ECOLOGICAL SURVEY AND STATUTORY ASSESSMENTS

OF

PROPOSED CONSTRUCTED WETLAND AND FILLING & CONCEPT PLAN ON PART LOT 123 DP 1106943, & LOT 5 DP 25886, OCEAN DRIVE, LAKE CATHIE

FOR

Luke and Company Pty Ltd

Port Macquarie

Assessment Undertaken By:

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NOTE:

This report is presented on an objective basis to fulfil the stated legislative obligations, consideration and requirements in order to satisfy the client's instructions to undertake the appropriate studies and assessments. It is not directly intended to advocate the proponent's ambitions or interests, but is to provide information required in the determination of development consent by the decision-making authority for the subject proposal.

To the best of our knowledge, the proposal described in this assessment accurately represents the proponent's intentions when the report was completed and submitted. However, it is recognised and all users must acknowledge that conditions of approval at time of consent, post development application modification of the proposal's design, and the influence of unanticipated future events may modify the outcomes described in this document. Completion of this report has depended on information and documents such as surveys, plans, etc provided by the proponent. While checks were made to ensure such information was current at the time, this consultant did not independently verify the accuracy or completeness of these information sources.

The ecological information contained within this report has been gathered from field survey, literature review and assessment based on recognised scientific principles, techniques and recommendations, in a proper and scientific manner to ensure thoroughness and representativeness. The opinions expressed and conclusions drawn from this report are intended to be objective, based on the survey results and this consultant's knowledge, supported with justification from collated scientific information, references/citations or specialist advice.

Furthermore, it is clarified that all information and conclusions presented in this report apply to the subject land at the time of the assessment, and the subject proposal *only*.

This report recognises the fact, and intended users must acknowledge also, that all ecological assessments are subject to limitations such as:

- Information deficits (eg lack of scientific research into some species and availability of information)
- Influences on fauna detectability eg season in which survey is undertaken
- Influences on species occurrence eg stage of lifecycle, migratory, etc
- Time/financial budgets.

All users should take into account the above information when making decisions on the basis of the findings and conclusions of this report.

For and on behalf of DARKHEART Eco-Consultancy,

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SUMMARY

1. BACKGROUND INFORMATION

This report presents the results of an ecological survey and impact assessment, and *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) - Matters of National Environmental Significance (MNES) assessments of a proposed constructed wetland and associated filling of land on Part Lot 123 DP 1106943 and Lot 5 DP 25886 Ocean Drive, Lake Cathie. This survey and assessment forms part of an Environmental Assessment for two development applications under Part 3A of the *Environmental Planning and Assessment Act 1979* to the Dept of Planning (DoP), NSW, as follows.

The first application ("*Concept Plan*") seeks consent for:

- The delineation of the limits of the residential subdivision
- The delineation of the three intersections with Ocean Drive
- The delineation of the extent of the future school sites
- The general location of the Greater Lake Cathie/Bonny Hills Village Centre
- The delineation of the site for future eco-tourist development
- The delineation of the extent of the Open Space, Drainage and Wildlife Habitat Corridor

The second application ("*Project Application – Open Space Corridor and Constructed Wetland*") seeks consent for the following elements:

- Open Space, Drainage and Wildlife Habitat Corridors
- Earthworks required for Constructed Wetlands and to create filled reclaimed areas
- Storm Water Treatment and Management, and
- District Sporting Fields and Facilities

The Director has issued Director General's Requirements (DGRs) for the Concept Plan Application (CPA) and the Project Application (PA).

The following Concept Plan Application DGRs are addressed in this report:

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.	**Recommendations**: Sections 6.1, 6.2, 6.3
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.	**Recommendations**: Sections 6.1, 6.2, 6.3

The following Project Application DGR's are addressed in this report:

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.	**Impacts**: Section 5.0 **Recommendations**: Section 6.1, 6.2

The site is part of a larger parcel of land approximately 180ha located east of Ocean Drive between Lake Cathie and Bonny Hills which has been previously surveyed by the consultant in 2003, 2005 and 2006, and another consultant in 1983.

The section of land proposed for development is approximately 10.72ha for a constructed wetland, and another 49.08ha for associated filling of land to the north, northwest and west for future urban development. The PA site is located roughly in the centre of the property, between the existing dwelling on the northern ridgeline and the largest currently existing lagoon to the south, and extends from the edge of the forested vegetation on the western boundary adjacent to Ocean Drive to the edge of Duchess Gully in the east.

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The property on which the Applications are proposed is situated at the southern outskirts of Lake Cathie village and is part of a currently rural area between expanding residential areas of Lake Cathie and Bonny Hills. The future development concepts in the UIA 14 Urban Design Structure Plan include residential development of the property including most of the proposed PA site where filling is proposed, with retention of some open spaces for drainage and habitat corridors/public reserves (where the wetland is proposed). The proposals are thus in line with this Plan.

The property has a very complex topography and geomorphological history. Topography ranged from broad flat poorly drained land, to a ridgeline in the north, a sandplain in the east, and two large lagoons which provided fill for previous residential development to the south. The property also includes the upper limits of Duchess Gully, and drainage over the property and also characteristics of Duchess Gully have long been artificially modified via deep drains and partial construction of a golf course as part of a previous abandoned development proposal.

The soils on the property are from the Cairnscross landscape on the lower sections, and Moripo landscape on the higher ground. The lower section was comprised of broad drainage plains with alluvial soils and slope-wash clays/silts, with poorly drained Gleyed Podzolic soils and Sodosols present. These soils are characterised by strong acidity, potential aluminium toxicity, poor drainage, seasonal waterlogging and low fertility. Field texture was a dark loam with high silt content. The higher ground was based on metadolerites and dacites, with moderately well drained, stony, brown and yellow Dermosols and Brown Chromosols. These are stony soils, neutral to moderate alkalinity, with localised seasonal waterlogging. The field texture was a fine sandy loam, consisting largely of fine sand and silt with little clay.

Deep below the soils on the poorly drained land are Potential Acid Sulfate Soils which have not been activated despite previous extensive lowering of the watertable and modification of surface water flow patterns by artificial drainage which occurred at least around the middle of the last century as evidenced by historical photos.

2. FLORA RESULTS:

2.1 Vegetation Communities

i) Vegetation Communities:

In broad overview of the vegetation communities of the total property, it is noted (especially via reference to historical aerial photos) that the property has been subject to a significant level of disturbance at various times, mostly for pastoralism and establishment of the previous abandoned development proposal in the 1980's. Appraisal of photos from the 1960's to present show various episodes and extents of clearing and regrowth over the property.

All of the property's vegetation has been subject to some form of disturbance, with some communities derived from this disturbance of previous communities or via colonisation of new habitat eg pasture/pastoral woodland, and probably most of the Swamp Oak swamp forest. Most of the vegetation communities currently present have been mapped as part of the UIA 14 Koala Plan of Management, and their approximate area are illustrated below.

Table A: Types and extents of vegetation communities on the property.

Vegetation Community/Habitat	Total Area (ha)
Blackbutt-Tallowwood-Needlebark Dry Sclerophyll Forest	1.98
Brushbox Wet Sclerophyll Forest	0.72
Blackbutt Dry Sclerophyll Forest	2.11
Grey Ironbark-Grey Gum Dry Sclerophyll Forest	2.39
Paperbark-Swamp Mahogany-Swamp Oak Swamp Forest/Woodland	10.45
Pasture/Pastoral Woodland	150.12
Dune Scrub	1.19
Swamp Oak	4.29
Aquatic	5.75
	179ha (Approx)

ii) Threatened Flora Species:

This and previous surveys failed to detect the presence of any threatened flora species on the property despite targeted searches in suitable habitat. The property has been subject to a range of disturbances at various intensities including clearing, drainage, earthmoving and cattle grazing. These threatening processes over time are considered likely to have significantly reduced the suitability of the subject land to support threatened species, or resulted in their elimination. In this regard, the property is considered to have at best minimal potential to possess a threatened flora species and none were considered likely potential occurrences.

iii) Endangered Ecological Communities:

Two low to medium quality Endangered Ecological Communities listed under the *Threatened Species Conservation Act* (TSCA) *1995* occur on the property (previously mapped in the UIA 14 KPoM), comprising about 14.74ha in extent.

- ***Swamp Sclerophyll Forest on Coastal Floodplains***: This EEC is considered to constitute the Paperbark/Swamp Mahogany/Swamp Oak swamp forest in the mid southwest, northwest and southeast of the property. Overall, all examples of this EEC on the property were considered to only qualify as low to medium quality examples due to the extent of disturbance and modification. Collectively the EEC – *Swamp Sclerophyll Forest* occurs over approximately 10.45ha of the property.

- ***Swamp Oak Floodplain Forest***: This EEC was considered to constitute the portion of Swamp Oak located in the northeastern section of the property which actually occurred on the poorly drained land. The community occupies 4.29ha of the property.

3. HABITAT EVALUATION:

The habitats/habitat components on the property are summarised as follows:

(a) Aquatic habitat:

The most significant habitat on the property appears to be a drain in the southwest that was found to support a small population of Wallum Froglets, and an artificial wetland formed by an unfinished excavation which supported a larger population of this threatened species. Other habitat on the property was not considered likely to support any other threatened frogs due to disturbance, isolation, trampling and grazing by cattle, and presence of Plague Minnow.

The two lagoons offered some known and potential non-breeding foraging habitat for EPBCA listed migratory species and perhaps the threatened Osprey and Bitterns. Duchess Gully offered some non-breeding foraging potential for Bitterns and some EPBCA migratory bird species (more so in downstream portions off-site). Most of these habitats were also considered suitable for foraging by the Southern Myotis.

(b) Terrestrial habitat:

Overall due to disturbance history and grazing management, the property did not contain significant quantities of logs and fallen branches. Most occurred in the dry sclerophyll forest in the southeast of the property. These logs had varying levels of decay and reasonable amounts of debris piled up against them hence offered some limited habitat potential.

Groundcover vegetation was generally sparse throughout most of the property due to periodic slashing for pasture management and generally it did not provide significant potential habitat for rodents, other smaller terrestrial species, or for small macropods. The exception was in some less accessible forested sections in the southwest of the property adjacent to the dry sclerophyll, the east-southeast patch of dense Swamp Oak swamp forest, and the native grassland to the east of Duchess Creek which provided a relatively dense cover up to 1m high (average 30-50cm), when not slashed. Two of these areas were found to support the TSCA listed Eastern Chestnut Mouse and one recorded a Common Planigale.

Leaf litter was present throughout the forested areas, particularly in the Swamp Oak and southern area of the dry sclerophyll where it was often the dominant ground cover. Generally the litter was up to 5cm deep. Throughout most of the forested areas, undergrowth was absent or present only as a sparse cover of shrubs and Lantana which provided limited habitat for passerine birds.

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(c) Arboreal habitat:

The area of scattered isolated trees located in the pastoral woodland in the centre and mid-north of the property contained the most hollows on the property. Within the PA alone, some 14 hollow-bearing trees with entrances ranging in diameter from approximately 5-35cm occurred. However, the utilisation of these hollows by arboreal species is likely to be significantly limited due to the small size of the habitat in which they occur, lack of other habitat components (eg understorey, groundcover, logs, etc), and most of all the effective isolation from similar (ie forest) habitat. Consequently, apart from highly mobile threatened fauna such as some Microchiropteran bats, only common woodland birds were considered or observed facilitating these hollows and no threatened arboreals are considered likely to facilitate these hollows.

The small area of dry sclerophyll at the northern boundary of the property also contained six hollows with entrances 5-10cm diameter. Other small hollows may be present but were not visible from below. Hollows were also observed in the southeast dry sclerophyll. In total these hollows provided good potential roost/nest habitat for *Antechinus*, possums, gliders (eg Squirrel Glider), other mammals (eg Brushtail Phascogale) and Microchiropteran bats.

(d) Foraging resources:

Overall, the property contains a potential year round arboreal flowering foraging resource and this foraging resource may contribute to the presence of birds, insects and other dependant fauna including threatened species such as the Grey-Headed Flying Fox or Squirrel Glider. However, this may not be a reliable year round resource due to variations in climatic factors and seasonal flowering incidences, and the limited extent, poor interconnectivity and dispersed distribution of this habitat on the large property.

The property contains a relative abundance of *Casuarina glauca*, predominantly in the Swamp Oak complex but also found in various communities throughout the property. The species preferred by the Glossy Black Cockatoo are reported to be Black Oak (*Allocasuarina littoralis*) and Forest Oak (*Allocasuarina torulosa*) and thus the Swamp Oaks on the property were considered only likely to provide at best a marginal secondary foraging resource. Black Oak was found in relatively low abundance on the property in the northern section of dry sclerophyll/swamp forest on the western boundary of the property. The species occurred as immature understorey specimens and were considered in their current form to provide low potential as a foraging resource.

The Swamp Mahogany, Forest Red Gum, Tallowwood and Small Fruited Gum on the site are Preferred Koala Food Species in the mid-north coast of NSW. Potential Koala Habitat occurs on the property, and Core Koala Habitat has been identified in the southeast corner by the UIA 14 Koala Plan of Management.

(e) Bat habitat:

The property offered some good potential for foraging by the Grey-Headed and Black Flying Foxes, but did not offer suitable roost sites for the species. Only limited potential occurred in specific areas for foraging by the Eastern Blossom Bat and no significant potential roosting habitat for this species which has been recorded roosting in adjacent littoral rainforest by another survey.

The property provided areas of continuous canopy forest suitable for aerial intercept species flying over the canopy (termed the ‘supra canopy zone’). These include threatened species such as the Common Bent-Wing Bat and Yellow-Bellied Sheathtail Bat. Potential opportunities for foraging at the border between forest communities and open pasture, grass or sedge land and beneath the canopy of forested habitat also occurred on the property. This potential foraging resource is considered suitable for threatened species such as the Greater Broad-Nosed Bat, Eastern Freetail Bat, Common Bent-Wing Bat and Little Bent-Wing Bat which have been observed in similar situations. The lagoons and Duchess Gully were considered structurally suitable for foraging by the Southern Myotis.

As noted above, tree hollows of varying sizes provide good potential roost sites for these bats but no caves or similar structures occur on the property. The peeling bark of Forest Red Gums and Blackbutts on the property also offers seasonal temporary roosts for the smaller Microchiropteran bat species.

(f) Wildlife Corridors and Habitat Linkages:

Internal linkage between forested habitats on the property is best described as tenuous. Limited and at times fragmented riparian vegetation along Duchess Gully provides the most defined link from the northwest dry sclerophyll and Swamp Oak

swamp forest to the southeast dry sclerophyll and swamp forest, and beyond to the southeast. An even more tenuous link is provided by the Paperbark/Swamp Mahogany swamp forest around the western lagoon and associated drain to the ribbon of dry sclerophyll and swamp forest in the far west. Overall, species dependant on continuous forest/woodland or dense groundcover would have significant difficulty moving across the property.

The eastern and western sides of the property is mapped by the DECC as part of the Lake Cathie-Camden Haven Regional Corridor which links Lake Innes Nature Reserve to the Grants Beach area (as well as being part of the Habitat Corridors designated in the Lake Cathie – Bonny Hills Structure Plan 2004). This regional link is fragmented by cleared private land, a main road, and ongoing residential development. No DECC sub-regional corridors were mapped in close proximity to the property. However, due to the current habitat fragmentation, the area designated as regional corridor is more likely to function as a sub-regional corridor. No portion of the property is mapped as Key Habitat.

The upper limits of Duchess Gully and Swamp Oak community in the northeastern corner of the property is identified in the UIA 14 Structure Plan as part of a northern corridor, and the broad drainage line running from the southwest to the east across the property to Duchess Gully is identified as a major east-west link to the dune vegetation and to Bonny Hills. Current habitat in these corridors however offers limited potential suitability due to fragmentation, immaturity and limited diversity. Hence an effective corridor through these areas is likely to require that existing forest habitats be significantly augmented by habitats with a diversity of structure and composition (eg dry and wet sclerophyll forest, sclerophyll swamp forest, sedgelands) and with continuous wooded cover linking to existing remnants.

The revised Structure Plan has also removed the previously mapped northernmost section of the northern corridor (ie from Ocean Drive to Lake Cathie) which linked to Lake Innes Nature Reserve. Consequently, this constricts the northern corridor's effectiveness to only highly mobile fauna such as birds and bats, with limited value to terrestrial/arboreal species such as the Koala.

4. FAUNA RESULTS:

Survey of the property by this consultant from 2003-2006 as well as another consultant in 1983 recorded the following threatened species:

(i) Wompoo Fruit-Dove: Previous study observed this bird 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 the property in 2003. The property does not offer any significant habitat for this species (ie no significant foraging habitat), hence its occurrence on the property is merely incidental.

ii) Square-Tailed Kite: This species was not detected on the property during the surveys but has been anecdotally recorded flying over the southern end by the consultant, as well as within 2km both north and south of the property. A limited potential foraging resource of passerines is present in the forest remnants on the property. No nests were observed and nesting is considered unlikely on the property due to the limited forest area, presence of another nesting raptor, and paucity of potential nest trees. At the least, the property overall is likely to fall within the home range of a local pair, hence the Square-Tailed Kite was considered at least a fair chance of occurrence on the property as an occasional forager.

iii) Eastern Chestnut Mouse and Common Planigale: These species were not detected in the PA area, but were recorded in 2003 in two separate portions of the property:

- East of Duchess Gully in native grassland which is an area created by disturbance (maintenance slashing) and dominated by dense Matrush, Bracken Fern and Bladey Grass (Eastern Chestnut Mouse only). This area of habitat is adjacent to dune scrub and southeast dry sclerophyll, but does not link to any similar habitat.
- Narrow drain dominated by ***Babingtonia pluriflora*** and sedges, adjacent to rank Bladey Grass in the southwest corner adjacent to the southwest patch of dry sclerophyll. This area of habitat is highly constricted by periodic slashing.

Due to the history of disturbance over the property and current management (ie slashing); the (at best) tentative connectivity; small population size; and the limited/restricted extent of dense groundcover/habitat; the populations of these species on the property are currently considered to have marginal long term viability.

iv) Little Bent-Wing Bat: This species was recorded foraging in the southeast most likely along the fire trail along the southeast boundary fence to the sewage treatment plant; and in the PA area. The property forms part of the extensive

non-breeding foraging range of at most a few individuals of this species, with limited potential to roost in tree hollows.

v) Wallum Froglet: The Wallum Froglet has been recorded in two locations in the southern end of the property during previous surveys:

- At least 50 individuals in an apparently constructed depression just north of the eastern large lagoon (just outside the proposed wetland and filling area).
- At least 2 individuals in a drain dominated by heath in the southwest corner of the property adjacent to the southwest dry sclerophyll (where the Common Planigale was also recorded).

vi) Koala: Koala scats indicating an Area of Major Activity were found in swamp forest in the southeast of the property adjacent to the Bonny Hills sewage treatment plant (STP) but nowhere else on the property despite searches. This correlated previous sightings and scats in this area by another consultant, and complimented historical records of the Koala on the property. The southeast corner of the property was considered to form part of Core Koala Habitat.

vii) Grey Headed Flying Fox: Several individuals were recorded foraging on flowering trees on the property. 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.

In addition to the above, the DECC Atlas of Wildlife shows a record of the Swift Parrot on the northern part of the property. The property overall offers rather marginal potential and at most may form a minute fraction of the potential non-breeding foraging range of this Winter migrant.

The following Migratory species listed under the EPBCA 1999 were observed by this consultant or have been previously recorded foraging on the property:

- Great Egret
- Cattle Egret
- White-Breasted Sea-Eagle
- Fork-Tailed Swift
- Rufous Fantail

A number of other threatened and migratory fauna species were also considered potential occurrences on the site and/or larger property and they were addressed by the Seven Part Tests and MNES assessments (below).

5. IMPACTS OF THE DEVELOPMENT:

A comprehensive review was undertaken of the potential ecological impacts the proposal may have, with specific focus on threatened species recorded on and near the site, or considered to have potential to occur.

(a) General Impacts:

As per the DGRs, impacts on threatened species are assessed for the Project Application. The broad impacts of the Concept Plan Application are considered in terms of 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.

The following tables illustrate the estimated loss per vegetation community and EEC.

Table B: Estimated areas of loss per vegetation community.

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	0.02	2.37
Paperbark-Swamp Mahogany-Swamp Oak Swamp Forest/Woodland	10.45	0.86	9.59
Pasture/Pastoral Woodland	150.12	62.85	87.27
Dune Scrub	1.19	0	1.19
Swamp Oak	4.29	0.7	3.59
Aquatic	5.75	0	5.75
	179 (Approx)	64.43	114.57

Table C: Estimated areas of loss per EEC

Endangered Ecological Community	Total Area (ha)	Area Retained (ha)	Area Cleared (ha)
Swamp Oak Floodplain Forest	4.29	3.8	0.49
Swamp Sclerophyll Forest	10.45	10.02	0.43

The development will generally have the following direct **negative** potential impacts:

- Loss of 64.43ha area of pasture/woodland, drain vegetation and swamp forest regrowth as a result of excavation and filling the land with clean fill to establish future urban development.
- Loss of 0.49ha of *Swamp Oak Floodplain Forest* EEC.
- Loss of 0.43ha 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 potentially the Jabiru.
- Loss of an area of seasonally waterlogged grassy poorly drained land 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 open space corridor 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.

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- Increased linkages and habitat for a range of threatened fauna (eg Koala, Squirrel Glider, etc) due to 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.

- Creation of about 53.82ha of habitat (mostly swamp forest) via current and ongoing bush regeneration works and landscape works.

(b) Other Issues:

The following are other issues associated with the specific type of development:

1. Acid Sulfate Soils (ASS): A specialist consultant's report has determined that temporary lowering of the watertable (currently around 3.5m AHD) by the waterbody (which will have an average surface level around 3.0m) should not expose ASS which are located at about 2.0 AHD on the western shoreline, and 1.0m on the eastern shoreline no more than the current invert effect created by Duchess Gully. This is further evidenced by lack of evidence of activation despite extensive historical drainage. Furthermore, filling on top of areas mapped as underlain by ASS is not considered likely to significantly result in the effect known as "sponging".

2. Temporary lowering of the watertable effects: The current watertable is around 3.5m (suggesting a current influence by the existing lagoons), grading down to 1m AHD to the invert of Duchess Gully. The proposed water level of the constructed waterbody is intended to be lower at an average of 3.0m AHD (min 2.1m). This effect is reported to be similar to the current large lagoons and Duchess Gully hence the specialist consultants consider the new waterbody will have no significant effect on the watertable level. The specialist consultant also determined that it will not expose any ASS and that construction of the wetland will be undertaken in cells under dry conditions to limit local drawdown effects and allow re-flooding of each cell once construction is complete to maintain the watertable.

   The temporary lowering of the watertable by the new major constructed wetland will reportedly have no effect on the hydrological regime of the adjacent Wallum Froglet habitat due to the localised range of the effect, and that the habitat in question depends upon direct rainfall and adjacent runoff, not the watertable due to isolation via a clay substrate.

3. Groundwater quality issues: The specialist consultant reports that based on their modelling, the proposal will not:
   - Expose ASS to oxidation.
   - Significantly affect net groundwater outflows.
   - Significantly affect the operation of the STP exfiltration.

