Figure 9: Recent aerial photo of property and general locality
(Source: LPIC, Orange © 1997-2008). Estimated photo date: 2006.

4.4.2 DECC Wildlife Corridors and Key Habitats

4.4.2.1 General

The Department of Environment and Climate Change (DECC) has mapped corridors and key habitats at a regional scale throughout northern NSW (Scotts 2002) and the corresponding map for the site locality was accessed via the website (www.npws.nsw.gov.au) and is shown in Figure 10.

4.4.2.2 Regional Corridors and Key Habitats.

Regional corridors connect important areas of habitat. Ideally they are of sufficient size to provide habitat in their own right and at least twice the width of the average home range area of fauna species identified as likely to use the corridor (Scotts 2002). Key habitats are defined as "*areas of predicted high-conservation value for priority forest fauna assemblages, endemic forest vertebrates or endemic invertebrates* (Scotts 2002).

As shown in figure 10, the eastern and western sides of the property are mapped as part of the Lake Cathie/Camden Haven Regional Corridor which links Lake Innes Nature Reserve to the Grants Beach area. The aerial photo (Figure 9) and observations during this study indicate that this regional link is at times highly fragmented by cleared private land, the villages of Lake Cathie and Bonny Hills, a main road and ongoing residential development. Most of the areas of the property falling into the corridor is essentially pasture/pastoral woodland and hence of very limited value.

The corridor includes key habitat identified around the STP, and the SEPP 26 Littoral Rainforest (surprisingly not identified as Key Habitat) which are considered to have good to very good habitat and corridor value eg a small group of Wompoo Fruit-Doves were observed flying along this area using it as a stepping stone to the major remnant at Sea Acres Nature Reserve. However, to the north the link becomes continually thin before coming to a halt at Lake Cathie. West of Lake Cathie there is more than sufficient vegetation to provide linkage to the north in Lake Innes Nature Reserve.

4.4.2.3 Sub-Regional Corridors

Sub-regional corridors connect larger landscaped features and are of sufficient width to allow movement and dispersal (generally >300m), but may not provide substantial species habitat (Scotts 2002).

No sub-regional corridors were mapped in close proximity to the property. However, it is considered that most of the area designated as regional corridor on the property has been subject to substantial habitat fragmentation and it is more likely to function as a sub-regional corridor.

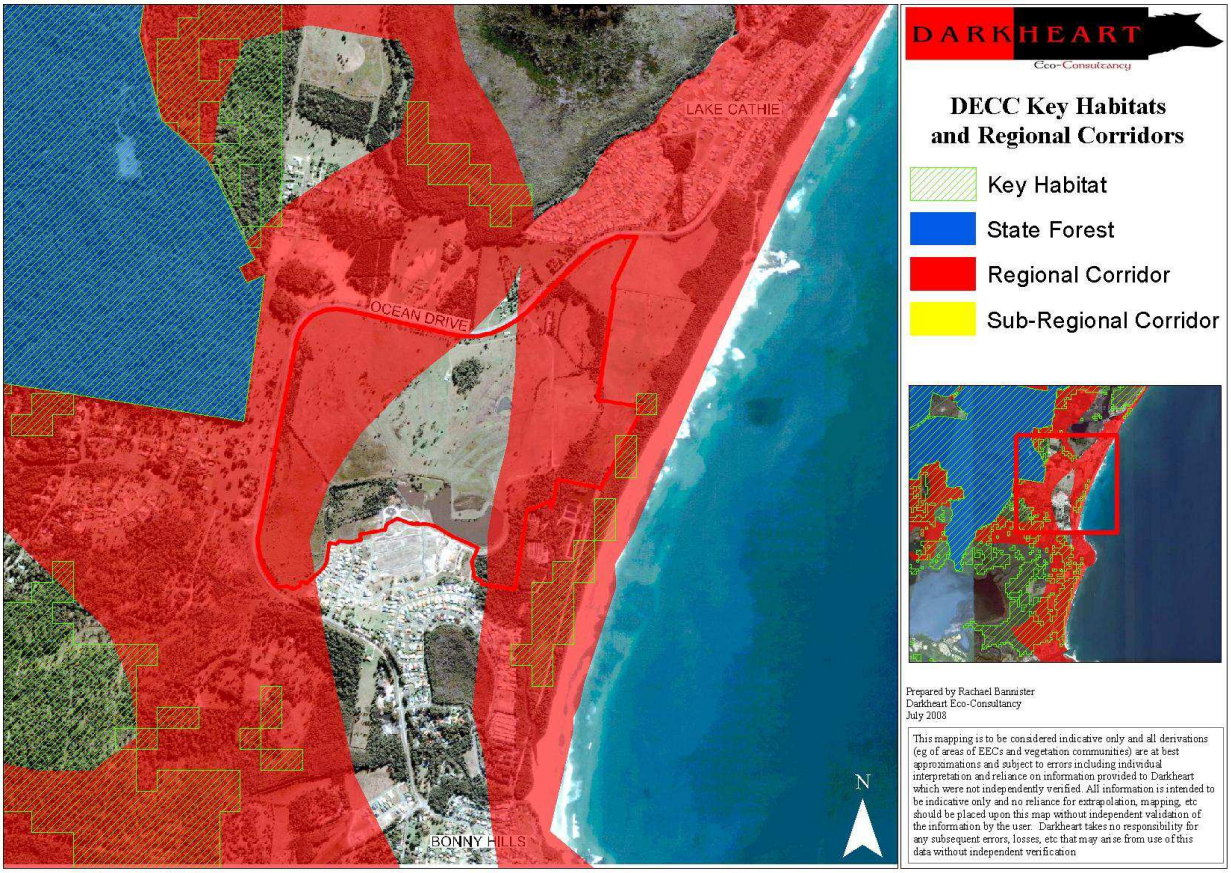
4.4.2.4 Local Corridors

Local corridors provide connections between remnant patches of habitat and landscape features. Due to their relatively small area and width (they may be <50m) these corridors are subject to edge effects (Scotts 2002).

As noted in section 3.5.1, the majority of forest habitats on the property are surrounded by cleared land and generally do not connect local remnant habitats. The only genuine connection is the dune scrub and southeast dry sclerophyll to the dune complex and habitat around the STP, and this is considered a significant link for fauna on the property.

Figure 10: DECC Regional Corridors and Key Habitats in the area

(Source: www.npws.nsw.gov.au)



As previously detailed, the UIA 14 Structure Plan proposes to create local corridors in the north along Duchess Creek but this terminates at Ocean Drive before reaching Lake Innes Nature Reserve; and from the west-southwest to the east to Duchess Gully via regenerating the major drainage line. This latter proposed link is considered to have significant potential to provide a key link for a range of fauna including threatened species known to occur in habitat around the STP eg Koala and Squirrel Glider (Biolink 2003).

4.4.2.5 Key Habitats

Key Habitats are areas of predicted high conservation value for forest faunal assemblages, endemic forest vertebrates or endemic invertebrates; spatially depicted as a merging of mapped assemblage hubs, assemblage hot spots and centres of endemism (DECC 2009c, Scotts 2002).

As shown in figure 10, the DECC have mapped the vegetation east of the STP and along the coastline as Key Habitats. No portion of the subject property is however mapped as such.

4.5 FAUNA SURVEY RESULTS

4.5.1 Trapping

4.5.1.1 Elliot B

4.5.1.1.1 2006

Elliot B trapping on the property was unsuccessful with no captures recorded.

4.5.1.1.2 2003

Previous surveys of the property by the consultant detected a Sugar Glider and a Brown Antechinus (*Antechinus stuartii*). Both were recorded in the southeast dry sclerophyll only.

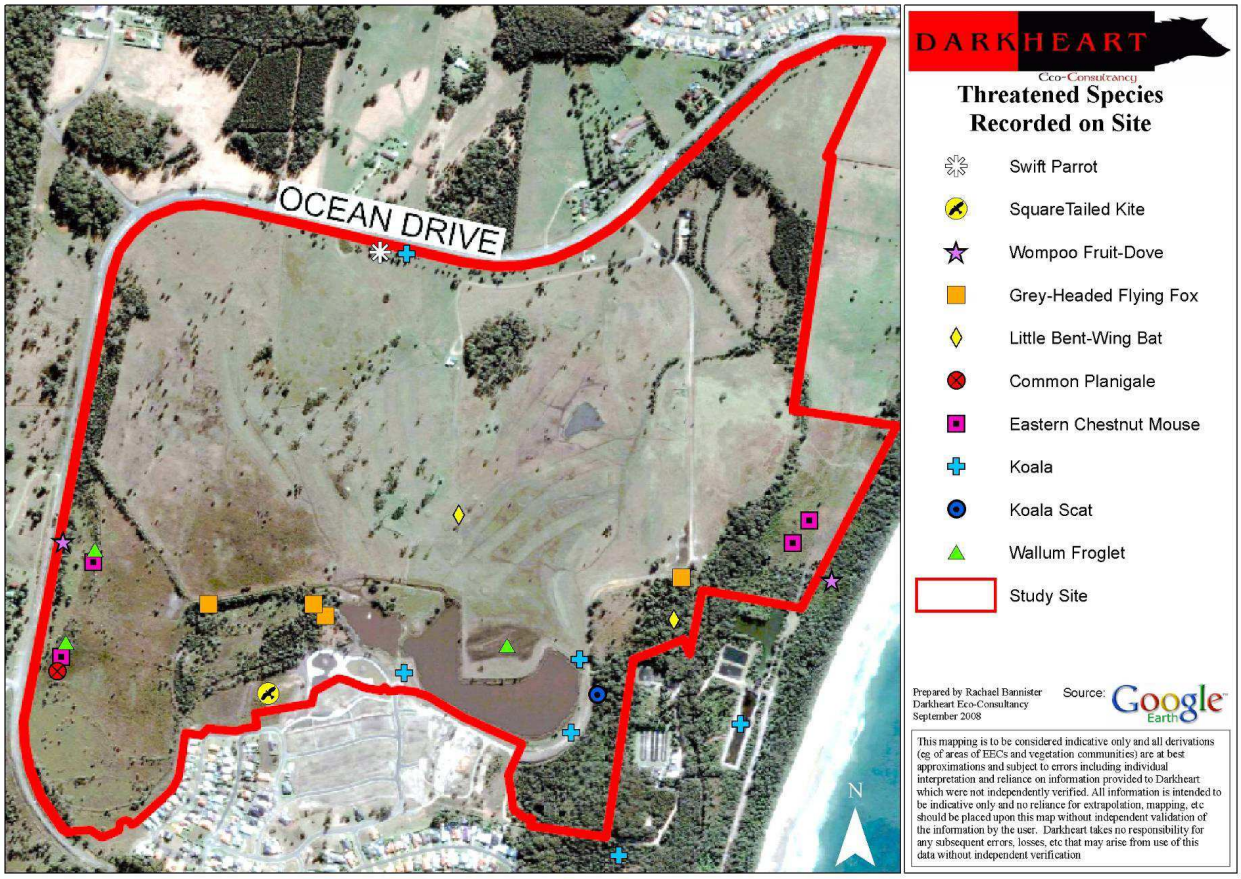
4.5.1.2 Elliot A

Captures in the northern Swamp Oak community were limited to Swamp Rats, Bush Rats and two Sugar Gliders. Surprisingly, both Sugar Glider captures were on the ground amongst dense saw sedge, with one Sugar Glider being a female with 4 pouch young. This area of Swamp Oak completely lacked hollows, with an old large stump possibly offering a den site.

Elliot A surveying was however more successful on other portions of the main property. A single Eastern Chestnut Mouse was recorded in dense Bladey Grass in the western dry sclerophyll remnant (see photo 4), and a female Common Planigale was found adjacent to this area in the dense growth of *Babingtonia pluriflora* occurring along the adjacent drain (see figure 12 and appendices).

Figure 11: Location of threatened species on property

Note: DECC Atlas records approximate at best. Actual location of sighting may be up to 1km away as per standard accuracy of the AoW.



In 2003, three more Eastern Chestnut Mice were recorded in dense Bladey Grass-Bracken Fern grassland east of Duchess Gully in an area designated for residential-tourist development (see photo 12). This area has been repetitively slashed since this time however.

These species are listed as Vulnerable under the TSCA 1995.

4.5.1.3 Wire Cages

No captures were recorded in the wire cages. One trap set in the swamp forest regrowth around the large lagoons in the southern end of the main property was activated without capture, and large tracks considered to be dog or possibly a dingo were observed in mud nearby.

4.5.2 Spotlighting

4.5.2.1 2006

Grey-Headed Flying Fox (*Pteropus poliocephalus*) were briefly observed on four occasions in the Paperbark/Swamp Mahogany swamp forest and southeast dry sclerophyll. Several Eastern Grey Kangaroos (*Macropus giganteus*) were observed feeding on grass in the pasture.

No fauna were observed during the stag watches.

4.5.2.2 2003

Sugar Gliders were observed in the in the northeastern section of the Swamp Oak forest and wet sclerophyll where they were captured in Elliot A traps set on the ground, and another one was observed in the dry sclerophyll adjacent to the sewage treatment plant.

Several Eastern Grey Kangaroos were observed feeding on grass in the drainage depression. Sleeping birds were observed in the former nursery and northwest dry sclerophyll, and also in the southeast dry sclerophyll.

No fauna were observed during the stag watches.

4.5.3 Call Playback and Recording

4.5.3.1 Birds

Playback of calls of the Sooty, Masked, Powerful, and Barking Owls and Bush-Stone Curlew failed to gather a response from any of these birds.

Only common diurnal birds were heard calling during the survey period.

4.5.3.2 Mammals

No Koala, Yellow-Bellied Gliders or Squirrel Gliders responded to call playback or where heard during the surveys.

A Sugar Glider (*Petaurus breviceps*) call was recorded on one occasion in the Swamp Oak swamp forest.

4.5.3.3 Bats

(a) 2006:

The following calls were identified by Mrs Anna Lloyd of Eco-Location Consultants:

Table 4: Microchiropteran bat call detection results 2006

SCIENTIFIC NAME	COMMON NAME	NO. OF DEFINITE PASSES	NO. OF PROBABLE/POSSIBLE PASSES
***Miniopterus australis*#**	**Little Bent-Wing Bat**	**3**	**2**
Tadarida australis	White-Striped Freetail Bat	1	0

Listed as Vulnerable under Schedule 2 of the Threatened Species Conservation Act 1995.

(b) 2003:

Insect abundance was very limited during the survey. This in association with the season (ie Winter) which produced cool nights during the survey was considered to be a substantial limitation on Microchiropteran bat detection. However some calls were recorded and these were sent to Mr Glenn Hoye (Fly by Night Bat Surveys) who identified them as follows:

Table 5: Microchiropteran bat call detection results 2003.

SCIENTIFIC NAME	COMMON SPECIES NAMES	CONFIDENT	PROBABLE
Chalinolobus gouldii	Gould's Wattled Bat	Yes	-
***Miniopterus australis*#**	**Little Bent-Wing Bat**	Yes	-
V. pumilis	Eastern Forest Bat	Yes	-
V. vulturnus	Little Forest Bat	-	Yes

Bat calls were only recorded along the fire trail around the southeast dry sclerophyll, though these or other bats may utilise other portions of the property at times depending on a range of factors such as season and weather.

4.5.3.4 Frogs

(a) 2006:

During the main survey, only *Crinia signifera* was heard calling from the depression, drains, etc.

Following rain, further inspection of the depression just north of the large lagoon recorded a handful of Wallum Froglets south of the dividing fence excluding cattle. These individuals appeared to have survived slashing and desiccation via remaining under slashed material which formed moist mulch (see photos in appendices). This species is listed as Vulnerable under the TSCA 1995. Several other species were re-recorded from the 2003 survey over the property (see below).

(b) 2003:

Two populations of the Wallum Froglet were recorded on the property during the 2003 survey of the entire property.

The first was in the aforementioned depression. At least 50 Wallum Froglets were recorded calling from this area, though an exact number of the species present is difficult to estimate due to various species calling, only males call, and not all individuals call in any given session.

Another two males were recorded calling on one occasion from the *Babingtonia pluriflora* lined drain in the southwest of the property (southeast of the western dry sclerophyll remnants).

The following other species were recorded on the property mostly in the dams, drains or Duchess Gully:

- Common Eastern Froglet (*Crinia signifera*)
- Striped Marsh Frog (*Limnodynastes peronii*)
- Banjo Frog (*L. dumerilii var. greyii*)
- Tusked Frog (*Adelotus brevis*)

- Freycinet's Frog (*Litoria freycineti*)
- Dwarf Tree Frog *(L. fallax*)

4.5.4 Secondary Evidence and Opportunistic Observation

4.5.4.1 Secondary evidence

Markings on tree trunks from arboreal fauna usage were common on Grey Gums in the isolated patch of dry sclerophyll and to a lesser extent in the northwest dry sclerophyll. The active species was not identified, but given the lack of mammal scats at these trees it was considered likely that the scratches were due to the Lace Monitor (*Varanus varius*).

4.5.4.2 Scats and tracks

4.5.4.2.1 Common Species

Eastern Grey Kangaroo scats were present throughout the property. Koala scats were observed (26 in total) in the southeast Paperbark/Swamp Mahogany swamp forest in the 2006 survey. No other scats were found in the other dry sclerophyll, swamp forest or in the pastoral woodland despite food trees by this or the previous survey. The only other mammal scats found were due to cattle.

