a list of foods recorded as used by them is given in Table 25. More detail is provided in Appendix 2, Table 5.
Marsupials recorded at or near Penrith Lakes include species of Antechinus, Bandicoots, Wombats, Gliders and Ringtail possums, Brushtail Possums, Feather-tail Gliders and Wallabies and Kangaroos.

Two species of *Antechinus* have been recorded from nearby localities. They occupy forested areas with dense understorey and thick ground cover with abundant fallen logs. They shelter within bushes or hollow logs and feed mainly on insects and soil invertebrates, and occasionally fruit. They nest in hollow logs, in creek banks or under cover of decaying logs or grass. Additionally the Spotted-tailed Quoll and the Common Dunnart are also recorded from nearby localities. The former lives in sclerophyll forests and rainforest, the latter in more open forests, woodlands and heaths. Both are nocturnal. The Spotted-tailed Quoll basks in the sun during the day and may forage also for food including small vertebrates (mammals, marsupials, reptiles) and insects. The Common Dunnart rests during the day in a nest of dried grass and leaves built in fallen hollow logs or grass clumps. It is insectivorous.

Long-nosed Bandicoots have been recorded from nearby localities. Generally they live in a variety of vegetation including rainforests, wet and dry woodlands, grasslands and suburban lawns. Bandicoots shelter during the day in a shallow hole covered with soil and debris. They forage at night, digging holes in the ground for insects, insect larvae, plant roots and tubers.

Common Wombats have also been recorded from nearby localities. They live in sclerophyll forests and woodlands, burrowing in friable or sandy soil slopes above creeks and gullies. They generally have a home

range of 5 to 23 hectares with many burrows. Food comprises native grasses but also sedges, mat rushes and roots of shrubs and trees. They may travel up to 3 km during the night while feeding.

Table 24. Dry land mammals - Main habitats, habitat components and breeding habitat components

	Kangaroos Wallabies	Rats	Bats	Gliders Possums	Antechinus	Bandicoots	Echidnas	Wombats
Main Habitats								
Creekline pastures	Yes							
Forests – riparian and moist	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Forests – drier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Woodlands – alluvial, moist	Yes		Yes	Yes		Yes		Yes
Woodlands – drier	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Forest clearings/edges	Yes		Yes	Yes				
Forest patches in cleared lands				Yes				
Caves			Yes					
Parks, Gardens, Urban areas			Yes	Yes		Yes		
Habitat Components								
Vegetated banks								Yes
Leaf litter/debris						Yes	Yes	
Loose soil						Yes		Yes
Caves/Overhanging rocks			Yes					
Buildings/timber stacks			Yes					
Tree hollows			Yes	Yes				
Loose bark			Yes					
Logs and hollow logs/tree stumps			Yes				Yes	
Fallen logs		Yes		Yes	Yes			
Shady trees and shrubs	Yes							
Dense undergrowth	Yes	Yes		Yes	Yes		Yes	
Dense grass and ferns/groundcover	Yes	Yes			Yes			
Habitat Components for Breeding								
Bank burrow, deep soil or soil hole					Yes	Yes	Yes	Yes
Hollow tree stumps/logss					Yes			
Rotted tree trunks					Yes			
Tussock grasses								
Grass/leaves and bark				Yes	Yes			

Gliders and Ringtail possums (family Petauridae). Gliders inhabit open eucalypt forest and woodland. Their diet is restricted to certain species of *Eucalyptus* (leaves and sap) or gum of Acacias, but they also feed on invertebrates and invertebrate exudates. They shelter during the day in tree hollow, usually high up and nest in tree hollows. The Common Ringtail Possums occupy vegetation where shrubs form dense tangled foliage. Leaves and flowers of Eucalypts form their main diet, and also fruits. They have adapted to gardens and use a wide variety of exotic flowers and fruits. They nest in hollows or amongst dense undergrowth.

Brushtail Possums (family Phalangeridae) have been recorded at Penrith Lakes. They live in open forests and woodlands and gardens. They often co-habit with humans. They shelter during the day in a hollow dead branch, tree trunk, fallen log or on the ground. In urban areas, any dark recess may be used but the space between roof and ceiling is favoured. They feed on Eucalypt leaves supplemented by flower buds, fruit, bark and pasture plants.

Feather-tail Gliders (family Acrobatidae) have been noted from nearby localities. They inhabit rainforest, sclerophyll forests and woodlands, parks and gardens. They feed on nectar, pollen, Eucalypt sap, and insects, foraging between ground level and the upper canopy. They nest in hollow tree limbs, nests of other animals, boxes or telephone poles.

Table 25. Foods of various mammal groups

Foods	Kangaroos Wallabies	Rats	Bats	Gliders Possums	Antechinus	Bandicoots	Echidnas	Wombats
Plants								
Acacia gum				Yes				
Bark.				Yes				
Eucalypt leaves				Yes				
Eucalypt sap				Yes				
Flowers and buds of eucalypts				Yes				
Fruits				Yes				
Grasses.	Yes	Yes		Yes				Yes
Herbs	Yes			Yes				
Mushrooms		Yes						
Nectar				Yes				
Plant food		Yes						
Pollen				Yes				
Roots of shrubs and trees.								Yes
Sedges and rushes								Yes
Soft fruit (e.g. blackberries)					Yes			
Animals								
Ants			Yes				Yes	
Beetles					Yes			
Cockroaches					Yes			
Insects		Yes	Yes	Yes	Yes			
Invertebrate exudates				Yes				
Invertebrates				Yes				
Moths			Yes					
Soil invertebrates					Yes			
Spiders					Yes			
Termites, plus nest and soil materials							Yes	
Terrestrial insects			Yes			Yes		
Underground foods.						Yes		

The Red-necked Wallaby is found usually in open forests with patches of dense undergrowth, and on forest edges, along creeklines or near pastures. It shelters in dense scrub during the day and feed mainly at night on grasses and other herbs. The Eastern Grey Kangaroo (recorded at the St Marys ADI site some 4 km to the east of the Castlereagh site), occupies open forested habitats, grazes on grasses and herbs in late afternoon to early morning and rests in the shade or shelter of trees and shrubs during the day. The Eastern Grey Kangaroo is listed here because there is the probability that the species may self-introduce or be introduced from the ADI site; however this possibility should be viewed with care because there is a question about the provenance of the population at the St Marys site. Eastern greys are noted as living at Scheyville (J. Russell, pers. comm.).Wallaroos have also been seen along the river bank; they probably came across from Yellowmundee.

The Bush Rat occupies forested and scrubby areas, often in gullies, with dense undergrowth and ground cover, and fallen trees to provide further shelter. Nocturnal, it feeds mainly on insects but also plant food and mushrooms. All nest in burrows in banks, occasionally in logs, or in tussock grasses where the ground is waterlogged (Swamp Rat).

Koala has been noted from nearby areas and may have been a resident species at the time of European colonisation. Koalas favour forests and woodlands on the more fertile soils and are often more abundant along watercourses and on adjacent floodplains. They are solitary with members of the population evenly distributed through available wooded areas. Koalas sleep in a tree fork during the day and travel and feed on particular *Eucalyptus* species during the evening and night.

Echidnas (Monotremes) are found in all types of habitat where their food – ants and termites – occur. They shelter under thick bushes, in hollow logs, under piles of debris, or in a burrow.

Some 16 species of bats (within three different families) might be expected at Castlereagh as they have been recorded there or from nearby areas. Five species are currently listed as vulnerable in Schedule 2 of the NSW TSC Act and one of these also as near threatened under the Commonwealth EPBC Act. Fruit Bats/Flying-Foxes belong to the family Pteropodidae. Flying Foxes are found in rainforests and sclerophyll forests with dense canopy. By day they roost in trees in large colonies (camps), often in gullies close to water. They feed on nectar and pollen of Eucalypts, Paperbarks and Banksias and also rainforest fruits such as Figs. They may fly up to 30 km a night to a feeding area. They also feed in orchards.

The Free-tail Bats (family Molossidae) live in sclerophyll forests and woodlands and forage above the forest canopy, in clearings, or at the edge of forests for moths, or also on the ground for terrestrial insects. Small colonies roost in tree hollows, under loose bark and in dead stumps. The Micro Bats (family Vespertilionidae) are a diverse group, they live in sclerophyll forests and woodlands, well-timbered valleys or gullies near water, also near large lakes and reservoirs. Some roost in tree hollows, under loose bark, in dead stumps or abandoned birds nests, others in caves or even crevices associated with human constructions. Such constructions may include: old mines or tunnels, abandoned buildings (ceilings or basements), timber stacks, or bridges. Some forage above the tree canopy, others just below it, others near the ground, for moths and other small flying insects. The Large-footed Myotis, forages over water, raking its surface for aquatic insects.

10.4 Likelihood of establishment or visiting

10.4.1 Wetland species

Current knowledge of these species suggest that the Swamp Rat could establish once the vegetation is relatively complex (intermediate phase) but that the Water Rat, Swamp Wallaby and Platypus would all require mature vegetation in order to establish and thrive at Castlereagh.

10.4.2 Likelihood of establishment or visiting

Given habitat requirements it is considered that only very few mammal species are likely to become residents at Castlereagh. The Brushtail and Ringtail Possums and the Bush Rat are likely to be the first to become established and they will need at least well developed vegetation complexity to do so. Echidna, and some of the marsupials (Dusky Antechinus, Long-nosed Bandicoot) and possibly also the Grey-headed Flying Fox may be able to establish resident populations once the vegetation reaches maturity.

On the basis of current knowledge the Brown Antechinus and the Spotted-tailed Quoll could be expected to visit Castlereagh once the vegetation is well developed and a number of other mammals, including the Common Dunnart, wombats, gliders and wallabies and kangaroos, would be likely to visit once the vegetation is mature. A number of Bat species have been recently recorded as foraging in riverbank vegetation at Penrith Lakes, so they could also be expected to visit at least from the time the vegetation is well developed. It is considered unlikely that either the Greater Glider or the Koala would visit Castlereagh even if mature vegetation was present as source populations are not within reasonable distance. The Koala could be introduced, however, if suitable habitat is developed.

Potential for Koala

While Koalas have not been recorded at Castlereagh they have been noted from within 5 km of the site (Abel Ecology, 2007) and they do occur in a number of different vegetation communities, some of which are present on the Cumberland Plain. There is therefore some potential for suitable habitat to be developed for them at Castlereagh. Current studies of Koala indicate that their population densities are low, usually between 0.2-2 koalas/ ha and they establish a home range of about 1-2.5 ha. They favour forests and woodlands that occur on the more fertile soils and are often more abundant along watercourses and on adjacent floodplains. They can use highly fragmented habitats, young forest and highly modified vegetation such as grazed, disturbed or thinned forest and regrowth areas – but prefer large trees. Site quality is important: tree health, foliage characteristics, ground cover and the level of disturbance.