4. Runoff: With full urbanisation of the property, it is anticipated that runoff will increase. Connection via a weir to the existing constructed wetland system to the south to the new major waterbody, and twin connections to upper Duchess Gully (one in the northern end of the new waterbody, and the existing overflow off the western lagoon) will distribute this increase in net streamflow, with most flow directed to the upper creek discharge point, which will reportedly have the benefit of increasing flushing of tertiary treated effluent deposited downstream by the STP. The specialist consultant predicts this will not have any adverse impacts on the character of Duchess Gully.

5. Erosion and sedimentation: 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.

   Statutory requirements, environmental management plans (EMPs) and design features are expected to mitigate these potential impacts.

(c) Secondary Impacts*:*

Secondary potential impacts of the development include:

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1. Noise: Likely to be relatively high during construction phases but generally not considered a significant threat, and contained generally within the site.

2. Dust: Statutory controls and an EMP should ensure this potential impact is controlled.

3. Pollution: Via fuel spillage, etc, is a potential threat to aquatic habitats especially the eastern Wallum Froglet population but again statutory controls, an EMP and standard provisions should be effective.

4. Eutrophication: May potentially occur via runoff into the wetland, Duchess Gully and Wallum Froglet habitat in the long term from urbanisation of the catchment. Engineering measures, the stormwater treatment system and chain, and the primary design function of the major new wetland should ensure this impact does not become significant.

5. Altered Bushfire Regime: The proposal should not have any substantial impact on the current bushfire regime.

6. Fences: The proposal will have the positive impact of removing internal boundary fences which are a physical barrier and injury/mortality threat. As only temporary construction fences may be implemented and will not enclose any habitat, no fences associated with the proposal should have any adverse impact.

7. Increased human presence: Human presence and associated impacts will significantly increase during construction which may deter usage of the adjacent lagoons by some shy waterbirds. Establishment of bushland and screening landscaping may counter this effect.

8. Exotic species: Increased activity of exotic fauna is not considered likely as a result of the proposal, though as such species are already present, they could colonise the proposed bush regeneration/landscaping. Measures are to be undertaken and proposed to minimise this threat.

9. Direct mortality of resident fauna during clearing operations: This is a genuine risk to hollow-obligate fauna that may be using tree hollows in the pasture during construction, and also to a Whistling Kite which has a nest in this area. Appropriate measures are to be undertaken.

7. RECOMMENDATIONS AND AMELIORATIVE MEASURES:

7.1 Open Space/Drainage/Habitat Corridor:

The major ameliorative measure is the Open Space/Drainage/Habitat Corridor which was a measure designated in the UIA 14 Structure Plan. The Open Space Management Strategy (OSMS), 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 this area (which will encompass some 53.82ha), 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.

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 (Cardno 2008b) 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.

7.2 Project Application Recommendations and Ameliorative Measures

The following primary recommendations are made to ameliorate potential 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 a condition of consent.

(a) Primary Recommendations:

(i) 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 via a range of measures detailed in this report. Measures are provided to ensure the natural vegetation is protected and recovers and mechanisms are emplaced to deal with any threat.

(ii) Constructed Wetland Design: The following are measures the proponent has incorporated into the design and unless specified, are not recommendations of this assessment:

- The wetland contains some 10.72ha of open water, with depth ranging from 0.25m to 2m. A band along the western bank will consist of macrophytes in a constructed water treatment cell, and it is also expected that species such as Giant Spikerush and waterlilies which can grow to around a depth of 1m and at times deeper, will colonise most of the remainder of the wetlands. As water in most of the new wetland is expected to be high quality, this will result in a significant increase in habitat for waterfowl, frogs and invertebrates and a substantial positive impact on the property and local biodiversity.

- The design includes two overflows to Duchess Gully. The northern one is intended to restore the natural flow regime and is expected to improve the water quality of the watercourse. Another will link the new wetland to the two large existing lagoons to complete the treatment chain. Both structures generally will be dry at most times, hence will not be a barrier to small terrestrial species movement, and will also contain structures to aid movement of fish. Recommendations are made to plant the edges to resemble a natural riparian zone, and also to include structures such as large rocks and logs.

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

(iv) ASS Management: An ASS Management Plan has been developed 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.

(v) Groundwater and Water Quality: 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 have been provided to ensure the predictions of the geotechnical 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, and also to provide feedback to managers eg to initiate remedial action such as addition of freshwater to the wetland.

(vi) Artificial lighting: Artificial lighting is be arranged to avoid the risk of spillage onto the wetland and Wallum Froglet habitats due to the potential impacts it may have ie disturbing roosting and foraging behaviour, exposure to predation, etc.

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(vii) Weed Management:

- 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 may inhibit Koala access to preferred food species, and hence limit realisation of the full potential of the habitat. This lantana infestation was recommended to be removed and ultimately eliminated by standard bush regeneration techniques, and to date, this has almost been effectively achieved by pre-emptive works. This action will most likely also be requested under the provisions of the UIA 14 Koala Plan of Management when finalised.

- 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.

(viii) Landscaping/Assisted Bush Regeneration: The following are provided for incorporation within landscaping/bush regeneration provisions, and also guidance:

- 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 and aesthetic aims of the landscape/vegetation plan.

  The Vegetation Management Plan has allowed for the total width of plantings to be around 30-50m wide (incorporating facilities such as pathways) around the western edge to minimise human intrusion to provide a refuge for waterfowl, and also to provide a good linkage with the southeast forest and Duchess Gully to the east, and corridor plantings along the southern end linking to the east-west corridor.

  Plantings in the emergent zone are to occur not only in the specific water treatment areas but around the majority of the wetland's periphery to maximise water treatment and habitat creation, as well as protect the banks from wave action. Planting zones should be maximised in width where practical though it is appreciated that natural colonisation of suitable habitat will occur in a relatively short time. Some of these species are also likely to colonise shallow zones in the deeper portions of the wetland over time which will increase habitat complexity (as noted above).

(ix) Wetland Habitat Enhancement: Some of the trees fallen during future urban development of the remainder of the property (particularly the large Forest Red Gums in the pastoral woodland) should be laid (eg via crane if the wetland has been constructed) in the other areas of the wetland to provide roosts for Water Dragons, tortoises and waterfowl. Location can be selected according to maintenance requirements to avoid any problems. Provision of large rocks along some sections (eg around the Duchess Gully linkage to the east) would also enhance habitat opportunities.

(b) Secondary Recommendations:

The following are provided for optional consideration by the determining authority and proponent as measures to enhance general biodiversity. It is not assumed that these recommendations are adopted as conditions of consent or in the conclusions of this report, but it is desired that proponents at least be advised to consider adopting them to enhance biodiversity.

1. *Other Koala habitat enhancement:* The hill off the southeast of the wetland is largely cleared. This area provides excellent potential for regeneration of the adjacent dry sclerophyll. To increase the Koala habitat values of the site and provide for expansion of the local population, it is recommended that plantings of Tallowwood and Forest Red Gum be made on or around this hill as part of a bushland regeneration project to re-establish forest on or around this hill.

2. *Other measures:*

    - The perimeter of the wetland and all adjacent habitat areas where pedestrian paths may pass through are to be designated leashed dogs only. This is required to prevent dogs harassing wildlife and swimming.

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- Swimming, recreational boating and model boats should not be encouraged in the wetland again to minimise disturbance to fauna.

- Signage will be required to ensure compliance with these restrictions.
- Hollow-bearing trees are to be removed via a method which minimises risk of mortality/injury of occupants. The Whistling Kite nest tree should also be removed when inactive. An approved animal handler is to be on site during removal of these habitat components to aid any injured fauna.

7.2 Concept Plan Application Recommendations

The following recommendations are provided for consideration for the long term development of the property as per the UIA 14 Structure Plan and the Concept Plan Application:

(i) Duchess Gully: Duchess Gully is intended to form the northern corridor in the Structure Plan. It is recommended that the present vegetation along this creek be expanded via stock exclusion, weed eradication and bushland regeneration. The majority of the riparian vegetation should be a wet sclerophyll forest to maximise habitat potential and extend on limited resources currently available in this habitat, though some areas may better be suited to swamp forest and dry sclerophyll forest. Primary preferred Koala food trees should also be included in suitable edaphic conditions eg Tallowwoods, Forest Red Gums and Swamp Mahogany. The value of this area as habitat could also be enhanced via erection of nest boxes, and placement of some hollow logs (derived from the Forest Red Gums in the pastoral woodland which will eventually be cleared).

(ii) Restoration and Habitat Enhancement of the East-West Corridor: The proposed east-west corridor includes a significant area of degraded "*Swamp Sclerophyll Forest on Coastal Floodplains*" EEC, with condition ranging from pasture with scattered trees to immature regrowth forest. Restoration of this area will require some active plantings to supplement the low rate of natural recruitment, and weed control to see elimination of the established pastoral species. This will take a number of years to be established. Some preliminary works have commenced ie cessation of slashing and exclusion of grazing. This will allow some natural regeneration from seed banks and possibly allow some colonisation of habitat by threatened species in the area (eg Eastern Chestnut Mouse) which may increase their potential viability.

In the medium term, subject to flooding constraints, large fallen logs from other portions of the property could be positioned as single trees and small piles of logs to provide shelter for a range of fauna eg rodents, reptiles and the Spotted-Tail Quoll given such key habitat components will take hundreds of years to naturally develop. Nest boxes may also be viable to place in the immature swamp forest just west of the main lagoon to provide potential dispersal/den site opportunities for Squirrel Gliders which may use the habitat in the medium term (eg when a woodland or young forest has been established).

(iii) Habitat Creation: Given the majority of the proposed east-west corridor is a broad, flat drainage line, periodic storm events are likely to wash down fauna which may occupy swamp forest and wetland habitats. Regeneration of this area should aim to cater for these species, as should habitat creation measures.

(iv) Proposed Southern School Site: The current delineated area for this site includes the densely vegetated drain adjacent to the southwest patch of dry sclerophyll which is known to support a small population of Common Planigale, Eastern Chestnut Mouse and Wallum Froglet. It is recommended that this habitat area (the entire drain and a vegetated buffer zone to the east) be excluded from any filling, etc, within the school footprint. This area should be collectively fenced off with southwest dry sclerophyll/swamp forest, and the total area regenerated and managed appropriately for these species to maximise the potential viability of these small populations.

(v) Proposed Eco-Tourism Site: The southern half of the generally native grassland falling within the proposed eco-tourism site was found to support the Eastern Chestnut Mouse in 2003, but subsequent agricultural practices, including slashing, since this time places doubt on whether this species has remained viable in this area and/or in adjacent vegetation.

The development footprint of the Eco-Tourism site is not known at this stage. However, the buffer to the STP ensures that the residential component of the development is restricted to the northern half of Lot 5.

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Any future applications for development of the Eco-Tourism Site must ensure either the population is extinct (in which case ecological constraints are limited), or is not placed at risk of extinction. In the latter, development and management must ensure:

- Sufficient habitat is retained to support a viable population.
- No barriers to movement/dispersal are emplaced.
- Fire/slashing is managed as required per the species ecology.

8. EPBCA 1999 – MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE:

The provisions of the EPBCA require determination of whether the proposal has, will or is likely to have a significant impact on a *"matter of national environmental significance"*. These matters are listed and addressed as follows:

i) **World Heritage Properties**: The site is not listed as a World Heritage area nor does the proposal affect any such area.

ii) **Ramsar Wetlands of International Significance**: No Ramsar wetland occurs on the site, nor does the proposal affect a Ramsar Wetland.

iii) **EPBCA listed Threatened Species and Communities**: No EPBCA listed threatened flora species or community, etc, was found on the site or property, nor considered a significant likelihood of occurrence. The Grey Headed Flying Fox and Swift Parrot are the only EPBCA listed threatened fauna species detected on the property, and no other species was considered a significantly likely potential occurrence. Assessment under the MNES guidelines determined the PA proposal would not significantly reduce the value of the property and the potential for these species to occur and subsequently the impacts were not considered likely to be a sufficient order of magnitude to be considered significant. The proposed Open Space/Drainage/Habitat Corridor bush regeneration and landscaping based on native species was considered likely to create new habitat for these species which could off-set losses and potentially increase the carrying capacity.

iv) **Migratory Species Protected under International Agreements**: Five migratory species listed under the EPBCA have been detected on the property and several others are considered at least a fair chance of potential occurrences (eg Rainbow Bee-Eater, Fork-Tailed Swift and White-Throated Needletail). Assessment under the MNES guidelines determined the proposal would not significantly reduce the value of the property and the potential for these species to occur and subsequently the impacts were not considered likely to be a sufficient order of magnitude to be considered significant. Furthermore, creation of the wetland and landscaping may provide additional habitat for these species and may increase their occurrence.

v) **Nuclear Actions**: The proposal is not a nuclear action.

vi) **The Commonwealth Marine Environment (CME)**: The site is not within the CME nor does it affect such.

vii) **National Heritage**: The site is not listed on the National Heritage List.

The proposal was not considered to require referral to the Dept of Environment, Water, Heritage and the Arts for approval under the EPBCA 1999.

9. CONCLUSION:

Overall, the PA proposal will have relatively minimal negative impacts on the current capacity of the property to support the recorded and potentially occurring threatened species and the viable EECs. The net effect of the proposal is considered likely to be an overall increase in biodiversity in the long term with a benefit to the biodiversity values of the locality as opposed to a net loss which is typically associated with urban developments, provided the appropriate ameliorative measures are implemented.

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1.0 INTRODUCTION

1.1 SCOPE OF THE ASSESSMENT

This firm has been requested by Luke and Co. Pty Ltd (on behalf of St Vincents Foundation Pty Ltd) to undertake an ecological survey, impact assessment and EPBCA – *Matters of National Environmental Significance* assessment of the land identified as Part Lot 123 DP 1106943 and Lot 5 DP 25886, Ocean Drive, Lake Cathie. This survey and assessment forms part of an Environmental Assessment for two development applications under Part 3A of the *Environmental Planning and Assessment Act 1979* to the Dept of Planning (DoP), NSW, as follows:

MP 06_0085	Rainbow Beach Concept Plan
MP 07_001	Open Space Corridor and Constructed Wetland, Rainbow Beach

The assessment has been undertaken according to:

- *Draft Guidelines for Assessment of Impacts on Threatened Species Under Part 3A* (Dept of Planning 2005).
- *Draft Threatened Species Survey and Assessment – Guidelines for Developments and Activities* (DEC 2004).
- *Ecological Consultants Association of NSW – Code of Ethics* (2002), available at www.ecansw.org.au.

1.2 SCOPE OF THE SUBJECT PART 3A APPLICATIONS

The first application ("*Concept Plan*") seeks consent for (see figure 2):

- The delineation of the limits of the residential subdivision
- The location of the three intersections with Ocean Drive
- The delineation of the extent of the future school sites
- The general location of the Greater Lake Cathie/Bonny Hills Village Centre
- The delineation of the site for future eco-tourist development
- The delineation of the extent of the Open Space, Drainage and Wildlife Habitat Corridor

The second application ("*Project Application – Open Space Corridor and Constructed Wetland*") seeks consent for the following elements:

- Open Space, Drainage and Wildlife Habitat Corridors
- Earthworks required for Constructed Wetlands and to create filled reclaimed areas
- Storm Water Treatment and Management, and
- District Sporting Fields and Facilities

Consent for the two Part 3A applications identified above and completion of the physical works subject of those consents, will advance the project to the point where:

- The layout (concept plan form) of the development site, consistent with Port Macquarie Hastings Council's strategic planning objectives, is approved and established;
- Future urban and residential development areas are reclaimed and appropriately protected and vegetated.

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- The open space, habitat and drainage corridor areas of the site are rehabilitated with typical indigenous coastal habitats appropriate to the location and readied for the future incorporation of passive recreational facilities (eg pathways, cycleways, park seating, children's playgrounds and picnic areas).

Urban and residential development will then be completed in a series of stages, each of which will be the subject of future applications.

1.3 DGR'S ADDRESSED IN THIS REPORT

The Director has issued Director General's Requirements (DGR's) for the Concept Plan Application (CPA) and the Project Application (PA).

The following Concept Plan Application DGR's are addressed in this report:

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.	**Recommendations**: Sections 6.1. 6.2 and 6.3
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.	**Recommendations**: Section 6.1 and 6.3

The following Project Application DGR's are addressed in this report:

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.	**Impacts**: Section 5.0 **Recommendations**: Sections 6.1, 6.2 and 6.3.

1.4 OTHER STATUTORY PROVISIONS

The relevant provisions of the Commonwealth *Environment Protection and Biodiversity Conservation (EPBCA) Act 1999 - Matters of National Environmental Significance* are also addressed in this document.

2.0 BACKGROUND INFORMATION

2.1 LOCATION AND ACCESS

The subject land is located off Ocean Drive, <1km south of the centre of Lake Cathie village and north of Bonny Hills. Current access is directly from Ocean Drive. Figure 1 shows the general location of the land in the locality.

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2.2 DEFINITIONS

The area affected by constructed wetland and filling area (ie the Project Application) is generally referred to as the "**site**". The remainder of the land which is subject to the Concept Plan Application, is referred to as the "**property**". Habitat within a 10km radius is referred to as the **locality**.

2.3 CLIMATE AND WEATHER

2.3.1 Climate of the Bioregion

The climate of the north coast of the North Coast Bioregion from just north of Newcastle to the Queensland border is generally warm temperate. The main influence is the latitudinal position of subtropical anticyclone centres which more easterly across Australia.

In Summer, warm moisture-laden east to south east winds predominate, sometimes bringing rain, with the heaviest in the form of thunderstorms or depressions from subtropical cyclones moving south. In Winter, the northern movement of the anticyclones leads to a dominance of usually dry west to south winds, often leading to fine sunny days and cool nights. Rainfall is usually associated with cold fronts and the coldest temperatures.

Rainfall tends to be distributed more in Summer in the north of the region, to a relatively evenly distribution in the south. Annual rainfall is most influenced by distance from the coast and topographic position, with a general decrease from east to west. Annual rainfall in the coastal Hastings area is around 1522mm pa (www.hastings.nsw.gov.au), falling predominantly in Summer and Autumn.

Temperature over the region primarily varies with altitude, decreasing about 5^{o} per 300m rise, and about 2-3^{o}C from north to south in areas of similar altitude. The average annual temperature on the coast is typically 16-20^{o}C, while the annual range is 18-22^{o}C (Australian Bureau of Meteorology, cited in Hager and Benson 1994).

2.3.2 Weather Conditions During Survey

The main ecological survey was conducted from the 22nd to the 26th of May 2006. Conditions were generally clear, cool and fine for the majority of the survey (15-24^{o}C). Night conditions were clear and cool (2-11^{o}C). Cloud cover and thunderstorms were observed to the south of the property on the 22nd of May, however no rainfall fell on the site during the main survey period. The area had not received any substantial rainfall prior to the survey though with good rain (about 30mm) fell over several days in early July which allowed a targeted frog survey to be undertaken after the main survey to check previous findings by Berrigan (2003h).

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Figure 1: Local position of site
(Source: Grants Head 9434-1N, 1:25 000 Topographical map, © LPIC Orange 2008)

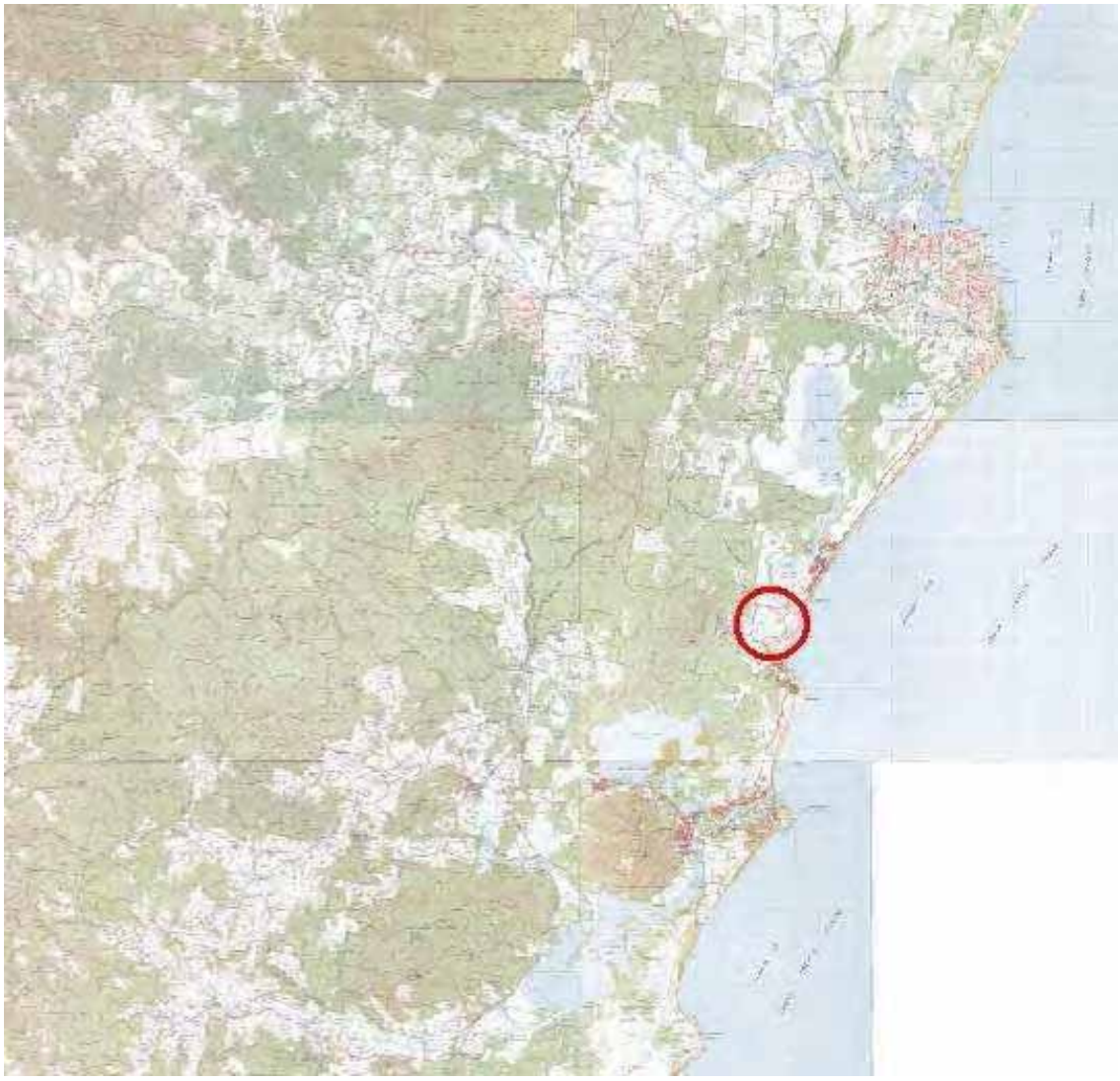

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Figure 2: Concept Plan

(Source Luke & Co)