After rain, dingo/dog tracks were observed along a road on the south of the property adjacent to the lagoon in 2006. These and deer tracks were observed in the swamp forest regrowth near the main lagoons in the southern end of the main property.

4.5.4.2.2 Koala

The level of scat detectability under trees over most of the property was good due to the absence of dense groundcover or heavy leaf litter accumulations. Some limited areas in the southeastern swamp forest complex were impossible to reach due to dense lantana thickets. On other portions, detectability was limited around the lagoons where dense grass obscured some areas of the ground.

Scats were observed in the southeastern swamp forest primarily under Swamp Mahogany. A large amount of scats was detected under a cluster of Needlebark Stringybarks which are not considered to be preferred forage trees (DECC 2008a). This cluster occurred in close proximity to several Swamp Mahogany hence use of these trees may have been incidental eg shade.

A Spot Assessment Technique assessment was conducted in the southeast swamp forest where Koala activity has also been recorded by Biolink (2003). A total of 7 of the 30 trees recorded scats in the SAT sample. This indicated medium (normal) usage (Phillips and Callaghan, unpublished), hence qualifying as a major area of activity ie presence of home range trees.

4.5.4.3 Feeding signs

4.5.4.3.1 Birds

No chewed *Allocasuarina* cones were found under any of the Black Oak or in the Swamp Oak forest in 2003, 2005 or 2006. Some of the larger Swamp Oaks on the property carried seed cones, but no chewed cones were found under those trees.

4.5.4.3.2 Sap Sucking - Arboreal Mammals

"L" or "V" shaped incisions and rectangular excisions of patches of bark are typical of the Yellow-Bellied Glider, which characteristically makes bigger incisions than the Squirrel or Sugar Glider. Some trees are sampled for their sap-exuding properties, but not used again (NPWS 2003b). Key trees used

by Yellow-Bellied Gliders are habitually used (trees often bear many incisions evident of various ages), which when found, may usually be surveyed with high probability of detection of this species. The smaller Squirrel Glider and Sugar Glider create small incisions or utilise existing damage to bark (Menkhorst and Collier 1987, Smith and Murray 2003, pers. obs., Sharpe and Goldingay 1998).

No fresh incisions were found in the dry sclerophyll forest on the property. Conversely, many old and healed incisions were noted in the isolated patch of dry sclerophyll which is to become a park in the UIA 14 Masterplan (Deicke Richards 2004). Intensive trapping and spotlighting in this area in 2003 failed to find the causal species, though Sugar Gliders were considered likely. Their absence was considered to possibly be due to predation, starvation or similar factors known to compromise the viability of small, isolated populations (Smith 2000, Murray 2006, Smith and Murray 2003, Lindenmayer and Fisher 2006).

4.5.4.3.3 Diggings

Diggings were commonly detected along the fringes of the southeastern section of Paperbark/Swamp Mahogany swamp forest, within the southeast dry sclerophyll and the dune scrub. These were attributed to common bandicoots (eg *Isoodon macrourus*, *Perameles nasuta*).

4.5.4.3.4 Bones, etc

Some cow bones and the remains of a deer were found.

4.5.4.4 Opportunistic Observations

Table 5 lists all the species detected on the site and property by this and previous surveys by spotlighting, call detection, opportunistic sighting and habitat inspections. A total of 36 birds, 1 mammal (not including Microchiropteran bats) 2 reptile and 8 frog species were observed on the site and property by this consultant.

Clancy and Ayres (1983) previously recorded some 47 birds, 2 mammals, 2 reptiles and one frog. Most significantly, they recorded Koalas in the northwest of the property (towards Houston Mitchell Drive), Koalas around the STP, and the following EPBCA 1999 migratory species:

- White-Breasted Sea-Eagle
- Fork-Tailed Swift
- Rufous Fantail

4.5.4.4.1 Birds

Three EPBCA listed migratory bird species have been detected on the property by this consultant. Cattle Egrets were observed in company with cattle. The Great Egret was observed in 2003 foraging around the dams/lagoons on the property. The White-Breasted Sea-Eagle was observed flying over the site and over the dams/lagoons in 2003 and 2005.

Most significantly, a total of 5 Wompoo Fruit-Doves (Vulnerable, TSCA) were observed on or near the property. A single bird roosted in a eucalypt in the southwest dry sclerophyll, and four birds were observed flying low above the coastal strip of forest towards the littoral rainforest near Middle Rock.

Passerine bird activity was moderate, particularly in the northwest and southeast dry sclerophyll. However, the activity was dominated by larger species such as Little Wattle Bird (*Anthochaera chrysoptera*) and Noisy Miner (*Manorina melanocephala*) which aggressively occupy habitats and may inhibit activity of smaller species (Catterall 2004).

The consultant has previously observed a Square-Tailed Kite (Vulnerable, TSCA) flying over the recently developed southern end of the property in 2004. A Whistling Kite nest was located in the southwest edge of the pastoral woodland near the large lagoons in the southern end of the property.

An abundance of waterbirds were observed around the main lagoons, with dozens of cormorants and ducks noted each day in 2003 and less so in 2006 (perhaps due to adjacent residential development).

4.5.4.4.2 Mammals

The only mammals observed opportunistically during the survey were cattle, a juvenile deer and Eastern Grey Kangaroos although the latter were less common than expected given the substantial area of grassland and presence of suitable rest areas.

A single Koala was observed in January 2007 during an inspection of current bush regeneration works. A mature animal (unable to be sexed due to sitting position) was observed in a Swamp Mahogany on the western edge of the low hill in the southeast of the property.

4.5.4.4.3 Reptiles

Other than Grass Skinks, no reptiles were detected during the surveys. This was considered most likely due to both the cold to mild conditions experienced during the survey and the disturbance history which has removed potential shelter for small terrestrial species and significantly fragmented habitat.

Table 6: Fauna detected on the property.

* indicates exotic species; **bold** indicates listed as threatened under TSCA and/or EPBCA; # indicates EPBCA Migratory

GROUP	COMMON NAME	SCIENTIFIC NAME
BIRDS	Straw-Necked Ibis	*Threskiornis spinicollis*
	Australian White Ibis	*Threskiornis molucca*
	#Cattle Egret	*Ardeola ibis*
	#Great Egret	*Ardea alba*
	#White-Bellied Sea Eagle	*Haliastur sphenurus*
	Little Black Cormorant	*Phalacrocorax sulcirostris*
	Hardhead	*Aythya australis*
	Chestnut Teal	*Anas castanea*
	Grey Teal	*A. gibberifrons*
	Pacific Black Duck	*A. superciliosa*
	Wood Duck	*Chenonetta jubata*
	Galah	*Cacatua roseicapilla*
	Scaly-Breasted Lorikeet	*Trichoglossus chlorolepidotus*
	Rainbow Lorikeet	*Trichoglossus haematodus*
	Masked Lapwing	*Vanellus miles*
	Golden Whistler	*Pachycephala pectoralis*
	Laughing Kookaburra	*Dacelo novaeguineae*
	Grey Fantail	*Rhipidura fuliginosa*
	Superb Fairy Wren	*Malurus cynaeus*
	Brown Thornbill	*Acanthiza pusilla*
	Eastern Whipbird	*Psophodes olivaceus*
	Grey Shrike-thrush	*Colluricincla harmonica*
	Richards Pipit	*Anthus cervinus*
	Black-Faced Cuckoo Shrike	*Coracina novaehollandiae*
	Crested Pigeon	*Geophaps lophotes*
	Wompoo Fruit-Dove	***Ptilinopus magnificus***
	Magpie	*Gymnorhina tibicen*
	Magpie Lark	*Grallina cyanoleuca*
	Square-Tailed Kite	***Lophoictinia isura***
	Crested Pigeon	*Geophaps lophotes*
	Noisy Miner	*Manorina melanocephala*
	Little Wattlebird	*Anthochaera chrysoptera*
	Lewins Honeyeater	*Meliphaga lewinii*
	Welcome Swallow	*Hirundo neoxena*

	Satin Bowerbird	*Ptilonorhynchus violaceus*
	Grey Butcherbird	*Cracticus torquatus*
	Wedge Tailed Eagle	*Aquila audax*
MAMMALS	Brushtail Possum	*Trichosurus vulpecula*
	Sugar Glider	*Petaurus breviceps*
	Koala	***Phascolarctos cinereus***
	Grey-Headed Flying Fox	***Pteropus poliocephalus***
	Red-Necked Wallaby	*Macropus rufogriseus*
	Eastern Grey Kangaroo	*M. giganteus*
	Long-Nosed Bandicoot	*Perameles nasuta*
	Eastern Chestnut Mouse	***Pseudomys gracilicaudatus***
	Swamp Rat	*Rattus lutreolus*
	Bush Rat	*R. fuscipes*
	Brown Antechinus	*Antechinus stuartii*
	Common Planigale	***Planigale maculata***
	Wild Dog	*Canis familiaris*
	Fallow Deer	*Dama dama*
	Gould's Wattled Bat	*Chalinolobus gouldii*
	Little Bent-Wing Bat	***Miniopterus australis***[#]
	Eastern Forest Bat	*V. pumilis*
	Little Forest Bat	*V. vulturnus*
	White-Striped Freetail Bat	*Tadarida australis*
REPTILES	Grass Skink	*Lampropholis delicata*
	Laced Monitor	*Varanus varius*
FROGS	Common Eastern Froglet	*Crinia signifera*
	Wallum Froglet	***C. tinnula***
	Tusked Frog	*Adelotus brevis*
	Freycinet's Frog	*Litoria freycineti*
	Dwarf Tree Frog	*Litoria fallax*
	Banjo Frog	*Limnodynastes dumerilii var. greyii*
	Striped Marsh Frog	*Limnodynastes peronii*

4.6 DISCUSSION OF FAUNA SURVEY FINDINGS

4.6.1 Success of Methodology

The methods used have been effective for a range of threatened species at other sites in the region and the failure to capture or detect the targeted fauna species on the property is considered to be due to either their absence or to their low levels of activity at the time of the survey (DEC 2004a). The lack of suitable habitat and/or physical isolation of remnants from other habitat on the property is also considered to be a factor limiting the potential occurrence of threatened fauna.

The Squirrel Glider and Brushtail Phascogale have been captured by this consultant elsewhere in similar situations to those found on the property (such as the southwest dry sclerophyll) and the small areas of potential habitat on the site and on other parts of the property were trapped at relatively high intensity well above minimum standards (DEC 2004a). Sugar Gliders were detected on the property and it has been anecdotally noted by this consultant that Squirrel Gliders are generally less frequent in their presence (eg Darkheart 2004l, 2004q, 2004u, 2004f, 2005c, 2006a, 2005b, 2005a, 2005b), although the two species are not mutually exclusive (Quinn 1995, Darkheart 2004f, 2004q, Berrigan 1999a, Smith and Murray 2003).

Despite surveys being undertaken in Winter, environmental variables were relatively favourable during the surveys. The weather conditions were considered to be typical for the time of year with cool to cold temperatures and generally light winds. Foraging resources available on the site were also considered to be typical of the season, with Swamp Mahogany coming into flower and a low level of invertebrate activity.

4.6.2 General

4.6.2.1 Proposed Wetland and Filling Area

Fauna detected in this specific area was limited only to a relatively low diversity of bird species and Eastern Grey Kangaroo. This low diversity is likely to be due to the poor structural diversity of the vegetation on the study site, which consisted predominantly of grazed pasture land and scattered trees and poses a barrier to movement of other species between isolated remnants or other significant areas eg to the southeast.

4.6.2.2 Property

The fauna detected on the site consisted of common mobile species and species capable of persisting in an agriculturally modified environment (NPWS 1995, Barret *et al* 1994, Fisher and Goldney 1997, Watson *et al* 2003, Ehmann 1997, Deacon and MacNally 1998, Dickman *et al* 2002, Gibbons and Lindenmayer 2002, Law *et al* 2000, Darkheart 2006b, 2005c, 2005i, 2005k, etc).

Amongst the mammals, the failure to detect the Squirrel Glider and Brushtail Phascogale by either trapping or spotlighting indicated a very low likelihood of the presence of these species on the property within the isolated remnants, though the Squirrel Glider is still a potential occurrence in the southeast portion of the property given a record in the adjacent STP (Biolink 2003).

Conversely, ground mammals were diverse in specific portions of the property and included two threatened species despite the extent of modification of the entire property. These could be relict populations restricted to possibly non-viable situations due to habitat loss and modification via progressive development of the property over recent decades (Lindenmayer and Fisher 2006).

The recording of a colony of Sugar Gliders in the Swamp Oak community was most unexpected given the lack of hollows, and detection on the ground suggests the colony was at least partly terrestrial.

Bird diversity was relatively low in the northeastern section of the property despite the extent of forest, with relatively few small passerines detected. This was likely to be due to the low structural diversity of the Swamp Oak community which represented the bulk of wooded vegetation in this part of the proposed northern corridor. Small passerines were more common in the southeast dry sclerophyll and associated swamp forest and dune scrub. In contrast, the large lagoons on the property significantly increased the diversity of waterfowl.

Suitable frog habitat was present throughout the property in drains, waterlogged pasture and around dams. However, most of this potential habitat was subject to physical disturbance by cattle, periodic slashing and presence of Plague Minnow. The large lagoons are considered to have relatively minimal significance for frogs with two areas of artificial habitat (a drain and the depression) containing threatened species.

Overall, the property contained a relatively low level of abundance with a limited diversity of arboreal mammals being detected; a moderate diversity of bird life; and few reptiles. However, the detection of populations of the Wallum Froglet, Eastern Chestnut Mouse in two locations, presence of Core Koala Habitat (Biolink 2003, 2005c) and the observation of the Wompoo Fruit Dove indicates that specific parts of the property maintains some valuable habitat assemblages, and lies adjacent to areas of habitat which may provide refuges or core habitat from which such species may use the habitat on the property as part of a wider range.

4.6.3 Recorded Threatened Species

A total of 9 threatened species have been recorded on the property by the consultants and previous studies, with the Swift Parrot apparently recorded by an unknown observer in the northern end. The following section evaluates the role of the study site and the property to the ecology of these species, and its value to the local population.

4.6.3.1 Square-Tailed Kite

4.7.3.1.1 Ecological Profile

The Square-Tailed Kite has an Australian population size of approximately 7000 breeding pairs (low reliability) and stable (low reliability), and it is classed as Least Concern in The Action Plan for Australian Birds (Garnett and Crowley 2000).

It typically inhabits coastal forested and wooded areas primarily within 250km of coast and rarely inland along wooded watercourses and in central Australia (Blakers *et al* 1984, Debus and Czechura 1989). Often associated with ridge and gully forests, Square-Tailed Kite usually prefers open eucalypt forest and woodland and will forage in open country or partially cleared pastoral country. It is never abundant anywhere, occurring as solitary birds or dispersed pairs. The Square-Tailed Kite has a marked preference for continuous stands of open forest/woodland. It may forage over mallee, heath and shrubs, and in wooded urban areas particularly if passerine birds present.

The Square-Tailed Kite is a specialist hunter of passerine birds, especially honeyeaters and nestlings, but also takes eggs, reptiles, rabbits and insects. It prefers to take prey from the outer foliage of the canopy; hunting in the morning and afternoon.

The home range of a pair is reportedly at least 100km^2 with ranges up to 1700km^2 being reported (AMBS 1996, Garnett 1993, Smith *et al* 1995, NPWS 2000).

Nests are constructed in mature, living trees in the fork or large horizontal limb of a tall eucalypt or angophora within forest, often near water. Breeding occurs in July to February (Debus and Czechura 1989). In southeast and southwest Australia, there is a recorded seasonal dispersal of this species north in the Winter and south in the Summer. This is more pronounced in the southwest (Smith *et al* 1995).

In recent years, breeding has been recorded in Kempsey-Wauchope Forestry Management Area and at Port Macquarie, where it is also known to tolerate human activity, even when nesting (Bischoff *et al* 2000). The Square-Tailed Kite may be adapting to well-vegetated outer fringes of cities in northern NSW, feeding on the plentiful introduced and native passerine birds there (Debus 1998).

4.6.3.1.2 Potential Site/Property Significance

This species was not detected on the study site during the survey; however, the consultant has recorded the species previously flying over the southern section of the property during other activities (Jason Berrigan pers. obs). It has also been observed within 2km both north and south of the site (DECC 2009a, Bionet 2009).

The study site offers limited value as a potential foraging resource for the species as passerines (preferred prey) were relatively rare on the site. However, a potential foraging resource of passerines is present in the dry sclerophyll communities and dune scrub. No nests were observed and nesting is considered unlikely on the site due to the limited forest area and paucity of potential nest trees. An unknown raptor nest of similar size to this species was observed on adjacent land just north of the property.

At the least, the site and property fall within the home range of a local pair; hence the Square-Tailed Kite was considered a low chance of occurrence on the site and at least a fair to moderate chance on the property using it opportunistically as part of its wider home range.

4.6.3.2 Eastern Chestnut Mouse

4.6.3.2.1 Ecological Profile

Large mouse patchily distributed within its range, predominantly within dense wet heath and swamp habitats, but also found in NSW within open areas of thick grassland; heathland amongst open forest; woodland within swampy areas; low closed scrub; and open woodland with grassy groundcover dominated by Bladey Grass and *Poa* spp on ridges, gullies and slopes (Fox 1998, Watts and Tweedie 1993, Meek and Triggs 1996, Luo *et a*l 1994, Luo and Fox 1995). These areas are usually associated with a short interval between fire events. This consultant has recorded this species next to sand dune Coastal Teatree scrub near Lake Cathie in an occasionally slashed paddock dominated by dense Spiny-Headed Matrush, Bracken Fern, Bladey Grass and patches of saw sedge (*Gahnia* spp).