Koalas feed on a number of different *Eucalypt* species and also use a number of other tree species. They often show a preference for a small number of food trees in any one locality. These are categorised as ‘primary tree species’ as they show significantly higher use by koalas than other eucalypt species. ‘Secondary tree species’ are those that have a lower level of use than primary trees and their use is affected by variables such as soil nutrient, soil moisture, topography and occurrence of any primary tree species. Additionally there are ‘supplementary tree species’ that form a further important resource used occasionally or seasonally by Koalas.

Table 26. Koala food tree species for planting at Castlereagh (planting ratios given)

Food tree category	Species	Plant communities			
		Alluvial Woodland	Riparian Forest	Shale Sandstone Transition Forest	Shale Gravel Transition Forest
Primary	*Eucalyptus amplifolia*	Yes	-	-	
	Eucalyptus punctata	Yes	-	Yes	Yes
	Eucalyptus tereticornis	Yes	Yes	Yes	Yes
	Eucalyptus moluccana	Yes	-	Yes	Yes
	Eucalyptus piperita	Yes	-	-	-
	Eucalyptus resinifera	-	-	Yes	-
	Eucalyptus saligna	-	-	Yes	-
Supplementary	*Allocasuarina torulosa*	Yes	-	Yes	Yes
	Angophora floribunda	Yes	Yes	Yes	Yes
	Casuarina glauca	Yes	-	-	Yes
	Corymbia gummifera	-	-	Yes	-
	Corymbia maculata	Yes	-	Yes	Yes
	Eucalyptus botryoides	-	Yes	-	-
	Eucalyptus crebra	-	-	Yes	Yes
	Eucalyptus eugenioides	Yes	-	Yes	Yes
	Eucalyptus fibrosa	-	-	Yes	Yes
	Eucalyptus globoidea	Yes	-	Yes	Yes
	Eucalyptus pilularis	-	-	Yes	-
	Melaleuca styphelioides	Yes	Yes	Yes	Yes
	Syncarpia glomulifera	-	-	Yes	Yes

Some 20 tree species will be planted that are known to be useful to Koalas. Eight of these are found in all vegetation communities and nine would be planted in frequencies that are 'common' and four as 'abundant'. Only three species, however, are considered as primary species, so planting ratios for these may need to be increased in any areas that are being considered as habitat for introduced Koala populations, and in corridors across the whole site to make up at least 15% of the total number of trees. The data from natural vegetation communities suggests that Koalas could be introduced to both the riverbank-floodplain and the Cranebrook escarpment areas. The riverbank-floodplain would have three primary species, four secondary species and 13 supplementary species, whilst Cranebrook escarpment would have three primary, four secondary and 15 supplementary species (not considered further here)

Koalas may range over considerable distances so management needs to extend beyond the immediate boundaries to other useful remnants/ corridors. Corridor use by Koalas is not well documented but they have been observed moving along 20m wide road reserves on the NSW north coast.

If Koalas are introduced to Castlereagh there are a number of threats that will need to be managed. These include: roads and tracks that provide open ground where animals are more vulnerable to predation or may be hit by vehicles; feral and domestic animals; and changes in environment and levels of disturbance resulting in stress-related diseases.

10.5 Vulnerable species

The Grey-headed Flying-Fox has been recorded at Castlereagh. The species is currently listed as Vulnerable in Schedule 2 of the NSW TSC Act and also as vulnerable under the Commonwealth EPBC Act. The Little Red Flying Fox has also been recorded from western Sydney; they occasionally form mixed aggregations at roost sites and are recorded as feeding together. Greater Broad-nosed Bat, East Coast Freetail Bat, Large Bentwing-bat, and Large-footed Myotis are also all currently listed as vulnerable under the NSW TSC Act, and the first named is listed as 'near threatened' under the EPBC Act.

In a recent survey (Abel Ecology 2007), the last three were detected on or near Penrith Lakes and were considered to be foraging on-site. It would seem feasible that all of these vulnerable species could forage at

Castlereagh once suitable food sources were further enhanced. Roosting on-site is considered unlikely unless assisted with bat boxes or enhanced artificial structures.

10.6 Management issues

10.6.1 Wetland species

Both the Water Rat and Swamp Rat are vulnerable to clearing and drainage of wetlands and flood mitigation practices, and the latter also to grazing and fire. Significant threats facing the platypus include altered river flow regimes and river regulation, declining water quality, loss of bank and riparian vegetation, increased bank erosion, litter (which can cause severe injuries), predation from foxes and cats, as well as other processes that impact on macro-invertebrate communities which make up the majority of the platypus diet.

10.6.2 Dry land species

Mammal populations have been reduced over many years through clearance of land resulting in removal and fragmentation of habitats, and by replacement of native forests with exotic plantations and agricultural lands. Human settlements and their associated infrastructure form barriers to movement and many species are killed on roads. Inappropriate fire regimes and predation by introduced animals and feral cats and dogs have also taken their toll. For the Dusky Antechinus controlled burning and removal of complex understorey vegetation and litter has removed much of the invertebrate food upon which it relies. The Bush Rat can survive some fires by remaining in burrows. For the Sugar Glider mortality is high in the first 12 months as the young gliders are eaten by owls, kookaburras, goannas and cats. Retention of interconnected systems of suitable forest and woodland habitat is essential for its conservation. For some of the bats, disturbance has a very deleterious effect, and those living or foraging near settlements may be taken by domestic cats.

11. Introduced species

11.1 Overview

A number of introduced species have been recorded at Castlereagh, including dogs, horses, brown hares, rabbits, black rats, pigs and foxes; feral cats have been recorded from nearby areas. Most of these species can be expected to visit from the establishment phase and several to become resident during that phase also. These species will need to be controlled to allow populations of re-introduced fauna to establish successfully.

Threat abatement plans have been developed so far for foxes, pigs, feral cats and rabbits under the Commonwealth EPBC Act. These plans establish a national framework to guide and coordinate responses to the effects of predation by particular introduced species on biodiversity. They identify the research, management and other actions needed to ensure the long-term survival of native species and ecological communities affected by these predators. A summary of the important habitat factors for each of the four species is given and the options for control are outlined. (DEH, 2005; DEWHA 2008a, b, c)

In developing an approach to manage the impacts of feral animals on native species and ecological communities, the extent and nature of the threat and the interactions of the feral animals with other species must be understood. From a wildlife management point of view, the key question is whether the removal of a feral animal will result in significant increases in the population or distribution of particular native species. Wherever possible, the pest population should be reduced to a manageable level using intensive control techniques and then maintained at that level with regular follow-up control. Ongoing monitoring of the effectiveness of the control in ameliorating impacts is necessary to determine the level of ongoing control necessary.

11.2 General characteristics and impacts

11.2.1 Foxes

Foxes have a wide dietary range, few serious diseases and few natural enemies. They have a high reproductive rate and high rate of cub survival. They predate on terrestrial mammals that weigh between 35 and 5500 grams and ground-nesting birds. Foraging efficiency is maximised in open habitats where they can range widely and freely. They make use of roads, tracks and other cleared access ways through denser vegetation or complex topography to hunt.

11.2.2 Feral cats

Adult feral cats weigh between 4-9 kgs. Some 10 square kilometres, or larger may be the home range for male feral cats, smaller for females. Populations are self-sustaining and are mobile, dispersing widely. As carnivores they can survive with limited access to drinking water because they consume adequate moisture from their prey: Predate on small mammals, birds, reptiles, amphibians, fish and insects. Native rodents weighing less than 35 g. Feral cats spend most of the day in burrows, logs or rock piles. They are solitary and tend to move directly across roads or travel only short distances along them.

Native species may also be deleteriously affected through parasites and diseases transmitted from cats. *Toxoplasmosis gondii* is able to infect a range of marsupial and other mammalian hosts, including humans.

11.2.3 Rabbits

Rabbits are most abundant on deep, sandy soils that are ideal for digging warrens but they can also readily live above ground in areas that provide protection. Their warrens protect them from predators and climatic extremes. They are extremely fecund and can colonise a wide range of habitats. Their small body size allows them to select high-quality feed under favourable conditions. They have well-defined home ranges, but will forage outside these when food is scarce.

As a significant herbivore they overgraze and inhibit the regeneration of native vegetation thus modifying natural plant communities and the fauna they support. They compete with native fauna for food and can cause soil erosion. Decline of terrestrial mammals that weigh between 35 and 5500grams is associated with the appearance of the rabbit.

11.2.4 Feral pigs

Pigs impact directly on native plants and animals through their destruction of habitat (rooting, wallowing, trampling), their consumption of water, animals, plants and soil organisms. They destroy plants, reduce regeneration, alter soil structure and cause erosion. Feral pigs eat bird eggs and chicks, reptiles and their eggs, frogs, earthworms and other invertebrates (amphipods, centipedes, beetles, crustaceans, snails), soil organisms, carrion, underground fungi and roots, tubers and bulbs of plants as well as plant seeds, fruits,

stems and leaves. Their impacts can also be less direct; they increase the potential for invasion and spread of weeds; increase access for other predators; can be vectors for the spread of diseases including the root-rot fungus *Phytophthora cinnamomi*.

11.3 Interactions between predators

Feral cats and foxes overlap in distribution and diet. There is evidence of interspecific competition, with foxes competitively excluding feral cats from food resources, and of direct predation of foxes upon feral cats. Several studies describe increases in cat abundance following reductions in fox numbers resulting from control operations.

Rabbits and foxes also have similar distributions and rabbits are one of the preferred foods for foxes. Where rabbit numbers are high, fox populations generally thrive, and when rabbit numbers drop, fox populations often decline. Rabbit control is of critical importance to achieve long-term suppression of fox numbers. However, if rabbit numbers are reduced foxes may switch to preying more regularly on native species.

Where they occur rabbits tend to be the main prey item of feral cats and native animals are then taken opportunistically. Where rabbits are absent, native species form the staple diet of feral cats. Rabbit burrows also provide shelter for feral cats. Feral cat numbers rise and fall with fluctuations in rabbit numbers and control of rabbits is important in lowering feral cat numbers.