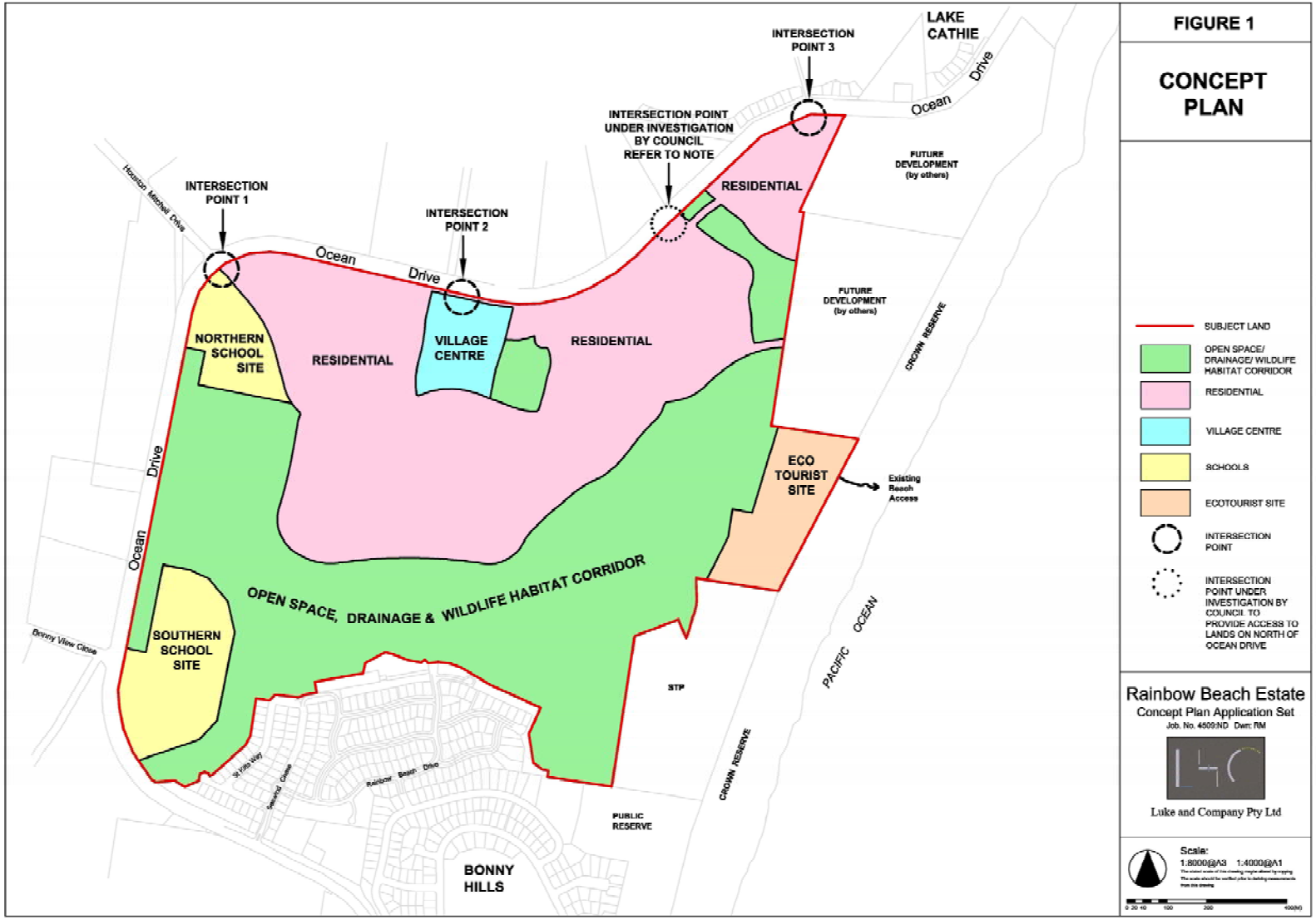
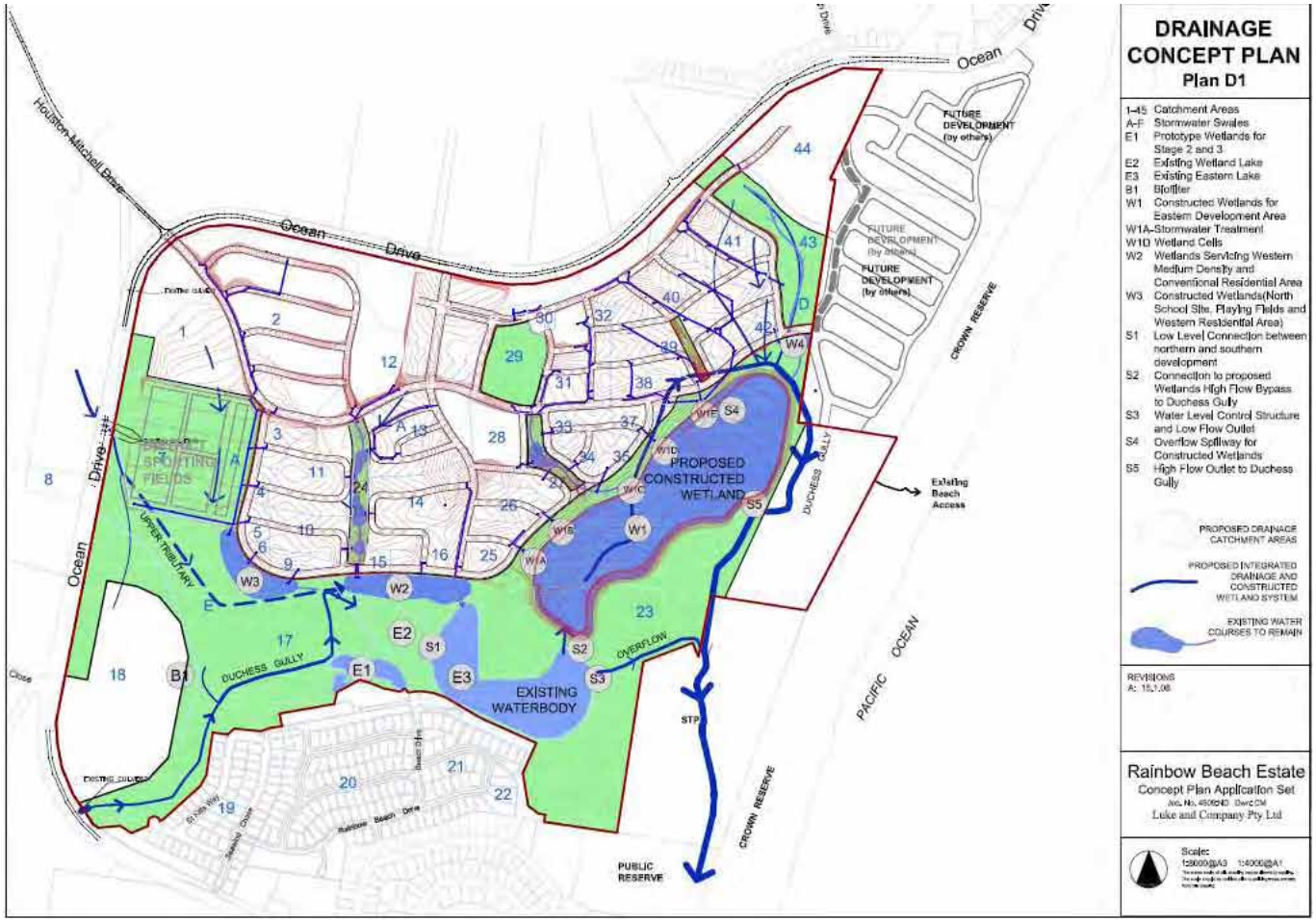
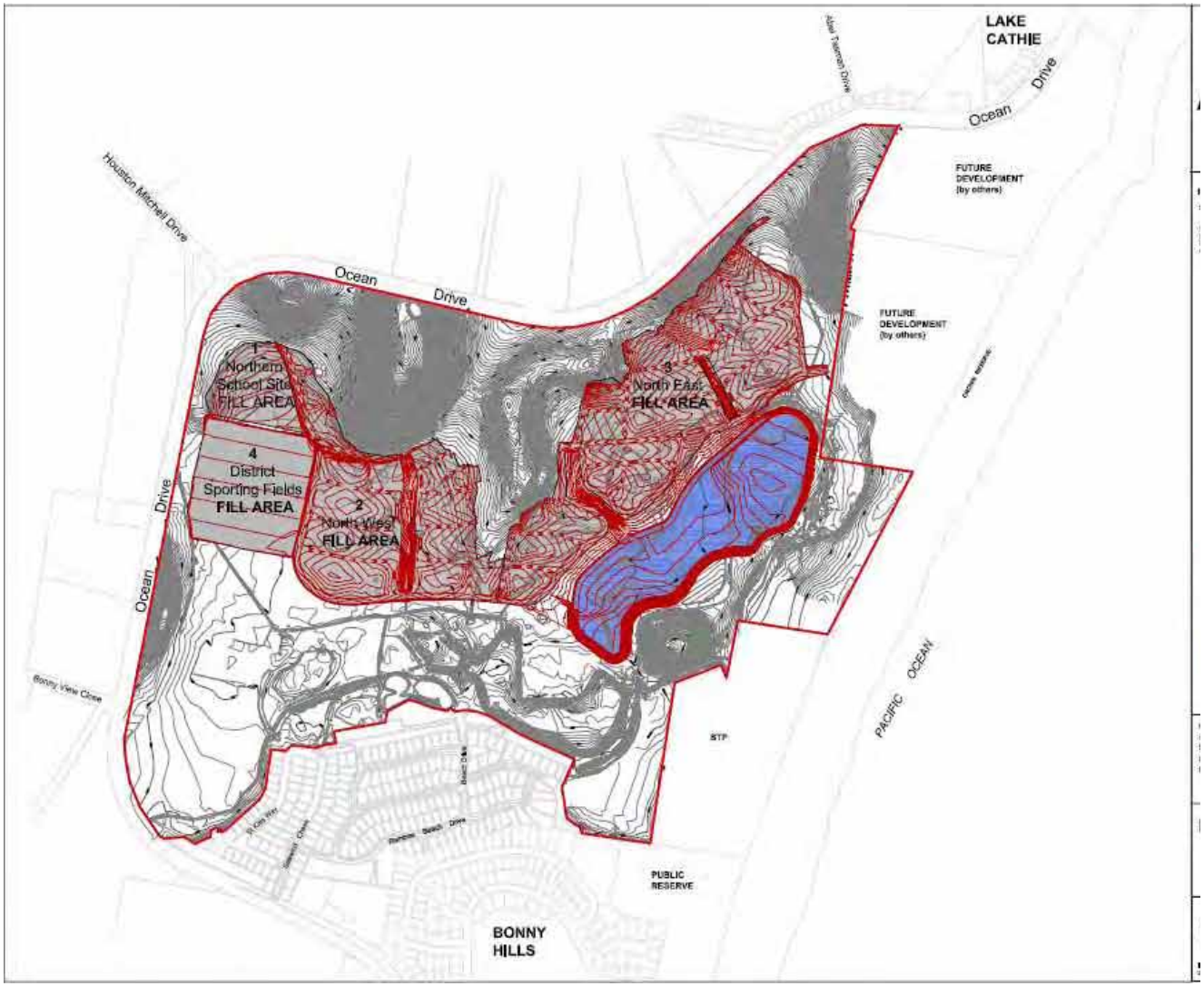


Figure 3: Project Application Plan - proposed excavation/wetland and filling.
(Source: Luke and Co Pty Ltd)

A: Drainage concept plan showing stormwater treatment train and exit points.



B: Proposed filling areas



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2.4 TOPOGRAPHY, GEOLOGY AND SOILS

2.4.1 Topography

Refer to the contour map in Figure 3.

2.4.1.1 Topography of the Property

As shown in figure 3, the topography of the property is rather complex due to the overlap and inter-relation between a range of geomorphological factors.

In general, the property includes the slopes of a large ridgeline along its northern and northwestern boundaries, which mostly fall to the south and southeast with minor drainage lines. Spurs running off this main ridge onto the site occur from the main ridge, with another crest rising to the northwest of the proposed wetland, with associated minor ridges running to the south. A spur from another ridgeline just enters the site at its west-southwest boundary and is composed of different geology. Another isolated small hill rises to the east-southeast of the wetland in the east-southeast of the property.

The far eastern section of the property consists of the sand plain (possibly a former hind dune removed by sand mining) of the adjacent coastal dune system. Topography in this area is not a true plain but appears to be a low flat dune, with an undulation down to the creek. A shallow drainage line rises just off the middle of the plain running southwest to Duchess Gully.

The sandplain is separated from the remainder of the property by the non-tidal section of Duchess Gully creek which rises at the foot of a drainage depression in the northwest of the site, and exits to the southeast by north of the isolated hill. This creek and general drainage of the property has been significantly modified by a network of artificial drains intended to improve the agricultural potential of the remainder of the property, which is essentially a coastal alluvial plain including a very broad drainage line (which lacks a well defined channel), entering the site from the south-southwest, with a tributary from the west-southwest. This drainage line encompasses two large lagoons (about 7ha in total), built as part of a previous development, and another smaller dam used for stock water in its northern extent, and exits via a modified channel on the south side of the isolated hill in the southeast to Duchess Gully.

2.4.2 Geology and Soils

The property falls into the soil landscapes in the Lake Cathie to Bonny Hills area which have been previously mapped and described by Ardill Payne & Partners (2002). The property was mapped as consisting of the Cairnscross and Moripo landscape groups.

The Cairnscross landscape comprised the lower section of the property which is described as broad drainage plains and slope-wash clays/silts with poorly drained Gleyed Podsolic soils and Sodosols. These soils are characterised by alluvial sediments, strong acidity, potential aluminium toxicity, poor drainage, seasonal waterlogging and low fertility (Ardill Payne & Partners 2002). Acid Sulphate Soils (ASS) derived from Pleistocene (not Holocene) marine deposits underlay parts of the property (Cardno 2008).

The Moripo landscape was present on the higher ground in the northern part of the property. It was described as low hills or undulating rises on metadolerites and dacites, with moderately well drained, stony, brown and yellow Dermosols and Brown Chromosols. These are stony soils, neutral to moderate alkalinity, with localised seasonal waterlogging (Ardill Payne & Partners 2002).

2.4.3 Groundwater

The flow pattern and chemical qualities of the groundwater on the property has been analysed and mapped by Cardno (2008).

Cardno (2008) reported the following salient features:

- Significant groundwater reserves occurred in the sediments especially in the east where marine sediments (derived from dune movements) dominated by sand occurred.
- Specific information on groundwater quality was limited but it is expected to be fresh (due to consistent base flow from the catchment to the ocean/Duchess Gully) with minor localised saline intrusion possibly up to the tidal limit of Duchess Gully (groundwater levels in the area subject to inundation are generally above tide level, hence limits penetration to the perimeter of the creek where a natural drawdown occurs due to Duchess Gully). Furthermore, groundwater around the adjacent sewage treatment plant is generally fresh (only brackish >4m down).
- Groundwater levels are likely to be maintained by direct rainfall onto the land affected by periodic inundation, with subsurface inflow from the western tributary (the broad drainage line entering the site from the southwest) expected to be limited by the low permeability clays. Flow from elevated areas west and north would be similarly limited.
- Groundwater flow pattern is predominantly west to east to Duchess Gully.
- No significant groundwater flow from the adjacent dune-based sewage treatment plant exfiltration into the area of periodic inundation on site, as such flows are intercepted by Duchess Gully.
- Recorded surface water quality on the area of periodic inundation is fresh, with relatively low nutrient levels (possibly increasing following storm events, etc). Due to interconnectivity with the upper aquifer, groundwater quality is likely to be similar.

2.5 LANDUSE AND DISTURBANCE HISTORY

The following information was collated from available sources.

2.5.1. Clearing and Pastoralism

The property appears to have a long history of pastoralism and grazing, and most modification has resulted from this enterprise with a large proportion of the property converted to pasture and grazed by cattle in the last 30-40 years.

Historical aerial photos of the neighbouring land to the east, indicated that it had once contained more extensive areas of open forest which was largely cleared and fragmented in the late 1970's (ERM 1996), with further clearing in the early 1980's especially in the west and mid-north where large remnants had once occurred (Clancy and Ayres 1983). Some of the clearing appears to be selective with pockets of open forest retained, and open woodland in other areas, with varying states and extents of regrowth also occurring. Retained eucalypt forest has also been used for selective logging for fence posts. The patterns and extent of clearing is evident in the photos in figure 4 from 1977-1989, which shows significant changes in vegetation compared to the present photo in figure 10.

An extensive drainage network eventually linked to Duchess Gully was constructed around the middle of the last century on the coastal plain (mostly as part of pastoralism and possibly modified as part of an abandoned tourist development) and has lowered the watertable, shortened standing time of surface water and hence altered edaphic conditions. This has allowed further pasture improvement and maintenance of regrowth via slashing in formerly wet areas.

In the last 10-15yrs, native regrowth has been allowed in certain areas (mostly where slashing was not practical eg due to bogging in wetter years). This primarily occurs along the riparian zone and upper reaches of Duchess Gully and along drains, resulting in linear strips of vegetation; as well as areas prone to waterlogging in all but the driest years eg parts of the western boundary and a drainage depression in the tip of the northern corridor. Swamp Oak forest on the property in general appeared to be mostly young regrowth, and has subsequently spread along the drains and wet areas on the property, demonstrating its success in colonising former pastoral land, especially where waterlogging is predominant (Darkheart 2006g, 2006a, NSWSC 2004b).

2.5.2. Abandoned Tourism/Sports Complex Proposal

The subject land was previously approved for an international sports and leisure village in the early 1980's (Cox and Corkill 1983). Works commenced on this later abandoned development including:

- Excavation of two large lagoons in the southern end of the property which were used to provide fill for about 50ha of residential development to the south (Cardno 2008).
- Construction of roads and guttering for residential land in the far southern end (now re-developed) adjacent to Bonny Hills.
- Partial construction of a golf course over the middle-south of the property (the area now proposed for the wetland and for filling.

Appraisal of the aerial photo in figure 9 shows the lagoons, the re-constructed residential area which is now fully developed, and the alignments of a number of fairways with bunkers and tees. From vegetation maps in Clancy and Ayres (1983) and the 1989 aerial in figure 4, it appears that the last major clearing events on the property occurred at this time eg removal of most of the swamp forest in the middle-south area and western side.

A double row of trees and shrubs were planted along the northern boundary of the property around this time, possibly in association with the former nursery on site (see next section). Species consist of a range of local (eg Swamp Mahogany) and non-local (eg River Oak) species, most of which have generally not developed well due to marginal edaphic conditions and exposure.

A small wetland habitat occurs north of the larger lagoon in a small depression which possibly occurs due to past construction activities on the site.

2.5.3. Abandoned Nursery

A former nursery was constructed at the head of the Swamp Oak forest in the northeastern corner of the property, but it was subsequently abandoned, and some of the nursery trees are now established in the ground.

2.5.4 Sand Mining

The coastal dune system adjacent to most of the property's east has been sand mined, as indicated by the dune scrub regrowth and modified topography. It is possible given the indicative vegetation on the sandplain of similar age east of Duchess Creek, that this portion of the property formed part of this activity ie either part of the mining area or cleared for parking, processing, etc. Sand mining is known to have historically extended to the northern fringes of Bonny Hills (RDM 1995).

Figure 4: Historical aerial photos of property
(Source: Dept of Lands/LPIC, Orange. Copyright 1977-2008.)

Photo A: 1977 Aerial of southern half of property

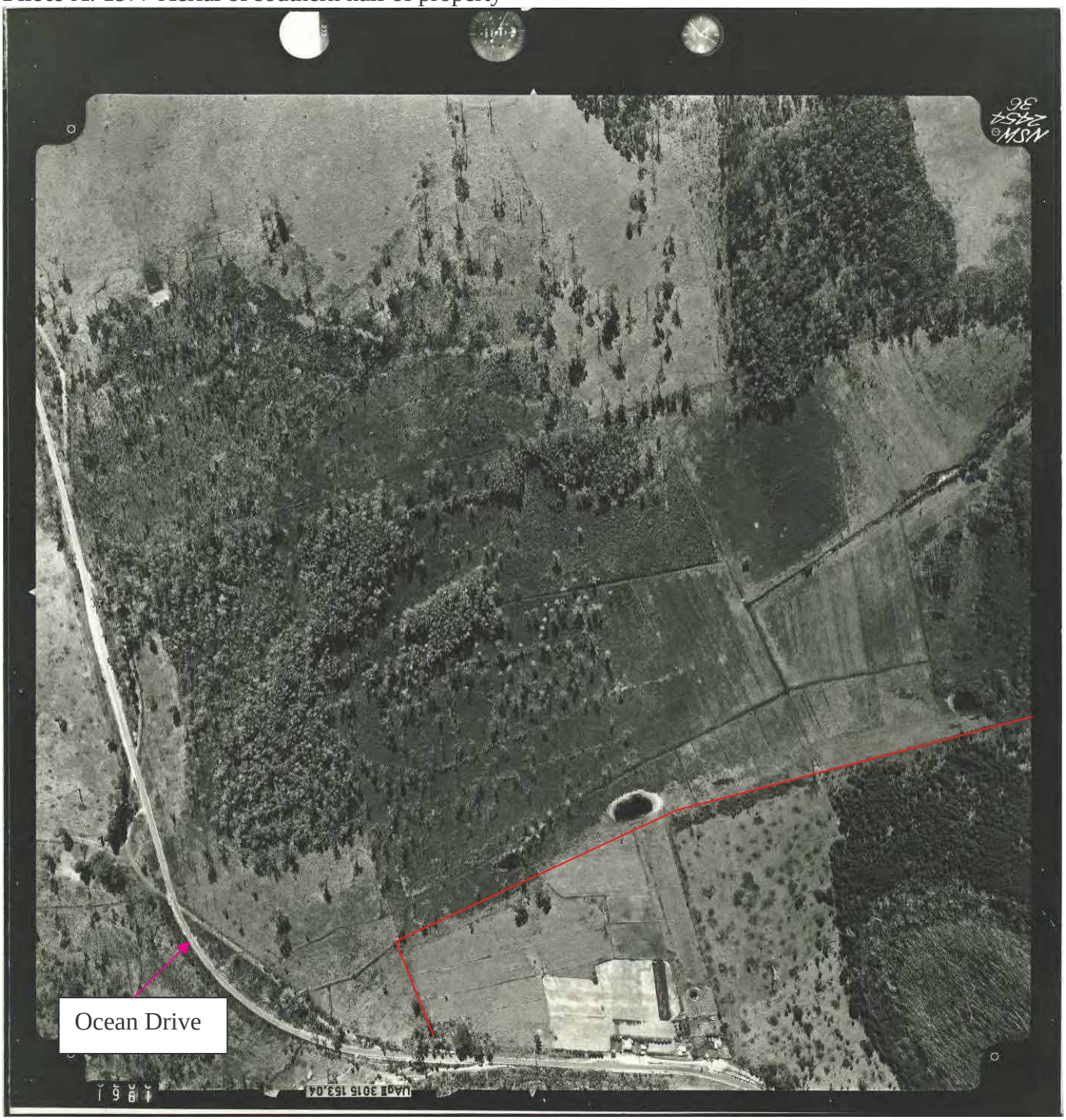


Photo B: 1989 aerial of total property.

Note the significant changes in vegetation from 1977 and compared to present in photo in figure 10.

2.5.5 Fire and Weed Invasion

A small area of grassland on the property had recently been burnt prior to the 2006 survey. The fire was restricted to a small patch of pasture land and did not impact upon any forest vegetation. No other evidence of fire was identified on the property.