Largely nocturnal with limited daytime movements. Uses and maintains runways under dense groundcover. Nest constructed out of grass above ground or part of a burrow complex. Breeds in NSW from about September to March, with breeding recorded peaking about 18 months after fire in heath to develop a density of 6 animals/ha. Average home range sizes likely to be <0.5ha, but has been recorded moving up to 250m (Fox 1998).

Overall an omnivorous rodent, with diet depending on seasonal availability of food, state of vegetation regeneration since fire and presence of the Swamp Rat which competitively suppresses the species as vegetation recovers (Fox 1998, Luo *et a*l 1994, Luo and Fox 1995). Seed makes up to 45% of diet in Summer, dropping to 20% in Autumn. Plant material primarily comprising of stem (leaves may used more in early regeneration stages due to availability) varying from 25-40% in Autumn and Winter respectively. Fungi particularly myphageous is consumed mainly in Winter (25%) and a little less in other seasons except Summer (2%) where insects become more important (due to their availability). Fungi use is also limited by abundance of the Swamp Rat (Luo *et al* 1994).

4.6.3.2.2 Site Occurrence Evaluation Significance

A lack of suitable habitat on the study site and hence no potential to occur eliminated the need/practicality to conduct Elliot A trapping on the site for this species.

4.6.3.2.3 Property Occurrence Evaluation

The Eastern Chestnut Mouse has been detected on two separate portions of the property during surveying in 2003 at the following locations (refer to figure 12):

- East of Duchess Gully in an area dominated by dense Matrush, Bracken Fern and Bladey Grass.
- Narrow drain dominated by *Babingtonia pluriflora* and sedges (both species), and in adjacent rank Bladey Grass in the southwest corner.

Other areas of potential habitat occur on the property as follows:

- An area of tall grass within the central Paperbark/Swamp Mahogany/Swamp Oak swamp forest west of the large lagoons was considered to have some potential, though survey in 2003 failed to detect the species here.

- Small areas of Saw Sedge and Matrush present in the northeastern Swamp Oak community offered some broadly suitable potential habitat, but again, survey failed to detect the species, recording only Sugar Gliders, Swamp Rats and Brown Antechinus. Some areas of grassland in the southeastern section of the Swamp Oak were comprised of a dense cover to 1m high of Bladey Grass and other grasses, and these were located near the confluence of the drains with their associated aquatic/wetland vegetation. Although regularly disturbed by cattle, this area may provide marginal potential habitat. Overall though, this vegetation is all regrowth and is rather isolated from other potential habitat or known habitat, and has been for some time. At the best it tentatively connected to the area of known Eastern Chestnut Mouse east of Duchess Gully hence potential for this species to colonise this area is significantly limited.

- The southern sections of the southeast dry sclerophyll and perhaps the southeast swamp forest may also provide potential habitat for the species. Only the dry sclerophyll has been surveyed, without result.

The population of Eastern Chestnut Mouse east of Duchess Gully occupies an area of habitat that, if allowed, would regenerate in the long term into coastal scrub which would probably have lesser habitat values for this species eg loss of continuous groundcover. The previous infrequent slashing may have mimicked the regular disturbance regime this species prefers normally by fire (Fox 1991, Luo and Fox 1993, 1994). Adjacent coastal scrub, the drainage line in the grassland, and the dry sclerophyll on the eastern side of Duchess Gully, probably provide temporary refuge following infrequent slashing events (one of which occurred during the 2006 survey, and a site visit in 2008 noted slashing has been undertaken again with litter indicating, at best, limited height of vegetation, in turn suggesting slashing frequency has increased). However, if slashing were to become regular (as it appears), this could lead to a detrimental shift in the structural and floristic nature (eg conversion to low pasture grasses, or lack of sufficient stratum height to provide cover from predators) of this habitat, and probably long term exclusion of this species from this area, and possible extinction if adjacent habitats are not suitable to maintain the population. Given slashing frequency appears to have recently increased, updated survey may be required to determine if this species remains in adjacent vegetation, or is now locally extinct.

In terms of the wider area, this population appears to be isolated given the forest and scrub around the STP, the southeast corner of the site, and the vegetation associated with the dune complex is the only interconnected habitat available (see aerial photo in figure 10). Surveys in northeast Bonny Hills (Darkheart 2005a, 2005b) and in the littoral rainforest north to Middle Head (Berrigan and Bray 2002, Parker 2002) have failed to detect this species. This suggests that this population is generally restricted to a finite area, and hence has doubt in regards to long term genetic viability and is at high risk of extinction due to catastrophic events (eg extensive bushfire), and/or via habitat modification (eg via frequent slashing of the native grassland).

The other, also small, population in the southwestern corner of the property was found to be persisting in , <1ha of rank Bladey Grass under the western dry sclerophyll, which appears to escape slashing due to uneven ground; and adjacent portions of an associated overgrown drain which also appears to have escaped total slashing due to wet conditions. The southwest population is essentially isolated from the eastern population due to historical clearing which has removed the formerly more extensive swamp forest that occurred over a significant portion of the middle south of the property (Clancy and Ayres 1983). An extremely tenuous permanent link is provided by the major drain running from the western swamp forest remnant to the central remnant, which has a patch of rank *Setaria* and regrowth shrubs which may be suitable habitat. Between this latter area and the southwest dry sclerophyll and southeast swamp forest, is pasture/pastoral woodland whose height varies with the most recent slashing event. However, any individual using this as a corridor would be at high risk of predation especially along the drain. In wetter years, most of the pasture/pastoral woodland in the southwest may not be slashed for some time and this could provide a better potential link to the central swamp forest to the STP. Dedication and rehabilitation of this area as a wildlife corridor as proposed in the UIA 14 Structure Plan could have a significant benefit on the long term viability of both populations.

However, the southwest population is currently at very high risk of extinction due to limited potential refugia (eg the remnants of shrubland around the drain), if slashing were to be more intense in one year, or extensive fire burnt out the entire habitat area (highly possible given the state of the Bladey Grass). It is also essentially isolated from other potential habitat to the west or southwest due to Ocean Drive, rural-residential development and pasture. Hence its long term genetic integrity is considered significantly limited without an effective avenue for dispersal and genetic exchange.

Both populations are considered to potentially be the last relics of a formerly larger population which occupied formerly extensive swamp forest/sedgeland across the southern low lying plain, as suggested in the historical aerial photo in figure 4. Subsequent drainage, clearing, pastoralism and creation of the dams/lagoons may have lead to loss of most of the original population, with the relic groups marginally persisting in the fragments of habitat that have remained. Restoration of a significant portion of the southern low lying plain into swamp forest as proposed in the Open Space Management Strategy (Cardno 2008) will significantly increase the extent of potential habitat for this species, but due to the limited size of the current population, some inflow of genetic material will be required to assure a viable population. The likelihood of this is limited given the barrier posed by Ocean Drive and adjacent modified rural land, and lack of records in neighbouring habitats (DECC 2009b, Bionet 2009, Darkheart 2004q, 2005a, 2005b, 2007c, Parker 2002, Berrigan and Bray 2002).

4.6.3.3 Common Planigale

4.6.3.3.1 Ecological Profile

Habitat requirements vary widely. It has been recorded in rainforest, sclerophyll forests, grasslands, marshlands, rocky areas and within vegetated reserves/gardens of urban areas. Most commonly recorded in heath as well as swampy areas near areas containing trees, scrub, sedges and/or grass. This consultant has recorded the species in dunal dry sclerophyll forest dominated by Blackbutt and Pink Bloodwood with a groundcover of Bracken Fern, Spiny-Headed Matrush and Bladey Grass (Berrigan 2002c); *Melaleuca quinquenervia* swamp forest with a dense groundcover of Spiny-Headed Matrush or sedges (Berrigan 2003f); and heathland with groundcover of sedges such as *Restio* spp (Berrigan 2002c).

May prefer dry-wet habitat ecotones (Denny 1982) were it preys on wide range of insects (Redhead 1991). Specific ecological requirements are poorly known (Smith *et al* 1995). Extremely small body size suggests need to inhabit wet habitats or dense vegetation to avoid heat/dehydration problems (SWC 1993). Home range size predicted to be around 0.5ha.

4.6.3.3.2 Site Occurrence Evaluation

A lack of suitable habitat on the study site and hence no potential to occur eliminated the need/practicality to survey the site for this species.

4.6.3.3.3 Property Occurrence Evaluation

This species was detected as a single female in the *Babingtonia pluriflora* dominated drain adjunct to the southwest dry sclerophyll forest patch in the southwest in 2003. Other areas on the property identified as potential habitat for the Eastern Chestnut Mouse (ie areas where groundcover is dense) are also considered to offer potential for this species, with the same limitations eg limited connectivity. This species was also considered a potential occurrence in the dune scrub and southeastern dry sclerophyll forest/swamp forest given records in similar habitat (Berrigan 2002a), however targeted survey in these areas failed to detect other populations.

As for the Eastern Chestnut Mouse, the population of this species in the southwest may be the last relic of the original population before the last phase of major habitat loss on the property in the 1980's, and is considered virtually isolated, and hence at very high risk of extinction via catastrophe (extensive fire

or slashing), breeding failure (high risk given the ecology of dasyurids) and inbreeding, even if the extent of habitat is increased as per the Concept Plan Application. Establishment of an effective corridor in the southwest linking to the east however, would probably be a positive impact on the long term viability of this population via at least increasing the potential likelihood of immigration and emigration.

4.6.3.4 Little Bent-Wing Bat

4.6.3.4.1 Ecological Profile

Similar in appearance, these species are known to share roosting and nursery habitats with the Common Bent-Wing Bat. Both species mainly roost in caves, mines, culverts, tunnels, buildings etc generally located close to or within dense vegetation, although the Little Bent-Wing Bat has been recording roosting in banana bunches during Winter (Hulm 1994) and both species in tree hollows (Schultz, referred to in AMBS 1996b). Both species are limited by the availability of nursery caves. The Macleay valley has the southernmost population of Little-Bent Wing Bats, which seem to depend on a larger nursery colony of Common Bent-Wing Bats to provide environmental conditions (Dwyer 1991, 1968). These nursery caves are protected in Willi Willi National Park, and are the only Little-Bent Wing Bat maternity caves known in NSW (Smith *et al* 1995) as of 1983. Another maternity cave of the Common Bent-Wing Bat occurs near Riverton (western tablelands) (Dwyer 1966).

Most roost sites selected by colonies of the Common Bent-Wing Bat are typified by their spaciousness and usually ease of access (although some caves, eg the Willi Willi maternity cave, may have restricted entrances). Most roosts in northeast NSW are sufficiently deep to provide portions of complete darkness which these species prefer for roosting (Dwyer 1966, 1968, personal observations). Dwyer (1966, 1968) found that many caves and mines in northeastern NSW not occupied were often very small or had restricted entrances via complicated vertical drops. Small caves are typically not able to provide adequate darkness or humidity, while restricted entrances are unsuitable to these fast-flying and relatively non-manoeuvrable species (Dwyer 1966). Within a roost, bats normally occur in clusters of varying numbers arranged by sex and breeding status (Dwyer 1966, 1968).

These species move and utilise different kinds of roost according to various stages of the lifecycle (Strahan 1995, Dwyer 19966, 1968) ie:

- *Mating roosts*: Consist of a constant male colony visited by transient females (April to mid-June). The main mating cave in the region appears to in the Willi Willi area (Carrai) and Back Creek.
- *Over-Wintering roosts*: Formed from February to July (region dependant) as the colonies appear to widely scatter over the region utilising a range of smaller roosts (possibly as individuals and small Winter colonies in smaller caves, etc, or as sizeable groups of thousands eg Wombeyan), or some larger roosts eg Yessabah, where they may enter short term torpor. Such caves are likely to offer relatively low temperatures that approximate the Winter mean for the area. This patterns continues till they (when the season warms) move to,
- *Acclimatisation roosts*: Several formed en route to maternity colonies, gradually larger with proximity to maternity caves. Used to acclimatise to high humidity levels to be experienced in maternity caves. Utilised till they move to,
- *Maternity/nursery caves*: Peaks around September to November. Where young are born and left when old enough while female forages. For both species, these are located in Willi Willi Nature Reserve, with other nearby caves also serving key functions. Females disperse to mating roosts following this season (usually by March).

Immature bats also utilise specific roosts in the first year after leaving the nursery eg Yessabah. Hulm (1994) considers all such roosts to provide key lifecycle roles, and thus have to be protected.

The Common Bent-Wing Bat is considered a habitat generalist, foraging for insects above and below the canopy in well-timbered valleys, containing wet and dry tall forest. This species may migrate large distances to maternity sites, travelling 60-70km a night (females have been recorded moving >160km

and juveniles dispersing >300km), utilising its range of roosts according to seasonal needs, age and reproductive status. This species occurs in discrete territorial populations based on maternity colonies whose ranges are often determined by watershed boundaries (Smith *et al* 1995), usually within 300km (Churchill 1998). Movement between territories is unusual, though distances of 1300km have been recorded (Churchill 1998).

The Little Bent-Wing Bat and Common Bent-Wing Bat generally forages above and beneath the canopy of tropical rainforest, warm temperate rainforest, tall open forest, riparian forest and dry sclerophyll forest, and in/on the edge of clearings adjacent to forest (Dwyer 1991, Smith *et al* 1995, Berrigan 2001d). Often recorded flying along tracks under canopy or forest edge (eg Berrigan 2001d, 2001e, 1998a, 1998b).

The main cause of mortality is young falling from the roof of nursery caves. Predators include the Green Tree Frog, pythons, feral cat, fox and owls (Dwyer 2000a, 2000b).

4.6.3.4.2 Site/Property Occurrence Evaluation

The Little Bent-Wing Bat was confidently recorded in 2003 and 2006 on the property, indicating it is regularly used by the species for foraging as part of its non-breeding range. The 2003 record was considered to be a bat observed foraging in the southeast dry sclerophyll forest along the fire trail along the boundary fence to the sewage treatment plant. It may generally forage over the study site but is considered more likely to occur foraging along tracks in forest and along the forest/woodland and pasture ecotone based on observations in similar habitats (eg Darkheart 2004q, 2006b, 2006f, 2006i, etc). The Little Bent-Wing Bat has also been recorded within 1km of the property (Darkheart 2004q, 2005b).

There are no caves, etc on site, but a relatively large culvert under Ocean Drive in the west may offer some marginal potential as a roost. Tree hollows potentially suitable for this species mostly in the pastoral woodland and also in the dry sclerophyll forest and these collectively offer better potential as non-breeding seasonal roosts.

4.6.3.5 Wallum Froglet

4.6.3.5.1 Ecological Profile

The Wallum Froglet inhabits relatively specific habitats such as acidic paperbark (*Melaleuca*) swamps, *Melaleuca*-Swamp Mahogany forest, Sedgeland, *Blechnum* (fern) swamps and ephemeral bogs, low closed scrub, warm temperate grasslands and wet heath. Occurrences in temporarily flooded areas, such as tall pasture adjacent to swamps/wetlands and heaths, are not infrequent (Robinson 1995, Cogger 1992, Tyler 1992, EEC 1998). This consultant has recorded this species in flooded pasture next to a remnant wetland (Berrigan 2002a), and on the side of a hill near a Spring dominated by *Melaleuca quinquenervia* with a dense *Gahnia* spp groundcover (Berrigan 2003e)

Breeding appears to mainly occur within shallow, ephemeral water bodies, often after heavy local Winter rainfall and/or flooding. During drier periods, it retreats to denser moist vegetation eg closed heath, and emerges when suitable moist conditions occur. It does not usually occupy permanent water bodies, and avoids deep water (EEC 1998).

4.6.3.5.2 Site Occurrence Evaluation

The site is not considered to offer any suitable habitat for this species unless broadscale flooding occurred in which case some of the low-lying sections of the pasture (eg where the proposed filling is to occur) could offer potential habitat for frogs washed out of known habitat. However, periodic slashing removing potential refuges and lack of reliable rainfall to generate breeding events reduces the potential for this to occur in such marginal areas away from core areas.

4.6.3.5.3 Property Occurrence Evaluation

The Wallum Froglet has been recorded in two locations in the southern end of the property:

- In 2003, at least 50 males were recorded in a depression possibly formed by excavation and formerly occupied by wet heath just north of the eastern large lagoon. In 2006, this habitat was found to have been slashed in subsequent drier years, however at least a small population of the frog appears to have survived.

- In 2003, at least 2 males were recorded calling from the drain (southeast off the edge of the western dry sclerophyll remnants) dominated by scrub/heath in the southwest corner.

Surveys in the Swamp Oak swamp forest, Duchess Gully and drains on the property have failed to detect the species in these areas. The drains in the northeastern section hold ephemeral water with some emergent vegetation, and together with seepage areas at the edge of Swamp Oak forest, may offer some marginal potential breeding habitat in broad structural terms. However, the marginal habitat, disturbance history (see figure 4), lack of connectivity, and failure to detect this species in these areas by successive surveys, despite occurrences on the remainder of the property, suggests it is not a likely occurrence in these areas.