11.4 Habitat management to reduce predation

11.4.1 Foxes

Given the characteristics of foxes it is possible to manage habitats to some extent to reduce their impacts. Suggestions that are applicable to Castlereagh include:

- Provision of dense vegetation and extensive wetlands
- Minimise open access points and maintain bait stations along any required access paths
- Provide a continuous canopy and a thick understorey of shrubs so that arboreal marsupials can move without risk from predation
- Minimise habitat fragmentation and investigate options for management practices that do not destroy ground habitat.

11.4.2 Feral cats

Important habitat considerations to minimise the impacts of feral cats include:

- Provision of open water as a barrier
- Provision of structurally complex habitats
- Increase density of vegetation
- Reduce habitat fragmentation by rehabilitation of fire trails, roads and clearings.

11.4.3 Rabbits

The destruction of warrens by ripping can be a cost-effective and efficient method for suppressing rabbit numbers and inhibiting reinvasion of the treated area, as it deprives rabbits of a safe place for breeding. Where surface refugia are used by rabbits, however, the destruction of these is more complex. This might require the removal of the shrub layer, logs and exotic weeds. The removal of native vegetation may be undesirable because such refugia also provide important habitat for species of amphibians, reptiles, small mammals and ground-dwelling or ground-feeding birds. Thus, the relative benefits of this action for enhancing the recovery of affected species must be carefully assessed against potential risks.

11.5 Trapping, use of poison baits and fencing

11.5.1 Trapping of feral cats, rabbits and pigs

Trapping of feral cats is expensive, labour intensive and time consuming, and is only recommended on a small scale or where eradication is the objective. Similarly trapping of rabbits is labour intensive and inefficient; it does not reduce rabbit populations significantly or maintain them at low levels. Trapping of feral pigs is effective in some situations.

If feral cats are to be trapped then soft-catch traps can be set to prevent lighter non-target species from being caught, or non-target species can be released with minimal harm. Traps must be sheltered from extreme weather and checked at least daily. The lure or attractant used is most important.

11.5.2 Poison Baits

The main toxin used for a range of vertebrate pest species including foxes, feral cats, pigs and rabbits is sodium fluoroacetate (1080). Benefits of this toxin are that it is effective (with mortality rates of up to 90 per cent) and relatively inexpensive. It degrades rapidly under field conditions and does not accumulate in animals that ingest a sublethal dose, and it is tolerated by some native species.

Poison baiting is considered the most effective method of reducing the numbers and impact of foxes.

For feral cats baiting is difficult because they are often found in low densities, can have large home ranges, may only feed on carrion when live food is scarce and are naturally wary. For a bait to be successful, feral cats must be able to detect it; also, it must be attractive to them, particularly where they occur at low densities. The timing of a baiting program is a critical element in the successful baiting of feral cats.

Effective rabbit control requires integration of different methods; any single technique used in isolation is less effective than two or more techniques carefully combined. The value of following up an effective myxomatosis epidemic with warren destruction has been known for many years and baiting is also important to keep rabbit numbers at a manageable level.

A drawback of baiting is that it may affect native carnivores and scavengers such as dingoes, quolls, goannas and some scavenging birds, and also domestic dogs. However, many native birds, reptiles and marsupials are more tolerant of 1080 than foxes. Among the native animals known to be most at risk from baiting are species of quoll (*Dasyurus*). Establishing area-specific baiting protocols can minimise the risk to non-target species, e.g. making the bait too big for smaller animals to swallow and too tough for them to tear apart; burying baits to make them less accessible; minimising the dose of 1080 in each bait; and conducting surveys to detect animals that may be at high risk and avoiding baiting near them.

The benefits of baiting are confined to the baited area and, unless some barrier prevents re-invasion, last only for as long as baiting is regularly applied.

11.5.3 Fencing

An integrated approach to fencing is usually used with fences designed to exclude foxes, cats and rabbits. More than 90 per cent of fences now incorporate electrification, as this is cheaper than traditional fencing. The types of fences used for fox, feral cat and rabbit exclusion are given in Appendix 2, Table 5.

For foxes the most effective fence is a 180 cm-high wire netting fence with a foot apron and a 60-centimetre-wide external netting overhang, curved in an arc and supported by lengths of heavy gauge wire. Steel posts are more effective than timber. Electric wires are effective only if supplemented with a physical barrier to ensure that animals receive a sufficiently severe shock to be repelled.

For feral cats it is important to have small mesh sizes at the base to exclude kittens. Cats can jump higher than 1.8 metres, and can land and jump again on vertical netting. Some cats can withstand many electric shocks in order to cross a fence. However, they do not like unstable surfaces.

For rabbit-proofing mesh aprons secured to the ground or buried are needed, but there has been little research into optimal sizes and configurations for such aprons. Long-term exclusion requires the use of wire-netting fences, and electrified wire-netting fences can be very effective if properly maintained as rabbits are unlikely to burrow under an electrified fence.

A drawback of fences is that they may pose a hazard to non-target wildlife, especially if breached, and also they limit the ability of native animals to disperse. The high cost of establishment of effective fencing and ongoing maintenance costs mean they are likely to be useful only for small areas. The combination of fencing with a baiting or trapping program is also an expensive option but is likely to be useful for small areas or areas with specific characteristics, such as peninsulas.

12. Monitoring

An integrated monitoring program is being progressively developed and implemented at Castlereagh so that progress towards sustainability can be measured in the newly established aquatic and terrestrial ecosystems and across the various catchment landscapes (Castlereagh Integrated Monitoring Program (CIMP);TCM Services, 2009). The following discussion focuses on some practical aspects for the wildlife lake and its environs; the framework to be applied is documented in the CIMP.

Aquatic ecosystem development

While standard methods for monitoring both physico-chemical and biological aspects of water quality in streams are available (ANZECC Guidelines, Signal 2, AusRivAS) and can be adapted to use in lakes and other wetlands, methods for monitoring the development of a wildlife lake and marginal wetlands are largely lacking. The use of reference sites to provide comparative data and 'targets' for the rehabilitation process is important. Initially monitoring could consider:

- development of plant cover - by mapping distribution and extent of submerged and emergent macropytes;
- progressive development of detritus on the substrate surface and of benthos – by use of permanent markers at appropriate sites;
- colonization by macro-invertebrates – rapid assessment of order-class-phyllum grades (Signal2)
- measuring changes in water depth - by use of permanent markers at appropriate sites.

Once the ecosystems are established then standard methods could be used to monitor water quality and macro-invertebrate populations within the lake and marginal wetlands to provide assessments of 'health' over time. The Hawkesbury-Nepean Wetland Assessment (Sainty & Jacobs, 1997) is a relatively rapid and well-tried method that considers disturbance factors (water clarity, presence/absence iron bacteria, submerged algae, odours, dryness- and salt-indicator plants) and shallow and deeper water attributes (total vegetation cover, native compared with weed cover, cover of free-floating, floating/attached, emergent, submerged species; and number of different native and exotic plant species present in different growth forms) to provide an overall assessment of wetland condition. This information can be used as a basis for adaptive management decisions to be made.

Plant diversity and structure, colonisation and development of animal populations

Regular surveys of vegetation structure and floristic composition will be useful to document the development of habitat complexity within the wetlands that will provide suitable habitats for both invertebrate and vertebrate animals to colonise.

It is important to observe and monitor the colonization and development of both the invertebrate and vertebrate animal populations once the wetlands are well established. Surveys of macro-invertebrates and of fish, amphibians, reptiles, birds and mammals using lake waters, islands within the lake and marginal wetlands should be considered at key sites. Such sites should cover a diversity of habitats, for example, where water enters the lake, across vegetation zones and ecotones, across the islands and their immediate shallows, etc. The information gathered can be used to determine where habitats or habitat components need to be improved in order to attract specifically desired animals or an increased suite of animals.

Terrestrial ecosystems

Ecosystem functionality

Progress over time in the development of terrestrial ecosystems from the earliest stage of soil foundation through to sustainability and biological diversity can be measured using Landscape Function Analysis (LFA) and Extended Function Analysis (EPA). LFA assesses landscape function at two scales: local landscape and soil surface, while EFA assesses the contribution of vegetation to the functioning system.

The basic premises are that

a) heterogeneity in natural landscapes is functionally structured on a landscape or local catchment scale; and

b) surface and near surface processes have a primary role in the allocation and re-allocation of resources to biota in space and time.

LFA uses indicators to assess how well an ecosystem is working as a biogeochemical system. Repeated measures provide a time series so that progress over time can be established. The two spatial scales used are:

a) landscape organization – patches and interpatches at 0.5 to 100 m scale are measured to document landscape heterogeneity;

b) soil surface assessment at ca 1 metre scale – a series of visually assessed indicators document patch quality.

EFA uses density, cover and species composition of plants within structured layers together with some distance measures to calculate plant density and cover (square metres per hectare) resolved into 0.5m height classes. The resultant graphs indicate where vegetation holds its foliage in space and provide the functional role of vegetation.

Both LFA and EFA methods requires reference sites to be selected as these provide the basis for comparisons for the rehabilitation sites and the 'targets' for rehabilitation progress. The references sites should be mature and as near pristine as possible, but as such sites are difficult to locate a number of different sites with known history (disturbance, number of years of regrowth, fire history, etc.) can be used, with attributes measured in the same way and at the same time as the rehabilitation sites.

Plant diversity and structure, colonisation and development of animal populations

A recent review of the value of revegetation for biodiversity (Salt & Lindenmayer, 2008) emphasizes the value of structurally complex and floristically diverse vegetation. It has been shown that structurally complex vegetation supports more animal species and a different faunal composition than structurally simple vegetation. Some attributes are particularly important for some groups, for example, complexity in the ground layer for amphibians and reptiles, complexity in the mid- and understorey layers for small mammals. Vegetation that is floristically diverse can be expected to contain more animal species than monocultures even if the structure is similar.

Regular surveys of vegetation structure and floristic composition would therefore be useful to document the development of habitat complexity within the different terrestrial vegetation communities and to link these with surveys of animals.

As with the aquatic ecosystems it will be important to monitor animal colonization and the development and sustainability of populations. The Salt and Lindenmayer (2008) review recorded for mine rehabilitation sites, where the sites are surrounded by native vegetation, that

- recolonisation took about 6 years for birds and successional trends were shown, beginning with generalist taxa followed by more specialized; many birds were breeding in revegetation sites within 10 years;
- in 4-6 years reptile species richness could resemble that of low quality remnant vegetation;
- within 7 years many invertebrate orders have similar species richness to surrounding unmined forest;
- native small mammals recolonised sandmined forest within 8 years.