Lantana was common in regrowth and forest vegetation on the property and was observed growing in dense thickets near forest edges, particularly in sections of forest along the middle sections of Duchess Gully. Lantana was also prevalent in the southeastern section of the swamp forest, where it occurred in impenetrable thickets to 2m high and had potential to dominate the understorey of this entire community if not appropriately controlled. However, weeds did not dominate the vegetation in any community (aside from pasture).

Vegetation over the majority of the property consisted largely of introduced pasture grasses with a few weed species. Pennywort was observed growing in dense clusters throughout pasture and sedge land, while Fireweed was also present on pasture land.

2.6 ADJACENT DEVELOPMENTS AND FUTURE DEVELOPMENT/PLANNING

2.6.1 Adjoining Landuses

The property is situated between the villages of Lake Cathie and Bonny Hills, and is part of a previously rural area. Consequently is it intended for urban expansion to interlink these two nodes. Subdivision of the southern end of the property has recently been completed allowing northern expansion of Bonny Hills in the last 6 years (pers. obs).

Land to the west and southwest is rural and rural-residential. Land to the northwest is currently rural/rural-residential but is intended for residential development (Deicke Richards 2004, 2003).

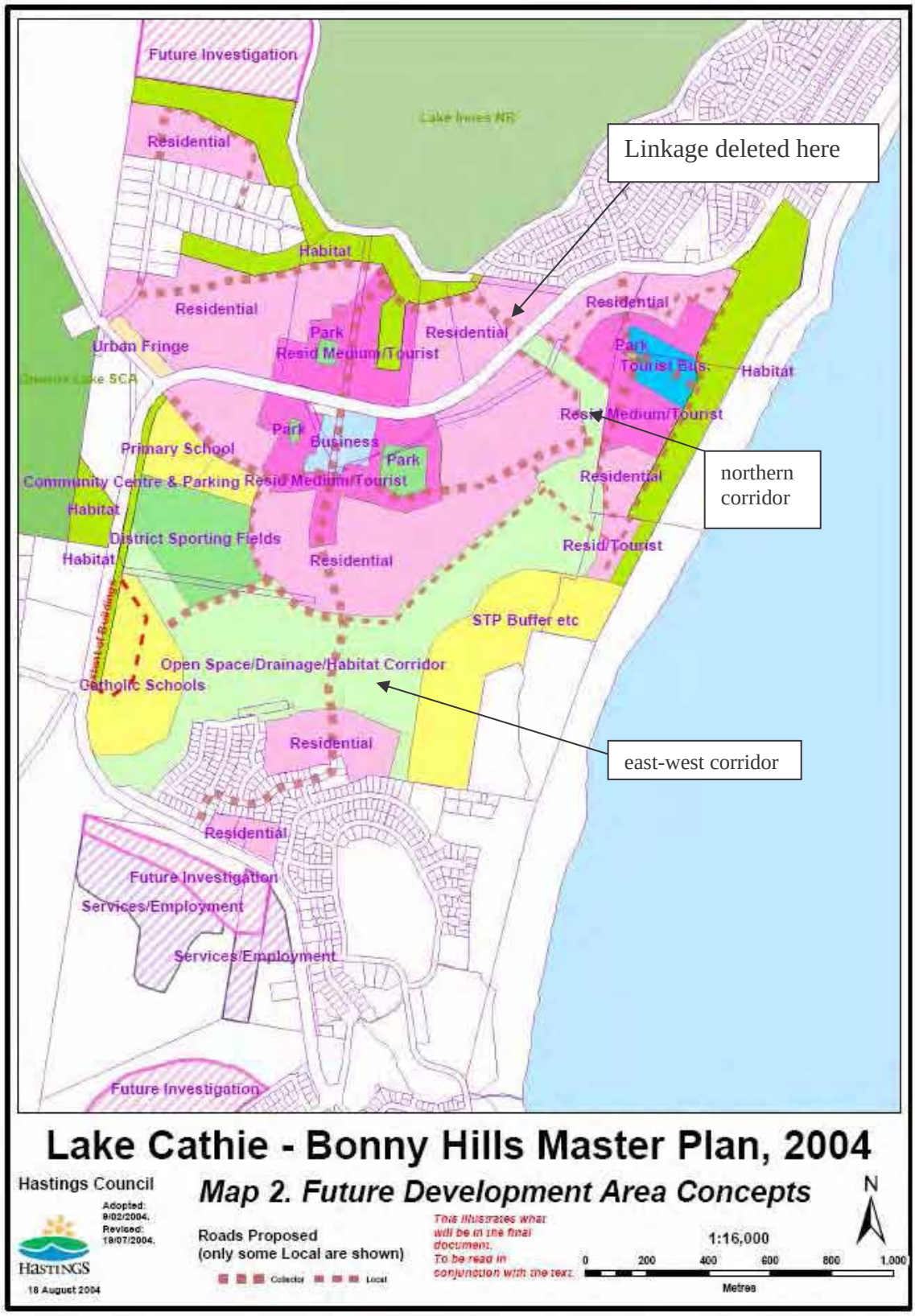
Land to the east is Crown land including the dune system, with SEPP 26 - *Littoral Rainforest* occurring just off the east-north east and extending to the southern end of Lake Cathie.

The Bonny Hills sewage treatment plant (STP) adjoins the southeast of the site, with vegetation on the property continuous with vegetation around the STP.

2.6.2 Future Development/Planning

The property falls in the Area 14 Urban Design Structural Plan (Deicke Richards 2004, 2003), which proposes tourist, residential, education, recreation and commercial development of the property, with retention of some open spaces for drainage and habitat corridors (Figure 5). The habitat corridors essentially encompass the portion of Duchess Gully creek, to the head of the drainage depression in the property's north (northern corridor), and all of the major drainage line running roughly east-west (east-west corridor) across the property. The constructed wetland is proposed to form part of the east-west corridor.

Figure 5 Lake Cathie-Bonny Hills Structure Plan – 2004 version.
(Source: Hastings Council 2004)



PART A: FLORA AND FAUNA SURVEY

3.0 SURVEY METHODS

3.1 GENERAL INFORMATION

Following an initial inspection to determine the threatened species potentially occurring and the appropriate survey techniques, the main survey for this assessment was conducted on the 22-26th of May 2006. A follow up survey of potential frog habitat was undertaken after rain on the 4th of July 2006. Previous survey of portions of the property undertaken in 2005 and 2003 were also incorporated into this assessment.

In addition, the available relevant literature and the NSW Department of Environment and Climate Change (DECC) Atlas of Wildlife, (www.wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas) and Rare or Threatened Plants 2008 (www.plantnet.rbgsyd.nsw.gov.au/search) databases were consulted for records of threatened species on the Bulahdelah, Wingham, Bare Point, Grafton, Coffs Harbour, Dorrigo, Camden Haven, Kempsey, Korogoro, Nambucca and Macksville 1:100 000 topographical maps. The Bionet (www.bionet.nsw.gov.au) website was also searched for records in proximity to the site. Species from this area were considered for those with potential to occur in the sub-region of the mid north coast of NSW, which included the site.

3.2 FLORA

3.2.1 Threatened Flora Records

A search of the DECC Rare or Threatened Plants (ROTAP) database (2008), Bionet (2008) and available literature (Biolink 2003, Berrigan and Bray 2002) indicated that the following Threatened flora species occur within 10km of the site (those in bold are dually listed under the EPBCA 1999):

1. *Melaleuca groveana*: Dooragan NP.
2. ***Melaleuca biconvexa:*** Lake Innes NR.
3. ***Acacia courtii***: Dooragan NP, Yoorigan NP
4. ***Grevillea caleyi:*** Dooragan NP
5. ***Allocasuarina defungens:*** Crowdy Bay NP.
6. ***Thesium australe:*** Kattang NR, Crowdy Bay NP
7. ***Cynanchum elegans:*** Middle Rock
8. ***Phaius tankervilliae:*** Cowarra SF
9. *Maundia triglochinoides*: Innes Ruins
10. *Diuris sp. aff. chrysantha:* Lake Innes Nature Reserve

The following ROTAP species (Rare or Threatened Australian Plants) are also recorded within 10km of the site:

1. *Acacia costiniana* (Kattang NR)
2. *Goodenia fordiana* (Dooragan NP)
3. *Eucalyptus fergusonii subsp. fergusonii* (Queens Lake NR)

3.2.2 Survey Methods

The flora survey routinely consists of two components:

- Identification, description and mapping of the major vegetation communities and any Endangered Ecological Communities.
- Searches for, identification of, and (if found) mapping of any threatened species and their habitat.

3.2.2.1 Vegetation Community Mapping

Biolink (*in preparation*) has previously mapped the vegetation communities of the property (via aerial photography and some limited ground truthing) as well as adjoining land which fell within the jurisdiction of the *Urban Investigation Area 14 – Koala Plan of Management* (UIA 14 KPoM). To ensure consistency with the KPoM, this mapping was, in principle, adopted for this assessment, with formal ground truthing via random meander and plot sampling compiled by this and previous assessments undertaken by this firm, to confirm Biolink's work.

For the purposes of this assessment, sub-formation names for vegetation types are adapted from the classification proposed by Beadle and Costin (1952) and Keith (2004) eg '*Dry Sclerophyll Forest'* to assist the fauna habitat evaluation.

3.2.2.2 Conservation Status Assessment

The conservation significance of the vegetation communities within the property was determined by comparing equivalent phytosociological associations and their conservation significance on the North Coast of NSW as per the CAR Assessment (Northern Zone NPWS 1999) in section 4.2.3.

Biolink (2005c) has previously identified the status of several vegetation communities on the property as Endangered Ecological Communities (see figure 12). This delineation was reviewed to confirm the required floristic associations were present, and compared with soils information to confirm the appropriate geomorphological setting (see section 4.2.2).

3.2.2.3 Species Identification and Recording

Over the course of the various studies of the property by this consultant from 2003-2006, all of the property's vegetation communities have been surveyed utilising random meander transects and plot based sampling. Any opportunistic sightings of plant species on the study site while undertaking other survey procedures were also recorded.

The combination of random meander transects and plot based surveys were considered most suitable for the following reasons:

- Provide the most amount of information for a given input.
- Provide a means to sample vegetation boundaries.
- Provide means for assessing floristic diversity and possible presence of threatened species (Forest Fauna Surveys *et al* 1997).

Species identification was made with the assistance of Bale (1993), Beadle (1982), Chippendale (1981), Harden (1993, 2000), Williams and Harden (1980), Robinson (1994), and Brooker and Kleinig (1999). Plant species were identified to species or subspecies level and nomenclature conforms to that currently recognized by the Royal Botanic Gardens and follows Harden and PlantNET for changes since Harden.

3.2.2.4 Threatened Flora Species Searches and Occurrence Assessment

3.2.2.4.1 Targeted Searches

Searches for locally recorded threatened flora as well as flora recorded in the LGA and/or in regionally similar habitats to those occurring on the property, were carried out during specific targeted searches and routinely during other survey activities (i.e. trapping) over the survey periods in 2003, 2005 and 2006. A total of 5 hours was spent on searches for threatened flora in 2006; 8hrs in 2005 (Darkheart 2005u) in the upper catchment reaches of Duchess Gully; and 20 hours spent on the total property 2003 (Berrigan 2003h). Searches consisted of plot based sampling and random meander transects through potentially suitable habitats within both the proposed development envelope and the remainder of the property.

Due to local records in broadly similar habitat to that on the property, the main targeted plants were:

- *Melaleuca biconvexa.*
- *Phaius tankervilliae*
- *Cynanchum elegans*.

Other targeted threatened species were:

- Aquatic/wetland species: *Asperula asthenes, Maundia triglochinoides* and *Gallium australe*.
- Rainforest/wet sclerophyll climbers: *Cynanchum elegans, Parsonsia dorrigoensis* and *Marsdenia longilobia.*
- Rainforest/wet sclerophyll epiphytes: *Psilotum complanatum, Peristeranthus hillii* and *Oberonia titania.*
- Terrestrial orchids: *Phaius australis*
- Sclerophyll forest species: *Eucalyptus tetrapleura* and ROTAP species *Eucalyptus fergusonii ssp fergusonii*.

Other threatened species from the locality (listed above) were not specifically targeted due to lack of suitable habitat on the site.

3.2.2.4.2 Potential Occurrence Assessment

Potential occurrence assessment of threatened flora species is provided in section 3.2 and Appendix 1. This section assesses all threatened species listed as threatened under the TSCA and EPBCA for their potential to occur on the site and the surrounding property, based on the following factors:

- Presence/absence of suitable habitat.
- Condition and disturbance history of habitat.
- Local and regional records.
- Location of site and property within known distribution of the species.

3.3. FAUNA

3.3.1 Threatened Fauna Records

3.3.1.1 Previous Surveys of Property

The following threatened species have been previously recorded on specific sections of the property by previous studies:

- ***Koala***: Recorded in former swamp forest now cleared (Clancy and Ayres 1983). More recently recorded in the Paperbark/Swamp Mahogany/Swamp Oak on the western fringe of the sewage treatment works by Biolink (2003). The DECC Atlas of Wildlife (2008) also has records in the northwest and southwest.

- ***Eastern Chestnut Mouse:*** Grassland east of Duchess Gully, and in Bladey Grass dominated grassland and associated *Babingtonia pluriflora* dominated drainage line in the west-southwest (Berrigan 2003h).

- ***Common Planigale****: Babingtonia pluriflora* dominated drainage line in the west-southwest (Berrigan 2003h).

- ***Little Bent-Wing Bat***: Along track under dry sclerophyll forest canopy in east-southeast behind the isolated hill (Berrigan 2003h).

- ***Wallum Froglet:*** Two discrete populations. One small population in *Babingtonia pluriflora* dominated drainage line in the west-southwest; and another large population (>50) in the heathy depression north of the eastern lagoon (south-southwest of proposed wetland) (Berrigan 2003h).

- ***Wompoo Fruit-Dove***: Single bird recorded roosting for a short period in the west-southwest patch of dry sclerophyll forest adjacent to Ocean Drive in the west-southwest of property, and four birds observed flying along the littoral rainforest to the east (Berrigan 2003h).

- ***Swift Parrot:*** An unknown observer has added a sighting in the northwest of the property on the 15/8/05 to the DECC Atlas of Wildlife (2008).

3.3.1.2 Other Local Records

The following table lists the species which have been recorded within 10km of the study site (DECC Atlas of Wildlife 2008, Bionet 2008, Biolink 2003, Parker 2002, ERM Mitchell McCotter 1996, ERM Mitchell McCotter 2002, Berrigan 2003g, 2003h, 2002b, Darkheart 2004q, 2005a, 2005b, 2005v, 2006a, 2006b, 2006e, 2006h, AMBS 1996a, 1996b, Mt King Ecological Surveys 1993, Milledge 1992, Kendall and Kendall 1993, Kendall and Kendall 1991, Hoye 1993, ERM Mitchell McCotter 1994, Engel and Chafer 1994, Laxton and Laxton 1992, Parker 2002, personal observations, Mrs Penny Marshal pers. comm., Mr Tony Bischoff pers. comm.). Those in bold are dually listed as threatened under the EPBCA 1999.

The following species (excluding marine mammals, birds and reptiles as no suitable habitat occurs on-site or is affected by the development) are considered likely to occur in the locality due to suitable habitat and/or regional records (some have been recorded within 20km) (DECC Atlas of Wildlife 2008, Bionet 2008, Strahan 2000, Smith *et al* 1995, Readers Digest 1990, Churchill 1998, Wilson and Knowles 1992, Simpson and Day 1996, Swan 2004, Tyler 1997, personal observations):

1. *Mammals:* **Long Nosed Potoroo**, **Dwyer's Bat,** Yellow-Bellied Sheathtail Bat, Beccari's Freetail Bat, Eastern False Pipistrelle, Eastern Cave Bat, Rufous Bettong, Eastern Pygmy Possum.

2. *Birds*: Grey-Crowned Babbler, Hooded Robin, Speckled Warbler, Diamond Firetail, Painted Honeyeater, **Red Goshawk,** Rose-Crowned Fruit-Dove, Barred Cuckoo Shrike, Barking Owl, Sooty Owl, Comb-Crested Jacana, **Painted Snipe**, Bush Stone-Curlew.

3. *Frogs:* ***Litoria olongburensis, Litoria aurea, Mixophyes balbus, M. iteratus***.

4. *Reptiles*: Stephens Banded Snake, Pale Headed Snake, **Three-Toed Snake-Toothed Skink**.

These species in addition to those considered potential occurrences on the property are assessed in later sections of this report and Appendix 1. They formed the primary target species for survey and assessment.

Table 1: Threatened fauna records in the locality

GROUP	COMMON NAME	SPECIES	LEGAL STATUS	DISTANCE FROM STUDY SITE/GENERAL LOCATION
MAMMALS	Koala	*Phascolarctos cinereus*	V-TSCA	At least one record appears to be on the property, Crowdy Head National Park, Laurieton/West Haven, Lake Innes Nature Reserve, Queens Lake State Forest/National Park, Lake Cathie, Pacific Highway east of Cowarra State Forest, Houston Mitchell Drive, northeast of Kew, Dunbogan, Lake Innes Nature Reserve-north of North Haven, Bonny Hills area, Carnegie Cove, etc
	Spotted-Tailed Quoll	*Dasyurus maculatus*	V-TSCA, E-EPBCA	4km west of Lake Cathie
	Brushtailed Phascogale	*Phascogale tapoatafa*	V-TSCA	Pacific Highway/Houston Mitchell Drive area, Lakewood, Dunbogan, Limeburners Flat
	Common Planigale	*Planigale maculata*	V-TSCA	At least one record appears to be on the property, Bonny Hills area, north of Bonny Hills, Lake Innes Nature Reserve, northeast of Kew, north of North Haven
	Squirrel Glider	*Petaurus norfolcensis*	V-TSCA	Lake Innes Nature Reserve, Lakewood, Bonny Hills Sewerage Works, Carnegie Cove, North Haven, north of North Haven
	Yellow-Bellied Glider	*Petaurus australis*	V-TSCA	Lakewood, West Haven area, Lake Ridge, Pacific Highway east of Cowarra State Forest, Houston Mitchell Drive, northeast of Kew, southwest of Queens Lake State Forest, northeast of Kew, Pacific Highway near Houston Mitchell Drive
	Eastern Pygmy Possum	*Cercartetus nanus*	V-TSCA	Kattang Nature Reserve
	Eastern Chestnut Mouse	*Pseudomys gracilicaudatus*	V-TSCA	At least one record appears to be on the property,, Bonny Hills, Lake Innes Nature Reserve, north of Bonny Hills, north of North Haven, northeast of Kew
	Little Bent-Wing Bat	*Miniopterus australis*	V-TSCA	North Brother, Middle Head area, Lake Innes Nature Reserve, Pacific Highway east of Cowarra State Forest, Lake Innes Nature Reserve north of North Haven, Carnegie Cove, Houston Mitchell Drive, North Haven, Lake Ridge, northeast of Kew, Lake Cathie, Dunbogan
	Common Bent-Wing Bat	*M. schreibersii*	V-TSCA	Lakewood area, Dunbogan, Carnegie Cove
	Eastern Freetail Bat	*Mormopterus norfolkensis*	V-TSCA	Lakewood area
	Eastern Blossom Bat	*Syconycteris australis*	V-TSCA	Middle Head area, Lake Innes Nature Reserve, Dunbogan
	Grey Headed Flying Fox	*Pteropus poliocephalus*	V-TSCA, V-EPBCA	Lake Innes Nature Reserve – north of North Haven and Lake Cathie, Carnegie Cove, Dunbogan, Queens Lake State Forest/National Park, etc
	Southern Myotis	*Myotis macropus*	V-TSCA	Lake Cathie, Lakewood "*probably*" recorded at Carnegie Cove
	Greater Broad-Nosed Bat	*Scoteanax rueppellii*	V-TSCA	Lakewood area, Dunbogan, Lake Innes Nature Reserve

BIRDS	Glossy Black-Cockatoo	*Calyptorhynchus lathamii*	V-TSCA	Carnegie Cove, Pacific Highway east of Cowarra State Forest, Lake Innes Nature Reserve, Queens Lake State Forest, west of Bonny Hills, southwest of Queens Lake State Forest, north of North Haven, northeast of Kew, Dunbogan, Houston Mitchell Drive, Lake Ridge
	Swift Parrot	*Lathumus discolor*	E-TSCA, E-EPBCA and Migratory	At least one record appears to be on the property, Laurieton area, Point Rd
	Brown Treecreeper	*Climacteris picumnus*	V-TSCA	North of Cowarra State Forest
	Powerful Owl	*Ninox strenua*	V-TSCA	Carnegie Cove, Lake Innes Nature Reserve, west of Bonny Hills, northwest of Bonny Hills, West Haven
	Masked Owl	*Tyto novaehollandiae*	V-TSCA	Lake Innes Nature Reserve north of North Haven, Bonny View Estate, Lakewood
	Grass Owl	*Tyto capensis*	V-TSCA	Lake Innes Nature Reserve
	Osprey	*Pandion haliaetus*	V-TSCA, EPBCA-Migratory	Bonny Hills, Lake Cathie, Queens Lake Nature Reserve, Dunbogan, southwest of Queens Lake State Forest, Crowdy Head National Park
	Square Tailed Kite	*Lophoictinia isura*	V-TSCA	At least one record appears to be on the property,, Lake Cathie, Bonny Hills area, Queens Lake State Forest
	Wompoo Fruit Dove	*Ptilinopus magnificus*	V-TSCA	Lake Innes Nature Reserve, north of Bonny Hills
	Regent Honeyeater	*Xanthomyza phrygia*	E-TSCA, E-EPBCA	Port Macquarie
	Osprey	*Pandion haliaetus*	V-TSCA	Bonny Hills, Lake Cathie, Lake Innes Nature Reserve, Dunbogan, southwest of Queens Lake State Forest, Lakewood
	Black Bittern	*Ixobrychus flavicollis*	V-TSCA	Laurieton
	Australasian Bittern	*Botaurus poiciloptilus*	V-TSCA	northeast of Kew
	Sooty Oystercatcher	*Haematopus fuliginosus*	V-TSCA	Diamond Head
	Pied Oystercatcher	*Haematopus longirostris*	V-TSCA	Dunbogan
	Little Tern	*Sterna albifrons*	E-TSCA	Lake Cathie
	Jabiru/Black Necked Stork	*Ephippiorhynchus asiaticus*	E-TSCA	Queens Lake, Dunbogan, North Haven, Lake Cathie, north of Kew
	Brolga	*Grus rubicunda*	V-TSCA	Lakewood
	Blue-Billed Duck	*Oxyura australis*	V-TSCA	Lake Innes Nature Reserve
FROGS	Wallum Froglet	*Crinia tinnula*	V-TSCA	At least one record appears to be on the property, Lake Innes Nature Reserve, north of Bonny Hills, Carnegie Cove, Lakewood, Bonny Hills area, north of North Haven
	Green-Thighed Frog	*Litoria brevipalmata*	V-TSCA	north of Kew

3.3.2 Fauna Survey Methodology

All field surveying was conducted as per the conditions of the consultant's Animal Research Authority and Section 132c Scientific License.