The survival of the population in the depression after apparently several slashing events post-2003 was unexpected given the major loss of cover and high exposure to predation. It appears that they have survived via taking refuge under dried algae and detritus from slashing. A similar phenomenon has been observed by the consultant elsewhere where the frog has dispersed from a refuge following heavy rainfall and called from under slashed grass (Berrigan 2002a). If this habitat is allowed to regenerate, this population may recover, however it is also an isolated population and hence at risk of long term genetic degradation, and is prone to risk of extinction via a catastrophic event eg fire. Given the limited potential for long terrestrial movements (DECC 2009b), the only potential genetic link is perhaps a major storm event which could wash individuals downstream from other known habitat (eg Darkheart 2004q).

The small population in the drainage line in the southwest is even more at risk of extinction due to limited genetic diversity and/or a catastrophic event. Again this population may have originated from individuals washed down in a major storm event from known upstream habitat (eg Darkheart 2004q), or are a relic of the formerly more extensive habitat on the property (ie see figure 4). In very wet years, the adjacent pasture/pastoral woodland could offer a large area of ephemeral potential habitat which could allow establishment of new individuals or expansion of the current population, and possibly even dispersal to the east (eg via washing down the main drain to the dams/lagoons or moving through the network of smaller dish drains, and then moving to the eastern depression). In this context and as demonstrated by the survey, the drain habitat is obviously a key refuge for this small population.

4.6.3.6 Wompoo Fruit-Dove

4.6.3.6.1 Ecological Profile

Recorded from large, undisturbed tracts of sub-tropical rainforest, dry rainforest, littoral rainforest, warm temperate rainforest and wet sclerophyll forests with a rainforest mid-storey. Occasionally in monsoon forest, tall open forest, open woodlands and vine thickets near rainforest (Marchant and Higgins 1993). This species demonstrates a preference for undisturbed or less disturbed moist forest and rainforest (Lindsey 1992). The Wompoo Fruit Dove is essentially restricted to central and northeastern NSW (Recher *et al* 1995).

Feeds almost entirely on fruit, foraging primarily high in canopy. Relatively sedentary to locally nomadic with dispersal over a local area according to fruiting pattern of preferred species (figs, native

tamarind, myrtles, laurels, lily pillys, Bangalow Palm, White Cedar, *Smilax australis*, oliveberry and pigeonberry trees). Favoured species include: *Ficus macrophylla, F. fraseri. F. rubiginosa, F. watkinsiana,* Wild Tobacco (*Solanum maritianum*), *Acronychia oblongifolia*, *Neolitsea dealbata* and *Cissus antarctica* (Recher *et al* 1995).

Breeding habitat is dense rainforest, with timing according to fruiting patterns (generally July-September). Nest a flimsy platform of vine tendrils located on slender horizontal branches in the dense rainforest canopy, generally below 10m and as low as 2m above ground.

The NSW population probably exceeds 7000 birds (Recher *et a*l 1995). The extent of the local population would be those individuals who use the locality as a seasonal forage resource.

4.6.3.6.2 Site and Property Occurrence Evaluation

This bird was observed on a chance occasion roosting in a tree in the southwest of the property, and as a few individuals flying along the littoral rainforest off the eastern boundary of property in 2003 by the consultant.

Neither the site or the remainder of the property offers any significant habitat for this species other than a handful of rainforest trees along Duchess Gully which are highly exposed. Its occurrence on the property is considered merely incidental. The adjacent littoral rainforest up to Middle Head is considered likely to be used seasonally as part of the species' wider non-breeding foraging range and as a "stepping stone" between larger remnants such as Sea Acres Nature Reserve (DECC Atlas of Wildlife 2008a).

4.6.3.7 Swift Parrot

4.6.3.7.1 Ecological Profile

This bird lives in eucalypt forests and woodlands, particularly box-ironbark, and feeds primarily on mostly on pollen and nectar of Winter flowering eucalypts, but also feeds on fruit, seeds, lerps and insect larvae (Schode and Tideman 1990, Brereton 1996, Garnett and Crowley 2000). Preferred sites have high soil fertility and large trees with large nectar production; often along drainage lines, or in isolated or small rural or urban remnants (Emison *et al* 1987, Tzaros 1996 and 1997. Favoured species are *E. robusta*, *Corymbia gummifera*, *E. globulus, E. sideroxylon, E. leucoxylon, E. labens, E. ovata, C. maculata, Banksia serrata* and *B. integrifolia*

This species only breeds in Tasmania (mostly along the southeastern coast, within 8km of the coastline). Nesting occurs in hollow bearing trees usually away from foraging sites.

Post-breeding (from about January), the species disperses throughout Tasmania and the mainland (Autumn onwards) from southeast South Australia (to the Adelaide Plains), along the coast and inland slopes of the Great Dividing Range, up to southeast Queensland (Duaringa and Chinchilla). Non-breeding birds are highly mobile, with movements varying between years (some sites are used repeatedly). Mainland sites usage varies year to year, probably also due to nectar availability (Wilson and Bennet 1999). Migrants return in Spring, forming flocks (Brereton 1996). The species is usually found on the mainland from March to September (Smith *et al* 1995).

The Swift Parrot is predicted to occur over 860 000km^2 (medium confidence), with only about 4000km^2 occupied and decreasing (low confidence). There are estimated to be about 1300-2000 breeding pairs: decreasing (Birds Australia 2002, Garnett and Crowley 2000).

4.6.3.7.2 Site and Property Occurrence Evaluation

A record of this species appears to fall in the northwestern corner end of the property, though this record may actually be within a 1km range due to the data format used for the Atlas of Wildlife (DECC 2009a, pers. comm.).

The property contains a relatively good extent of potential forage for this species in the form of Forest Red Gums (mostly in the pastoral woodland), Swamp Mahogany in the swamp forest communities, and *Banksia integrifolia* in the southeast dry sclerophyll forest. The latter species is also very common along the adjacent coastline in dune scrub (Berrigan and Bray 2002), hence the general area has good potential to attract this seasonally nomadic species. However, the property's values are declining as all the Forest Red Gums in the woodland are dying back and will eventually succumb. This will leave habitat only in the swamp forest and limited habitat in the southeast dry sclerophyll forest on site.

4.6.3.8 Koala

4.6.3.8.1 Ecological Profile

(a) Diet:

Koalas feed primarily but not exclusively on (and also intra-specifically, depending on poorly understood edaphic, chemical and socio-behavioural factors) selected species of the genus *Eucalyptus*. Nationally, they have been observed feeding or resting in about 120 eucalypt species (66 in NSW) and 30 non-eucalypt (7 in NSW) species. In the Hastings and Macleay regions, some eucalypt species not listed under Schedule 2 of SEPP 44 that are known to be used by Koalas are: *E. amplifolia, E. seeana* and *E. propinqua.* Non-endemic species also used by Koalas include *E. nicholii* and *E. citriodora.*

Some non-eucalypt species reported to be used for feeding or other behavioural purposes (some in this region) are *Acacia costata, A. mearnsii, A. melanoxylon, Allocasuarina torulosa, Bombax malabrica, Lophostemon conferta, L. suaveolens, Exocarpus cupressiformis, Leptospermum laevigatum, Melaleuca ericifolia, M. quinquenervia, Pinus radiata* and *Cinnamonum camphora* (Martin and Lee 1984, Kel Mackay pers. comm.). Koalas have also been observed using trees with dense foliage or retreating to rainforest during adverse weather such as high temperatures, strong wind or heavy rain (Jurskis and Potter 1997).

Research by the Australian Koala Foundation (AKF) suggests that usage of habitat by Koalas may be a function of the abundance of the present species. The AKF describes Primary Habitat as areas where the dominant tree species are preferred browse species, with their usage being independent of the species' density. However, in some areas, a species considered a secondary browse species may be preferentially used as a primary tree, often where its occurrence in the area is infrequent.

A Koala food tree is usually identified by a significant number of scats at its base, though such trees may also be used for roosting. Contrary to a long held assumption though, observation of Koalas resting in a tree does not always indicate that it is a feed tree (Phillips 2000b, NPWS 2003).

Koalas appear to prefer young leaves rather than mature leaves, and preferred foliage usually has a threshold for minimum moisture content (which may vary seasonally) and nitrogen content (Jurskis and Potter 1997, Pahl and Hume 1990). Other studies have also shown threshold levels for essential oils, with preferred species having more volatile oils and less heavy oils (Hume 1995); preferences for higher concentrations of crude protein, phosphorous and potassium, and lower concentrations of fibre (Ullrey et al 1981); and more simple sugars and less complex sugars (Osawa 1993). These components all vary interspecifically and intraspecifically, and factors such as species, age, size and crown condition also influence the physiological processes that ultimately affect nutritional quality and palatability, especially in a suboptimal environment (Jurskis and Potter 1997).

Species, individual tree and foliage selection for browsing by Koalas hence, is still poorly understood. In addition to the above, it also varies with season (which may be an indication of varying nutritional value), as well as location (Koalas may feed on one particular species at a specific location, and ignore it at another); and may also be influenced by local abundance of food species, as well as social organisation of the population (Hindell and Lee 1990; Reed *et al*., 1990). As mentioned above, nutritional quality of individual trees may also be a factor, with nutrition shown to vary inter and intraspecifically (Braithwaite *et al*., 1983; Anon 1999).

Usage may also be determined by site-dependant edaphic factors eg soil type (Sharp and Phillips 1999), which affects the nutrient quality of forage. A gradient in nutrient concentration in soils and foliage is a major determinant of the distribution of arboreal fauna (Anon 1999, Gibbons and Lindenmayer 2002). Forest consisting of primary browse species associations located on deep, fertile soils on floodplains, in gullies and along watercourses are generally considered preferred habitat. This may possibly be a reflection of the nutritional value of the foliage.

Other research suggests that concentrations of plant chemical defences (especially diformyl-phloroglucinols or DFPs) may be a key factor. Koalas may be selecting trees with lower concentrations of DFPs. This would suggest that Koala preference is not based on species, but on an individual tree basis, as DFP levels vary intraspecifically as well as interspecifically (Anon 1999). DFP level also does not appear to vary due to environmental factors, as trees of the same species within the same area can vary widely (Anon 1999).

Structural features may also be important in individual tree selection. For example, on hot days, Koalas are often observed in trees with greater foliage cover. Large trees are thought by some researchers to be preferred for their greater amount of foliage which reduces the need for returning to the ground to move to another tree and thus risking predator attack (Hindell and Lee 1990; Reed *et al.,*1990). However, research in other areas has found highest activity on younger trees eg 20-30cm trunk DBH (Mackay 1996) which could be a function of nutrition (eg varies with vigour/health or age) or forest structure (eg age classes may have been modified by logging) (Jurskis and Potter 1997).

Research for the Pine Creek State Forest KPOM (Smith and Andrews 1997) found a preference for trees with trunk DBH 40-100cm (and a dislike for <20cm DBH), while Lunney *et al* (1999) found a preference for trees from 50-60cm DBH in the Coffs Harbour area.

Jurskis and Potter (1997) suggest that climbing "mechanics" may be a factor, as they found Koalas near Eden to prefer trees 30-90cm diameter. They suggest Koalas climb more efficiently if tree diameter is close to the combined reach of the forelegs, and they are physically/mechanically disadvantaged when tree width is significantly less than the Koalas reach.

(b) Home Range

Home range is the territory of a single Koala, usually occupied for at least several years, or more commonly throughout its life (Phillips 1997, Sharp and Phillip 1999). Size may vary from a hectare to hundreds of hectares (eg Jurskis and Potter 1997 report home ranges of 38-520ha, with average of 169ha, near Eden); varying with habitat quality (eg if primary browse species dominate the tree component, home range size is expected to be small and carrying capacity high), sex (males have larger territories and may make forays into other areas), age of the animals (eg sub-adults versus adults), and location (Jurskis and Potter 1997, Phillips 1997, Sharp and Phillip 1999).

Home range and hence Koala density varies per region due to the above factors. For example, Jurskis and Potter (1997) collated Koala densities from Queensland to Victoria, and showed Koala density ranging from 0.006-7.5 Koalas/ha. Koalas have been recorded at very low densities in areas as a result of dispersed food resources and possibly due to historical disturbances eg clearing of fertile lands for agriculture (eg Jurskis and Potter 1997). Within such large home ranges, a few specific areas may be subject to a relatively higher level of use, while others are less commonly used (Jurskis and Potter 1997).

As mentioned previously, the alpha male has a large home range to overlap those of his females, thus he may include secondary (lower quality) habitat within his home range to achieve this. The alpha male's home range is also vigorously defended from other males to ensure rights to food resources and females (Phillips 1997).

In the initial stages of independence, young female Koalas usually remain within their mother's home range for about a year, until they establish their own, often overlapping with their mother's, or dispersing to other aggregates. In contrast, a young male is often turned out of the maternal home range (usually around 2 years of age) and becomes a nomad (forced out of other Koala home ranges by the dominant males especially during breeding season) for up to 3-4 years, until they are of sufficient size to establish their own home range. During their younger years, these males may be forced into marginal habitats, and become more generalist in their dietary intake.

Both sexes may travel and are also capable of traversing large distances, depending on demand (eg up to 50km over a few weeks or months), which is more often driven by the need to find other Koalas (ie to mate), than potential habitat (Phillips 1997). Movements, distances and reasons for such movements are considered complex and poorly understood (Dr Steven Phillips, pers. comm.). Distance travelled per day will vary with many factors such as topography, distance between forage trees, season/climate, breeding state, and threats. Koalas have been recorded moving from 10m to several hundred metres during the day, and >1.3km overnight when they are typically more active (Jurskis and Potter 1997, Kel Mackay pers. comm.). Movement is greatest during the breeding season, especially by males (Kel Mackay, pers. comm.), with a female recorded moving 2.6km out of its range to mate, presumably in response to male territorial calls, and returned to its home range (Lee and Martin 1998, Lee *et al* 1998).

(c) Home Range Trees

Within a home range, a few specific trees (*home range trees*) are used by Koalas to mark territories and identify individual Koalas. Such trees are recognisable by heavy scratching and collections of scats close to the tree base, and may also have significant forage value (Phillips and Callaghan 1995, Hume 1989). Male Koalas may leave their scent by rubbing the gland on their chest against the bark. Koalas frequently return to these trees, or deliberately seek them out during travel (Koalas have been recognised to have the ability to know where they are and return to a discrete location (Phillips 1997). Such trees are very important as they maintain social cohesion through identification of population members and assist geographical location (Phillips 1997, Sharp and Phillips 1999).

4.6.3.8.2 Site and Property Occurrence Evaluation

Despite historical records of Koalas on the property (Clancy and Ayres 1983, Atlas of Wildlife 2008), and the presence of variable quality and limited extent of Potential Koala Habitat, only a single Koala was seen once by the consultant in the period 2003-2007. Scats were only detected in the southeast Paperbark/Swamp Mahogany swamp forest, where an Area of Major Activity was determined via the SAT.

The single Koala observed by this consultant in 2007 was near the edge of the southeast dry sclerophyll forest, which correlated with work by Biolink (2003, 2005c), who recorded Koala activity (sightings and Area of Major Activity) around the Bonny Hills sewage treatment plant, most significantly in the swamp forest on the western side of the STP, which mostly falls on the property. Biolink identified Core Koala Habitat in these areas, hence the southeast corner of the property forms part of an area of Core Koala Habitat. The UIA 14 Koala Plan of Management (Biolink 200c) covers this area and hence has appropriate management provisions for the property.

Consideration of the findings of these studies, previous and subsequent studies by this and other consultants (Biolink 2003, Connell Wagner 2000b), local records (DECC 2009a, Bionet 2009, BHPA 2007, Darkheart 2005a, 2005b, 2004q, 2007a, 2007c), and discussions with Dr Steven Phillips, leads

to the opinion that a discrete population of Koalas occurs in the limited area of remnant habitat in the northeastern side of Bonny Hills. This area includes remnants and urban woodland within the SEPP 14 area enclosed in the Ocean Woods Estate area; forest around Duchess Gully and Bonny Hills sewage treatment plant; habitat along Saltwater Creek; and the limited habitat in Rainbow Beach Holliday Village. It is hypothesised that this discrete population essentially survives in the northeast of Bonny Hills and immediate western and southern environs, as suggested by community records concentrated within Bonny Hills, and major studies to the west and southwest of Bonny Hills finding minimal Koala activity (Darkheart 2007a, 2007c, 2004q).

Lack of Koala activity on the remainder of the property is considered to be reflection of the immaturity of much of the habitat (eg much of Potential Koala Habitat is regrowth), poor linkage (eg extensive open ground or unsuitable habitat between remnants, with high predator exposure), and Koala ecology (ie the desire to be near an established colony).

4.6.3.9 Grey-Headed Flying Fox

4.6.3.9.1 Ecological Profile

Refer to section 4.3.5.1

4.6.3.9.2 Site and Property Occurrence Evaluation

Several individuals were recorded foraging on flowering trees on the property. This was reasonably expected given the potential food sources, plethora of local records and presence of major colonial roosts in the locality. The presence of potential Autumn-Spring flowering species such as Swamp Mahogany, Forest Red Gum, *Banksia integrifolia,* Grey Ironbark and Broad-Leaved Paperbark is particularly significant given this is generally a period of seasonal shortage in nectar flows.

Overall, the property has capacity only to form a small part of the very large foraging range of this species which varies according to incidences of flowering and fruiting (see section 4.3.5.1).