At other revegetation sites it was found that:

- remnant vegetation adjacent to the rehabilitation site can increase the use of the revegetated areas by birds and by other highly mobile animals rather than less mobile species; and
- birds, arboreal mammals and reptiles are more likely to inhabit revegetated areas when remnant cover is high.

There were few studies available to provide information for many of the animal groups: arboreal marsupials, small terrestrial mammals, bats, reptiles, amphibians, invertebrates, and the findings varied from one study to another and were inconclusive. It was noted, however, that the revegetation plantings examined in the review were mostly under 30 years age and hence a number of the key resources for some animal groups, such as large logs, dead trees, tree hollows or ground cover complexity were not present. Such attributes take longer than 30 years to develop.

For monitoring purposes the above findings suggest the need to allow sufficient time for the vegetation communities to develop before surveys of animal species would be worthwhile.

13 Recommendations

1. Meet all government requirements relating to all aspects of the wildlife lake development (section 1.1) and also more general legislative requirements where relevant.
2. Ensure the basic ecological principles relating to plants and animals are incorporated into the planning of the development of the wildlife lake (section 1.2).
3. Ensure the more detailed ecological and design principles for the wildlife lake are followed to maximise the wildlife values of the area.(section 2).
4. Employ a landscape approach and scale for planning the vegetation communities for the wildlife lake and its environs. Ensure there is a mosaic of vegetation communities available that link aquatic, semi-aquatic and dry land habitats together and ecotones and corridors between them are provided. Low level vegetation communities should be included where view lines are important.
5. Provide a range of wetland and dryland vegetation communities with different structure and floristic composition to provide habitat and other resources for animals (sections 3, 4).
6. Assist development of the aquatic ecosystems of the wildlife lake and associated wetlands through provision of a variety of substrates (silt, mud, sand, gravel, rocks) and of leaf litter and other organic detritus on the substrate surface and in the shallows; these habitat components should encourage colonisation by a wide variety of microorganisms and other invertebrates (section 5.1). Transplanting from established natural wetlands will increase the rate of colonisation.
7. Assist development of the terrestrial ecosystems through provision of habitat components essential to invertebrates: adequate depths of soil and leaf litter, woody detritus and decaying plant matter, rocky sites and a variety of plants with different growth forms and foliage densities (section 5.2).
8. Consider development of specific and protected habitat for Cumberland Land Snail in riverbank areas (section 5.3).
9. Plan fish habitats for both the lake waters and re-established creeklines, incorporating varied substrates and water depths and a variety of other habitat components (rocky areas, woody debris, etc.). Include submerged benches in lake waters to allow different macrophytes, other aquatic plants and emergent wetland plants to establish and flourish. (sections 3, 6)
10. Re-established creeklines should include pools and riffles, varied substrates (rocky, sandy, silty) and a variety of different bank slopes for burrowing species; dense groundcover and shrub areas, open grasslands and tree canopy to provide a range of habitat features for different animal groups. (sections 3, 8-10)
11. Consider development of specific habitats for platypus and water rats and ensure their needs are met (section 10)
12. Islands should be at least 30 metres distant from the shorelines, placed to provide protected waters from prevailing winds, and shallows on one side and deep water on the other. A variety of aquatic, emergent and marginal wetland habitats should be provided, backed by dryland grasslands and fully-structured woodlands to provide adequate refuge areas for water birds and other species. (sections 7-10)
13. Consider development of specific habitats for international and native migratory birds and rare species such as Latham's Snipe. (section 7)
14. Consider development of specific habitats for Green and Golden Bell Frog and other frog species ensuring habitat components and components for breeding are available. (section 8)
15. Whilst home ranges and other spatial data are lacking for particular animal groups use a precautionary approach – provide as large an area as possible for each main vegetation community to meet the needs of different animal groups.
16. Keep fragmentation of habitats to a minimum, plant densities high and community structure complex to reduce incursion by pest animals and weeds.
17. Incorporate rare and threatened plants and those considered significant in Western Sydney into relevant vegetation communities.

18. Set aside an area as habitat for Koalas ensuring adequate food species are available and other habitat components to meet their needs. (section 10)
19. Address management issues particularly relating to pest animals by considering and implementing the most appropriate control methods. Work in concert with neighbours. (section 11)
20. Document the progressive development of aquatic ecosystems (including wildlife lake waters, islands within the lake and marginal wetlands) through standardised monitoring procedures (section 12).
21. Document the progressive development of terrestrial ecosystems (including wetland-dryland ecotones, dryland forest and woodland vegetation communities, grasslands, etc.) using LFA and EFA procedures (section 12).
22. Undertake regular surveys of vegetation structure and floristics of both wetland and dryland communities to determine the level of complexity and 'health' status as a basis for adaptive management decisions.
23. Document progressive development over time of invertebrate and vertebrate animal populations in both wetland and dryland areas as a basis for reviewing, and where necessary enhancing, faunal habitats and resources.

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Appendix 1

Table 1. Aquatic and other wetland plants for the Wildlife Lake

Plant species	Plant type & Status	Family	Ephemeral Wetlands	Permanent Wetlands	Deep Water/ Lakes	Water Table #	Wildlife Value:
Azolla filiculoides var rubra	Fern SWS	Azollaceae			X	Aquatic – free floating – deep water	Food plant of Australian Wood Duck, Australasian Shoveller Black Swan, Blue-billed Duck, Freckled Duck, Hardhead, Musk Duck, Pacific Black Duck and Pink-eared Duck (1)
Lemna disperma Duck Weed	Herb	Lemnaceae			X	Aquatic – free floating – stationary or slow moving water	Food plant of Australiasian Shoveller, Black Swan, Grey Teal, Hardhead, Pacific Black Duck, Pink-eared Duck (1)
Vallisneria americana Ribbonweed	Herb	Hydrocharitaceae			X	Aquatic submerged – water to 4m deep, stationary to fast flowing	Stolons form a favourite food of Black Swan (Sainty & Jacobs, 1981)
Potamogeton tricarinatus Floating Pondweed	Herb	Potamogetonaceae			X	Aquatic – floating attached; water to 3m deep; stationary or slow moving	Food plant (leaves) of Australasian Shoveller, Black Swan, Blue-billed Duck, Grey Teal, Hardhead, Musk Duck, Pacific Black Duck, Pink-eared Duck (1)
Phragmites australis Common Reed	Grass	Poaceae	X	X	X	Aquatic emergent – water depth to 3m; also seasonally inundated areas	Important wetland component; cover for waterfowl; prevents wave damage and stream erosion (2)
Eleocharis sphacelata Tall Spikerush	Sedge	Cyperaceae		X	X	Emergent aquatic – shallow water to 2m	Food plant of Grey Teal, Hardhead, Latham's Snipe, Pacific Black Duck, Purple Swamphen, (1) Seed and rhizomes used Excellent cover for waterfowl (2)
Typha orientalis Cumbungi	Grass	Poaceae		X	X	Aquatic emergent – water to 2m deep	Source of food and shelter for wildlife (2); stabilise banks, reduce erosion; reduce evaporation
Myriophyllum variifolium	Herb SWS	Haloragaceae	X	X	X	Aquatic – shallow water to 2m deep but also 30-50 cm ; and drying mud	Various *Myriophyllum* species are food plants for Australian Wood Duck, Australiasian Shoveller, Black Swan, Blue-billed Duck, Freckled Duck, Grey Teal, Hardhead, Musk Duck , Pacific Black Duck , Pink-eared Duck (1, 2)
Myriophyllum simulans	Herb	Haloragaceae	X	X		Aquatic – water 30-50 cm deep; also damp mud	
Nymphoides geminata	Herb SWS	Menyanthaceae	X	X		Aquatic – floating attached; water to 1.5m deep; also margins and ephemeral wet areas	Food plant (seed) of Grey Teal, Hardhead, Pacific Black Duck, Latham's Snipe, Pink-eared Duck (1)
Ludwigia peploides subsp. montevidensis Water Primrose	Herb	Onagraceae	X	X		Aquatic – floating attached or creeping in shallow water; stems to 4m (water depth to 2m?)	Seeds provide food for waterbirds (2)
Paspalum distichum Water Couch	Grass	Poaceae	X	X		Aquatic emergent - water to 50 cm deep; also wetland margins, damp grasslands and drying flats	Various *Paspalum* species are food for Pacific Black Duck, Black Swan, Pink-eared Duck, Freckled Duck, Short-tailed Sandpiper, Grey

Plant species	Plant type & Status	Family	Ephemeral Wetlands	Permanent Wetlands	Deep Water/ Lakes	Water Table #	Wildlife Value:
							Teal, Australian Wood Duck, Masked Lapwing (1)
Cyperus exaltatus Tall Flat-sedge	Sedge	Cyperaceae	X	X		Aquatic emergent – water to 40 cm deep; colonising species swamps , wetland margins; not long-lived	Good food source and nesting sites for waterbirds (2)
Marsilea hirsuta	Fern SWS	Marsileaceae	X	X		Aquatic- floating attached – shallow water; also adjacent drying flats	Various *Marsilea* species are food plants (seed) for Australian Wood Duck, Hardhead, Australiasian Shoveller, Musk Duck, Blue-billed Duck, Pacific Black Duck, Pink-eared Duck, Freckled Duck, Red-kneed Dotterel, Grey Teal (1)
Elatine gratioloides Water Wort	Herb – annual SWS	Elatinaceae		X		Aquatic – submerged; shallow water; drying flats	Food plant for Latham's Snipe – seed (1)
Damasonium minus Star Fruit	Herb SWS	Alismataceae	X	X		Aquatic emergent – water depth to 30cm; also in ephemeral wet areas	Food for waterbirds (2)
Maundia triglochinoides	Herb Vuln Sched 2 TSC Act	Juncaginaceae		X		Aquatic – emergent – water depth 30-60 cm	
Philydrum lanuginosum Frogsmouth	Herb	Philydraceae	X	X	X	Aquatic – emergent – 2 m tall – (water depth to 1.5m?); also periodically shallow inundated areas	Food and cover for birds and animals (2)
Schoenoplectus validus	Sedge SWS	Cyperaceae	X	X		Aquatic – emergent; shallow water swamps, creekline, lake margins, with *Phragmites*, *Casuarina glauca* woodland	Food plant of Black Swan, Pacific Black Duck, Grey Teal, Freckled Duck (1)
Triglochin microtuberosum	Herb	Juncaginaceae		X		Aquatic – emergent – water depth to 50 (-120) cm	Tubers are edible (3)
Triglochin procerum Water Ribbons	Herb	Juncaginaceae		X		Aquatic –emergent; shallow water to 1m deep	Food plant of Australian Wood Duck (1); valuable habitat component of waterfowl and fish (2)
Triglochin striatum	Herb	Juncaginaceae	X	X		Aquatic –emergent; shallow water to 15 cm deep; also in drying mud	Food plant of Australian Wood Duck (1)
Carex appressa	Sedge	Cyperaceae		X		Water table H – floodplain swamps	Various species of *Carex* provide seed for Australian Wood Duck, Hardhead, Blue-billed Duck, Latham's Snipe, Pacific Black Duck, Freckled Duck, Pink-eared Duck, Grey Teal
Cyperus flaccidus	Sedge SWS	Cyperaceae	X	X		Water table H-M – sedgelands; margins of ephemeral pools	Various species of *Cyperus* provide seed for Australian Wood Duck, Latham's Snipe, Blue-billed Duck, Pacific Black Duck, Pink-eared Duck, Freckled Duck
Cyperus gunnii	Sedge SWS	Cyperaceae	X			Water table H-M – swamp margins, periodically wet; woodlands	