3.3.2.1 Habitat Evaluation

The site was initially inspected to determine the available potential habitats, and the support value of these habitats for threatened species. Habitats were defined according to parameters such as:

- Structural and floristic characteristics of the vegetation, eg understorey type and development, crown depth, groundcover density.
- Degree and extent of disturbance, eg fire, logging, weed invasion, grazing, modification to structure and diversity.
- Soil type and suitability, eg for digging and burrowing.
- Presence of water in any form, eg dams, creeks, drainage lines, soaks.
- Presence of rocky foreshores, seacliffs, islands, mangroves, beaches, mudflats, sandspits, etc.
- Size and abundance of hollows and fallen timber.
- Availability of shelter, eg rocks, logs, hollows, undergrowth.
- Wildlife corridors, refuges and proximate habitat types.
- Presence of mistletoe, nectar, gum, seed, sap, sources.

3.3.2.2 Trapping

Trapping was undertaken for the 2006 assessment over one week: 22nd to the 26th of May 2006, with works centred on the proposed filling/excavation area. Overall, the extent of trapping effort was very limited due to the low diversity of potential habitat types in proposed filling/excavation area, and previous survey over the property undertaken by the consultant to identify broad ecological constraints.

Survey of the property in 2003 was undertaken in two periods. The first period involved trapping of the northwest swamp forest, isolated pocket of open forest in the mid-northwest, and other habitat in the southeast (dry sclerophyll forest), east (grassland and Duchess Gully riparian zone) and the Bladey Grass grassland and associated vegetation along the western side of the property. The second period involved further trapping of the southeast, and an area of grassland and coastal scrub east of the Duchess Gully.

3.3.2.2.1 Elliot A

Elliott A traps were not utilised in 2006 due to the lack of suitable habitat for target species in the proposed filling/excavation area.

In 2003, 80 Elliott A traps were placed in transects in the following areas (see figure 6):

- The swamp forest, wet sclerophyll, former nursery and dry sclerophyll in the proposed northern corridor.
- A low rise and associated drains in the southwest (proposed school site and part of east-west corridor).
- A patch of dry sclerophyll in the southeast on a hill adjacent to the Bonny Hills sewage plant (also part of the eastern corridor).
- A patch of sparse shrubby swamp forest regrowth (part of proposed filling area).
- Regrowth swamp forest around the two large lagoons in the southern end of the property.
- The patch of dense groundcover (grassland) east of Duchess Gully.

The target species were Common Planigale and Eastern Chestnut Mouse. The traps were baited with a rolled oats/peanut butter/honey mix. The cold nights experienced during the 2003 survey were considered likely to impair the survival (as demonstrated by hypothermia of trapped Antechinuses) hence bedding material was provided in the traps. A total of 1300 Elliot A trap nights were performed on the entire property in 2003.

3.3.2.2.2 Elliot B

3.3.2.2.2.1 2006

Twenty Elliot B traps were mounted on platforms to trees throughout the Forest Red Gum dominated woodland to the north/northwest of the study area. While most of this community is not to be removed as part of the proposed filling/excavation proposal, this habitat has not been surveyed previously and is identified in the Area 14 Structure Plan and the Concept Plan Application for future residential development.

Traps were baited with apple and a honey soaked rolled oats and peanut butter mixture. The routinely target species were the Eastern Pygmy Possum, Squirrel Glider and Brushtailed Phascogale. All traps were mounted on platforms so as to drain out the entrance. The trunk of arboreal Elliot trap trees and adjacent tree trunks were spayed with a honey-water solution from a pressure sprayer as an attractant. All traps contained bedding material for warmth. A total of 80 trap nights were performed. The trapping area is illustrated in figure 5.

3.3.2.2.2.2 2003

Twenty Elliot B traps were mounted on platforms to trees in the small clump of dry sclerophyll forest in the southwest near Ocean Drive; the small clump of isolated forest (proposed park) in the mid-northwest; the dry sclerophyll on the hill in the southeast; and throughout the swamp forest, small patches of sclerophyll forest and nursery in the proposed northern corridor.

Traps were baited with a honey soaked rolled oats and peanut butter mixture. The target species were the Eastern Pygmy Possum, Squirrel Glider and Brushtailed Phascogale. All traps were mounted on platforms so as to drain out the entrance. The trunk of arboreal Elliot trap trees and adjacent tree trunks were spayed with a honey-water solution from a pressure sprayer as an attractant. All traps contained bedding material for warmth. A total of 160 trap nights over 8 nights were performed.

3.3.2.2.3 Pitfalls

Pitfalls were not utilised in 2006 due to a lack of suitable habitat in the proposed filling/excavation area.

In 2003, pitfalls consisting of 10L buckets and 10m of 50cm high drift fencing was placed in two areas:

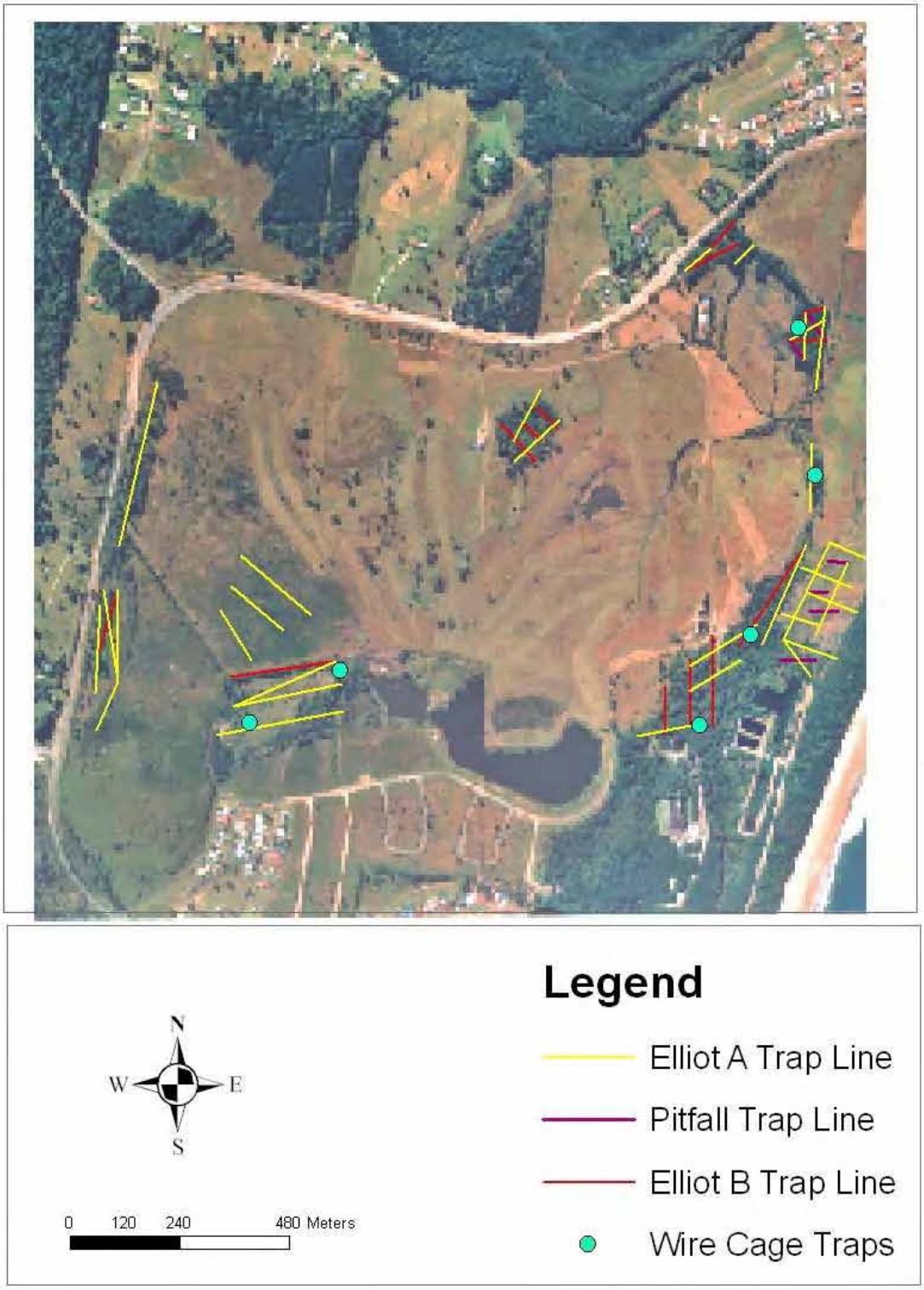
- The extensive area of dense groundcover east of Duchess Gully and adjacent dune scrub regrowth.
- The eastern portions of the Swamp Oak swamp forest in the northern corridor where dense Saw Sedge dominated the groundcover.

A total of 75 pitfall trap nights was performed. The Common Planigale was the primary target species.

Figure 6: 2006 Elliot B trapping area

This mapping is to be considered indicative only and all derivations are at best approximations and subject to errors including individual interpretation and reliance on information provided to Darkheart that were not independently verified. All information is intended to be indicative only and no reliance for extrapolation, mapping, etc should be placed upon this map without independent validation of the information by the user. Darkheart takes no responsibility for any subsequent errors, losses, etc that may arise from use of this data without independent verification

Figure 7: 2003 trapping locations



This mapping is to be considered indicative only and all are at best approximations and subject to errors including individual interpretation and reliance on information provided to Darkheart that were not independently verified. All information is intended to be indicative only and no reliance for extrapolation, mapping, etc should be placed upon this map without independent validation of the information by the user. Darkheart takes no responsibility for any subsequent errors, losses, etc that may arise from use of this data without independent verification

3.3.2.2.4 Wire Cages

Cage traps were not utilised in this survey due to a lack of suitable habitat in the proposed filling/excavation area for target species, or minimal potential to occur.

In 2003, six wire cages were set on site over 8 nights (48 trap nights). Four were baited with meat targeting the Quoll, and the remainder baited with rolled oats/honey/peanut butter mix targeting the Long-Nosed Potoroo. Two traps were placed in the northern corridor; two were placed in the regrowth around the large lagoons; and the remainder in the dry sclerophyll in the southeast.

3.3.2.2.5 Harp Trapping

Harp trapping in either survey due to high risk of extreme cold adversely affecting trapped animals (as per ARA requirements) and high proximity to dwellings (hence risk of theft, vandalism, etc).

3.3.2.2.6 Hair Tubes

Hair tubes were not used at any time due to the high success rate of previous trapping on the subject land (Berrigan 2003h), and lack of suitable habitat for target species in the study area.

3.3.2.3 Spotlighting, Den Watches and Torch Searches

3.3.2.3.1 2006

Spotlighting was conducted for 1.5hr per night over the property. It involved driving and walking over property with a hand held 50/100 watt spotlight, with most surveying focussing on pockets of forest. Spotlighting was also periodically conducted during call playback activities to identify target species attracted by calls but not responding. A total of 7.5hrs was spent spotlighting.

Den watches were conducted on 3 occasions. This involved watching a potential denning/nesting/roosting tree for 30 minutes prior to sunset and 60 minutes after sunset, while spotlighting to identify any fauna emerging from hollows. This was conducted under hollow-bearing trees and one stag in the north/northwest of the study area and a Needlebark Stringybark located in the Dry Blackbutt Forest to the east of the site.

Torch searches for frogs were also undertaken during spotlighting. This was carried out around the edges of all dams/lagoons, the disturbed wetland, along drains and drainage lines and Duchess Gully. These areas were searched on four occasions for a total of 6hrs.

Spotlighting and torch search conditions were clear and largely still for all but the first night when slight cloud cover was present.

3.3.2.3.2 2003

Spotlighting was conducted for around 2hrs per night over the entire property in 2003. It involved walking through forested sections of the site with a hand held 50/100 watt spotlight, with most surveying focussing on pockets of forest. Spotlighting was also periodically conducted during call playback activities. A total of 18hrs was spent spotlighting.

Den watches were conducted at dusk on 3 occasions. This involved watching a potential denning/nesting/roosting tree from 30 minutes prior to and 60 minutes after sunset, with spotlighting to identify any fauna emerging from hollows. This was conducted under 3 trees in the patch of dry sclerophyll near the western end of the northern corridor; and under two Blackbutts on the hill in the southeast.

Torch searches for frogs were undertaken around the edges of all dams/lagoons, drain; and Duchess Gully. These were walked each night for 8 nights.

Spotlighting and torch search conditions were consistently clear and largely still. The first quarter moon phase was experienced on the first surveying night, thus conditions were initially dark. However, conditions became slightly brighter by the end of the survey.

3.3.2.4 Microchiropteran Bat Call Detection

3.3.2.4.1 2006

An Anabat II bat call detector was carried during spotlighting to opportunistically record bats. A 2nd detector was also left in various locations overnight on four occasions. Locations for overnight detection were selected to maximise potential identification, with special effort made to identify possible corridors of high bat activity eg the main lagoons. A total of 55.5hrs was spent on call detection.

3.3.2.4.2 2003

An Anabat II bat call detector was carried during spotlighting to opportunistically record bats. The main detector was also left in various locations for 30 minute recording intervals. A second detector was left at fixed positions to record calls for 3hrs (tape length). At dusk, time was also exclusively devoted to Anabat work (ie bat detecting) particularly along the forest edge. A total of 48hrs was spent on Microchiropteran bat call identification.

3.3.2.5 Call Playback

Recorded calls of the following species were routinely played back on the property:

- Koala
- Masked, Barking, Sooty, Grass and Powerful Owls
- Bush-Stone Curlew
- Yellow-Bellied Glider and Squirrel Glider.
- Green-Thighed Frog
- Wallum Froglet
- Wallum Sedge Frog
- Green and Golden Bell Frog.

Calls were played through a laptop computer utilising Windows Media Player via a 30W PA system. The amplifier was positioned at a level approximating natural intensities of the species (i.e. Koala, owls, etc). The general methodology involved an initial period of listening and spotlighting; followed by playback of the calls simulating a natural pattern. This was followed by an initial period of 5-10 minutes of listening and was followed by spotlighting for fauna attracted by the calls, but not responding vocally, within 100m radius of the playback point. Calls were generally played soon after dusk, when such calls are normally heard; with the greater part being from dusk to 8.30pm.

Approximately half an hour of call playback was conducted per surveying night, for a total of 2.5 hours in 2006. Approximately 1hr of call playback was conducted per surveying night in 2003, for a total of 22 hours.

3.3.2.6 Reptile, Frog, Bird and Habitat Surveys and Secondary Evidence

Physical habitat searches involving lifting up of timber and debris, inspection of dense vegetation and leaf litter for frogs and reptiles, binocular inspection of potential hollows, observation of likely basking sites and searches for scats, tracks and scratches, was conducted during time especially devoted to this activity, as well as opportunistically during other survey activities. This time was also devoted to searching under

Oaks for chewed cones indicative of the occurrence of the Glossy Black Cockatoo; under preferred forage species for Koala scats; and opportunistically for owl regurgitation pellets.

Birds were generally surveyed by detecting calls and searching by binoculars at dawn and dusk (when call chorus and peak activity occurs); while walking around the entire site; and opportunistically during other activities. Specific attention was made to detect potential presence of the Brown Treecreeper, Grey-Crowned Babbler, etc.

A total of 43 hours was spent on this part of the survey in 2003, and 12hrs in 2006.

Species identification was assisted by Simpson and Day (1996), Swan ***et al*** (2004), Strahan (1991, 2000), Triggs (1996), Robinson (1996), and Menkhorst and Knight (2001).

3.4 SURVEY LIMITATIONS

All surveys are limited in their ability to fully document all species of flora and fauna likely or actually occurring on a site. Surveys such as this are merely "snapshots" in time, and can only be expected to provide an indicative not absolutely comprehensive representation of a site's species assemblage (DEC 2004).

To counter this limitation, this survey has employed methods recommended in literature (ie from habitat evaluation to actual direct survey of fauna) and known from personal experience to best detect the target species or assess their potential to occur, as per DEC (2004) requirements for flora and fauna surveys. In addition, the consultant's previous studies of the property (Berrigan 2003h, Darkheart 2005u), offer a broader scope of the area's ecology than would be generally gained by a single survey period.

3.4.1 Flora

The total species list of an area is usually much greater than can be detected in such a short time and it can be influenced by factors such as: size of the site; fire history; time since disturbance; flowering season (particularly orchids); and presence of reproductive material (DEC 2004).

Surveys of the property have been conducted at similar times of the year which may have potentially limited the species identified to those occurring during the cooler months. For threatened species, this limitation is compensated via objective habitat evaluation and potential occurrence assessment as detailed in Appendix 1.

Identification limitations for species possibly being of conservation significance are routinely dealt with by referring samples to other consultants or the Royal Botanical Gardens Herbarium Identifications Service, however accurate identification of some taxa is not always possible due to the absence of specific features, such as flowers or fruits, at the time of the survey.

3.4.2 Fauna

Fauna detectability is limited by seasonal, behavioural and lifecycle aspects of each species, and dynamic habitats (eg flowering periods), which can vary within a year, between years, decades, etc (DEC 2004). Habitat evaluation is used to counter this limitation by assessing the potential occurrence of threatened species based on potentially suitable habitat in the study area and local records (see Appendix 1).

The survey periods of all studies by this firm on site fell into late Autumn-Winter when general fauna activity is generally expected to be at relatively low levels (DEC 2004). Summer migratory or nomadic birds may be absent, while Microchiropteran bats may be limited in activity (DEC 2004). Hence,

detectability was expected to be reduced for these species. The cold conditions also precluded use of harp traps for Microchiropteran bats due to risk of fatal hypothermia.

Detection of seasonal breeding frogs was also limited for species that breed in Spring or Summer, although the survey period was suitable for the Wallum Froglet. Rainfall occurred after the main survey period in 2006 therefore, frog searches were carried out after this rain to assess potential habitat and to attempt detection of frog species.

4.0 SURVEY RESULTS

4.1 VEGETATION COMMUNITIES

4.1.1 General Overview

Biolink (2005c*)* identify a total of 7 native vegetation communities. The majority of the site is not classed as any vegetation type, and this generally incorporates what is designated in this report as "pasture/pastoral woodland". Biolink (2005c*)* also omit a small patch of regrowth identified in this report as "dune scrub" as it does not fit into any other of Biolink's vegetation community classification. The delineation of the extent of forest communities along Duchess Gully and in the southeast is also incorrect.

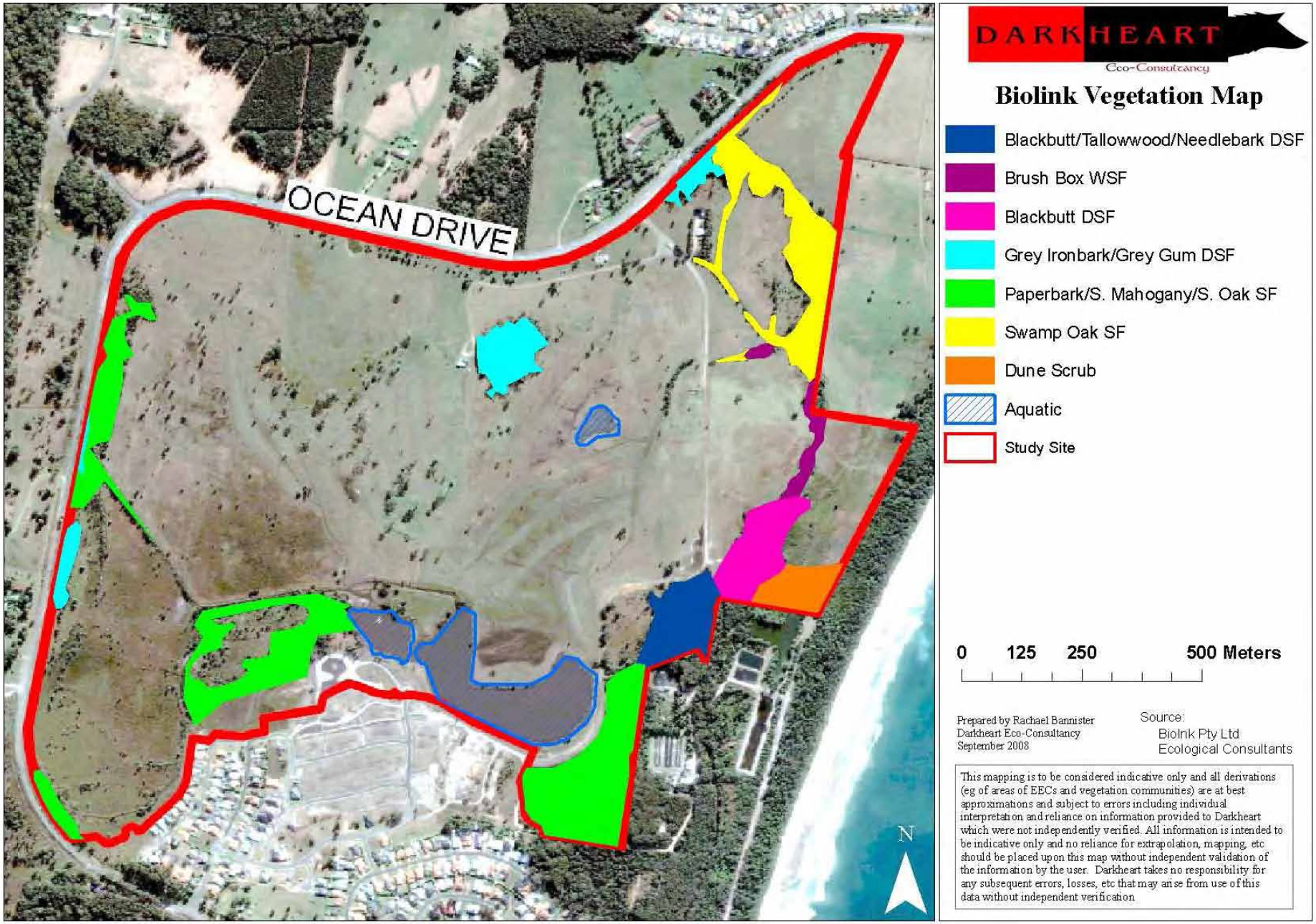
Biolink's ground-truthed vegetation map transposed over an aerial photo is shown in Figure 8. Table 2 lists the area of each community on the property.

Table 2: Vegetation communities on St Vincents Foundation land, Bonny Hills

Vegetation Community/Habitat	Total Area (ha)
Blackbutt-Tallowwood-Needlebark Dry Sclerophyll Forest	1.98
Brushbox Wet Sclerophyll Forest	0.72
Blackbutt Dry Sclerophyll Forest	2.11
Grey Ironbark-Grey Gum Dry Sclerophyll Forest	2.39
Paperbark-Swamp Mahogany-Swamp Oak Swamp Forest/Woodland	10.45
Pasture/Pastoral Woodland	150.12
Dune Scrub	1.19
Swamp Oak swamp forest	4.29
Aquatic	5.75
	179 (Approx)

The following sections details descriptions and location of the communities listed in table 2.

Figure 8: Biolink's vegetation map over aerial photo
(Source: Biolink 2005c)



4.1.2 Community Descriptions

4.1.2.1 Dry Sclerophyll Forest A (Very Tall Open Forest): Grey Ironbark-Grey Gum

Distribution and Extent:

Biolink maps this community occurring in 4 locations on the site as follows:

- 0.47ha in the northwestern end of the northwest corridor. This area also has about 0.15ha of nursery escapees.
- 1.44ha comprising the isolated remnant in the mid-north of the property.
- 0.13ha and 0.50ha in two small ribbons separated by swamp forest along the lower mid-west boundary.