4.6.4 Potentially Occurring Threatened Fauna Species

As detailed in section 3.3.1, a significant number of threatened species have been recorded in the locality and/or in habitats similar to that on and near the site/property in the North Coast Bioregion. These species are discussed further in section 10 and Appendix 1, and assessed for their potential occurrence on site and the broader property based on a review of local and regional records, habitat evaluation and the survey results (see Appendix 1). As a result of this assessment, the following species are considered significant (ie at least "fair") potential occurrences on the property:

- **Mammals**: Common Bent-Wing Bat, Greater Broad-Nosed Bat, Eastern Freetail Bat, Yellow-Bellied Sheathtail Bat, Eastern Blossom Bat, Squirrel Glider.

- **Birds**: Jabiru/Black Necked Stork, Osprey, Glossy Black Cockatoo, Powerful Owl, Masked Owl, Barking Owl, Blue Billed-Duck, Black Bittern, Australasian Bittern, Little Lorikeet, Little Eagle.

4.6.5 Other Locally and Regionally Recorded Threatened Species

As noted previously, a significant number of other threatened species have been recorded in the locality or regionally in habitats similar to those within the locality. These species were considered to have lesser or no potential to occur on site or property due to lack of suitable habitat, or the habitat limitations of the site and larger property imposed by a history of periodically extensive disturbances (eg logging, under-scrubbing, fire, etc) which are considered to have had a significant effect on the site's habitability and carrying capacity to support most of these species. Consequently, there are a number of major

ecological factors limiting its habitat potential for most threatened species recorded in the locality, such as:

- *State of significant structural and floristic modification of the site vegetation* (especially the understorey and groundcover):
  - Loss/modification and disturbance of potential and known habitat (eg understorey and groundcover) through clearing
    - gross alteration to structural and floristic diversity leading to simpler communities
    - displacement of resident species via loss/modification of habitat or invasion by competitors (native and exotic)
    - increased competition for scarce resources and habitats
    - impacts on ecological processes, eg recruitment of hollow-bearing trees, seed establishment, recovery of moist sclerophyll community.
    - declining carrying capacity of the area due to unpredictability of disturbance
    - fragmentation of larger remnants in the general area into smaller patches, leading to increased edge effects, lack of interconnectivity/isolation, etc.

- *Lack of abundance or diversity of prey species* i.e. arboreal mammals, invertebrates, passerine birds, etc, due to lack/loss of habitat; constant interruption to life cycle stages (eg breeding, torpor, dispersal and recruitment); loss of refuge, foraging and nesting habitat; etc

- *Insufficient time for recovery of habitats and habitat components as result of periodic disturbance (eg logging) or secondary processes (eg weed invasion)*: For example, although some habitat components exist (eg tree hollows), other key resources (eg preferred forage or prey species) are either absent, limited in development or insufficient in abundance, and thus incapable of supporting the dependent threatened species.

Overall, the limited extent of habitat on site and the property and study area's history of disturbance were considered to have restricted the site's potential for those threatened species sensitive to disturbance. However, the site has retained values for some threatened species especially those that are habitat generalists (eg Microchiropteran bats) or species that can persist by being tolerant of the habitat modifications endured by the site (eg by having large ranges and thereby including more natural areas within their range).

5.0 POTENTIAL IMPACTS OF THE DEVELOPMENT

This section addresses the following Project Application DGR's:

- *PA 4.1: Outline potential impacts on flora and fauna and their habitats (within the meaning of the Threatened Species Conservation Act 1995) across the site and where relevant provide conservation measures.*

The impacts of the Concept Plan Application are only to be considered in very broad terms as per the relevant DGRs (CP 7.3 & CP 7.4). As specific designs for each element of the Concept Plan are not currently known, then a more specific assessment of the Concept Plan elements will be required with future applications.

Threatened species recorded on the property or considered likely to occur, and identified occurrences of EECs, are specifically evaluated in subsequent sections.

5.1 HABITAT MODIFICATION AND DIRECT THREATS

This section gives a general description of processes and impacts that may arise from the development proposal, with specific evaluation for threatened species that could occur on property and considered at least fairly likely to occur (as determined in Appendix 1), given in later sections. Ameliorative measures and recommendations to mitigate or avoid these impacts are provided in section 6.0.

5.1.1. Establishment of the Proposal

5.1.1.1 Proposal Design

5.1.1.1.1 General Description

(a) **Constructed Wetlands**:

As shown in figures 3A and 3B, the primary proposal is to establish an approximately 10.72ha constructed wetland surrounded by public areas and vegetation. This multifunction waterbody is primarily intended to win the fill required to raise the low lying plains to the west, northwest and north of the wetland to allow future urban development (see figure 2). In terms of local hydrology, it will be integrated with two new smaller constructed wetlands upstream (see figure 3A), the existing large lagoons (which will be rehabilitated to increase their biodiversity values), and Duchess Gully; and form the major component of the stormwater management system for future development of the total property (Cardno 2008, Luke and Co. 2008), as per the UIA 14 Structure Plan and the Concept Plan Application.

In addition to its stormwater treatment role, the major waterbody has also been designed to provide a range of wildlife habitat features such as emergent vegetation along the shallow margins (especially the western side where an extensive bed of macrophytes will form a designated treatment cell), and open water. Extensive landscaping/assisted bush regeneration based on native endemic species will strategically established around its perimeter, forming part of the proposed east-west corridor. The proponent's vision for this waterbody and the existing lagoons and other proposed constructed wetlands within the Open Space/Drainage/Habitat Corridor, is to create a mosaic of artificial wetlands and swamp forest habitats similar to those at the Shortlands Wetland Centre (Luke and Co. 2008, Cardno 2008). Cardno (2008) expects that water quality in the major new wetland will be of similar high quality as the existing two large lagoons to the south.

The proposed main waterbody will modify about 10.72ha of the property, which only affects pasture with a few scattered trees ie the pasture/pastoral woodland. It does not affect any area considered by Biolink (2005c) as an EEC (see section 3.2.2).

The wetland will have an average bed level of RL 1m AHD, with a normal top height of 3.0m AHD, giving it a capacity of about 142.ML (Cardno 2008). This wetland will be connected to the existing dam/lagoon to the south, to establish the stormwater treatment chain (Cardno 2008). During normal flows (reaching above 3.4m AHD), water will flow from the existing lagoons to the new major wetland, exiting via the new weir (3.7m AHD) in the northeast to the middle of Duchess Gully to re-instate the former hydrological regime and improve water quality in this part of the creek (Cardno 2008). During higher flows, water from the existing lagoons will equally overflow the reconstructed eastern weir of the eastern lagoon to enter Duchess Gully, and will exit the northeast of the major wetland via the new weir. During larger events (eg >1:5 ARI), the new major constructed wetland has been designed to allow slow overland flow on its eastern boundary to Duchess Creek (Cardno 2008).

(b) Proposed filling:

The fill excavated from the major waterbody is primarily to be used to raise low-lying portions of the property to allow maximum residential development. Some 400 000 tonnes of material are expected

to be used for fill to allow the maximum property yield of about 66.22ha of residential development (Cardno 2008).

The estimated approximately 49ha proposed filling area will predominantly only affect pasture/pastoral woodland, some drains and a small portion (0.4ha) of the *Swamp Oak Floodplain Forest* EEC in the northeast which consists of regrowth along fences and a drain, and about 0.4ha of Swamp Sclerophyll Forest on the western side. Refer to Appendix 4 for photos of the affected areas.

5.1.1.1.2 General Impacts

The development will require the removal of vegetation with the following direct **negative** potential impacts:

- Loss of about 64.35ha of pasture/woodland, drain vegetation and Swamp Oak regrowth as a result of excavation and raising the low lying plain with clean fill to establish future urban development.
- Loss of about 0.4ha of *Swamp Oak Floodplain Forest* EEC.
- Loss of about 0.4ha of *Swamp Sclerophyll Forest* EEC.
- Loss of about 14 hollow-bearing trees within the pastoral woodland.
- Loss of two small dams which provide limited foraging habitat for some migratory birds and the potentially the Jabiru/Black-Necked Stork.
- Loss of an area of seasonally waterlogged grassy low lying plain which offers potential foraging habitat for the Jabiru, several migratory birds (eg Latham's Snipe, Great Egret, Cattle Egret, etc) and perhaps Microchiropteran bats.
- Relatively minor reduction in current terrestrial east-west connectivity due to placement of a large waterbody and clearing of scattered woodland trees.

The construction of the wetland and associated measures will also have the following **positive** impacts:

- Creation of a relatively large area (about 13ha including the two small constructed wetlands) of potential habitat for waterfowl including a number of threatened species (eg Black Bittern, Australasian Bittern, Osprey), migratory species (eg Great Egret and White-Bellied Sea-Eagle); potential foraging habitat for the Southern Myotis; fish; and a range of potential habitats for frogs (most likely common species tolerant of water with residues from roads, etc).
- Increased buffering to Duchess Gully from urban and agricultural runoff from the future urbanised catchment.
- Increased linkages and habitat for a range of threatened fauna (eg Koala, Squirrel Glider, etc) due to 53.82ha of habitat creation via landscaping/bushland regeneration with native species including food species (eg Tallowwoods, Forest Red Gum and Swamp Mahogany); reinforcing linkages from the southeast dry sclerophyll to the central patch of swamp forest.
- Restore some 15.1ha of Coastal Floodplain EECs an offset to loss of 0.8ha of these EECs.

5.1.1.2 Construction

5.1.1.2.1 General

Construction is expected to take at least 6 months depending on the staging of construction and filling (Luke and Co. pers. comm.). Routine measures to comply with statutory obligations will be undertaken to address the following impacts/issues:

- Acid Sulfate Soils (ASS).
- Watertable and dewatering management.
- Erosion and sedimentation.
- Dust
- Noise.
- Pollution
- Access roads and tracks

Evaluation of potential impacts associated with these issues is detailed as follows:

5.1.1.2.2. Acid Sulfate Soils

5.1.1.2.2.1 Description and Impacts

Geotechnical investigations have determined that Potential Acid Sulfate Soils (PASS) occur on the property. Due to the complex geomorphological origins of the property, PASS lie below the groundwater surface ie >2.5m below the natural ground surface and under the watertable (Luke and Co. 2008). Hence they have not been activated by previous drainage.

(a) Construction of the Major Waterbody:

The constructed waterbody's design and location has generally been sited via mapping of the distribution of ASS to minimise risk of ASS excavation (Luke and Co. 2008, Cardno 2008). As per the *Acid Sulfate Soils Management Plan* (Cardno 2008) prepared for the project, precautionary measures will be implemented as per statutory and Council regulations during construction to ensure no fill material (if it contains PASS) is allowed to produce acidified leachate that could enter an adjacent aquatic ecosystem (Luke and Co. 2008, Cardno 2008).

Temporary lowering of the watertable (currently around 3.5m AHD) by the waterbody (surface level predicted range around 2.1-3m) should not expose ASS which are located at about 2.0 AHD on the western shoreline, and 1.0m on the eastern shoreline (Luke and Co. 2008, Cardno 2008), no more than the current invert effect created by Duchess Gully (Cardno 2008).

(b) Filling area:

PASS are located under the area proposed for filling (Cardno 2008). All ASS on the site are currently only potential (ie non-activated), hence oxidation products are not likely to be present or present in significant quantities (Luke and Co. 2008, Cardno 2008).

Cardno (2008) consider that the groundwater regime under the filling area should not be significantly affected, given geotechnical information shows that the affected soils are not likely to significantly settle under the prescribed depth of fill. Hence ASS should not be affected ie via the 'sponging' effect.

5.1.1.2.3. Watertable and Dewatering Management

5.1.1.2.3.1 Description and Impacts

(a) Watertable Issues:

Excavation in waterlogged or swampy areas can result in lowering of the watertable. This can detrimentally affect vegetation communities (eg EECs), habitats (eg of frogs) and other biophysical attributes eg salinity (NSWSC 20004a, 2004b, 2004c, 2004d, 2004e, 2004f, 2002e).

The current watertable is around 3.5m (suggesting a current influence by the existing lagoons), grading down to 1m AHD at Duchess Gully (Luke and Co. 2008). The proposed watertable level of the constructed waterbody is intended to be lower at around 3m AHD. The waterbody is predicted to have the effect of creating a parabolic phreatic surface in the existing watertable level around the western margins (as groundwater has been mapped predominantly moving west to east – Luke and Co. 2008, Cardno 2008), potentially drawing it down to the minimum waterbody level of 2.1m AHD, and exiting the waterbody's north and east at about 3m AHD till it dips again down to 1m at Duchess Creek (Luke and Co. 2008, Cardno 2008). This effect is reported to be similar to the current large lagoons and Duchess Gully hence Luke and Co (2008) and Cardno (2008) consider the new waterbody will have no significant long term effect on the watertable level. Cardno (2008) also determine that it will not expose any ASS and that construction of the wetland will be undertaken in cells during dry periods to limit local drawdown effects and allow re-flooding of each cell to 3m AHD once construction is complete to maintain the watertable and buffer PASS.

As noted in 5.3.3, the lowering of the watertable by the new wetland is localised to its immediate edges. Cardno (2008) consider it is not likely to have any deleterious impacts on the hydrological regime of the Wallum Froglet habitat in the adjacent depression (ie via reducing the length of surface inundation intervals, which could lead to breeding failure, habitat changes, etc) as the depression is dependent on direct rainfall and surface runoff not groundwater for its hydrological regime, due to its isolation from the watertable via an impermeable clay bottom.

(b) Groundwater Issues:

As the height of the water surface in the proposed (and current) waterbody is below the current watertable, there will be groundwater inflow and mixing of surface and groundwater. This will have the benefit of maintaining water levels in the waterbody in dry years, with a minimal drop in groundwater flow to Duchess Gully. This drop in recharge from groundwater is likely to be compensated by increased surface flow via discharge from the lagoon and constructed wetland especially once the property catchment is urbanised (Luke and Co. 2008).

Cardno (2008) report that based on their modelling, the proposal will not:

1. Expose ASS to oxidation.
2. Significantly affect net groundwater outflows.
3. Significantly affect the operation of the STP exfiltration.

(c) Runoff:

With full urbanisation the property, it is anticipated that runoff will increase significantly. Creation of the major new waterbody will fractionally reduce total groundwater inflow Duchess Gully (Cardno 2008). However, connection via weirs with the existing lagoon system to the south, and twin connections to Duchess Gully (storm overflow and primary discharge at the head of Duchess Gully) will result in a substantial increase in net streamflow. This will reportedly have the benefit of increasing flushing of

tertiary treated effluent deposited downstream by the STP (Cardno 2008, Luke and Co. 2008), and restoring the original hydrology of Duchess Gully (Cardno 2008).

5.1.1.2.4 Erosion and Sedimentation

5.1.1.2.4.1 Description and Impacts

Erosion and sedimentation may be an issue associated with the following areas:

- Construction of access roads/tracks.
- Erosion of the fill.
- Fill storage areas.
- Erosion of the wetland walls/edges via wave action post-development.

If unabated, erosion and sedimentation may result in sedimentation of adjacent waterways (drains, lagoons and Duchess Gully) and impact on EECs. These threats should be abated by required erosion and sedimentation measures applicable during construction and earthmoving (Cardno 2008). Specific care will have to be taken to ensure sedimentation does not occur in the existing Wallum Froglet habitat to the southwest of the wetland (see recommendations). An Erosion and Sediment Control Plan (ESCP) will be prepared as per statutory obligations (Cardno 2008), hence this impact's significance should be minimised if the ESCP is implemented effectively.

Erosion of the new wetland edges via wave action may occur if aquatic vegetation does not develop sufficiently, or is absent from some areas. This will result in turbidity and sedimentation at least in localised areas, and may impact on benthos. Establishment of aquatic vegetation and provision of rocks, etc, around the edges would reduce the effects of wave action and the severity of this impact.

5.1.1.2.5. Dust

5.1.1.2.5.1 Description and Impacts

Dust is typically associated with earthmoving activities. If unabated, dust could also impact upon adjacent watercourses and waterbodies, and associated EECs. Standard dust suppression measures are expected to be employed (Cardno 2008), hence dust should not be an issue. Dust must not be allowed to enter the Wallum Froglet habitat as it can carry disease, etc.

5.1.1.2.6. Noise

Noise associated with the construction of the wetland and filling will be substantial due to the range of associated large earthmoving machinery and extent of excavation, etc, required.

5.1.1.2.6.1 Literature Review

Noise impacts on wildlife are poorly studied and understood in Australia, as noted by an impact study, review and Species Impact Statement for a proposed shooting range at Scotts Head which potentially affects known habitat of the Yellow-Bellied Glider, Powerful Owl, Glossy Black Cockatoo, Long-Nosed Potoroo, Stuttering Frog, Wompoo Fruit-Dove and Common Bent-Wing Bat (Clancy 2001, 2003, Berrigan 2001). Some species show sensitivity especially at primary exposure, though evidence has been presented to demonstrate long term adaptation to noise eg photos of Eastern Grey Kangaroos lying on the range used by active skeet shooters, and statutory declarations reporting sightings of Glossy Black Cockatoos feeding at the end of an active shooting range (Berrigan 2001i, Clancy 2003). This consultant has also observed a Wompoo Fruit-Dove roosting in an isolated woodland tree adjacent to a busy road (Ocean Drive); Glossy Black Cockatoos foraging in a tree under which firewood was being chainsawed; Bitterns foraging on oyster leases adjacent to motorboats; and Jabiru foraging beside earthmoving machinery (at Greenmeadows, Port Macquarie) or under traffic bridges over estuaries (Lake Cathie and North Haven).