Plant species	Plant type & Status	Family	Ephemeral Wetlands	Permanent Wetlands	Deep Water/ Lakes	Water Table #	Wildlife Value:
Cyperus sanguinolentus	Sedge SWS	Cyperaceae		X		Water table H – sedgelands; riverflat forest	
Eleocharis cylindrostachys s	Sedge SWS	Cyperaceae	X	X		Water table H – sedgeland; *Melaleuca, Casuarina* woodlands; periodically inundated	Various species provide food for waterfowl – see *Eleocharis sphacelata* above
Eleocharis dietrichiana	Sedge SWS	Cyperaceae	X	X		Water table H – sedgeland, wetland margins, ephemeral creeks	
Fimbristylis dichotoma	Sedge	Cyperaceae	X	X		Water table H – wetlands, woodlands	Various species of Fimbristylis provide seed for Masked Lapwing, Grey Teal, Pink-eared Duck, Hardhead, Latham's Snipe
Fimbristylis velata	Sedge SWS	Cyperaceae	X			Water table H-M – ephemeral watercourses	
Juncus usitatus	Rush	Juncaceae	X	X		Water table H – floodplain sedgelands, rushlands, periodically wet areas; damp places in woodlands	Provides cover and food for animals (2)
Eragrostis elongata Clustered Love Grass	Grass SWS	Poaceae	X			Water table H – riverbanks, woodland	Various species of Eragrostis provide food (seed) for Grey Teal (1)
Glyceria australis Australian Sweet Grass	Grass SWS	Poaceae	X	X		Water table H- swamps; sometimes in standing water	
Hemarthria uncinata Matt Grass	Grass SWS	Poaceae	X			Water table H – swamp margins, damp places	Rhizomes eaten by Purple swamphen (Lepschi 1993, quoted in 3)
Brachycome graminea	Herb	Asteraceae	X	X		Water table H – swamps, wetland margins, damp grass	Seed eaten by Latham's Snipe (1)
Cardamine paucijuga	Herb	Brassicaceae	X			Water table H – moist riverflat alluvial areas, forest	
Centella asiatica Pennywort	Herb	Apiaceae	X			Water table H – swamp margins, ephemeral wetlands, damp places in woodland	
Centipeda minima Spreading Sneeze Weed	Herb SWS	Asteraceae	X			Water table H – floodplain wetlands, lagoon edges herbland	
Dichondra repens Kidney Weed	Herb	Convoluvlaceae	X			Water table M-H – creekflats, woodland	Seed eaten by Pacific Black Duck (1)
Eclipta platyglossa Twinheads	Herb SWS	Asteraceae	X	X		Water table H – swamps, creeklines, swamp woodland	
Epaltes australis Spreading Nutheads	Herb	Asteraceae	X			Water table H – swamp margins, periodically wet	
Goodenia paniculata Branched Goodenia	Herb	Goodeniaceae	X			Water table M-L – swampland margins, open forest, woodland, grassland	
Gratiola pedunculata	Herb SWS	Scrophulariaceae	X			Water table H – lagoon banks, swamps, poorly drained sites	
Haloragis heterophylla	Herb SWS	Haloragaceae	X	X		Water table H – *Melaleuca* swamps, swamp margins, drainage channels, wet areas	

Plant species	Plant type & Status	Family	Ephemeral Wetlands	Permanent Wetlands	Deep Water/ Lakes	Water Table #	Wildlife Value:
Hydrocotyle peduncularis	Herb	Apiaceae	X	X		Water table H – swamps, moist sitesd	
Hypoxis hygrometrica Golden Weather grass	Herb	Hypoxidaceae	X	X		Water table H- moist sedgeland, open woodland	
Hypoxis pratensis var prat.	Herb	Hypoxidaceae	X			Water table M-H – moist sites, grassy hillsides	
Lagenifera gracilis	Herb	Asteraceae	X			Water table H-M- moist gullies, open forest seepage areas	
Lythrum hyssopifolia	Herb SWS	Lythraceae	X	X		Water table H – tolerant of water to a few cm deep; sedgeland; swamp margins; damp places	
Persicaria decipiens Slender Knotweed	Herb	Polygonaceae	X			Water table H –creeklines, wet herblands	
Persicaria hydropiper Water Pepper	Herb	Polygonaceae	X			Water table H –alluvial flats; ephemeral wetlands as tolerates flooding	Food plant of Black Swan, Pacific Black Duck, Grey Teal (1)
Pratia purpurascens Whiteroot	Herb	Lobeliaceae	X			Water table H – shaded wet areas in open forest, woodland, on levee banks	X
Pratia surrepens Mud Pratia	Herb	Lobeliaceae	X			Water table H –swamp margins, impeded drainage, depressions	
Ranunculus inundatus	Herb	Ranunculaceae	X	X		Water table H – sedgeland, swamp margins, wet mud, alluvium	
Ranunculus plebius	Herb SWS	Ranunculaceae	X	X		Water table H-M; swamp margins, swamp forests; woodland; moist places	Various species of *Ranunculus* are food plants (seed) of Latham's Snipe, Australian Wood Duck, Black Swan, Pink-eared Duck, Grey Teal (1)
Juncus australis Austral Rush	Rush	Juncaceae	X	X		Water table H-M- wet or seasonally wet places; grassland, woodland	
Juncus fockei	Rush SWS	Juncaceae	X	X		Water table H – sedgelands, swamps, damp places	
Juncus planifolius	Rush	Juncaceae	X			Water table H-M – crreklines, gullies, moist sites in woodland, open forest	
Juncus prismatocarpus Branching Rush	Rush	Juncaceae	X	X		Water table H – sedgelands, swamp margins, drainage channels	
Juncus remotiflorus	Rush SWS	Juncaceae	X			H-M – ephemeral wetlands, woodlands	
Juncus subsecundus Finger Rush	Rush	Juncaceae	X			Water table H – swamp margins, open forest, periodically moist	
Eleocharis acuta	Sedge	Cyperaceae	X			Water table H – swamp margins	X
Isolepis inundata	Sedge	Cyperaceae	X	X		Water table H – sedgeland margins; Melaleuca swamp forest; wet places in open forest	

Plant species	Plant type & Status	Family	Ephemeral Wetlands	Permanent Wetlands	Deep Water/ Lakes	Water Table #	Wildlife Value:
Lipocarpha microcephala	Sedge	Cyperaceae	X			Water table H – damp places, seepage areas, moist grassland	
Ptilothrix deusta	Sedge	Cyperaceae	X			Water table H-M – swamp margins periodically moist; woodland;, pen woodland	

Table 2. Woody species (trees and shrubs) tolerant of high and fluctuating watertables

Species	Plant type & status	Family	Water Table#	Wildlife Value:
Acacia elongata Swamp Wattle	Shrub	Fabaceae – Mimosoid	H	Host to seed predator beetles
Acacia floribunda White Sallow Wattle	Tree	Fabaceae - Mimosoid	H-M	Mainly seed as food for Australian King Parrot, Bar-shouldered Dove, Black-faced Cuckoo-shrike, Common Bronzewing, Crested Pigeon, Crimson Rosella, Galah, Glossy Black-Cockatoo, Little Corella, Masked Lapwing, Painted Button-quail, Silvereye, Spotted Turtle-Dove, Sulphur-crested Cockatoo, Swamp Quail and Brown Quail, White-bellied Cuckoo-shrike, White-winged Chough, Yellow-tailed Black-Cockatoo. Also gum exudate used by Yellow-tailed Black-Cockatoo
Acacia irrorata subsp irrorata Green Wattle	Tree	Fabaceae - Mimosoid	H-M	
Acmena smithii Lilly Pily	Tree	Myrtaceae	H	Fruit eaten by Pied Currawong and Satin Bowerbird
Bossiaea lenticularis	Shrub	Fabaceae	H	
Bossiaea prostrata	Shrub	Fabaceae	H-M	
Brachychiton populneus Kurrajong	Tree SWS	Sterculiaceae	H-M	Seed eaten by Common Bronzewing and Crested Pigeon
Callistemon linearis Narrow-leaved Bottlebrush	Shrub	Myrtaceae	H	Pollen and nectar of various species used by Scarlet Honeyeater, Red Wattlebird, White-plumed Honeyeater, Yellow-faced Honeyeater, Brown-headed Honeyeater, White-naped Honeyeater, Eastern Spinebill, Yellow-faced Honeyeater
Callistemon pinifolius Pine-leaved Bottlebrush	Shrub	Myrtaceae	H-M	
Callistemon salignus Willow bottlebrush	Tree	Myrtaceae	All	
Casuarina cunninghamiana River She-Oak	Tree	Casuarinaceae	All	Seed of various species used by Peaceful Dove, Glossy Black-Cockatoo, Red-browed Finch / Firetail, Sulphur-crested Cockatoo, Australian King Parrot
Casuarina glauca Swamp Oak	Tree	Casuarinaceae	H	
Einadia nutans Climbing Saltbush	Shrub	Chenopodiaceae	H	Seeds eaten by Variegated Fairy Wren
Eucalyptus amplifolia Cabbage Gum	Tree	Myrtaceae	H	Flower buds, flowers, pollen, nectar, seeds and gum exudate from stems have been recorded as used by Australian King Parrot, Bell Miner, Brown Honeyeater, Brown-headed Honeyeater, Channel-billed Cuckoo, Common Bronzewing, Crested Pigeon, Crimson Rosella, Eastern Spinebill, Galah, Glossy Black-Cockatoo, Noisy Friarbird, Noisy Miner, Peaceful Dove, Red Wattlebird, Regent Honeyeater, Silvereye, Sulphur-crested Cockatoo, Swift Parrott, White-naped Honeyeater, White-plumed Honeyeater, White-winged Chough, Yellow-faced Honeyeater, Yellow-tinted Honeyeater.
Eucalyptus baueriana Blue Box	Tree SWS	Myrtaceae	H-M	
Eucalyptus benthamii Camden White Gum	Tree Vul TSC Act	Myrtaceae	All	
Eucalyptus parramattensis Parramatta Red Gum	Tree	Myrtaceae	H	
Eucalyptus tereticornis Forest Red Gum	Tree	Myrtaceae	H-M	
Gonocarpus teucroides	Shrub	Haloragaceae	All	Food plant of moth larvae
Goodenia ovata Hop Goodenia	Shrub	Goodeniaceae	H-M	Used by Stubble Quail. Foodplant of tige rmoth caterpillar
Hakea sericea Silky Hakea	Shrub	Proteaceae	H-M	Recorded as used by Common Bronzewing. Host plant for Cerambycid beetles
Kunzea ambigua Tick bush	Shrub	Myrtaceae	H	Source of pollen for native bees; important for support of nectar-dependent insects. Flowers visited by beetles (Buprestidae, Scarabaeidae, Mordellidae, Cleridae)
Leptospermum polygalifolium Lemon-scented Tea tree	Shrub	Myrtaceae	H	Green fruit and seed eaten by Crimson Rosella, European Goldfinch*, Silvereye. Important for support of nectar-dependent insects; foodplant of moth larvae, adult beetles feed on flowers.
Lissanthe strigosa	Shrub	Epacridaceae	H	
Lomatia myricoides River Lomatia	Shrub	Proteaceae	H	
Melaleuca decora White Feather Honeymyrtle	Tree	Myrtaceae	H-M	Flowers are used by Brown Honeyeater, Common