Structure and Floristic Composition:

1. ***Northwest Patch*****:**

(i) *Main area***:**

(a) Canopy:

Structure and Species: The mid-dense canopy consisted of mixed-aged trees 20-60cm DBH (diameter at breast height), 15-20m high. Some of the larger trees contained small hollows in the trunk and/or branches. The dominant species were Northern Grey Ironbark (*Eucalyptus siderophloia*), Small-Fruited Grey Gum (*Eucalyptus propinqua*), Tallowwood (*Eucalyptus microcorys*) and Brushbox (*Lophostemon confertus*). A few young Pink Bloodwood (*Corymbia intermedia*) were also present. A stag at the north-eastern edge of the association was the only emergent above the canopy.

(b) Understorey/Small Tree Layer:

Structure and Species: The understorey was a mid-dense cover of small trees 5-10cm DBH and 3-6m high. They consisted of saplings of eucalypts and young Black Oaks (*Allocasuarina littoralis*).

(c) Shrub Layer

Structure and Species: This stratum consisted of a sparse cover of Lantana, shrubs and small trees 1-3m high. Lantana (***Lantana camara***) was common but with an open structure. Shrubs and small trees included: Mock Olive (*Notelaea longifolia*), Brush Muttonwood (*Rapanea howittiana*) and Coffee Bush (*Breynia oblongifolia*).

(d) Ground Layer

Structure and Species: Groundcover vegetation was a mid-dense cover to 1m high consisting of: Matrush (*Lomandra longifolia*); Bladey Grass (*Imperata cylindrica*); Settlers Flax (*Gymnostachys anceps*); Basket Grass (*Oplisemenus aemulus*); Pennywort (*Centella asiatica*); and twiners such as *Glycine microphylla*.

(e) Lianas, scramblers, etc:

Climbers were uncommon and poorly developed, except in the ground cover. *Hardenbergia violacea* was the most common species and a few *Smilax australis* were also present.

Comments: This community was largely regrowth, although the presence of some older trees indicated that it had not been completely cleared in the past. The floristic diversity was low, but typical of a small area of this forest type following extensive disturbance. Apart from the presence of Lantana, weeds were not abundant. This community was mapped separately from DSF C due to the different understorey and the latter contains an ecotone of paperbark swamp forest.

(ii) *Former nursery***:**

<u>Structure and Floristic Composition</u>:

(a) Canopy:

Structure and Species: The canopy consisted of young trees 5-15cm DBH, 6-12m high. The trees were closely spaced (typically <50cm) in rows or bands with a dense crown cover along each row. The tree species consisted largely of Swamp Oak and Gums (*C. citriodora, C. maculata, E. salignus*), together with a few White Banksia, *Melaleuca armillaris, Hakea salicifolia* and exotics such as Maples.

(b) Understorey/Small Tree Layer:

Structure and Species: Absent.

(c) Shrub Layer

Structure and Species: Absent apart from a sparse growth of Lantana.

(d) Ground Layer

Structure and Species: Groundcover vegetation was a sparse cover of grasses (*Oplisemenus aemulus*), herbs such as Violet (*Viola hederacea*) and Bindii (**Soliva sessilis*) and mosses.

(e) Lianas, scramblers, etc:

Climbers were uncommon and poorly developed. A few vines of Monkey Rope were present near the southern edge.

<u>Comments</u>: This vegetation was an accidental occurrence and it was considered to have no conservation value as a floristic community, although it contributed to the potential fauna habitat on the property.

Photo 1: Sample photo of northwest patch

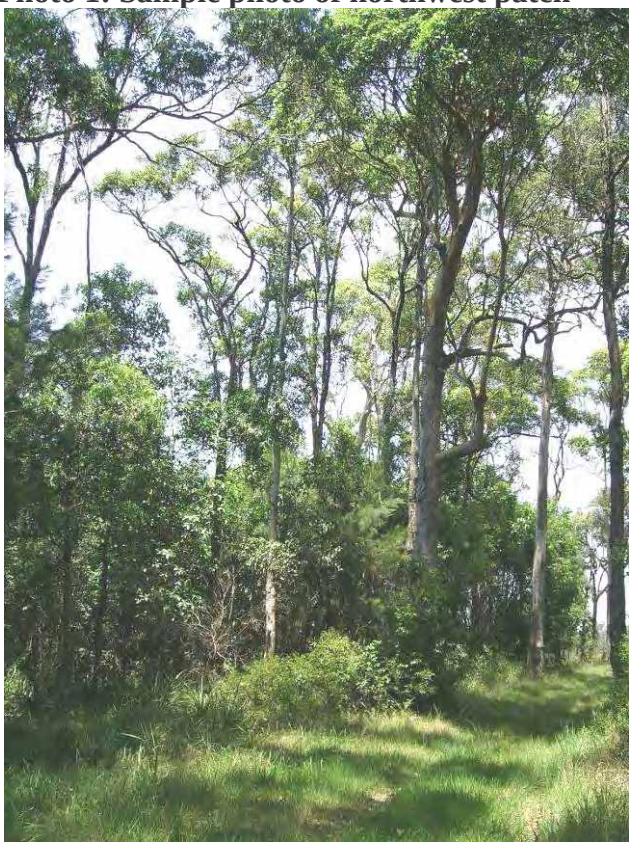
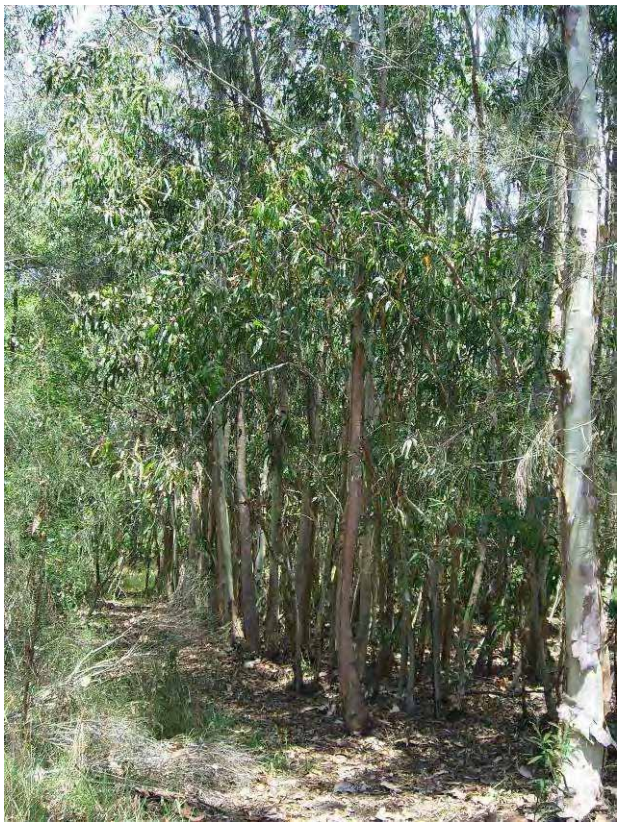


Photo 2: Sample photo of nursery escapees



2. *Mid-North Remnant*:

Distribution and Extent: The isolated community occurs adjacent to the central dwelling on the property and covers an area of 1.44ha. The land slopes downward from the western extent of the community to the east. This community has been underscrubbed and its understorey is maintained as grazing land.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The canopy consisted of mixed-aged trees 30-80cm DBH (diameter at breast height), 15-20m high. The dominant species were Grey Gum (*Eucalyptus propinqua*) and Grey Ironbark (*Eucalyptus siderophloia*), with other species including Forest Red Gum (*E. tereticornis*) and Brushbox. This graded to the east and southeast into an ecotone of Broad-Leaved Paperbark (*Melaleuca quinquenervia*).

(b) Understorey/Small Tree Layer:

Structure and Species: Absent but for some younger trees, and some *Callistemon salignus*.

(c) Shrub layer

Structure and Species: Absent but for a few scant shrubs near bases of trees eg Breynia.

(d) Ground-layer

Structure and Species: Consisted of Carpet Grass, Whisky Grass and Fireweed (***Senecio madagascariensis***) as well as various natives such as Native Violets and Basket Grass. Various tussocky sedges became more common in the east eg *Juncus usitatus* and *Carex* spp.

(e) Lianas, scramblers, etc:

Structure and Species: Essentially absent except for the rare Hibbertia scandens or Monkey Vine.

Comments: This community appears to be one of the few original remnants on the property. Appraisal of an aerial photo pre-1983 shows it formed the northwest corner of a more extensive body of forest that spread southeast onto the plain, and as suggested by the remnant paperbarks, was likely to have mostly been swamp forest. This larger remnant appears to have been removed as part of the abandoned sports complex development in the 1980's. The current community has been further degraded by underscrubbing and probably some slashing to suppress regeneration of the understorey, as well as grazing. Without recruitment, this community will eventually senescence and thin to a woodland. This area is currently marked for retention as open space in the UIA 14 Structure Plan and the Concept Plan.

Photo 3: Sample photo of mid-north isolated forest remnant

3. *Lower Western/Southwestern Patches*:

Distribution and Extent: Occurred in two small pockets totalling 0.63ha on the west-southwestern boundary of the property.

Structure and Floristic Composition:

(a) Canopy:

Structure and species: Southern patch dominated by Tallowwood and Red Mahogany (*Eucalyptus resinifera*) with Broad-Leaved White Mahogany (*Eucalyptus umbra*) a common associate in the southern patch. Northern patch dominated by a handful of remnant senescent Forest Red Gums (*Eucalyptus tereticornis*) with some younger Pink Bloodwood (*Corymbia intermedia*). Broad-Leaved Melaleuca and Swamp Oak also occurred over a broad ecotone, more commonly in the northern patch. Trunk DBH varied from 30-70cm with a canopy height to 20m. Most of the canopy trees were mature to senescent.

(b) Understorey:

Structure and Species: Understorey vegetation consisted of an open cover of young sapling eucalypts and other small trees 5-10m in height. The most common species were Swamp Oak (*Casuarina glauca*) and Black Oak (*Allocasuarina littoralis*) over a broad ecotone, though Cherry Ballart (*Exocarpus cupressiformis*) also occurred.

(c) Shrub Layer:

Structure and Species: Poorly developed, with a few Cherry Ballart, Mock Olive (*Notelaea longifolia*), Breynia and young eucalypts.

(d) Ground-Layer:

Structure and Species: Dominated by pasture species such as Carpet Grass (**Axonopus fissifolius*), Parramatta Grass (**Sporobolus indicus*), Whisky Grass (**Andropogon virginicus*) on the fringes along with dense Bladey Grass, Matrush, Bracken Fern (*Pteridium esculentum*) and False Bracken Fern (*Calochlaena dubia*) also occurring.

(e) Lianas, scramblers, etc:

Structure and Species: Absent but for a few *Hibbertia scandens* and Twining Lily.

Comments: This community was a mix of a few remnant trees from historical clearing with some regrowth. Understorey was poorly developed in the south due to continuing disturbance by periodic slashing and the community overall contained a low floristic diversity. The floristic association mapped by Biolink for this area is incorrect as Grey Gum and Grey Ironbark are completely absent.

Photo 4: Sample photo of southwestern patch

4.1.2.2 Dry Sclerophyll Forest B: Dry Blackbutt (Very Tall Open Forest)

Distribution and Extent: This community occupies an area of approximately 2.11ha. It occurs in the southeast corner of the property around Duchess Gully on sand.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The mid-dense canopy consisted of mixed-aged trees 20-100cm DBH (diameter at breast height), 15-25m high. Most trees were <30cm DBH. Some of the larger trees contained small hollows in the trunk and/or branches. The community is dominated by Blackbutt (*Eucalyptus pilularis).* Pink Bloodwood, Broad-Leaved Paperbark, Red Mahogany (*Eucalyptus resinifera*) and Swamp Mahogany are also present though not especially common. Some patches of Broad-Leaved Paperbark also occur at times along Duchess Gully.

(b) Understorey:

Structure and Species: The understorey was a mid-dense covering of juvenile canopy species 5-10m in height. Blackbutt is dominant along with Broad Leaved Paperbark and Needlebark Stringybark. Coastal Banksia (*Banksia integrifolia*) common near the creek line with Sydney Golden Wattle (*Acacia longifolia*) more common on the fringes of the community in the northern section of this community.

(c) Shrub Layer

Structure and Species: Consists of a sparse cover of Sydney Golden Wattle, Coastal Banksia and Old Man Banksia (*Banksia serrata*). The shrub layer becomes increasingly sparse toward the southern extent of the community. Lantana is dominant through the central area of the community near the boundary of the STP.

(d) Ground-Layer

Structure and Species: Groundcover vegetation was a mid-dense cover to 1m high consisting of: Spiney Headed-Matrush, Bladey Grass (*Imperata cylindrica*); Basket Grass, Bracken Fern, Pennywort (*Centella asiatica*) and twiners such as *Glycine microphylla*. Batswing Fern and *Restio tetraphyllus* became common to locally dominant on the eastern side of the creek intergrading into the Dune Scrub.

(e) Lianas, scramblers, etc:

Largely absent, though Wombat Berry (*Eustrephus latifolius*), Native Sarsaparilla (*Smilax glyciphylla*) and *Smilax australis* occurred at times.

Comments: This community was largely regrowth in the northern section, although the presence of some older trees indicated that it had not been completely cleared in the past. Lantana is currently dominating an area in the centre of the community on the boundary of the STP and has the potential to spread further if not controlled.

Photo 5: Sample photo of Blackbutt DSF on sand

4.1.2.3 Dry Sclerophyll Forest C: Blackbutt-Tallowwood-Needlebark (Very Tall Open Forest)

Distribution, Extent and Soils: This community occurred on the hill in the southeast adjacent to the STP on clay.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The mid-dense canopy consisted of mixed-aged trees 20-120cm DBH, 15-25m high, with a good range of tree ages. Some of the larger trees contained small hollows in the trunk and/or branches. Dominated by Blackbutt with occasional Needlebark Stringybark (*Eucalyptus planchoniana*) on the eastern edges.

(b) Understorey:

Structure and Species: The understorey consisted of juvenile canopy species 5-10m in height. Blackbutt is dominant along with some Needlebark Stringybark. Coastal Banksia (*Banksia integrifolia*) is present and becomes the dominant understorey species in the southern area of the community. Sydney Golden Wattle is also common.

(c) Shrub Layer

Structure and Species: Consists of a very sparse cover of Sydney Golden Wattle, Coastal Banksia and Old Man Banksia (*Banksia serrata*). Lantana is common near the boundary of the STP.

(d) Ground-Layer

Structure and Species: Groundcover vegetation was a mid-dense cover to 1m high consisting of: Matrush, Bladey Grass (*Imperata cylindrica*); Basket Grass, Bracken Fern, Pennywort (*Centella asiatica*) and twiners such as *Glycine microphylla*.

(e) Lianas, scramblers, etc:

Largely absent, though Wombat Berry (*Eustrephus latifolius*), Native Sarsaparilla (*Smilax glyciphylla*) and *Smilax australis* occurred at times.

Comments: This community could be lumped with the Dry Blackbutt occurring on sandy substrates adjacent. Tallowwood is rare hence Biolink's classification is not accurate.

4.1.2.4 Wet Sclerophyll Forest: Brushbox (Tall Open Forest)

Distribution and Extent: This community occurred as a very small area of trees approximately 0.72ha along Duchess Gully and part of the adjoining main drain. The western section of the complex occurred as a narrow strip 5-10m wide (i.e. 2-3 trees across) and 100m long, broadening to 20m as it approached the junction with Duchess Creek, and continued downstream where it became fragmented and thinner. Soils were a moist but well-drained fine sandy loam. The area mapped as this community includes patches of Swamp Oak and pasture due to the extremely patchy nature of its distribution and hence is indicative only.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The canopy consisted of young trees 10-15cm DBH (diameter at breast height), 7-12m high with crowns touching or overlapping to form a dense cover, or open. These trees were immature to mature with intact crowns and no hollows were observed in the crowns or trunks. No species was clearly dominant throughout and the canopy was comprised of a mix of Brushbox (*Lophostemon confertus*), Cheese Tree (*Glochidion ferdinandi*), Hickory Wattle (*Acacia implexa*), White Banksia, Swamp Oak, Broad-Leaved Paperbark, Flooded Gum (*E. grandis*) and Moreton Bay Fig (*Ficus macrophylla*). While relatively low, the canopy did not appear to be stunted by wind shear.

(b) Understorey:

Structure and Species: The understorey often intergraded with the canopy, and consisted of canopy species plus a range of common pioneer rainforest species such as Lilly Pilly (*Acmena smithii*), Kurrajong and Common Acronychia (*Acronychia oblongifolia*), together with vines covering from the canopy.

(c) Shrub Layer

Structure and Species: This stratum consisted of a thick cover of Lantana in the southern section, juvenile canopy species and a range of rainforest shrubs such as Orange Thorn (*Citriobatus pauciflorus*) and Palm Lily (*Cordyline stricta*).

(d) Ground Layer

Structure and Species: Groundcover vegetation was generally sparse with some dense patches, and consisted of patches of ferns (*Doodia aspera, Blechnum indicum,* Bracken Fern), Spiney-Headed Matrush, Basket Grass, Bladey Grass and small seedlings of rainforest trees. Sedges such as *Carex appressa* also occurred in some areas.

(e) Lianas, scramblers, etc:

Climbers were common throughout the association, given it at times the appearance of viney scrub. The main species present were: Native Sarsaparilla (*Smilax australis*), Kangaroo Grape (*Cissus antarctica*), Devil's Twine (*Cassytha glabella*), White Passionflower (**Passiflora subpeltata*), and Jasmine Morinda (*Morinda jasminoides*). No plants of the families Apocynaceae or Asclepiadaceae were found in the wet sclerophyll (although *Parsonsia straminea* was present in the Swamp Oak Forest).

(f) Epiphytes:

The trees in this association were relatively young and no epiphytic ferns or orchids were found.

Comments: This eclectic mix of vegetation is a product of a range and frequency of disturbances and regrowth events and may not represent any indication of the original vegetation. The rainforest species present are known to occur in the littoral rainforest to the northeast (Berrigan and Bray 2002, Parker 2002) and may have been transported to the riparian zone by birds, with other species being common pioneers eg Hickory Wattle. In time this community may develop into wet sclerophyll forest ie eucalypt canopy underlain by rainforest species, though invasion by lantana may be an inhibitor, as will increased abundance of Swamp Oak which occurs interspersed between clumps of this community.

Photo 6: Sample photo of wet sclerophyll forest

4.1.2.5 Swamp Forest A: Swamp Oak (Tall Open Forest/Woodland)

Distribution and Extent: Swamp Oak dominates overs most of the northern corridor of the property/upper reaches of Duchess Gully, and also occurs as a number of patches and strips along adjacent drains and fence lines (some too small to be mapped at a suitable scale). A small patch also occurs in the west-northwest.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The canopy consisted largely of even-aged young regrowth, with some areas of mixed-aged trees. Trees in the younger stands were 5-15cm DBH (diameter at breast height) and 8-12m high, while trees in the mixed-age stands were 10-20cm DBH and 10-15m high. Stems were closely spaced in the young regrowth where they were typically 1-2m apart. Canopy cover was usually dense with crowns touching, but some stands were mid-dense. In mixed-age stands the structure was more open and the crowns were usually slightly separate. The crowns were intact and did not contain visible hollows. Swamp Oak was the dominant species, with an occasional Broad-Leaved Paperbark present in the canopy near the southern edge of the larger section of Swamp Oak in the north. A few Forest Red Gums also occurred in the west-northwest patch.

(b) Understorey:

Structure and Species: Understorey trees were typically absent in the young regrowth, but in mixed-age stands they were present as saplings of Swamp Oak and a few small trees of Broad-Leaved Paperbark, *Melaleuca stypheloides*, Hickory Wattle (*Acacia implexa*), Willow Bottlebrush (*Callistemon salignus*) and Boobialla (*Myoporum acuminatum*). These were mostly present at the edges of the stands or on ecotones with the mixed wet sclerophyll forest.

(c) Shrub Layer:

Structure and Species: This stratum typically absent, with some patches of sparse cover of Lantana (**Lantana camara*) in the northwest, or *Leptospermum polygalifolium*. A few other shrubs were present in some areas eg Mock Olive (*Notelaea longifolia*) and Common Acronychia (*Acronychia oblongifolia*) and other pioneer rainforest species.

(d) Ground Layer:

Structure and Species: Groundcover vegetation was generally either sparse or absent in the wettest areas and it consisted of occasional clumps of Saw Sedge (*Gahnia clarkei*), Basket Grass, Carpet Grass, Kurnell Curse (***Hydrocotyle bonariensis*), and Ivy-Leafed Violet (*Viola hederacea*).

The extent of groundcover vegetation was greater in areas with an open canopy structure. In the southern end of the stand where a drainage ditch was present in Swamp Oak forest, the ground vegetation formed an open to mid-dense cover to 1m high and dominated by clumps of Saw Sedge with a few small areas of Rasp Fern (*Doodia aspera*). At the stand of Swamp Oak along the road verge, the groundcover at the edges was dominated by dense growth of Bladey Grass and Rhodes Grass (***Chloris gayana***). In the small patch in the west-northwest, it consisted of pasture grasses.

(e) Lianas, scramblers, etc:

Monkey Rope was common and it extended into the canopy in the main patches of forest. Lantana also extended into the canopy in some places. Other climbers were rare, except at edges with the wet sclerophyll where Kangaroo Grape (*Cissus antarctica*) and some climbing species were common.

Comments: This community was considered to be entirely regrowth, although several age classes were present. It is not confined to soils which were wet or at least very moist, but also extended well up the slopes to the midslope and crest.

Photo 7: Sample photos of Swamp Oak swamp forest

Left: Typical Swamp Oak along a fenceline. Right: Sample from large block in northern corridor.

4.1.2.6 Swamp Forest B: Paperbark/Swamp Mahogany/Swamp Oak (Tall Open Forest/Woodland)

Distribution and Extent: This community occurs over 10.45ha in four main areas:

- The western remnant which occurs in a fragmented ribbon in a drainage line adjacent to the western boundary, and partially extended along a drain as a single line of trees.
- The middle remnant will occurs along drains and around and over a small area of fill from the excavation of the original large waterbodies.
- The southeast corner of the property, adjunct to the STP.
- A small patch in the far southwestern end of the property.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: The dominant species overall was Swamp Mahogany and Broad-Leaved Melaleuca, especially in the middle and southeast remnant. Canopy was to 8-20m with trunk DBH varying from 20-80cm.

(b) Understorey:

Structure and Species: Varied per remnant, with height 2-10m.

Narrow-Leaved Melaleuca (*Melaleuca linariifolia*), Swamp Mahogany and Prickly-Leaved Paperbark (*Melaleuca styphelioides*) were most common in the middle remnant, southwest and most of the western remnant, with Cherry Ballart (*Exocarpus cupressiformis*), Black Oak (*Allocasuarina littoralis*), Slender Tea Tree (*Leptospermum polygalifolium*) and Swamp Oak (*Casuarina glauca*) also occurring in the western and southeast remnants.

Black Oak and Cherry Ballart was very common on higher portions in the western remnant, grading to pure melaleucas (mostly *M. quinquenervia*) where the remnant followed the drain.

The southeast remnant contained at times dense Coastal Tea Tree (*Leptospermum laevigatum*) and Prickly-leaved Paperbark.