When the EIS for the Sydney's second airport location (Badgery's Creek) was exhibited, the EPA was asked to assess the impact of noise on wildlife within the Blue Mountains National Park. The review found that all major studies of noise impact on wildlife have been carried out in the USA, and very little Australian work had been done. The EPA's literature review found in summary (Paul Wilkes EPA, pers. comm. to Macksville SSAA) the following:

- Risk of hearing damage in wildlife is greatest from exposure to close or nearby blast noise rather than long-lasting exposure to continuous noise.
- Decreased responsiveness after repeated noise is frequently observed and usually attributed to habituation.
- Military and civilian blast noise (quarry and mine activity) had no unusual effects on wildlife.
- Peregrine Falcons indicate no sensitivity to blast noise, even rearing young near blast construction areas.
- An endangered mammal species, the Red Squirrel, showed no reaction to noise and blasting.
- When a new noise occurs in an area, animals initially turn towards the noise source, once determined that no harm associated with the sound, habituation occurs.
- Acoustic scaring methods such as gas guns lose their effect as target species habituate to them.
- Anecdotal accounts of terrestrial wildlife living with noise loud enough to cause pain in humans eg seabirds near airports and Ospreys near Defence Force testing areas.
- On shooting ranges, anecdotal observations of ground birds such as Plovers nesting on the ground directly near firing mounds, raptors hunting the grass areas for prey during shooting competitions, and Currawongs hunting insects on the ground during shooting.
- Raptors nesting and rearing young alongside airstrips and quarries that have blasting activity.

Furthermore, this consultant has undertaken inspections of two long established shooting ranges (Kempsey and Wingham). A population of Koalas was found at Wingham, and evidence of other arboreal fauna was found at both. Another survey of a range at Coffs Harbour recorded Sugar Gliders and the Powerful Owl. The Grey Headed Flying Fox was observed at all three foraging at night (Berrigan 2002e, 2002f, Clancy 2003).

5.1.1.2.6.2 Proposal Assessment

Noise associated with the construction of the wetland and filling should be relatively short term (several months dispersed over a longer period) as the relevant portions of the site are reformed to form the wetland and filling areas. This will be limited to the programmed construction periods, and to daytime periods only (7am to 6pm Monday to Saturday – Cardno 2008).

This noise is most likely to affect fauna using the adjacent lagoons, swamp forest and dry sclerophyll forest.

Given the information in the preceding paragraphs, and the following information, it is considered unlikely that noise will have any significant effects as:

- Noise generated from the major stages of construction are short term.
- The threatened species recorded on the site, property and potentially occurring have been recorded in high human-presence environments eg the Little Bent Wing Bat (Mr Glenn Hoye pers. comm.), Grey-Headed Flying Fox (personal observations, Eby 2002, etc), Wallum Froglet (Darkheart 2005a), Squirrel Glider (Darkheart 2004n, 2004p, 2005a, 2005b, 2005d, 2005m, 2005r, 2006f, Murray 2006) and Koala (Darkheart 2004p, 2004n, Wilkes and Snowden 1998, Connell Wagner 2000b, Lunney *et al* 1999, etc) have been recorded foraging in urban bushland, and the Grey Headed Flying Fox recorded roosting within urban remnants (Eby 2002, Smith 2002, personal observations).
- Urban noise is a current presence on the southern boundary, thus fauna are likely to have some tolerance.

- Calls of the Wallum Froglet mostly take place at night when noise is minimal; hence breeding should not be interfered with.

5.1.1.2.7. Pollution

5.1.1.2.7.1 Description and Impacts

Pollution refers to contamination of aquatic ecosystems via petrochemicals, fertilisers, herbicides, etc. These chemicals generally reach adjacent habitats via contaminated runoff, spillage, sedimentation and erosion.

At the construction stage, pollution may potentially occur via:

- Storing and spillage of petrochemicals and other chemicals on the site or within the catchment area without proper measures undertaken.
- Improper use of fertilisers (eg used to establish plantings) and herbicides (eg to control weeds on the fill area) leading to contamination of runoff, soils, wetland and groundwater.

Statutory controls and provisions of a specific Environmental Management Plan (EMP) will apply to ensure these avenues of pollution do not occur (Cardno 2008). This is especially important to the Wallum Froglet population off the southwest as pollution of this finite and isolated habitat could lead to extinction of this population.

5.1.1.2.8. Access Roads and Tracks

5.1.1.2.8.1 Description and Impacts

Access roads and tracks will be required for the following:

- Machinery access to the wetland.
- Loading and transport of the fill to the fill area/stockpiles.
- Staff parking and associated temporary sheds, toilets, etc.
- Site access.

Site access and main movements of machinery will use the existing gravel road on the property, with access to Ocean Drive (thereby minimising movement of large trucks through an established residential area to the south). Due to the land's waterlogging nature, the internal tracks will need to be formalised (eg via importing road base material) to avoid bogging. Internal tracks will fall within the designated construction area hence no tracks will be established outside the footprint of the development envelope. These do not affect any significant habitat area or EEC.

5.2 SECONDARY/INDIRECT IMPACTS

The following impacts may potentially occur once the wetland is established, and are generally associated with developments.

5.2.1. Alteration of Hydrological Regime of Duchess Gully

As noted in section 5.1.1.2.3, the construction of the wetland will alter the current hydrological regime of Duchess Creek via initially reducing surface and also groundwater flows. However, as urbanisation increases, runoff is expected to increase, and the stormwater treatment chain has been designed to reinstate the original regime of the watercourse by directing most flow to the upper end of the watercourse, with the new and existing discharge point to be used during higher flows. Cardno (2008) predict that increased flushing of the system may have the positive impact of reducing nutrients, etc associated with inflows from the STP and the agricultural (and future urban) catchment, thereby promoting a healthier aquatic system.

Cardno (2008) also predict that flow velocity should not lead to scouring.

5.2.2. Eutrophication

Eutrophication is the addition of excess nutrients into aquatic ecosystems (eg via use of fertilisers in the catchment), leading to impacts such as algal blooms, toxicity to aquatic life, and excess macrophyte growth. This impact is not considered a substantial risk at the construction of the wetland, but could be a risk in the long term post-urbanisation via (DLWC 1998a, 1998b):

- Excessive nutrient loads from the wetland discharged into Duchess Gully (eg during very wet years where insufficient treatment has occurred).
- Runoff from bitumen roads containing petrochemical residues.
- Runoff from car washing.
- Illegal deposits to stormwater drains.
- Fertilisers, herbicides, etc used on domestic gardens.

These may have the following impacts on the wetland:

- Death/disease in aquatic fauna eg frogs, macroinvertebrates.
- Algal blooms, weed invasion or excessive macrophyte growth, leading to public health problems, maintenance issues, inadequate water treatment (with downstream impacts) and impacts on aquatic organisms (eg frogs, fish and macroinvertebrates).
- Sediment contamination, resulting in poisoning of fauna eg waterbirds sifting benthos.

These secondary impacts may also occur in Duchess Gully, with associated impacts on an EEC and potential prey of threatened species (eg Bitterns).

The wetland forms part of a chain of mechanisms and structures to treat stormwater, hence the water entering the wetland is expected to be of reasonable quality (Cardno 2008). In addition, the design of the major wetland incorporates macrophyte areas and a substantial waterbody to “polish” water before emission. These combined measures are reported to be sufficient to ensure the quality of water entering Duchess Gully is not inferior to current standards (Luke and Co. 2008, Cardno 2008).

5.2.3 Altered Fire Regime

The current fire regime on the property is essentially exclusion. Habitats considered at risk (ie high fuel loads) and sensitive to altered fire regime are:

- Southeast dry sclerophyll
- Paperbark/Swamp Mahogany/Swamp Oak Swamp Forest.
- Native grassland east of Duchess Creek
- Dune scrub.
- Littoral rainforest (northeast of property)

Extensive fire in these communities may either result in potential extinction (eg of the isolated populations of Eastern Chestnut Mouse, Wallum Froglet and Common Planigale), hence must be avoided or managed intensively.

The proposal is not likely to have any effect on the fire regime, hence current patterns will remain.

5.2.4. Fences

Fences can provide a physical barrier to fauna movement eg Koalas (Wilkes and Snowden 1998, AKF 2003, Connell Wagner 2000, Port Stephens Council 2001, Lunney *et al* 1999, NPWS 2003), or a threat eg Yellow-Bellied Gliders, Squirrel Gliders, Koalas and Grey Headed Flying Foxes have been recorded being injured or entangled leading to death (via starvation, injury, predation, exposure, etc) (Gibbons

and Lindenmayer 2002, Berrigan 2001h). Owls have also been observed being injured or killed via collisions with fences (personal observations, The Owl Pages 2002).

Other than temporary construction fences around the development envelope, no fence is proposed to be constructed. These are not considered likely to pose a threat to any fauna or pose any substantial barrier.

The proposal will also have the positive impact of seeing fencing removing from parts of the property to allow machinery access. This will remove this barrier/hazard from these areas.

5.2.5. Increased Human Activity

Human presence on the site/property will significantly increase from periodic to permanent. This may discourage the activity of some fauna, while others may become accustomed. In general, those threatened species which have some potential to occur on the site (Grey-Headed Flying Fox, Microchiropteran bats and Square-Tailed Kite) are known to be active in urban environments and are unlikely to be deterred from using the site.

The Common Planigale and Eastern Chestnut Mouse typically have small home ranges (Smith *et al* 1995) and could be displaced by continuing disturbances to the habitat in the southeastern and southwestern sections of the property.

Increased human presence and activity also has potential to impact on flora on the property particularly by creation of tracks which can result in soil compaction, physical damage to plants and introduction of weeds. In general, the Swamp Oak community is likely to be resistant to such intrusions due to its closed canopy and location on wet areas which are unlikely to be significantly used for tracks. The wet sclerophyll on the property is more susceptible to damage due to its small area, although its location away from the area of residential development is unlikely to attract attention and the dense edge vegetation will inhibit access to it. Northern sections of the dry sclerophyll forest are easily accessed but as the community continues south, it becomes increasingly dense and is unlikely to be accessed. In addition this community's close proximity to the STP is likely to reduce human interest in the area.

5.2.6 Noise

Noise impacts on wildlife are poorly studied and understood in Australia, as noted by an impact study, review and Species Impact Statement for a proposed shooting range at Scotts Head which potentially affects known habitat of the Yellow-Bellied Glider, Powerful Owl, Glossy Black Cockatoo, Long-Nosed Potoroo, Stuttering Frog, Wompoo Fruit-Dove and Common Bent-Wing Bat (Clancy 2001, 2003, Berrigan 2001d). Some species show sensitivity especially at primary exposure, though evidence has been presented to demonstrate long term adaptation to noise, eg photos of Eastern Grey Kangaroos lying on the range used by active skeet shooters, and statutory declarations reporting sightings of Glossy Black Cockatoos feeding at the end of an active shooting range (Berrigan 2001d, Clancy 2003). This consultant has also observed a Wompoo Fruit-Dove roosting in an isolated woodland tree adjacent to a busy road (Ocean Drive), Glossy Black Cockatoos foraging in a tree under which firewood was being cut by chain-saw, Bitterns foraging on oyster leases adjacent to motorboats, and Jabiru foraging beside earthmoving machinery (at Greenmeadows, Port Macquarie) or under traffic bridges over estuaries (Lake Cathie and North Haven).

In a review of overseas studies on noise impacts, Mitchell McCotter (ERM 1996) generalised that "*fauna may experience only limited effects of noise below 50dB(A), with some reaction between 50dB(A) and 70dB(A), and strong reactions above 70dB(A)*." Background noise at Bonny Hills has been measured at 49-52dB(A) (ERM 1996) and similar levels are expected to occur at the site post-development. During the construction phase the noise levels due to heavy machinery are likely to be about 70 dB(A) at 50m from the source (ERM 1996).

Overall, the levels of noise likely to be generated by the development are expected to have minimal impact on the threatened species with potential to occur on the property, particularly as they are generally mobile species which would utilise the property as a small part of a larger home range. Species with smaller ranges such as the Common Planigale have been recorded in urban remnants (Smith *et al* 1995) and are located away from the development envelope, hence are not considered likely to be significant affected by noise.

5.2.7. Exotic Fauna and Flora

5.2.7.1 Exotic Fauna

Potential impacts of exotic fauna are increased predation and competition (Austeco 1994, Smith *et al* 1995, Birds Australia 2009, etc).

The species most likely to be involved are pets such as dogs and cats, and any increase in these animals has the potential to affect wildlife by predation or by behavioural avoidance (Austeco 1994, Smith *et al* 1995, Birds Australia 2009, Dickman 1996, etc). Dog (possibly wild or wandering domestic) tracks were found in mud in the southern end of the property, but no evidence of cats was found, although they may occur. The restricted distribution of Koalas, Eastern Chestnut Mouse and Common Planigale on and near the property, and Koalas attempting to traverse the open pasture land on the property to access food trees makes these species susceptible to attack/predation.

Foxes occur locally and generally have the potential to increase their activity following developments which create new tracks or open up dense undergrowth (as occurs in fire hazard reduction. The proposal has no such effect hence will not increase the success of this predator.

Exotic rodents may compete with native fauna, although their abundance may depend on the seral stage of the habitat. These species may potential colonise landscaping around the wetland and compete or exclude native species.

Grazing cattle currently occur on-site and the property, but they are likely to be removed as development proceeds. This should allow regeneration of native vegetation which is considered a positive impact.

5.2.7.2 Exotic Flora

Weed invasion can modify vegetation structure and reduce diversity of habitats, often as an edge effect adjacent to disturbed areas (Andrews 1990, NSWSC 2003a). On the site, weeds were present throughout the grassland which was comprised largely of exotic pasture species. Lantana was also present in a number of vegetation communities on the property. It occurred along the fringes of the wet sclerophyll, Swamp Oak and Paperbark/Swamp Mahogany swamp forest communities. In sections of the southeastern Paperbark/Swamp Mahogany swamp forest, it dominated the shrub layer and producing a dense impenetrable layer. Bitou Bush was present in relatively limited abundance.

The proposal has limited potential to introduce exotic flora as fill be won from the site which is currently dominated by exotic pasture species. Weeds may potentially occur on the fill via vehicles or contamination of any seeds used to establish sediment control, but these will eventually be removed again as part of future residential subdivision.

Weed development around the edges of the wetland should be controlled by the landscape consultant as part of their contractual arrangements for the landscaping works (see section 6.0).

5.2.8. Direct Mortality

Potential mortality of native fauna typically occurs directly via habitat removal and refuge destruction. Specifically, the removal of hollow bearing trees and large fallen logs can potentially result in the

mortality of residing hollow obligate fauna (Gibbons and Lindenmayer 2002, Smith *et al* 1995, Austeco 1994) and the removal of dense groundcover can affect small terrestrial species (Smith *et al* 1995, Austeco 1994).

The proposed development will remove at least 14 hollow-bearing trees in the area of Forest Red Gum pastoral woodland with the potential for injury to threatened species such as Microchiropteran bats which could utilise these hollows as roosts, or the Little Lorikeet which has some marginal potential to nest (subject to intensive competition with other lorikeets as noted in the survey).

A Whistling Kite nest also occurs in the fill area, and if filling occurs during the breeding season, a clutch of this protected bird may be killed.

5.2.9 Artificial Lighting

Lighting may discourage nocturnal native species from foraging near areas of development, with a potential effect similar to the full moon on the hunting success of predators such as owls, or a behavioural avoidance impact on potential prey species. Anecdotal evidence also suggests it deters exit from tree hollows with the Squirrel Glider noted to wait until adjacent artificial lighting in an industrial area shining on the entrance switched off automatically at 9.30pm (Darkheart 2005i). However, wallabies, kangaroos, Kookaburra, Magpies, Tawny Frogmouth Owls and possums have been noted foraging under artificial lighting in the residential areas eg around Lake Innes, Port Macquarie (personal observations). Artificial lighting may also be beneficial to Microchiropteran bats by localised aggregation of insects, with these animals being observed foraging under streetlights, and even landing on lit footpaths to scamper for insects (personal observations). Conversely, artificial lighting has also been found to alter Microchiropteran bat assemblages.

Artificial lighting can also have the positive impact of increasing sight detection of fauna on roads, thus reducing risk of road kills eg Koalas (Wilkes and Snowden 1998, AKF 2003, Connell Wagner 2000, Port Stephens Council 2001, Lunney *et al* 1999, DECC 2008a).

Artificial lighting will be minimal on site ie for security of machinery and on-site offices only during construction, hence this impact is considered inconsequential.

5.2.10 Disease

This threat is most relevant to Koalas which were not detected on the site but occur on the property. Most Koalas are naturally infected with *Chlamydia* pathogens (Sharp and Phillips 1999, Phillips 1997). This and other diseases may develop when Koalas are under stress, of which one cause is habitat loss/disturbance (DECC 2008a).

The proposal will remove a number of mostly senescent potential Koala browse species, however identified Core Koala habitat and further Potential Koala habitat will be retained on the property reducing the potential impact of the habitat loss on the species. With consideration given to this habitat retention, that no evidence of Koala activity was found in the development envelope and any Koala occurrence is likely to be at low levels only, any potential impact on the property is likely to be minimal.