Species	Plant type & status	Family	Water Table#	Wildlife Value:
Melaleuca linariifolia Snow in Summer	Tree	Myrtaceae	H-M	Bronzewing, Little Corella. Seed eaten by Australian King Parrot
Melaleuca nodosa Prickly-leaved Paper bark	Shrub	Myrtaceae	H-M	
Melaleuca styphelioides Prickly Paperbark	Tree	Myrtaceae	H	
Melaleuca thymifolia	Shrub	Myrtaceae	H	
Phyllanthus gunnii	Shrub SWS	Euphorbiaceae	All	Used by Bar-shouldered Dove, Common Bronzewing, Crested Pigeon, Peaceful Dove
Plectranthus parviflorus Cockspur Flower	Shrub	Lamiaceae	H-M	
Rubus parvifolius Native Raspberry	Shrub	Rosaceae	All	Lewin's Honeyeater; laevae and adult Jewel Beetles feed on plant
Tristaniopsis laurina Water Gum	Tree SWS	Myrtaceae	H	

*SWS = Significant Western Sydney; # H = High; M = Medium; L = Low.

Table 3. Tree and shrub species tolerant of fluctuating medium to low watertables

Species	Plant type & Status	Family	Water Table	Wildlife Value:
Acacia falciformis Broad-leaved Hickory	Tree	Fabaceae - Mimosoid	M-L	See Table 2
Acacia linifolia Flax-leaved Wattle	Shrub	Fabaceae - Mimosoid	M-L	
Acacia mearnsii Black Wattle	Tree	Fabaceae - Mimosoid	M-L	
Acacia parramattensis Sydney Green wattle	Tree	Fabaceae - Mimosoid	M-L	
Acacia ulicifolia Prickly Moses	Shrub	Fabaceae - Mimosoid	M-L	
Angophora subvelutina Broad-leaved Apple	Tree	Myrtaceae	M-L	Blossoms eaten by Grey-headed Flying Fox and Little Red Flying Fox
Astrotricha latifolia	Shrub	Araliaceae	M-L	-
Backhousia myrtifolia Grey Myrtle	Tree	Myrtaceae	M-L	-
Boronia polygalifolia	Shrub SWS	Rutaceae	M-L	-
Cassinia trinerva	Shrub	Asteraceae	M	-
Clerodendrum tomentosum Hairy Clerodendrum	Shrub	Verbenaceae	M-L	Fruit eaten by Satin Bowerbird
Correa reflexa Native Fuchsia	Shrub	Rutaceae	M-L	Leaves and roots eaten by Wombat
Corymbia gummifera Red Bloodwood	Tree	Myrtaceae	M	Blossoms eaten by Grey-headed Flying Fox & Little Red Flying Fox; Nectar taken by New Holland & White-cheeked Honeyeaters; sap taken by Yellow-bellied Glider. Important source of nectar for insects. Foodplant of miner fly, larvae of moths and of longicorn beetles.
Croton verreauxii	Shrub	Euphorbiaceae	M-L	Fruit probably eaten by parrots
Cryptandra amara	Shrub	Rhamnaceae	M-L	-
Dodonaea viscosa ssp *cuneata* Hop bush	Shrub SWS	Sapindaceae	M-L	-
Eucalyptus botryoides Bangalay	Tree	Myrtaceae	M-L	See Table 2
Eucalyptus botryoides x *saligna*	Tree	Myrtaceae	M	
Eucalyptus crebra Narrow leaved Ironbark	Tree	Myrtaceae	M-L	
Eucalyptus deanei Mountain Bluegum	Tree	Myrtaceae	M-L	
Eucalyptus elata River White Gum	Tree	Myrtaceae	M-L	

Eucalyptus resinifera Red Mahogany	Tree	Myrtaceae	M-L	
Eucalyptus sclerophylla Scribbly Gum hard leaved	Tree	Myrtaceae		
Eucalyptus sideroxylon Mugga Red Ironbark	Tree	Myrtaceae	M-L	
Gompholobium inconspicuum	Shrub	Fabaceae	M-L	-
Gonocarpus longifolius	Shrub SWS	Haloragaceae	M	-
Hibbertia aspera	Shrub	Dilleniaceae	M-	-
Hibbertia diffusa Wedge Guinea Flower	Shrub	Dilleniaceae	M-L	Pollen taken by short-tongued bees
Hibbertia pedunculata	Shrub SWS	Dilleniaceae	M	-
Leptospermum trinervium	Shrub	Myrtaceae	M-L	Source of nectar for insects; scarab beetles feed on flowers
Olearia viscidula Wallaby weed	Shrub SWS	Asteraceae	M-L	-
Opercularia aspera Coarse Stinkweed	Shrub	Rubiaceae	M	Eaten by rabbits
Pittosporum revolutum	Shrub	Pittosporaceae	M	Birds eat green fruit; host plant of Cerambycid beetles
Podolobium scandens Climbing Shaggy Pea	Shrub	Fabaceae	M-L	-
Polyscias sambucifolia subsp. A Ornamental Ash	Tree SWS	Araliaceae	M-L	Fruit eaten by Currawongs; foodplant of moth caterpillars
Pomaderris elliptica	Shrub	Rhamnaceae	M-L	Foodplant of butterfly larvae
Pultenaea villosa Hairy Bush-pea	Shrub	Fabaceae	M-L	Pollen and nectar used by bees; host to seed predator beetles
Rapania variabilis Muttonwood	Tree	Myrsinaceae	M-L	Fruit eaten by Lewin's honeyeater, Rose-crowned Fruit Dove; host plant of Cerambycid beetles.
Stenocarpus salignus Scrub Beefwood	Tree	Proteaceae	M	-
Syncarpia glomulifera Turpentine	Tree	Myrtaceae	M	Fruit, pollen and nectar used; Flying Foxes and insects
Trema aspera Native Peach	Shrub	Ulmaceae	M	Fruit eaten by Brown Cuckoo-dove, Figbird, Lewin's Honeyeater, Olive-backed Oriole, Brown Pigeon, King Parrot; foodplant of moth larvae

Table 4. Plant species found along gullies and creeklines

Species	Plant type & Status	Family	Wildlife Value:
Acacia floribunda *White Sallow Wattle*	Tree	Fabaceae - Mimosoid	See Table 2
Acacia paramattensis	Tree	Fabaceae - Mimosoid	
Acmena smithii	Tree	Myrtaceae	See Table 2
Alphitonia excelsa	Tree	Rhamnaceae	Fruit eaten by Grey-headed Flying Fox , Brown Cuckoo-dove, Green Catbird, Lewin's Honeyeater, Olive-backed Oriole, Pied Currawong, Silvereye, Brown Pigeons, Regent Bowerbird; foodplant of butterfly larvae
Angophora floribunda	Tree	Myrtaceae	Blossoms eaten by Grey-headed Flying Fox & Little Red Flying Fox; foliage foraged by White-plumed Honeyeater; nesting site for Regent Honeyeater. Foodplant of moth larvae; host plant of Cerambycid longicorn beetles
Aristida ramosa	Grass	Poaceae	Host plant for common army worm
Arthropodium milleflorum	Herbs	Anthericaceae	Palatable to rabbits
Backhousia myrtifolia	Tree	Myrtaceae	See Table 3
Billardiera scandens	Climbers	Pittosporaceae	Palatable to rabbits
Breynia oblongifolia	Shrub	Euphorbiaceae	-
Calotis dentex	Herbs	Asteraceae	-
Clematis glycinoides	Climbers	Ranunculaceae	Pollen taken by honeybees
Commelina cyanea	Herbs	Commelinaceae	Palatable to rabbits
Desmodium varians	Climbers	Fabaceae	Eaten by cattle

Dianella longifolia	Herbs	Phormiaceae	-
Echinopogon caespitosa	Grass	Poaceae	Foodplant of butterfly larvae; grazed by stock
Einadia nutans	Shrub	Chenopodiaceae	Seeds eaten by Variegated Fairy-wren
Elaeocarpus reticulatus	Tree	Elaeocarpaceae	Fruit eaten by Crimson Rosella, Figbird, Olive-backed Oriole, Regent Bowerbird, Wonga Pigeon, White-headed Pigeon
Entolasia marginata	Grass	Poaceae	Seed eaten by finches; eaten by rabbits
Eucalyptus elata	Tree	Myrtaceae	See Table 2
Eucalyptus piperita	Tree	Myrtaceae	
Gahnia aspera	Sedge	Cyperaceae	Foodplant of butterfly larvae
Galium propinquum	Herbs	Rubiaceae	-
Glycine microphylla	Climbers	Fabaceae	-
Hibbertia aspera	Shrub	Dilleniaceae	see Table 3
Lachnagrostis filiformis	Grass	Poaceae	-
Lepidosperma laterale	Sedge	Cyperaceae	Seed eaten by Crimson Rosella; eaten by rabbits
Leptospermum polygalifolium	shrub	Myrtaceae	Seed eaten by Crimson Rosella; support for nectar-dependent insects; foodplant of moth larvae and adult beetles; flowers eaten by Soldier beetles and Jewel beetles
Lomandra longifolia	Herbs	Lomandraceae	Foodplant and shelter for moth larvae; foodplant for butterfly larvae; leaves eaten by rabbits
Olearia viscidula	Shrub	Asteraceae	-
Oplismenus aemulus	Grass	Poaceae	Eaten by rabbits
Phyllanthus gunnii	Shrub	Euphorbiaceae	-
Plantago debilis	Herbs	Plantaginaceae	-
Poa affinis	Grass	Poaceae	-
Rumex brownii	Herbs	Polygonaceae	-
Syncarpia glomulifera	Tree	Myrtaceae	See Table 3
Tristaniopsis laurina	Tree	Myrtaceae	-
Wahlenbergia gracilis	Herbs	Campanulaceae	-