(c) Shrub Layer:

Generally poorly developed in the western remnants with sparse *Babingtonia pluriflora, Leptospermum polygalifolium*, and young understorey/canopy trees; to well developed in the remnant west of the lagoons where it included at times a dense layer of shrubs up to 2m tall. Species included young Broad-Leaved Paperbark and Swamp Mahogany, with *M. sieberi*, *Babingtonia pluriflora, Leptospermum polygalifolium, Xanthorrhoea fulva, Pultenaea villosa, Acacia elongata* var. *dilatatum, Pultenaea retusa* and *Pultenaea villosa*.

About half of the southwest drainage line consisted of a very dense shrub layer 2m high and up to about 5m wide (the maximum width of this community in this area). It consisted of dense *Babingtonia pluriflora, Leptospermum polygalifolium, L. liversidgei, Acacia elongata* var. *dilatatum, Xanthorrhoea fulva* and *Pultenaea villosa.*

Much of the southeast remnant was dominated by impenetrable lantana, or a dense stand of shrubs as *Leptospermum polygalifolium,* Sweet-Scented Wattle (*Acacia suaveolens),* Wallum Beard Heath (*Leucopogon lanceolatus var. gracilis*), and Wallum Heath *(Epacris pulchella)*

(d) Ground Layer

Structure and Species: Ranges with location.

In the western remnants, Carpet Grass and Torpedo Grass (*Panicum repens*) were the most common species, with *Setaria pumila* dominating the middle remnant and occasional Fire Weed (*Senecio linearifolius*). Other common species included Whiskey Grass, Bladey Grass, Basket Grass, *Ischaemum australe,* Swamp Fern, Slender Knotweed, Frogsmouth, Kurnell Curse and *Eleocharis acuta.* Spiney-Headed Matrush, Bracken Fern, and False Bracken Fern occurred in higher areas.

The southwest remnant varied with position. The centre of this community was dominated by *Xanthorrhoea fulva* which formed a thick cover. Spiney-Headed Matrush, *Restio tetraphyllus*, Bracken Fern and False Bracken Fern (*Calochlaena dubia*) occurred in the remainder.

(e) Lianas, scramblers, etc:

Structure and Species: Largely absent with only Twining Lily and few Monkey Rope.

Comments: This community consists almost entirely of regrowth with a handful of eucalypts representing the original vegetation. Almost all of the regrowth in the western, southern, central and southeast remnants are the same age (15-25yrs old), indicating recovery from a common clearing event. The central and linear portions of this community have developed due to lack of access for slashing or wet conditions preventing practical maintenance, or have been retained to buffer the STP. Appraisal of the aerial photo in Clancy and Ayres (1983) shows this community was much more extensive especially in the west where it occupied about a quarter of the property, and also extended further across the eastern plain, with clearing appearing to occur as part of the defunct sports complex.

Photo 8: Sample photos of Paperbark/Swamp Mahogany swamp forest

4.1.2.7 Dune Scrub (Very Tall Shrubland)

Distribution and Extent: This community occurs in the east-southeast on the western side of Duchess Gully, north of the STP. It occupies the southern end of the sandplain and constitutes 1.19ha. Soils are Aeolian sands to loamy sand near Duchess Creek.

Structure and Floristic Composition:

(a) Canopy/Understorey:

Structure and Species: Due to the immaturity of this vegetation, there is no clear canopy or understorey. Height ranges from 5-10m, with trunk DBH 10-30cm. Overall dominated by a combination of Coastal Tea Tree (*Leptospermum laevigatum*), Tall Broom Heath (*Monotoca elliptica*) and Satin Wood (*Nematolepsis squamea subsp. squamea*). Coastal Banksia (*Banksia integrifolia*), Sydney Golden Wattle (*Acacia longifolia*), Ball Honey Myrtle (*Melaleuca nodosa*), Geebung (*Persoonia conjuncta*), and *Melaleuca sieberi* also commonly occurred.

(c) Shrub Layer:

Structure and Species: Relatively well developed where canopy/understorey is sparser, but also often intergrades with understorey. Height ranges from 0.5-4m. Species consist of above species plus true shrubs such as Prickly Moses (*Acacia ulicifolia*), *Boronia pinnata, Leptospermum polygalifolium,* Sweet-Scented Wattle (*Acacia suaveolens),* Wallum Beard Heath (*Leucopogon lanceolatus var. gracilis*), and Wallum Heath *(Epacris pulchella).*

Lantana (*Lantana camara*) was present though it was not widespread.

(d) Ground Layer

Structure and Species: Patchy, ranging from dense where no upper/limited stratums to absent under denser cover. Contained a mixture of species eg Pomax (*Pomax umbellata*), Broom Bush (*Jacksonia scoparia*), Spiney-Headed Matrush, Cord Rush (*Restio tetraphyllus),* Old Man's Beard (*Caustis recurvata var. recurvata*), Kangaroo Grass, *Gahnia clarkei,* Flannel Flower (*Actinotus*

helianthi), Bat's Wing Fern (*Histiopteris incisa*), Bracken Fern and False Bracken Fern all occurred.

(d) Lianas, scramblers, etc:

Structure and Species: Largely absent but for some Devils Twine (*Cassytha glabella*).

Comments: This community represents an area of regrowth after total clearing in the last 10-15yrs, and is an early seral stage in the recovery of a normal sand dune vegetation succession sequence. Over time it is expected to contain an overstorey of Blackbutts similar to the adjacent vegetation to the west, subject to maritime influences from the east. This community has not been identified and/or mapped by Biolink (2005c).

Photo 9: Sample photo of Dune Scrub

4.1.2.8 Pasture/Pastoral Woodland

Distribution and Extent: This highly variable community occupies the majority of the property, totally about 150.12ha. The southern sections of this community were on flat land (ie the coastal plain/drainage line) with poorly drained soils, with the remainder occurring on the ridges and slopes in the north and northwest of the property. Soils on the ridges and slopes consist of loamy clay derived from metamorphics, with alluvial soils characterised by yellow and grey duplexes and dark waterlogged loams on the coastal plain/drainage line. Areas of the pasture/pastoral woodland on the flats were observed to be waterlogged and holding shallow ephemeral water after substantial rain.

A separate area occurred on Aeolian soils on the sandplain east of Duchess Creek.

Structure and Floristic Composition:

(a) Canopy/Understorey:

Structure and species:

The only area where this stratum is truly defined is southwest of the main dwelling on the slopes and footslopes where remnant Forest Red Gums (*Eucalyptus tereticornis*) with average trunk DBH 0.6-1m and height of 20-25m occurred. These trees represented the remnants of former forest, and are largely senescent or declining (evidenced by epicormic bud shooting), possibly due to higher watertable levels.

In other areas, this stratum is represented as minor patches, strips or scattered individuals of Swamp Oak 2-18m tall identical in age to other regrowth. Swamp Oak and rarely Pink Bloodwoods, Swamp Mahogany and Broad Leaved Paperbark occurred in other areas as scattered trees ranging in height from 2-18m.

In the southwest of the area of periodic inundation, widely scattered trees, mostly <3m high but up to 6-10m have been allowed to regrow with other regrowth suppressed by slashing. These consisted of a few scattered Swamp Mahoganies, Swamp Oak and Broad Leaved Paperbarks.

Along the northern boundary, 2 rows of planted trees spaced 5-10m apart and up to 5m high were present. They consisted of Broad-Leaved Paperbark (*Melaleuca quinquenervia*), gums (*Corymbia citriodora, Eucalyptus saligna*), Tallowwood, Swamp Mahogany, River Oak (*Casuarina cunninghamiana*), Brushbox and White Banksia.

(b) Shrub Layer:

Structure and Species: Absent over the majority of this community. Exceptions in some localised areas as follows:

- *Babingtonia pluriflora, Pultenaea villosa, M. sieberi* and juvenile Swamp Mahogany seedlings dominate a drain in the southwest corner adjacent to the dry sclerophyll. The edges of this community has been removed or suppressed by continuation of slashing in drier seasons.

- A localised patch in the mid-west just above the middle swamp forest remnant in 2003 had a patchy shrub layer consisting of young *Melaleuca sieberi* and *M. linariifolia*, with some *Callistemon pachyphyllus*, Swamp Mahogany seedlings, and *Pultenaea villosa* up to 1.5m high which allowed trapping with Elliot A traps. At this time, this area was waterlogged with some surface water, and subsequent drought has allowed access for slashing. At time of the 2006 survey, some of the Melaleucas were noted to be shooting from rootstock but this stratum had been effectively removed.

- East of Duchess Creek, depending on slashing frequency, this stratum may be absent or consist of a few scattered juvenile White Banksia (*Banksia integrifolia*) and other colonisers from the Dune Scrub mostly in the southern end or around the edges of the drainage line.

(c) Ground Layer:

Structure and Species: This layer was generally continuous but is generally periodically slashed.

Depending on location and waterlogging, it generally consisted of a varying mix of sedges and grasses up to 0.2-1m high.

On elevated ground, the dominant species were: Carpet Grass (**Axonopus fissifolius*), Whisky Grass (**Andropogon virginicus*), Cats Ear (**Hypochaeris radicata*), Plantain (**Plantago lanceolata*) and White Clover (**Trifolium repens*). Patches of Parramatta Grass (**Sporobolus indicus*) also occurred. In poorly drained areas, Kurnell Curse (**Hydrocotyle bonariensis*) and Buttercup (*Ranunculus lappaceus*) were also common. A strip of grassland along the eastern boundary on poorly drained soils was dominated by Broad-Leaved Paspalum (**Paspalum wettsteinii*).

On the low flat ground, the moist soils were dominated by an assemblage of Torpedo Grass, Carpet Grass, *Setaria pumila* and Whisky Grass, with Common Spikerush (*Eleocharis acuta*). In the localised patches where shrubs occur as noted above, native species were more dominant and in addition to spikerush included *Xanthorrhoea fulva, Ischaemum australe, Juncus*

polyanthemus, J. continuus, J. cognatus, Cyperus polystachyos, and Swamp Fern.

East of Duchess Creek, this stratum is periodically slashed except the very edges of a small drainage line. Overall, it is dominated by a mixture of Bladey Grass, Spiney-Headed Matrush and Bracken Fern with some Kangaroo Grass (*Themeda australis*) and patches of *Gahnia clarkei*. *Gahnia clarkei*, Bracken Fern, Pouched Coral Fern (*Gleichenia dicarpa*), *Selaginella uliginosa* and Cord Rush dominated the drainage line with Sphagnum Moss.

(d) Lianas, scramblers, etc:

Structure and Species: Absent.

Comments: In general, this community consisted of a mixture of introduced pasture species along with native sedge land species. Review of the aerial photo in Clancy and Ayres (1983) shows that a substantial portion of the low lying areas were formerly swamp forest, as evidenced by the remaining elements not completely extinguished by pastoralism, but being gradually phased out by progressive slashing, drainage and even cultivation in some areas. With relatively limited intervention, the wettest portions of this community has very good potential to recover into swamp forest, which is beneficial given a significant portion of this community falls into the proposed east-west corridor.

The Forest Red Gum woodland represents the last vestige of the original forest in this area cleared in the 1980's, and canopy trees are rapidly declining. With no recruitment, this area would degenerate to open pasture.

This community has not been specifically mapped by Biolink (2005c) – only showing as the default colour.

Photo 10: Sample photos of pasture/pastoral woodland

Photo 11: Sample photo of southwest pasture/pastoral woodland

Photo 12: Sample photo of native grassland east of Duchess Creek
Photo taken July 2008. Note windrows. Noted to be in this condition in 2006.

4.1.2.9 Artificial Wetlands/Aquatic Vegetation

Distribution and Extent: This collective community refers to aquatic vegetation in Duchess Gully, numerous drainage ditches which contained standing water at least in wetter years, the two main lakes, two farm dams, and a depression north of the largest lagoon which is south of the proposed wetland.

Drains varied in size from 1m deep and 2-3m wide with shallow clear water 5-10cm deep in the central and southwest Paperbark/Swamp Mahogany swamp forest remnants; to 1m wide and 1m deep with moist soils but with no standing water in the pasture.

Aquatic vegetation also occurred around the fringes of all the dams/lagoons in deep, standing water, and throughout most of Duchess Gully which contained tannin-stained water up to 1m deep throughout its upper freshwater reaches.

The depression just north of the main lake appears to be a result of earth works related to the construction of the lagoons and abandoned sports centre as apparent from its particular shape and uniform depth. This community was dry during the 2006 survey but after rain the community was completely inundated by ephemeral water up to 25cm deep.

Structure and Floristic Composition:

(a) Canopy:

Structure and Species: Absent.

(b) Understorey:

Structure and Species: Absent

(c) Shrub layer:

Structure and Species: Absent in all but the depression.

In the depression, prior to the 2006 survey, this community had been slashed for what appears to be several times since 2003 and hence this component was evidenced only by a few Wallum Bottlebrush (*Callistemon pachyphyllus*) along a fenceline which bisects this community. In 2003, the shrub layer was noted to be very well developed, resembling a wet heath with species consisting of Wallum Bottlebrush, *Babingtonia pluriflora*, *Leptospermum liversidgei*, *Acacia elongata* var. *dilatatum, Pultenaea retusa* and *Pultenaea villosa*.

(d) Ground Layer

Structure and Species:

Duchess Gully: The vegetation in the creek ranged from low herbs to tall dense sedges with ferns and sedges fringing the edges. Cumbungi (*Typha orientalis*) dominated most of the watercourse, together with Giant Spikerush (*Eleocharis equisetina),* Common Spikerush, Jointed Twigrush, and *Schoenoplectus mucronatus*). Shallower areas were dominated by Frogsmouth, Streaked Arrow Grass (*Triglochin striatum*), Kurnell Curse, *Fimbristylus dichotoma,* Slender Knotweed (*Persicaria decipiens*), Yellow-Marsh Flower (*Villarsia excaltata*) Water Buttons (*Cotula coronopifolia*) and Water Primrose (*Ludwigia peploides spp montevidensis*). Tassel Sedge (*Carex fascicularis*) was common along the edges. Some water lilies (*Nymphaea* spp) occurred in the deeper sections of the creek.

Dams/Lagoons: The large dams/lagoons were lined with patches or bands of about 1-2m tall of Common Spikerush, Cumbungi, etc, in the shallow edges, grading to Torpedo Grass on the perimeter and banks. Other small dams were lined with patchy Common and Giant Spikerush, Tussock Rush and *Schoenoplectus mucronatus.* Some of the above groundcovers/herbs were present though cattle grazing and stomping limited abundance. Some water lilies were present in the lakes.

Drains: Drains in the pastoral areas consisted of Carpet Grass, Torpedo Grass and Common Spikerush. The large drains contains vegetation ranging from Cumbungi to Frogsmouth, Streaked Arrow Grass, Kurnell Curse, *Fimbristylus dichotoma,* Slender Knotweed, Yellow-Marsh Flower Water Buttons, Water Primrose and Tassel Sedge.

Depression: In 2006, the groundcover in the depression was reduced to about 20cm high but was formerly dense and up to 1m high. This stratum was dominated by Common Spikerush with some Jointed Twig-Rush (*Baumea articulata*), and dense Torpedo Grass on the shallower margins, as well as some Kurnell Curse, Fireweed and Carpet Grass on the outskirts of the community.

(e) Lianas, scramblers, etc:

Structure and Species: Absent.

Comments: Duchess Gully was considered to have the best conservation value as a floristic community, with the others merely representing colonisation of artificial habitats although they do contribute to the potential fauna habitat on the property.

The community in the depression may be the result of colonisation of an unfinished excavation created as part of previous earthworks. In 2003, its vegetation was considered to qualify more as wet heath than a wetland. However, subsequent slashing in drier years has effectively eliminated the woody shrub layer leaving only sedges and grasses. This ephemeral habitat however shows great potential to recover if slashing were to cease and cattle excluded from grazing the green shoots of the regrowth.

Biolink (2005c) has only mapped the two lagoons and major stock dam.

Photo 13: Sample photo of depression vegetation in 2008

This is regrowth 2yrs since slashing. Compare to photo in Appendix 1 taken in 2006.

Photo 14: Sample photo of aquatic vegetation in a small dam

Photo 15: Sample photo of vegetation in existing major dams/lagoons

4.2 FLORA OF CONSERVATION SIGNIFICANCE

4.2.1 Threatened/Rare Species

4.2.1.1 Targeted Searches

No threatened species were found by extensive searches of all vegetation communities on the property by this or previous surveys.

4.2.1.2 Review of Atlas of Wildlife/Bionet/Literature Records

Table 11 in Appendix 1 evaluates the threatened flora species recorded in the locality, and species considered potential occurrences, for their potential to occur on the property.

In regards to potential occurrence of threatened flora, it should be noted that threatened plants often occur in habitats with a precise mix of essential ecological requirements, and not randomly in the landscape or a broad structural form of vegetation (eg dry sclerophyll forest). Such essential requirements may be a complex nexus of position, soil type (which affects fertility, acidity, etc) and climate, but may also include specific (sometimes symbiotic) association with fungi and bacteria (eg Proteaceae), dispersal vectors (eg bats) and disturbance regimes eg *Acacia aprica* will not recruit without a suitable fire regime (Vallee *et al* 2004). Absence of such essential habitat variables or their modification (eg by disturbance such as frequent fire) can thus reduce or negate a site's potential for such plants to occur. These often poorly understood ecological factors are also a major contributor in the reason that many translocations of threatened plants fail (Vallee *et al* 2004).

4.2.1.3 Conclusion

In regards to potential occurrence of threatened flora, it should be noted that threatened plants often occur in habitats with a precise mix of essential ecological requirements, and not randomly in the landscape or a broad structural form of vegetation (eg dry sclerophyll forest). Such essential requirements may be a complex nexus of position, soil type (which affects fertility, acidity, etc) and climate, but may also include specific (sometimes symbiotic) association with fungi and bacteria (eg Proteaceae), dispersal vectors (eg bats) and disturbance regimes eg *Acacia aprica* will not recruit without a suitable fire regime (Vallee *et al* 2004). Absence of such essential habitat variables or their modification (eg by disturbance such as frequent fire) can thus reduce or negate a site's potential for such plants to occur. These often poorly understood ecological factors are also a major contributor in the reason that many translocations of threatened plants fail (Vallee *et al* 2004).

The general property and especially the site of the proposed wetland and filling area have experienced at times a range of severe disturbances, including almost total clearing, underscrubbing, periodic slashing, sand mining and grazing. These threatening processes over time are likely to have significantly reduced

the suitability of the property to support threatened species, or resulted in their elimination. Consideration of this disturbance history and the failure to detect these species is considered a representative indication that they do not occur on the property, and consequently, they are no longer considered in this assessment.

4.2.2 Ecological Communities and Populations

As shown in figure 12, Biolink (2005c*)* have identified the occurrence of two Coastal Floodplain EECs on the property as part of vegetation mapping for the UIA 14 KPoM. These EECs are:

- *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast Bioregion* (NSWSC 2004b).
- *Swamp Oak Floodplain Forest on Coastal Floodplains of the NSW North Coast Bioregion* (NSWSC 2004a).

These have been reviewed in association with the floristic and geomorphologic characteristics of the property via literature review (Luke and Co. 2008) and ground truthing.

4.2.2.1 Review of Final Determination Criteria

In assessing the validity of the occurrence of the EECs mapped by Biolink (2005c*)* on the subject land, some preliminary discussion of legal precedents and literature review is required. The most relevant literature and legal precedents assisting the interpretation of the Coastal Floodplain EEC Final Determinations are:

- *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367*
- DECC (2008a). *Swamp Sclerophyll Forest on Coastal Floodplain – Identification Guide*. NSW DECC. Available at http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.
- DECC (2008b). *Swamp Oak Floodplain Forest on Coastal Floodplain – Identification Guide*. NSW DECC. Available at http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.
- Keith (2004). *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*. NSW Department of Environment and Conservation, Sydney.
- Keith, D. and Scott, J. (2005). Native vegetation of coastal floodplains – a diagnosis of the major plant communities in New South Wales. *Pacific Conservation Biology*, **11**: 81-104.
- *Motorplex (Australia) Pty Limited v Port Stephens Council [2007] NSWLEC 74*
- NSWSC (2004a). *Swamp Oak Floodplain Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* - endangered ecological listing.
- NSWSC (2004b). *Swamp Sclerophyll Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* - endangered ecological listing.
- Preston, B.J. and Adam, P. (2004a). Describing and listing threatened ecological communities under the *Threatened Species Conservation Act 1995* (NSW): Part 1 – the assemblage of species and the particular area. *Environmental and Planning Law Journal*, **21**:250-263
- Preston and Adams (2004b). Describing and listing threatened ecological communities under the *Threatened Species Conservation Act 1995* (NSW): Part 2 – the role of supplementary descriptors and the listing process. *Environmental and Planning Law Journal*, **21**:372-390

- *VAW (Kurri Kurri) Pty Ltd v Scientific Committee (2003) 58 NSWLR 631)*

Preston and Adam (2004a, 2004b) provide a very comprehensive and thorough review of how to assess a vegetation community for qualification as an EEC from a legal standpoint. As this is crucial to the process, their discussion is summarised here.

Firstly, Section 4(1) of the TSCA 1995 defines an "*ecological community*" simply as an "*assemblage of species occupying a particular area*". This definition identifies three requirements in order for there to be an ecological community under the TSCA:

a) The constituents of the community need to be "*species*"
b) The species need to be brought together in such a way as to constitute an "*assemblage*" of species; and,
c) The assemblage of species needs to occupy a "*particular area*".

The concept of the key term "*species*" needs no further explanation here (though Preston and Adams 2004a explore the term in all its facets), however "*assemblage*" and "*particular area*" deserve discussion given their legal significance as expressed in various precedents (Preston and Adams 2004a, 2004b, *Motorplex (Australia) Pty Limited v Port Stephens Council [2007] NSWLEC 74, CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367, VAW (Kurri Kurri) Pty Ltd v Scientific Committee (2003) 58 NSWLR 631),* and the relevance to the subject land in this instance.

Preston and Adam (2004a) state that an "*assemblage*" is essentially a collection of species in a location. The latter qualifier is significant in that if the species do not occur in a specific location, then by definition, they are not assembled but scattered. Preston and Adam (2004a) elaborate on the significance of the term "*assemblage*" in that by its ecological context as applied to an ecological community, it refers to "*a number of species, animal and plants interacting ecologically to sustain the community…This interaction is enabled by the species co-occurring in the one place*." If such interactions did not take place thus, no distinct assemblage could be defined.

Preston and Adam (2004a) follow on from this discussion to define the key significance of the term "*particular area*" as relevant to an EEC, in that it logically follows from the above that the location of the assemblage of the species is its natural habitat ie where suitable ecological conditions exist.

However, Preston and Adam (2004a) consider that "*satisfaction of each of these three requirements of the definition of "ecological community" does not generate a description of an ecological community at any particular level of specificity or spatial scale of biological diversity*". As Preston and Adam (2004a) argue, "*the level of specificity and the spatial…will depend on the nature of the species, the assemblage of species and the particular area occupied…*" Hence the requirement for (and significance of) a range of primary and supplementary descriptors within the Final Determinations for EECs to allow separation by a reasonably informed lay man of floristically similar assemblages at different "*locations*" (Preston and Adams 2004a, 2004b).

Primary descriptors are considered by Preston and Adams (2004a, 200b4) to be:

a) ***Floristic diversity*** ie characteristic species (including dominants) that comprise the assemblage of species that defines the community.

b) ***Location*** eg bioregion, Local Government Area (LGA). This may also include topography/landform elements.