There are diseases which are considered Key Threatening Processes to parrots and frogs which may occur in the area, as well as plant disease, *Phytophora* spp (DECC 2009b). The latter two have a very low potential to be introduced to the site/property via landscaping plants containing the pathogen or infected individuals.

5.3 IMPACTS ON THREATENED FAUNA SPECIES

This section identifies the potential impacts and their significance to threatened species recorded on the property by this survey, or considered a reasonable chance of occurrence on the site (as determined in appendix 1).

5.3.1 Koala

Potential habitat for Koalas in the development envelope (the study site) consisted of a handful of Forest Red Gums scattered over pasture well away from other Potential Koala Habitat. This small area of potential habitat was considered insufficient to support a breeding aggregate. No Koala activity was detected in this area and Koalas were considered to at best rarely use these trees or the western side of the property, at most as dispersing animals due to the poor connectivity of the site to known habitats in the southeast, south and north. Consequently, the site was considered unlikely to be part of a frequently used route for dispersal and genetic exchange. Hence, the potential habitat on the site could provide at best temporary support, but was not considered to be key habitat or link for local populations of Koala at this time.

The development will require the removal of all the Forest Red Gums and hence Potential Koala Habitat from the study site, resulting in the loss of the temporary support for dispersing Koalas and therefore the loss of the site's limited potential to act as a corridor on the broader property and also a contraction of the extent of locally available Potential Koala habitat.

Animals potentially occurring outside the identified Core Koala Habitat in the southeast are most likely to be young males, and the loss is not expected to directly affect the home range of existing local breeding aggregates. Until urban development of the remainder of the property occurs, remaining scattered trees on the ridges and slopes will retain the limited corridor potential to the northwest, with other corridors via the Paperbark/Swamp Mahogany swamp forest and Duchess Gully retained. Post-development, linkage will be provided by the corridors proposed in the UIA 14 Structure Plan (Richards 2004, Luke and Co 2006).

Overall, the proposal will consist of the loss of an area of low density Potential Koala Habitat currently subject to apparently accelerated natural attrition, with recruitment prevented by agricultural maintenance. Identified Core Koala Habitat and the majority of Potential Koala Habitat as well as linkages will remain post-development. Future landscaping around the wetland based on Koala species will have a positive impact on this species via habitat creation, with the establishment of the proposed east-west corridor considered to have potential for a significant positive impact via potentially increasing genetic exchange and population size. Provisions of the UIA 14 Koala Management Plan (Biolink 2005c) will also ensure impacts on Koalas are mitigated as per the aims of SEPP 44.

5.3.2 Common Planigale and Eastern Chestnut Mouse

The proposal does not affect known or potential habitat for these species either directly or indirectly, hence is considered inconsequential to the current viability.

The creation of natural bushland around the wetland and the rehabilitation of pastoral land into a fully vegetated wildlife corridor (generally swamp forest) should create both potential habitat and enhance linkages for these species allowing the small populations to potentially expand and increase their potential viability. This is thus considered a positive impact.

Future urban development of the remainder of the property is not considered in this assessment.

5.3.3 Wallum Froglet

5.3.3.1 Western Population

The western population in the drain adjacent to the southwest dry sclerophyll is not affected in any manner by the wetland/filling project application.

5.3.3.2 Eastern Population

The population in the depression off the southwest of the proposed constructed wetland will be physically retained via location of the wetland and fill areas beyond its confines, hence the proposal should have no direct impacts upon this habitat (Cardno 2008, Luke and Co. 2008).

As noted in section 5.1.1.2.3, the localised lowering of the watertable around the constructed wetland is considered by Cardno (2008) to have no potential to alter the hydrological regime of the Wallum Froglet habitat in the adjacent depression. This is due to the fact that the hydrological regime of the depression is dependent on direct rainfall and immediate surface runoff, not groundwater levels due to a layer of impermeable clay which isolates it from the groundwater level (Cardno 2008).

Furthermore, the depression currently has a demonstrably highly variable regime from periods of prolonged surface inundation to extreme dry periods. The latter was evidenced by the slashing of the area in 2006. This regime appears to be beneficial to the Wallum Froglet in that it allows elimination of the Plague Minnow (should it enter via major storm flows) and possibly also some competitive frog species. Security of the population should also be increased by the regeneration of the heath and sedge vegetation noted in 2003, which would retain a deep layer of moist humus for the frog to survive in during these periods, as it appears to have done post-slashing in 2006. Some monitoring will be required to ensure the population and its habitat remains viable.

Sedimentation during construction and contaminated runoff from future urbanisation should not affect this habitat as drainage will be directed away from these areas to the constructed wetland, and standard erosion control measures will be put in place (Cardno 2008, Luke and Co. 2008).

Exclusion of cattle will benefit the species via reducing habitat loss via grazing. The re-establishment of swamp forest in the east-west corridor may also provide additional habitat for population expansion, and enable linkage for genetic exchange between the two populations.

5.3.4 Jabiru

This species is considered at least a fairly likely occurrence periodically foraging around the dams/lagoons and seasonally waterlogged portions of the pasture. The area affected by the Project Application only offers a relatively marginal area of seasonally waterlogged pasture which may offer a small area of foraging habitat for this species as part of its wider nomadic non-breeding range (Smith *et al* 1995, DECC 2009b, Birds Australia 2009).

The proposal will have minimal short-term impact on this species via loss of the small area of relatively marginal area of seasonally waterlogged pasture will be removed. Relative to more optimum habitat in the locality and that breeding is not likely to potentially occur on the property, this loss is considered insignificant.

The species may continue to potentially forage on other parts of the property post-development eg in the southwest drainage line and around the lagoons. Post-development with establishment of the major new wetland and macrophytes, it may potentially use the new habitat as part of its non-breeding migratory range (eg a single bird). Such usage may be deterred in the long term as well as usage around the existing

lagoons via future increased human presence (eg pedestrians) or harassment by dogs, though the species has been recorded foraging near the Stingray Creek traffic bridge in North Haven (pers. obs.).

5.3.5 Microchiropteran Bats

This and a previous survey confirmed the presence of the Little Bent-Wing Bat on the property. This species is likely to use the property for foraging and perhaps non-breeding roosting in tree hollows. The Yellow-Bellied Sheathtail Bat, Greater Broad-Nosed Bat, Common Bent-Wing Bat and Eastern Freetail Bat are considered at least fair potential occurrences using at least parts of the property for foraging. The project application site also contained 14 hollow-bearing trees which offered potential as temporary roost habitat for all five species. These hollows also have some potential as breeding habitat for the Eastern Freetail Bat, Greater Broad-Nosed Bat and possibly for the Yellow-Bellied Sheathtail Bat, although this latter species is typically recorded in southeast Australia only between January-June (Churchill 1998) and may breed elsewhere.

The Southern Myotis is considered to potentially forage over the existing large lagoons on the property and along the permanent sections of Duchess Gully, and potentially roost in tree hollows. The two small dams within the project application site are considered to offer marginal potential.

The proposal will see loss of about 62.85ha of mostly pasture with trees which includes 14 hollow-bearing trees. This will see loss of marginal foraging habitat (due to limited prey habitat) and a substantial portion of the property's tree hollows. The latter may potentially also result in direct mortality during tree felling if these trees are used as roosts at the time.

The loss of 62.85ha of rather marginal foraging habitat for these species is considered inconsequential to the extent of more optimum habitat on the remainder of the property and within the species' range (Churchill 1998, Strahan 2000, Smith *et al* 1995, Dwyer 1968, 1966). This loss is considered likely to be at least in part compensated by the new habitat with ultimately higher productivity created by the macrophytes zones of the main wetland and adjacent landscaping/bush regeneration, as well as the open water which may support fish and aquatic insects preferred by the Southern Myotis.

The loss of potential roosts is more negative impact given this is a resource which is not particularly abundant on the property and takes a prolonged period to regenerate (Gibbons and Lindenmayer 2002). However, potential roosts will remain on site (some will ultimately be removed via urbanisation) post-development and others are known to occur within range of the property (eg Darkheart 2006h, 2004q). Hence the viability of these species should not be compromised as a result of the proposal.

5.3.6 Other Species

The following species have been recorded on the property outside the project application development envelope:

- Grey Headed Flying Fox, Wompoo Fruit-Dove, Square-Tailed Kite and Swift Parrot.

The following species are considered potential occurrences on the property (generally specific sections which are continuous with other potential or known habitat):

- *Foraging as part of larger range*: Glossy Black Cockatoo, Powerful Owl, Osprey, Masked Owl, Barking Owl, Black Bittern, Australasian Bittern, Little Eagle, Little Lorikeet, Eastern Blossom Bat, Blue Billed Duck.
- *Potentially foraging on the property and directly adjacent habitat within larger range*: Eastern Pygmy Possum and Squirrel Glider.

For all of these species, the property does not contain sufficient habitat to meet their lifecycle or ecological needs ie all would range beyond the property, with many only using it as a minute fraction of their wider range.

The proposal will have no negative impact on the following species as their potential or known habitat is outside the project application site:

- Osprey, Glossy Black Cockatoo, Eastern Pygmy Possum, Bitterns, Eastern Blossom Bat, Wompoo Fruit-Dove and Squirrel Glider.

The proposal will remove some marginal potential foraging habitat for the following species:

- Grey Headed Flying Fox, Square-Tailed Kite, Powerful Owl, Masked Owl, Barking Owl, Blue Billed Duck, Little Eagle, Little Lorikeet, and Swift Parrot.

It will also remove some (mostly marginal and isolated from other habitat) potential den and nest sites for the following species:

- Squirrel Glider, Little Lorikeet, Square-Tailed Kite, Powerful Owl, Masked Owl and Barking Owl.

However none of these species is currently known or considered significantly likely to use the resources on site for this purpose due to isolation from other habitat, high inter and intra-species competition, and insufficient internal dimensions of tree hollows (ie for large forest owls and Glossy Black Cockatoo). Overall thus, the proposal will result in contraction of an area of marginal habitat for these species, and is considered relatively inconsequential.

For some species, the creation of wetland and adjacent landscaping based on native forage species will create new habitat which will be considered a positive impact ie Masked Owl, Powerful Owl, Osprey, Blue-Billed Duck, Squirrel Glider, Eastern Blossom Bat, Bitterns and Square-Tailed Kite.
Due to the mobility of these species or location of their habitat well away from the site, the proposal will not create any barrier between any areas of habitat.

5.4 IMPACTS ON FLORA

The following addresses potential impacts of the proposal on flora.

5.4.1 General

As detailed previously, the disturbance history of the property has included clearing of much of the original forest communities, pasture improvement and maintenance, drainage and ongoing cattle grazing. The majority of the site vegetation is pasture with negligible conservation value.

The loss per community as a result of the proposal is detailed in table 7. As shown in the table, the proposal does not significantly affect any intact forest communities, and connectivity will be retained for genetic dispersal vectors.

Indirect potential impacts that could affect the property's flora include: changed fire frequency, introduction of weeds and accidental removal of threatened plants. These potential impacts can be addressed by implementation of ecologically-based management of fire and weeds.

Table 7: Estimated areas of loss per vegetation community for the Project Application

Vegetation Community/Habitat	Total Area (ha)	Area Removed (ha)	Area Retained (ha)
Blackbutt-Tallowwood-Needlebark Dry Sclerophyll Forest	1.98	0	1.98
Brushbox Wet Sclerophyll Forest	0.72	0	0.72
Blackbutt Dry Sclerophyll Forest	2.11	0	2.11
Grey Ironbark-Grey Gum Dry Sclerophyll Forest	2.39	0.04	1.99
Paperbark-Swamp Mahogany-Swamp Oak Swamp Forest/Woodland	10.4	0.4	10.0 (14.5ha regenerated)
Pasture/Pastoral Woodland	150.12	62.85	87.27
Dune Scrub	1.19	0	1.19
Swamp Oak	4.3	0.4	3.9 (0.6ha regenerated)
Aquatic	5.75	0	5.75
	179ha (Approx)	64ha(Approx)	113ha(Approx)

5.4.2 Threatened Flora Species

The proposed development does not affect any threatened flora species as no such species has been recorded on the site or property, and no significant potential habitat for such species will be removed.

The creation of the wetland may provide potential habitat for some threatened flora species eg *Maundia triglochinoides*, which could potentially be planted in the future (eg as part of a recovery plan), or colonise habitat via dispersal vectors (eg waterbirds), hence this is considered a positive impact on the site's current habitat potential.

5.4.3 EECs

As shown in figure 12, the proposal will see the loss of approximately 0.49ha of low to medium quality (ie degraded to highly degraded) *Swamp Oak Floodplain Forest* (SOFF) EEC. This comprises 11.42% of the extent of this EEC on the property – the remainder of which will be retained, protected and enhanced by bush regeneration under the Open Space Management Strategy (Cardno 2008).

The playing fields will also trim 0.3ha of the eastern edge of the *Swamp Sclerophyll Forest* (SSF) EEC on the western side of the property. This comprises 2.8% of the total occurrence.

In general, the loss of the 0.4ha of SOFF EEC and 0.4ha of SSF EEC is considered inconsequential to the viability of these EECs on site as current processes (eg grazing, edge effects, etc) severely limit biodiversity of these areas, and hence they only consist of the most resilient pioneer flora species and common agricultural woodland fauna.

All of the other extents of EECs will be permanently retained on the property and expanded by the regeneration works (about 15.1 ha in total within the Open Space/Drainage/Habitat Corridors (Richards 2004, Cardno 2008, Biolink 2005c), hence the proposal will not see the extinction of the local occurrence of these EECs.

No new effective barrier to movement of potential fauna or exchange of genetic materials associated with these EECs will be created by the proposal eg given the east-west and northern corridors will be retained and enhanced via bush regeneration (Cardno 2008). The latter will provide greater potential for genetic exchange and diversity, hence this is considered a positive impact on the viability of the remaining EECs.

Figure 12: Loss and Offset Replacement of EECs

Cardno (2008) state that the proposal should have no significant negative impact on the current groundwater regime or flooding patterns, other than re-establishing more water flow through a greater length of Duchess Gully, which should restore and improve ecological conditions and processes. Groundwater level drawdown has only a localised influence around the wetlands. Consequently, the ecological processes underlying the remaining EECs should not be compromised.

Provided erosion and sedimentation are controlled, the proposal should have no substantial impact on these remaining EECs.

Future urbanisation of the remainder of the property has potential for a range of other impacts, but this is not assessed in this report as per the DGR's.

6.0 AMELIORATIVE MEASURES AND RECOMMENDATIONS

6.1 GENERAL

6.1.1 DGR's Addressed

The following Project Application DGR's are addressed section 6.1:

- *PA 4.1: Outline potential impacts on flora and fauna and their habitats (within the meaning of the Threatened Species Conservation Act 1995 across the site and where relevant provide conservation measures.*

The following Concept Plan Application DGR's are addressed in sections 6.1 and 6.2:

- *CP 7.3: Outline measures for the conservation of flora and fauna and their habitats within the meaning of the Threatened Species Conservation Act 1995.*
- *CP 7.4: Outline measures for the conservation or enhancement of existing wildlife corridors and/ or the connective importance of any vegetation on the subject land.*

6.1.2 UIA 14 Structure Plan – Open Space/Drainage/Habitat Corridors

As shown in figure 5, the UIA 14 Structure Plan (Deicke Richards 2004) has delineated an east-west and northern corridor centred along low lying plains and watercourses. This prerequisite urban design measure forms the key instrument for conserving flora and fauna habitats and connectivity (and hence addresses the DGR's) as it contains:

- The overwhelming majority of habitat, including the large Wallum Froglet population and identified Core Koala Habitat.
- The overwhelming majority of the EECs.

As shown in figure 2, these linkages have been duly incorporated in both the Concept and Project Applications. The Open Space/Drainage/Habitat Corridor covers some 80.9ha (45%) of the property.

The Open Space Management Strategy (Cardno 2008), which forms part of both Applications, details the specific measures (eg via a Vegetation Management Plan) that will be undertaken to formally establish and improve the ecological functioning of these corridors, with the aim to:

- enrich the current native biodiversity of existing vegetation within the Open Space Corridor;
- enhance the existing corridor values of vegetation along Duchess Gully;
- create better movement opportunities in an east-west direction for native wildlife;
- reduce the extent of existing weed infestations within the Open Space Corridor;
- protect and enhance aquatic habitat values within existing and to be constructed waterbodies within the Open Space Corridor; and

- provide an appropriate interface between native vegetation and wildlife habitats within the Open Space Corridor and adjacent areas of urban development.

More specifically, the OSMS and its component Vegetation Management Plan (VMP) and Landscape Management Plan (LMP) management objectives and actions will result in (Cardno 2008):

- the protection and improvement to the area that supports a relatively large Wallum Froglet population just below the new constructed wetland;
- increasing the prevalence of known Koala food trees and other plants with multiple-species values throughout the Open Space Corridor;
- restoration of the floristic and structural elements of degraded EECs, resulting in a net increase in extent of 15.1ha;
- providing structural complexity and cover for ground-dwelling fauna such as the Eastern Chestnut Mouse and Common Planigale;
- reinstating degraded fauna movement corridor values throughout the Open Space Corridor; and;
- removal and management of weed infestations.

In addition to having positive impacts on the biodiversity of the property, the Open Space/Drainage/Habitat Corridor and OSMS will have positive impacts on the adjacent vegetation communities and nearby SEPP 26 area via (Cardno 2008) via:

- establishment of the Open Space Corridor will provide appropriate vegetated spatial buffers between residential development and Littoral rainforest vegetation to the east;
- stormwater control devices will be implemented within the development footprint and Open Space Corridor in order to control the quality and quantity of storm water run-off generated by the development and minimise its potential impact on surrounding environments; and
- source populations of weed species such as Lantana (*Lantana camara*) will be managed as part of a comprehensive weed management program.