Appendix 2

Table 1 Cumberland Plain Woodland – RBG listing of Invertebrates

Phylum/Class/Order	No. Families	No. Genera + (unnamed taxa)	Common Names
Phylum: Chelicerata			**Spiders and Scorpions**
Class: Arachnida Order: Araneae	**8** :Araneidae, Corinnidae, Lycosidae, Salticidae, Sparssidae, Tetragnathidae, Theridiidae, Thomisidae	**12**: Arachnura, Argiope, Austracantha, Eriophora, Supunna, Lycosa, Sandalodes, Delena, Leucauge, Nephila, Latrodectus, Diaea.	Spiders–Orb-weaving Spiders Scorpion-tailed Spider, St Andrew's Cross Spider, Spiny Spider, Spotted Ground Swift Spider, Wolf Spiders, Jumping Spider, Flat Huntsman Spider , Four-Jawed or Long-Jawed Spiders, Golden Orb Weaver, Cob-Web Spiders , Red-backed Spider
Order: Scorpiones	**1**: Buthidae	**1**: Lychas	Scorpions – Little Marbled Scorpion
Phylum: Mandibulata			**Insects and Centipedes**
Class: Insecta Order: Blattodea	**2**: Blaberidae, Blattellidae	**3**: Calolampra, Laxta, Ellipsidion	Cockroaches – Bark Cockroach, Bush Cockroach
Order: Coleoptera	**9**: Belidae, Cantharidae, Cerambycidae, Chrysomelidae, Curculionidae, Elateridae, Lycidae, Scarabaeidae, Tenebrionidae	**15 + 4**: Belus, Chauliognathus, Syllitus, Dicranosterna, Callidemum, Calomela, Lamprolina, Lema, Paropsis, Paropsisterna, Chrysolopus,Unnamed weevil, Unnamed Click Beetle, Metriorrhynchus, Porrostoma, Anoplognathus, Polystigma, Unnamed beetle larva, Unnamed Darkling Beetle	Beetles – Soldier Beetles, Leaf Beetles, Pittosporum Beetle, Eucalyptus Tortoise Beetle, Eucalypt Leaf Beetle, Weevils, Diamond Beetle/ Botany Bay Weevil, Spotted Flower Chafer, Dead Leaf Skeletonizer, Darkling Beetles, Click Beetles, Scarab Beetles
Order: Dermaptera	**1**: Anisolabidinae	**1**: Titanolabis	Giant Earwig
Order: Diptera	**6:** Apioceridae, Calliphoridae, Syrphidae, Tabanidae, Tachinidae, Tephritidae	**6**: Apiocera, Amenia, Melangyna, Scaptia, Microtropeza, Hendrella	Flies – Blow Flies
Order: Hemiptera	**12**: Aphididae, Cicadidae, Coreidae, Eriococcidae, Eurymelidae, Lygaeidae, Margarodidae, Pentatomidae, Pyrrhocoridae, Reduviidae, Scutelleridae, Tingidae	**12 + 1**: *Aphis, Psaltoda, Mictis, Apiomorpha, Eurymeloides, Lygaeus, Monophlebulus, Monteithiella, Poecilometis, Dysdercus, Unnamed Assassin Bug, Choercoris, Froggattia	Aphids , Oleander Aphid, Cicadas, Black Prince, Crusader Bug, Eucalyptus Galls, Small Milkweed Bug, Pale Cotton Stainer, Olive Lace Bug
Order: Isoptera	--	--	Termites
Order: Hymenoptera	5: Apidae, Formicidae, Ichneumonidae, Scoliidae, Typhildae	12 + 2: *Apis, Camponotus, Crematogaster, Heteroponera, Iridomyrmex, Linepithema, Melophorus, Meranoplus, Myrmecia, Ochetellus, Pheidole, Rhytidoponera, Unknown wasp, Discolia, Unnamed Flower Wasp	Ants, Bees and Wasps – Honey Bee, Golden Black Sugar Ant, Banded Sugar Ant, Black Sugar Ant, Inland Flumed Sugar Ant, Valentine Ant, False Pony Ant, Meat Ant, Tufted Meat Ant, Tyrant Ant, Argentine Ant, Furnace Ant, Shield Ant, Bull Ant, Bull Ant, Black House Ant, Big-headed Ant, Green-headed Ant, Black Flower Wasp

Phylum/Class/Order	No. Families	No. Genera + (unnamed taxa)	Common Names
Order: Lepidoptera Moths Butterflies	**10**: Arctiidae, Cossidae, Geometridae, Hepialidae, Lasiocampidae, Limacodidae, Noctuidae, Notodontidae, Psychidae, Pyralidae **4**:Hesperiidae, Lycaenidae, Papilionidae, Pieridae	17 + 3: Aloa, Amata, Anestia, Asura, Nyctemera, Scoliacma, Urethesia, Endoxyla, Phallaria, Pholodes, Abantiades, Entometa, Doratifera, Agarista, Neola, Trichiocercus Unnamed Case Moths 1, 2, 3; *Cactoblastis **9**: Ocybadistes ,Paralucia, Jalmenus, Zizina, Zizeeria, Leptotes, Theclinesthes Papilio, *Pieris	Magpie Moth, Giant Wood Moth, Brown Leaf Moth, Inchworms, Swift Moth, Four Spotted Cup Moth, Mottled Cup Moth, Case Moths, Painted Vine Moth, Prickly Pear Moth Skippers, Green Grass Dart, Blues, Fiery Copper, Common Imperial Blue, Common Grass Blue, Spotted Grass Blue, Plumbago Blue, Saltbush Blue, Swallow-Tails, Orchard Swallowtail, Small Citrus Butterfly, Whites, Cabbage White
Order: Mantodea	1: Mantidae	1: Orthodera	Praying Mantids
Order: Neuroptera	1: Nymphidae	1: Nymphes	Lacewings
Order: Odonata	3: Gomphidae, Hemicorduliidae, Libellulidae	3: Austrogomphus, Hemicordulia, Rhyothemis	Dragonflies and Damselflies – Yellow-striped Hunter, Australian Emerald Dragonfly, Graphic Flutterer
Order: Orthoptera -	4: Acrididae, Gryllacrididae, Pyrgomorphidae, Tettigoniidae	4 + 1: Goniaea, Macrotona, Unnamed Raspy Cricket, Monistria, Torbia	Grasshoppers, Locusts and Crickets – Gumleaf Grasshopper, Common Pyrgomorph
Class: Myriapoda Order: Diplopoda	1: Julidae	1: Ommatoiulus.	Centipedes & Millipedes –Millipede
Order: Polydesmida	1: Paradoxosomatidae	1: *Unnamed sp.	Millipede
Phylum: Crustacea			**Crustaceans**
Class: Malacostrata Order: Isopoda	1: Porcellionidae	1: Porcellio	Woodlice, Slaters – Common Woodlouse
Phylum: Mollusca			**Snails and Slugs**
Class: Gastropoda Order: Eupulmonata	4: Camaenidae, Helicidae, Rhytididae, Limacidae	3 + 1: Meridolum, *Helix, Austrorhytida, Unknown 1	Cumberland Plain Land Snail, Common Garden Snail, Carnivorous Land Snail, Slugs

Table 2. Waterbirds and their Potential Habitats in the Wildlife Lake

Bird Species (Common Name)	Castlereagh Status R=Recorded E=Expected P-Potential	Plant Communities										
		Riparian Forest	Alluvial Woodland	Shale Gravel Transition Forest	Creeklines and Ephemeral Drainage Lines	Casuarina Stands	Melaleuca Swampland	Castlereagh Swamp Woodland	Grasslands	Herblands	Sedgelands, Rushlands (Aquatic Emergents)	Aquatics - Attached and Floating
International Migratory Waterbirds												
Cattle Egret	R				X		X		X	X		
Pacific Golden Plover	P				X				X	X	X	
Whiskered Tern	P				X				X			X
Sharp-tailed Sandpiper	P				X					X	X	
Curlew Sandpiper	P				X					X	X	
Pectoral Sandpiper	P				X				X	X	X	
Red-necked Stint	P				X				X	X	X	
Latham's Snipe	E				X				X	X	X	
Wood Sandpiper	P				X				X	X	X	
Common Greenshank	P				X				X	X	X	
Marsh Sandpiper	P				X					X	X	
Native Visiting Waterbirds												
White-necked Heron	E				X				X	X	X	
Glossy Ibis	P				X				X	X	X	
Hardhead	R											X
Pink-eared Duck	P			X	X	X	X	X	X	X	X	X
Freckled Duck	R				X		X	X	X	X	X	X
Australian Spotted Crake	R	X	X	X	X	X	X	X	X	X	X	
Baillon's Crake	P				X	X	X	X	X	X	X	
Red-kneed Dotterel	P				X		X	X	X	X	X	
Australian Reed-Warbler	P				X					X	X	
Native Resident Waterbirds												
Great Crested Grebe	R										X	X
Hoary-headed Grebe	E										X	X
Australasian Grebe	R										X	X
Australian Darter	R						X	X				X
Australian Pelican	R								X	X		X
Great Cormorant	R				X		X	X	X			X