6.1 PROJECT APPLICATION RECOMMENDATIONS

As noted above, by far the main measure for conservation of flora and fauna and their habitats has been the designation of most of the property's forest vegetation within the east-west and northern corridors/open space areas, as recommended by the UIA 14 structural plan (and noted above).

The following are specific recommendations to help achieve the OSMS aims, and many of have been incorporated into the OSMS (Cardno 2008), and/or have been enacted eg weed control.

6.1.1 Primary Recommendations

The following primary recommendations are made to ameliorate the risk of potentially significant impacts. They are integral to the basis of later assessment and conclusions as it is assumed they will be implemented in some form, such as an enforceable condition of consent, Development Control Plan measure, etc.

To date, many of these recommendations have already been initiated or incorporated into the Concept and Projection Applications and Open Space Management Strategy (as noted below).

6.1.1.1 Protection and Maintenance of the Wallum Froglet Habitat

The population of Wallum Froglets in the depression to the southwest of the constructed wetland is to be retained as per design of the proposal, and protected during construction and operational phases as follows:

6.1.1.1.1 Design Measures

The following design measures have been incorporated in the Project Application, Concept Plan Application and OSMS to protect the species and its habitat:

- Location of the constructed wetland and all works outside the habitat area with a sufficient buffer to erosion and sedimentation, etc.
- Location of all infrastructure (powerlines, sewage, etc) outside the above buffer zone.
- Location of car parks, etc, away from the habitat to discourage adverse human interaction.
- Provision for native species based landscaping/assisted bush regeneration around the habitat to provide a screen, filtration strip/buffer and linkage to the swamp forest to the west (part of the proposed corridor) and to the constructed wetland to the north to allow potential dispersal of the species to new habitats eg macrophytes zones in the constructed wetland.
- Diversion of untreated stormwater from the urbanised catchment away from the habitat.

6.1.1.1.2 Construction Measures

The following is to be undertaken to avoid impacts during construction:

- A proper formal buffer is to be established around this habitat, and its boundary clearly marked/ fenced off prior to earthmoving to prevent inadvertent disturbance during construction.
- Staff induction is to include information regarding the importance of this area and essential requirement for it not to be disturbed under any circumstance.
- No storage of fill, fuels, etc within the buffer zone.
- Provision of sediment detention fences on the aspect exposed to the construction area to prevent any risk of sedimentation.
- No mowing, slashing, etc, of the habitat area.

6.1.1.1.3 Operational Measures

These measures are to be implemented as part of final development of the property and under an on-going management regime (as per the OSMS):

1. **Weed control**: Weeds are not allowed to establish in the habitat and must be controlled. Physical (hand) removal is only allowed – no herbicides or machinery.
2. **Fire control**: Under no circumstance is fire to be allowed in the habitat. As per (6), monitoring is to ensure the risk of fire via arson is averted via artificial filling if required.

3. **Public and Pet Access**: Signage stating public access to the habitat is to be erected prohibiting such without Council approval eg for educational or scientific research. No cats or dogs are to be allowed in the habitat area.

4. **Interpretative signage**: A pathway leading to an observation point with interpretative signage is recommended at the Wallum Froglet habitat to encourage awareness and community stewardship of the population.

5. **Prohibition of vegetation removal**: No mowing, slashing, etc, is to occur in the habitat area at any time. The only vegetation removal allowed is of weeds by hand or selective brushcutting.

6. **Monitoring and Emergency Procedures**: Periodic inspection of the habitat is required (eg by Council's environmental officer) during seasonal drought to ensure dry intervals are not excessively prolonged to allow the risk of significant drying and induced risk of fire in the wetland. If such conditions occur, treated water from the open water section of the major wetland is to be pumped into the wetland.

6.1.1.1.4 Landscaping/Habitat Regeneration

Due to the slashing of the Wallum Froglet habitat in recent years, significant modification of the floristic structure and composition has occurred since 2003. This needs to be rectified to maximise the long term viability of this population.

The habitat is to be allowed to naturally regenerate with monitoring to ensure weeds/exotic species (including Torpedo Grass) do not become dominant (as per the OSMS). If the latter appears to be developing, appropriate weed removal and planting with native species is to be undertaken to maintain the habitat (as per the OSMS).

Monitoring of this habitat's recovery by the proponent is required to be undertaken until the habitat has regained its previous natural state at least (as demonstrated by a tall dense mixture of sedges and shrubs). Monitoring may cease when water quality/watertable monitoring associated with other aspects of the proposal has demonstrated that weeds are controlled and that the creation of the wetland has not adversely affected the hydrological regime of this habitat.

To protect this area from potential impacts associated with public visitation, appropriate groundcover, shrub and tree vegetation which discourages (ie spikey and sharp species such as Spiney Headed Matrush and Dagger Leaved Hakea) human entry is recommended to be preferentially established around the margins of the depression, to confine human activity to a specified point/areas ie the viewing area and footpath/cycleway. These plantings will form part of the designated biodiversity enrichment area #12 in the VMP component of the OSMS (Cardno 2008), as shown in figure 13.

6.1.1.2 Constructed Wetland Design

The following are measures the proponent has incorporated into the design and unless specified, are not recommendations of this assessment.

6.1.1.2.1 Macrophyte Zone

The wetland contains some 10.72ha of open water, with depth ranging from 0.25m to 2m, with an average of 1m (Cardno 2008, Luke and Co. 2008). As macrophytes such as Giant Spikerush will grow to around a depth of 1m and at times deeper (DLWC 1998a, 1998b. pers. obs.), it is expected that much of the approximately 2km perimeter of the wetland outside the designated macrophyte cell will readily become a macrophyte zone, which is to be primarily achieved via plantings (Cardno 2008). This will result in a significant increase in habitat for waterfowl, frogs and invertebrates (DLWC 1998a, 1998b) and a positive impact on the site/property and local biodiversity.

6.1.1.2.2 Drainage Weirs and Fishways

The design includes two overflows to Duchess Gully (see figure 3B). Both will be generally dry at most times as water levels must rise above at least 3.4m AHD, hence they will pose no significant barrier to movement of terrestrial species. It is recommended that the edges of these weirs throughout their length be planted with riparian vegetation from sedges such as tussocky *Juncus* spp to overhanging trees like Broad-Leaved Paperbark, *Syzgium* spp, *Callistemon salignus*, etc, to mimic a natural riparian zone and maximise corridor connectivity. Large rocks laid along the edge, or even logs crossing the weirs would also assist in maximising corridor effectiveness and biodiversity eg via providing refugia.

Both weirs will also contain structures and design measures which will maximise their potential to be used by native fish to enter/leave the wetland system (Cardno 2008), which will further enhance biodiversity and habitat opportunities.

6.1.1.3 Erosion and Sedimentation Control

As per Council planning controls, an Erosion and Sedimentation Plan will be implemented for the construction phase of the proposal (Luke and Co 2008, Cardno 2008). This is expected to be implemented effectively by the construction contractors with follow-up compliance enforcement.

As noted previously, measures are most important to be implemented to protect Duchess Gully, adjacent EECs and the Wallum Froglet habitat from sedimentation from erosion of tracks, fill storage or spreading areas, and dewatering areas.

6.1.1.4 ASS Management

Cardno (2008) provide an *ASS Management Plan* for monitoring, control and management of any exposed PASS, and a construction plan to minimise risk of excessive watertable lowering and PASS exposure. This is expected to be implemented effectively by the construction contractors with follow-up compliance enforcement.

These measures must protect the Wallum Froglet habitat, existing lagoons, EECs, the constructed wetland and Duchess Gully.

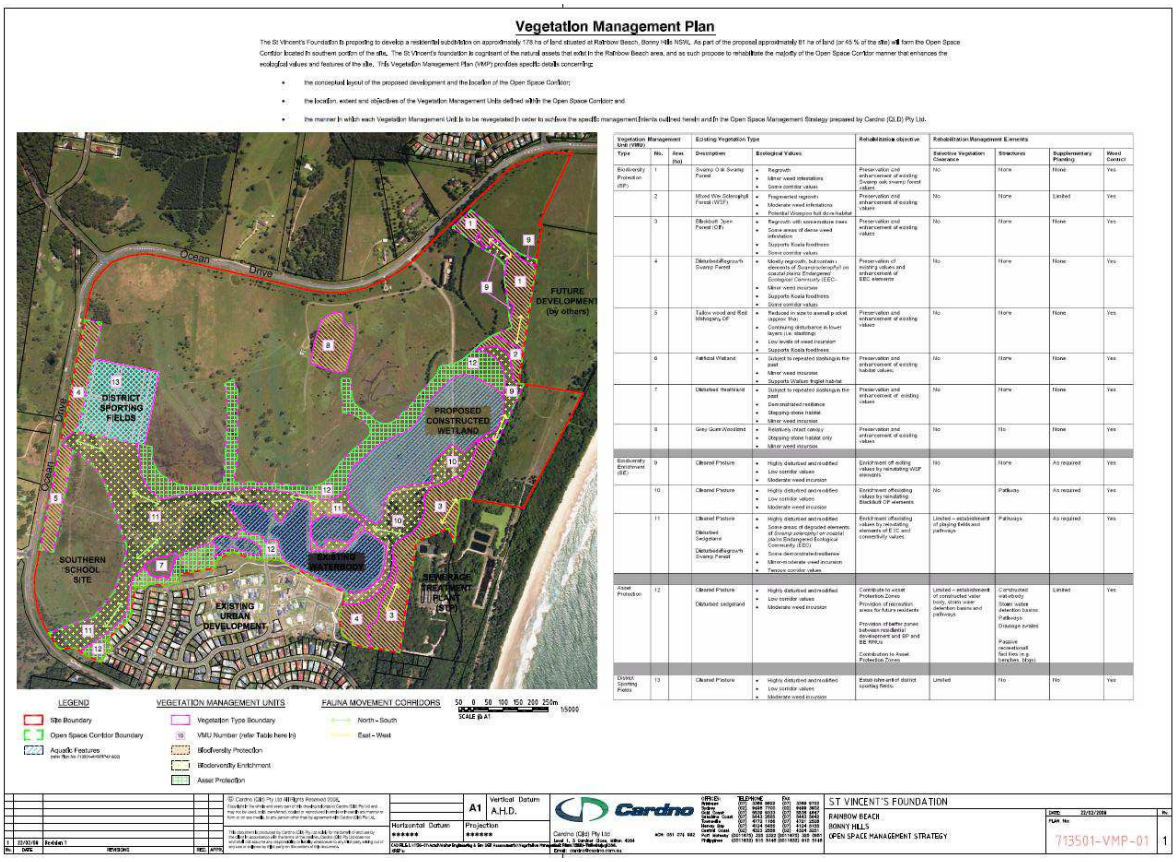
6.1.1.5 Groundwater and Surface Water Quality Management

Cardno (2008) provide *Groundwater and Surface Water Monitoring and Management Plans* for monitoring, control and management of groundwater and surface water throughout the construction period and for at least 5yrs post-development to ensure the predictions of their report are validated ie no significant adverse impacts will occur.

This is expected to be implemented effectively by follow-up compliance enforcement, and will allow early identification of any issues which require amelioration.

It is recommended that a monitoring station be established in the Wallum Froglet habitat to ensure the hydrological regime and water quality of this habitat is not adversely affected as per predictions of the Cardno (2008) report, and also to provide feedback to managers eg to initiate remedial action such as addition of freshwater to the wetland.

Figure 13: Vegetation Management Plan for the property
(Cardno 2008b)



6.1.1.6 Artificial Lighting

Artificial lighting will be required for street lighting and most likely along the footpath on some edges of the wetland.

Artificial lighting must be arranged in a manner which avoids spillage onto the constructed wetland and especially the adjacent Wallum Froglet habitat, due to the potential impacts it may have ie disturbing roosting and foraging behaviour, exposure to predation, etc.

6.1.1.7 Weed Invasion/Removal

6.1.1.7.1 Core Koala Habitat

At time of survey in 2006, the portion of identified Core Koala Habitat in the southeast adjacent to the STP was noted to have at times a very high constitution of lantana. This was considered a significant constraint on the Koala's full utilisation of this key area. The VMP identifies this area for weed removal, and works have been ongoing since 2007 with significant success with Lantana effectively under control (see Appendix 4 for example photo). Works are programmed to continue under the OSMS (Cardno 2008b) to see this key area fully restored to maximum ecological effectiveness.

6.1.1.7.2 General Weed Control

6.1.1.7.2.1 Filling and Excavation Area:

Disturbance of the study site's soils has potential to encourage weed invasion. Hence, it is recommended that:

- Machinery to be used for the work should be cleaned to remove seeds (ie on wheels, tracks, guards etc) prior to transport to and from the site.

- Measures should be taken to inhibit the establishment of weeds following the work especially in fill storage and spread areas ie via a weed management plan.

6.1.1.7.2.2 Open Space/Wildlife Corridors

The majority of the east-west linkage has a high component, consisting of Torpedo Grass. The margins of the existing dams/lagoons are particularly affected and has limited development of macrophytes (Cardno 2008).

The VMP identifies areas to be treated to reduce/control infestations of this weed, and a range of field trials testing control methods have been undertaken already eg physical removal of Torpedo Grass from the lagoons/dams. These are expected to continue in company with macrophyte and other native species planting and bush regeneration to restore native vegetation communities and maximise habitat opportunities of these wetlands.

6.1.1.8 Landscaping/Bush Regeneration

The Project and Concept Plan Applications includes provisions (via the Vegetation Management Plan and Landscape Plan) for extensive landscaping/bush regeneration around the constructed wetland for a range of purposes ie nutrient uptake, aesthetics and habitat (Luke and Co. 2008, Cardno 2009). These also form part of the east-west and northern corridors.

The following recommendations were made in a preliminary report in 2006, and have largely been incorporated into the VMP/OSMS.

6.1.1.8.1 Constructed Wetland Landscaping/Vegetation Buffers

All plantings around the wetland are to be based on native species indigenous to the LGA. Apart from lawns and ornamental gardens in specified areas, no exotic species are to be used in the fringing vegetation around the wetland.

6.1.1.8.1.1 Location, Structure and Function of Plantings

Plantings around the wetland should generally mimic natural structure ie combine trees with shrubs, etc to form a forest or woodland structure depending on location, function (eg discourage access to water) and aesthetic aims of the landscape plan/VMP.

The VMP has allowed for at least 30-50m wide plantings (incorporating facilities such as pathways and APZ) around the western edge to minimise human intrusion and maximise the buffer zone. More structured plantings will occur at the northern and southern ends to establish, formalise and/or widen corridors along Duchess Gully and link the southeast dry sclerophyll/swamp forest with the central swap forest (Cardno 2008).

Plantings in the emergent zone are to occur around the majority of the wetland's periphery to maximise water treatment and habitat creation, with the western side being a dedicated primary treatment area (Cardno 2008). Planting zones in general should be maximised in width where practical though it is appreciated that natural colonisation of suitable habitat will occur in relatively short time (DLWC 1998a, 1998b). Some of these species are also likely colonise shallow zones in the deeper portions of the wetland over time which will increase habitat complexity (as noted above).

6.1.1.8.1.2 Recommended Planting Species

Some suggested recommended species are:

- **Trees**: *Melaleuca quinquenervia, Eucalyptus robusta, E. microcorys, E. patentinervis, E. resinifera E. tereticornis, Corymbia intermedia, C. gummifera*. Littoral and subtropical rainforest species such as *Ficus coronata, Ficus macrophylla, F. rubiginosa, Syzygium australe*, *Cryptocarya* spp, etc are also desirable to maximise biodiversity.

- **Understorey/Shrubs**: *Callistemon pachyphyllus, M. stypheloides, M. linariifolia, M. sieberi, Babingtonia similis, Allocasuarina torulosa, A. littoralis, Acacia suaveolens, A. binervata, A. implexa, Banksia integrifolia, B. serrata, B. oblongifolia, B. robur, Trochocarpa laurina, Backhousia spp, Acmena smithii,* Cabbage Palm*, etc*

- **Groundcovers:** *Lomandra longifolia, L. hystrix, Juncus usitatus*, *J. polyanthemus, J. continuus, Schoenus spp, Carex appressa, Carex fascicularis, Gahnia aspera, G. clarkei, Crinium pedunculatum, Caustis recurvata, Pseudoraphis spp, Restio spp,* Bracken Fern*,* Bats Wing Fern, Swamp Fern, False Bracken,

Recommended species for the emergent zone are:

- *Eleocharis acuta, E. sphacelata, Triglochin procerum, Juncus spp, T. striatum, Alisma plantago-aquatica, Baumea rubiginosa, B. articulata, Carex appressa, Cyperus exaltatus*, *Lepironia articulata, Paspalum distichum, Phragmites australis, Schoenus spp, Schoenoplectus mucronatus, S. validus, Typha domingensis, Phragmites australis* and *Philydrum lanuginosum, Chorizandra spp, and Lepironia articulata*.

Recommended species for the submerged zone and open water are:

- *Vallisneria spp* (shallow areas)*, Nymphaea spp*, *Ludwigia peploides, Ottelia ovalifolia,* Duck Weeds and *Triglochin spp.*