Little Pied Cormorant	R				X		X	X	X			X
Little Black Cormorant	R				X		X	X				X
Pied Cormorant	R				X		X	X				X
Great Egret	R				X	X	X	X		X	X	
Intermediate Egret	E				X	X	X	X		X	X	
Little Egret	R				X	X	X	X		X	X	
White-faced Heron	R	X	X	X	X	X	X	X	X	X	X	
Nankeen Night Heron	P	X	X	X	X	X	X	X	X	X	X	
Yellow-billed Spoonbill	E				X		X	X	X	X	X	
Royal Spoonbill	R				X		X	X	X	X	X	
Australian White Ibis	R	X	X	X	X	X	X	X	X	X	X	
Straw-necked Ibis	R				X		X	X	X	X	X	
Chestnut Teal	R	X	X	X	X	X	X	X				X
Grey Teal	R				X	X	X	X				X
Australasian Shoveler	R								X	X	X	X
Pacific Black Duck	R				X	X	X	X	X	X		X
Musk Duck	P								X	X	X	X
Australian Wood Duck	R	X	X	X	X	X	X	X	X	X		X
Black Swan	R								X	X	X	X
Eurasian Coot	R								X	X	X	X
Dusky Moorhen	R				X		X	X	X	X	X	X
Buff-banded Rail	E				X		X	X	X	X	X	
Purple Swamphen	R				X		X	X	X	X	X	
Spotless Crake	E				X		X	X	X	X	X	
Red-capped Plover	P						X	X	X	X	X	
Black-fronted Dotterel	R						X	X	X	X	X	
Silver Gull	R								X	X	X	X
Black-winged Stilt	R				X				X	X	X	
Masked Lapwing	R								X	X	X	
Golden-headed Cisticola	P				X				X	X	X	
Little Grassbird	P				X				X	X	X	
Introduced Resident Waterbirds												
Mallard	R				X				X	X	X	X
Totals		**6**	6	7	44	13	30	29	42	46	45	24

Table 3. Non-Waterbirds and their Potential Habitats in the Wildlife Lake

Bird Species (Common Name)	Castlereagh Status R=Recorded E=Expected P-Potential	Plant Communities										
		Riparian Forest	Alluvial Woodland	Shale Gravel Transition Forest	Creeklines and Ephemeral Drainage Lines	Casuarina Stands	Melaleuca Swampland	Castlereagh Swamp Woodland	Grasslands	Herblands	Sedgelands, Rushlands (Aquatic Emergents)	Aquatics - Attached and Floating
International Migratory Non-Waterbirds												
White-throated Needletail	E	X	X	X	X	X	X	X	X	X	X	
Native Visiting Non-Waterbirds												
Spotted Harrier	P		X	X	X	X	X	X	X	X		
Stubble Quail	R		X	X	X				X	X		
Bar-shouldered Dove	P		X	X	X		X	X	X			
Musk Lorikeet	E	X	X	X			X	X				
Little Lorikeet	P	X	X	X			X	X				
Swift Parrot	P	X	X	X								
Horsfields Bronze-cuckoo	R	X	X	X		X		X				
Shining Bronze-cuckoo	R	X	X	X		X	X	X				
Pallid Cuckoo	P	X	X	X				X				
Brush Cuckoo	R	X	X	X		X	X	X				
Common Koel (Asian Koel)	R	X	X	X		X		X				
Channel-billed Cuckoo	R	X	X	X		X		X				
Dollarbird	E	X	X	X				X				
Sacred Kingfisher	E	X	X	X	X	X	X	X	X			
Rainbow Bee-eater	R	X	X	X	X			X				
Fairy Martin	R				X		X	X	X	X	X	
Tree Martin	E	X	X	X	X	X	X	X	X	X	X	
Cicadabird	R	X	X	X		X	X	X				
White-winged Triller	P			X				X	X			
Rufous Whistler	R	X	X	X		X	X	X				
Scarlet Robin	P	X	X	X	X	X		X	X			
Fuscous Honeyeater	P	X	X	X			X					
Black-chinned Honeyeater	P	X	X	X			X					
Scarlet Honeyeater	E		X	X				X				
Noisy Friarbird	R	X	X	X			X	X				
Regent Honeyeater	R	X	X	X			X	X				

White-throated Gerygone	E	X	X	X	X	X	X	X				
Satin Flycatcher	P	X	X	X	X			X				
Leaden Flycatcher	E	X	X	X								
Rufous Fantail	E	X	X	X				X				
Dusky Woodswallow	E	X	X	X				X				
White-browed Woodswallow	P		X	X	X			X	X			
Brown Songlark	P				X			X	X	X		
Rufous Songlark	P				X			X	X	X		
Native Resident Non-Waterbirds												
Collared Sparrowhawk	E	X	X	X				X				
Brown Goshawk	R	X	X	X				X				
Grey Goshawk	P	X	X	X				X				
Wedge-tailed Eagle	E	X	X	X	X	X	X	X	X	X		
Pacific Baza	P	X	X	X		X		X				
Swamp Harrier	R				X	X	X	X	X	X		
Black-shouldered Kite	R	X	X	X	X			X	X	X		
White-bellied Sea Eagle	R	X	X	X	X	X	X	X	X	X		
Whistling Kite	E	X	X	X	X	X	X	X	X	X		
Little Eagle	P		X	X	X	X	X	X	X	X		
Square-tailed Kite	P	X	X	X	X	X	X	X	X	X		
Brown Falcon	E		X	X	X	X	X	X	X	X		
Nankeen Kestrel	R		X	X	X	X	X	X	X			
Australian Hobby	R		X	X	X	X	X	X	X			
Peregrine Falcon	P	X	X	X		X	X	X				
Brown Quail	R				X		X	X	X	X		
Painted Button-quail	P	X	X	X								
Peaceful Dove	R	X	X	X	X	X	X	X				
Wonga Pigeon	P	X	X	X				X				
Brown Cuckoo-Dove	P	X	X									
Crested Pigeon	R		X	X	X			X	X			
Common Bronzewing	E	X	X	X	X			X				
Sulphur-crested Cockatoo	R	X	X	X	X			X	X			
Galah	R		X	X	X			X	X			
Little Corella	R	X	X	X	X			X	X			
Long-billed Corella	P	X	X	X	X			X	X			
Gang-gang Cockatoo	P	X	X	X		X		X				
Yellow-tailed Black-cockatoo	R	X	X	X		X	X	X				
Glossy Black-cockatoo	P	X	X	X		X		X				
Australian King Parrot	E	X	X	X		X		X				

Crimson Rosella	R	X	X	X	X			X				
Eastern Rosella	R	X	X	X	X			X				
Red-rumped Parrot	R		X	X	X			X	X			
Rainbow Lorikeet	E	X	X	X			X	X				
Fan-tailed Cuckoo	R	X	X	X		X	X	X				
Southern Boobook	R	X	X	X		X		X				
Barn Owl	R		X	X	X			X	X			
Tawny Frogmouth	R		X	X	X	X		X				
Australian Owlet-nightjar	P	X	X	X		X		X				
Azure Kingfisher	R	X	X	X		X	X	X				
Laughing Kookaburra	R	X	X	X	X	X		X				
Superb Lyrebird	R	X										
Welcome Swallow	R	X	X	X	X	X	X	X	X	X	X	
Richard's Pipit	E		X	X	X			X	X			
Black-faced Cuckoo-shrike	R	X	X	X								
White-bellied Cuckoo-shrike	E	X	X	X				X				
Grey Shrike-thrush	R	X	X	X				X				
Crested Shrike-tit	E	X	X	X				X				
Golden Whistler	E	X	X	X			X	X				
Eastern Yellow Robin	R		X	X				X				
Jacky Winter	P	X	X	X				X				
Rose Robin	E	X						X				
Eastern Whipbird	E	X										
Superb Fairy-wren	R	X	X	X				X				
Variegated Fairy-wren	E	X	X	X			X	X				
Varied Sittella	P	X	X	X				X				
White-throated Treecreeper	E	X	X	X				X				
Eastern Spinebill	R	X	X	X			X	X				
Red Wattlebird	E	X	X	X			X	X				
Little Wattlebird	R	X	X	X			X	X				
Yellow-faced Honeyeater	R	X	X	X			X	X				
White-eared Honeyeater	P	X	X	X			X	X				
Yellow-tufted Honeyeater	P	X	X	X			X	X				
White-plumed Honeyeater	R	X	X	X			X	X				
Noisy Miner	R	X	X	X			X	X				
Bell Miner	R	X										
Lewin's Honeyeater	R	X	X	X			X	X				
Brown-headed Honeyeater	E	X	X	X			X	X				
White-naped Honeyeater	E	X	X	X			X	X				
White-cheeked Honeyeater	P	X	X	X	X		X	X				

New Holland Honeyeater	E	X	X	X			X	X				
Mistletoe Bird	R	X	X	X		X		X				
Yellow-rumped Thornbill	E				X			X	X	X		
Striated Thornbill	E	X	X	X				X				
Yellow Thornbill	R	X	X	X		X	X	X				
Brown Thornbill	P	X	X	X	X	X	X	X				
Buff-rumped Thornbill	P	X	X	X				X				
Speckled Warbler	P	X	X	X				X				
Brown Gerygone	P	X										
Spotted Pardalote	R	X	X	X				X				
Striated Pardalote	R	X	X	X				X				
White-browed Scrubwren	R	X	X	X		X		X				
Weebill	P	X	X	X								
Chestnut-breasted Mannikin	R				X			X	X	X		
Red-browed Finch	R	X	X	X	X			X	X			
Double-barred Finch	R	X	X	X	X			X	X			
Zebra Finch	R	X	X	X	X			X	X			
Olive-backed Oriole	E	X	X	X				X				
Magpie-lark (Pee wee)	R	X	X	X	X	X	X	X	X			
Restless Flycatcher	E	X	X	X	X	X	X	X	X	X		
Grey Fantail	R	X	X	X				X				
Willie Wagtail	R				X		X	X	X			
Satin Bowerbird	E	X	X	X				X				
White-winged Chough	E	X	X	X								
Apostlebird	E	X	X	X				X	X			
Grey Butcherbird	R	X	X	X		X	X	X				
Australian Magpie	R	X	X	X		X		X				
Pied Currawong	R	X	X	X		X		X				
Australian Raven	R	X						X	X			
Silvereye	E	X	X	X		X	X	X				
Introduced Resident Non-Waterbirds												
Rock Dove (Feral Pigeon)	R								X			
Spotted Turtle-dove	R								X			
Skylark	E				X				X	X		
Red-whiskered Bulbul	R											
European Goldfinch	R											
Nutmeg Mannikin	P								X	X		
House Sparrow	R											
Common Myna	E	X	X	X	X			X	X	X		

Common Starling	E	X	X	X				X	X	X		
Common Blackbird	E	X	X	X				X	X	X		
Totals		113	123	123	52	46	56	124	49	25	4	0