These are the key descriptors as they directly embody constituents of the statutory definition of an ecological community (Preston and Adams 2004a, 2004b) ie an "*assemblage of species occupying a particular area*".

Supplementary descriptors include:

a) Structure and physiognomy eg height, vegetation type, and response to disturbances.

b) Abiotic factors eg climatic, physiographic and edaphic factors such as soil types and parent material, or elevation.

c) Biotic and ecological factors eg typical fauna associated with the community, ecological relationships

Following their thorough discussion and reference to legal precedents to validate their points of view, Preston and Adam (2004b) conclude in regard to supplementary factors that they "*cannot be used as a substitute for a description of the assemblage of species and the particular area in which the community is located. Rather, they should be seen as a valuable adjunct*".

The papers by Preston and Adams (2004a, 2004b) were regrettably published before the gazettal of the Coastal Floodplain EECs, hence do not evaluate the key descriptors in these Final Determinations, of which there is still some debate and doubt (ECANSW 20008a). However, subsequent development consent refusal challenges in the Land and Environment Court have led to some major relevant precedents which have provided some clarity in interpreting the key descriptors, most particularly in *Motorplex (Australia) Pty Limited v Port Stephens Council [2007] NSWLEC 74* and in *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367.*

As detailed in his judgement on *Motorplex vs Port Stephens Council*, Commissioner Preston uses these primary and supplementary descriptors in clarifying uncertainty at specific site situations where there is difficulty in delineating the presence and extent of an EEC. Commissioner Bly in *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367* also evaluates the potential occurrence of the subject EEC via evaluation of the descriptors, but arrives at a different conclusion in regard to the key phrase, "*associated with*", which had a significant bearing on the outcome of that case.

In general there is a high degree of similarity between these two cases which deal with the Coastal Floodplain EECs. Each systematically evaluates the primary and supplementary descriptors eg landform, soils and vegetation. Both cases follow similar lines of argument from the applicant and respondent, with vegetation meeting the floristic criteria for example (ie the "*assemblage*"), and an assessment of whether the soils and geomorphology match the edaphic and landform requirements to satisfy the legal definition of a "*particular area*" under the TSCA as explained by Preston and Adam (2004a).

The site assessed in *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367* primarily fails the EEC identification test by the soil profile (and hence underlying geomorphology) being determined to be derived from colluvial not alluvial processes – the latter being the key indicator of a floodplain or landforms associated with a floodplains and the underlying ecological process defining the Coastal Floodplain EECs (*Motorplex (Australia) Pty Limited v Port Stephens Council [2007] NSWLEC 74*, Keith and Scott 2005, 2004, DECC 2008a, 2008a-c, Dr David Keith pers. comm.); hence an ecological pre-requirement for identifying the occurrence of a Coastal Floodplain EEC (ie the "*particular area*"). In this case, Commissioner Bly accepts that the applicant's view that the subject landforms do not constitute an alluvial flat or drainage line as tendered by the applicant's consultants due to a lack of alluvial geomorphology. This is a key requirement (as detailed subsequently) as floristic and structural assemblages matching the Final Determination may occur in locations and landforms other than floodplains eg sandplains and hill slopes, as detailed in Keith and Scott's (2005) seminal paper which forms the basis for the Coastal Floodplain EECs.

Furthermore, as discussed by Preston and Adam (2004a, 2004b), meeting of some broad criteria does not qualify a specific assemblage in a specific location as the EEC ie "*satisfaction of each of these three requirements of the definition of "ecological community" does not generate a description of an ecological community at any particular level of specificity or spatial scale of biological diversity*". As

noted above, the legal definition of an ecological community under the TSCA is an "*assemblage of species occupying a particular area*"". Hence the floristic assemblage and the required location must be matched to produce the EEC. The absence of alluvial processes (hence alluvial soils and landforms associated with a floodplain) thus failed the subject sites in *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367* from qualifying as an occurrence of the *Swamp Sclerophyll Forest on Coastal Floodplains* EEC.

The primary area of divergence between Commissioners Bly and Preston is on the issue of "*associated with coastal floodplains*". Commissioner Bly determined that the subject site was not "*associated with coastal floodplains*" as the vegetation was not continuous to the floodplain (as presented by the applicant's ecologist). Commissioner Preston and the NSW Scientific Committee (in communication to Commissioner Preston) state that it is the continuity of the landform (ie the drainage line or alluvial flat) not the vegetation that is the required association. Hence Commissioner Preston's following recommendation at paragraph 87 is in regard to interpretation and application of the phrase, "*associated with*":

> "*Insofar as the decision of Commissioner Bly in CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367 (12 July 2005) paras 45-47 held to the contrary of the construction of the Final Determination for the Swamp Sclerophyll Forest community that I have explained, I am of the opinion that it was wrongly decided and should not be followed*."

4.2.2.2 Biolink EEC Mapping

4.2.2.2.1 Presence of a Coastal Floodplain on the Property

The property has been identified by geotechnical studies (Luke and Co. 2008, Cardno 2008) to contain alluvial soils on the coastal plain/major drainage line which comprises most of the southern end of the property.

As accounted previously in section 2.4, the general eastern side of the Rainbow Beach area was originally formed with a sand barrier (dunes) in the Pleistocene between Tacking Point and Bonny Hills, which formed a large estuarine lagoon, which later filled in the Holocene with marine sediments (probably from dune movement). This was gradually filled by the watercourse to the southwest to form a low lying plain. The upper sediments on the plain are composed of sediment deposited via the former watercourses in the southwest carrying eroded materials from the western ranges (Luke and Co. 2008, Cardno 2008). Colluvial soils occur on the lower slopes of the ridgeline which runs along the northern side of the property.

The portions of the property thus associated with this ancient low lying plain, the drainage lines and Duchess Gully are thus considered to satisfy the soils, elevation and geomorphological criteria of the Final Determinations (NSWSC 2004a, 2004b).

4.2.2.2.2 EEC - *Swamp Sclerophyll Forest on Coastal Floodplains*

Biolink (2005c*)* generically map the stands of Paperbark/Swamp Mahogany/Swamp Oak swamp forest on the mid-west boundary, the lower middle of the property west of the lagoons, and in the southeast, as this EEC.

In general, these classifications are correct as floristic, soils and geomorphological descriptors are met (as verified by soil information).

These occurrences are all regrowth from low to medium levels of disturbance ie regrowth that may have been subject to some interference/modification at low frequency but is generally intact. These stands have good to very good potential for regeneration with relatively limited assistance.

Overall, this EEC is considered to cover approximately 10.45ha on the property (see table 2).

4.2.2.2.3 EEC - *Swamp Oak Floodplain Forest on Coastal Floodplains*

Biolink (2005c*)* generically maps the entire Swamp Oak swamp forest on the property as this EEC. This is not quite correct as a substantial portion of the Swamp Oak swamp forest in the northwestern end of the proposed northern corridor occurs on the slopes of the main ridge, and hence occurs on colluvial not alluvial soils. The occurrence of Swamp Oak forest above the 1:100 ARI or not even on a floodplain or alluvial soils is not unusual but demonstrates that Swamp Oak and several key indicator species (eg Bladey Grass) are poor defining criteria of this EEC.

The patch in the west-northwest is also on colluvial soils (as determined by soil data provided by Coffey Pty Ltd), hence also does not satisfy the "*particular area*" requirement of TSCA EEC definition. The overwhelming majority of Swamp Oak on adjacent land to the north and northwest mapped as EEC by Biolink (2005c) also occurs on colluvial soils (again, confirmed by soils data) and hence does not qualify as an EEC (Darkheart 2006k, 2006l).

On site, it is readily apparent that Swamp Oak (with its evidently wide range of preferred edaphic conditions) has invaded the slopes/toe of the adjacent slopes and displaced pasture and regeneration of the previously cleared sclerophyll forest on higher areas (as evidenced by remnant species on the ecotone). Such situations are noted in the Final Determination (NSWSC 2004b), and this consultant has personally observed similar situations with the opportunistic species even occurring on coastal headlands in place of littoral rainforest or coastal *Banksia* scrub (Berrigan 2002a, 2002b). Locally, it can be seen dominating table drains along the Pacific Highway from the Oxley Highway/Pacific Highway intersection to the Bago Rd intersection where dry sclerophyll forest previously existed on a ridgeline.

Consequently thus, the extent of this EEC on the property is not as extensive as illustrated in the KPoM (Biolink 2005c*).* Again, all occurrences are largely regrowth (as evidenced by historical photos) and range from low to moderate-high condition, with the best examples occurring parts of the northern corridor.

4.2.3 Conservation Status of Vegetation Associations

The Comprehensive, Adequate and Representative (CAR) Assessment was completed in 1999-2000 for the Upper North East or Lower North East study areas (incorporating the local region). It was designed to assess Forest Ecosystem diversity, richness and extent of reservation in the broader context of the regional CAR reserve system design strategy.

Due to the extent of modification of the property's original vegetation, it is difficult to assign many communities to the recognised CAR categories, however the following may be indicative:

- **Ecosystem 143 Swamp Oak**: Corresponds to the Swamp Oak swamp forest community and is considered Rare and inadequately represented.

- **Ecosystem 27 Coastal Sands Blackbutt**: Is likely to qualify as the DSF B and C Blackbutt Forest, and is adequately represented.

- **Ecosystem 36 Dry Grassy Tallowwood-Grey Gum**: Matches DSF A, and is considered adequately represented.

- **Ecosystem 46 Eastern Red Gums**: May include the portion of the pastoral woodland where Forest Red Gum is locally dominant (yet declining). This ecosystem is considered Vulnerable but is adequately represented.

- **Ecosystem 112 Paperbark**: May apply to western and part of the middle and southeast remnants of Paperbark/Swamp Mahogany/Swamp Oak swamp forest. This community is considered Vulnerable and inadequately represented.

- **Ecosystem 142 Swamp Mahogany**: This also applies to most of the stands of Paperbark/Swamp Mahogany/Swamp Oak swamp forest. This ecosystem is considered Rare and inadequately represented.

- **Ecosystem 96 Natural Grassland:** This may apply to the area of grassland east of Duchess Creek dominated by Bladey Grass and Bracken Fern. Considered rare and inadequately represented.

The dune scrub and wet sclerophyll does not fit into any recognised ecosystem.

4.3 FAUNA HABITATS

4.3.1 Aquatic Habitat

4.3.1.1 Proposed Wetland and Filling Area

Aquatic habitat was chiefly present on the site in terms of two small dams. Potential aquatic habitat also occurred after overnight rain created shallow ephemeral water on the flats of the pasture/pastoral woodland and in minor grassed drains within this area.

(a) Stock Dams:

The small stock dams on site are about 6m x 10m and 15m x 10m and about 1-1.5m deep, with some surrounding sedge vegetation. They offered general potential for frog habitat on its fringes amongst dense reed cover with relatively clear water. No aquatic fauna were detected in the northern dam and this dam is also noted to contain acidic water which may limit its habitability (Luke and Co. 2008). The western dam offers better potential with abundant aquatic vegetation around and in the dam, and was noted to contain abundant common frog species but also contained Plague Minnow (NSWSC 1999) which may deter usage of threatened species.

Neither of these dams was considered to offer any significant potential habitat for the Southern Myotis (*Myotis adversus*) though form a very small part of such habitat on the property. Numerous waterfowl were observed foraging on the fringes of these habitats including two species listed as migratory under the EPBCA 1999. These dams offer a minor area of potential foraging habitat for the Jabiru and Brolga as part of the wider area of habitat on the property but were not considered suitable for Bitterns.

(b) Ephemeral habitats:

After overnight rain, low lying parts of the pasture/pastoral woodland (mainly in the west and especially the southwest) held shallow pools of ephemeral water mostly in shallow grassed drains, former golf bunkers, etc, which also provided at best marginal potential frog habitat due to limited groundcover. Due to grazing, periodic slashing and the ephemeral nature of these habitats, potential to support any significant frogs is considered minimal at best. At most these areas again may be used during very wet years by non-breeding Jabiru and EPBCA 1999 listed migratory waterfowl as part of the wider area of habitat on the property and in the locality.

4.3.1.2 Remainder of the Property

Aquatic habitat was present on the remainder of the property as:

- Duchess Gully
- Two large dams/lagoons

- Extensive drains.
- Depression wetland
- Swamp forest.
- Eastern drainage line.

(a) Duchess Gully:

Duchess Gully ranges from freshwater to brackish within the property. The majority is considered freshwater with depth ranging from ephemeral in the northern end, to about 1m deep in the southern end where it becomes more brackish (as indicated by estuarine fish such as Long-Finned Eels). The creek is generally about 2m wide throughout its length, and mostly heavily vegetated with limited open water. Water quality appears good with tannin staining but minimal suspended clay, becoming very dark tannin stained in the brackish area.

The mid to upper reaches are considered the best potential frog habitat, however no threatened species which uses creeks or similar watercourses (eg *Mixophyes* frogs) are considered likely occurrences due to unsuitable watercourse type/structure, disturbance history and lack of/limited suitable riparian vegetation.

The majority of the freshwater section of the creek has limited potential for the Southern Myotis due to the dense vegetation especially Cumbungi impeding access, or lack of water at most times. The downstream sections are increasingly open and the species is known to use brackish habitats (Mr Ray Williams, Ecotone Consultants, pers. comm.), and overall the remainder of Duchess Gully is considered good potential habitat.

Various waterfowl may use the differing sections of the creek, including migratory species eg egrets, and there is some minor potential for bitterns to use the brackish sections of the creek, especially downstream off site where it widens considerably.

(b) Large Dams/Lagoons:

Two relatively large dams/lagoons occur south of the proposed development envelope as a relict of earlier development proposals (Cardno 2008). The largest in the east is about 300m long and 50m wide, and possibly at least 2m deep as suggested by lack of aquatic vegetation in the open water. The smaller lagoon to the west is about 40m x 40m and around 1-1.5m deep with a central island. These lagoons are considered be good freshwater environments with no evidence of stratification and have good water quality (Cardno 2008).

These lagoons were observed at times to support a relative abundance of waterfowl including ducks, moorhens, swans, cormorants and even pelicans. The latter species were observed feeding in these lagoons and also the northern dam. Cardno (2008) have recorded a range of freshwater and estuarine fish present which offer a food source. The presence of fish including Mullet indicate the lagoons could potentially be used for foraging by the Osprey (V-TSCA). The White-Breasted Sea-Eagle (Migratory-EPBCA) has also been recorded foraging over these lagoons (Clancy and Ayres 1983). The large lagoon was considered marginally suitable for the Blue-Billed Duck (Vulnerable-TSCA 1995) given the species' reported preference for open water habitats (NPWS 1999, DECC 2008b, Smith *et al* 1995, Marchant and Higgins 1990).

The dense fringe of sedges and grasses also provides ideal foraging habitat for egrets listed as migratory species eg Great Egret. The limited cover may however not be suitable for bitterns, and limited width of the littoral zone and steep banks may be insufficient or unsuitable for the Jabiru.

While some common frogs have been recorded breeding in the edges of this lagoon by the consultant, the potential for threatened species such as the Green and Golden Bell Frog and Wallum Sedge Frog is considered very limited due to lack of cover in the open water, limited emergent vegetation and high

risk of predation by numerous waterbirds occupying the habitat. Additionally, as these are artificial habitats created in an area where potential habitat was not pre-existing, the species would have to migrate from known habitat (which does not occur within range – Atlas of Wildlife 2008, Bionet 2008, pers. knowledge). Plague Minnow (KTP – TSCA, EPBCA) were also observed in these lagoons further limiting occurrence potential.

The open water of these lagoons however is structurally ideal foraging structure for the Southern Myotis (Churchill 1998, Mr Ray Williams Ecotone Ecological Consultants pers. comm.).

(c) Major Drains:

Several major drains occur on the property. Three main drains (with branches) drain the drainage depression and central pasture on the plain in the north, and another major drain runs through the middle of a drainage line runs east-southeast to the western main lagoon. Another sizeable drain connects to this latter drain from the south-southwest, and this is turn connected to another drain which runs east terminating in the lower southeast corner adjacent to the northern limits of Bonny Hills. These drains were typically 1-5m wide and 0.2-1.5m deep. Most had a muddy floor disturbed by cattle but others had either a sparse to dense cover of aquatic plants, sedges, and/or grasses. The most vegetated drain was the one mapped as a linear patch of Paperbark/Swamp Mahogany/Black Oak Swamp Forest spurring of the mid-west remnants.

Small areas of standing water were present in most of these drains prior to the rainfall after the 2006 survey, though most of these drains have been observed to carry water throughout the majority of their length in 2003. Water quality varied with cattle access, with drains subject to grazing or crossing having muddy water, and less disturbed ones being tannin stained only. A rust-brown layer of sediment covered the substrate in the northern drains indicating iron flocculate.

Most of these drains offer habitat only for common frogs and egrets, and are not considered likely to be used by any threatened waterfowl due to insufficient size or steep banks. None were ideally suitable for the Southern Myotis either for various reasons.

The exception to the above was the heavily vegetated south-southwest drain in the southwest of the property. The southern end of this drain falls into a localised area of dense shrubs which prevented access of cattle. This area thus contained a protected area of habitat and was noted to support a small population of Wallum Froglets (V-TSCA) in 2003.

(d) Depression/artificial wetland:

The artificial wetland community formed in the depression adjacent north of the large eastern lagoon appears likely to have been formed as part of excavation works for the abandoned sports complex as its position and shape do not fit into the geomorphological processes known to have shaped the property's topography (Luke and Co 2008, Cardno 2008).

In 2003, this community contained water up to 25cm deep amongst very dense vegetation comprising a mix of sedges, grasses and woody heath plants. A population of over 50 Wallum Froglets was recorded calling at this time. In subsequent drier years which has seen this area become so dry one could drive over it without leaving muddy tracks, this area has been slashed on more than one occasion, and in 2006, the Wallum Froglet was considered potentially extinct as cover was reduced to sparse sedges amongst the litter and the area was completely dry. However, following sufficient rain, water again pooled in this area and the species was recorded albeit in reduced abundance. This area was subsequently fenced off and allowed to revegetate to its current state (see photo 13), and was observed to contain surface water over most of its extent in July 2008, and supporting an abundance of *Crinia signifera*. Due to lack of other suitable habitat (the adjacent lagoons are considered structurally unsuitable) in close proximity, this habitat is thus considered critical to the survival of this localised population.

This habitat is suitable for foraging by wading birds (which poses a significant threat to the long term viability of the Wallum Froglets when cover is reduced), ducks and other common frogs, and may be marginally suitable for the Southern Myotis eg foraging on insects over the water.

(e) Swamp Forest:

Swamp forest on the property is present as a number of remnant stands. Of these, only the central and western remnant may support some surface water in depressions and drains, especially the southern end of the western remnant which stretches over a natural drainage line and an artificial drain. These areas provide some potential for frogs (marginal at best for threatened species) but minimal if any potential for other species including the bitterns due to their small size, lack of open water or dense vegetation.

(f) Eastern Drainage Line:

In 2003, the minor drainage line east of Duchess Gully on the sandplain covered by native grassland contained very clear water with Sphagnum moss and other mosses densely lining it, as well as dense sedges on the edges and within. This habitat was significantly drier in 2006 and 2008, however still offers excellent potential habitat for frogs such as the Wallum Froglet, though this species has not been detected in this area as yet despite repeated survey (its absence may be due to isolation from flooding). It also offered some minor foraging potential for wading birds (ie egrets) but not for bitterns or the Southern Myotis due to lack of shelter, dense groundcover or sufficient foraging structure.

4.3.2 Terrestrial Habitat (Logs, Undergrowth, Rocks, etc)

4.3.2.1 Proposed Wetland and Filling Area

(a) **Logs:**

Absent.

(b) **Rocks, Caves, etc:**

There were no ledges, caves, cliffs or other rock formations on the study site.

(c) Groundcover:

The majority of the proposed wetland and filling area contained poorly developed groundcover due to slashing and grazing, and it did not provide significant potential habitat for rodents, frogs, etc, or for small macropods. At most it offered minor habitat for common birds, macropods, etc, typical of agricultural woodland landscapes (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).

(d) **Leaf litter and Soil:**

Leaf litter was poorly developed throughout the majority of the site due to slashing and grazing, as well as lack of forest and hence was not considered to be of any significance.

The soils were easily dug and considered suitable for digging however poor drainage would preclude burrowing.

(e) **Undergrowth:**

Absent.

4.3.2.2 Remainder of Property

(a) **Logs:**

The pastoral woodland contained a low number of logs which have been predominantly produced via natural windfall. These logs are almost exclusively from Forest Red Gums and were typically small (5-20cm), however three larger logs (90cm) were also present. These contained small hollows and/or were moderately rotted. This substrate was considered to provide potential shelter for a range of predominantly small terrestrial fauna (eg reptiles and rodents) as well as foraging substrate for invertebrate prey. However, due to their location in an agricultural landscape and isolation from intact habitat, their use by any significant fauna was considered unlikely (Austeco Pty Ltd 1994, Gibbons and Lindenmayer 2002).

Logs were observed in the southeastern extent of the Dry Sclerophyll Forest. These logs had varying levels of decay and reasonable amounts of debris piled up against them. Decaying branches and logs are likely to provide good habitat for fungi and invertebrates, and are potential foraging substrates and refuges for frogs, reptiles, birds and small terrestrial mammals (Austeco Pty Ltd 1994). Hollow potential was high with many of the larger logs and branches containing deep hollows providing potential habitat for small to medium ground dwelling mammals, frogs and reptiles (Gibbons and Lindenmayer 2002).

(b) **Rocks, Caves, etc:**

There were no significant ledges, caves or cliffs on the property.

A small number of rocks were present in the drains where they had been used to line culverts. Cement block have also been used. These offered a minor potential basking spot for reptiles and shelter for reptiles and invertebrates with limited crevices (pers. obs).

(c) **Groundcover:**

Groundcover vegetation is generally kept low throughout most of the property and in these areas generally did not provide significant potential habitat for rodents, etc, or for small macropods (see photos). Most of the pasture/pastoral woodland is regularly slashed and grazed by cattle and retains little potential shelter for fauna.

The easternmost portion of the Swamp Oak swamp forest contained a dense to patchy ground layer of saw-sedge which offered excellent cover for a range of fauna species, with runways noted. The seeds of this species also offered a food source to granivores (Austeco Pty Ltd 1994, Smith *et al* 1995, Strahan 2000). This area was however isolated from other habitats with dense groundcover, though tentative linkage to the native grasslands and Blackbutt dry sclerophyll forest is provided by the riparian vegetation along Duchess Gully. This habitat is considered in broad terms to be potentially suitable for the Common Planigale (*Planigale maculata*), though its relative isolation and disturbance history significantly reduces potential for this species to occur.

Similar highly suitable groundcover occurred in the dry sclerophyll forest east of Duchess Gully where dense ferns, sedges (*Restio tetraphyllus*) and saw sedge occurred and extended partially into the dune scrub. Again numerous runways were observed in this area. This habitat is considered potentially suitable for the Common Planigale (*Planigale maculata*) and Eastern Chestnut Mouse (*Pseudomys gracilicaudatus*). This area is interconnected to the south and east via dune scrub and dry sclerophyll forest, and also to native grassland, hence offers better potential to support these species (Smith *et al* 1995, Strahan 2000, Luo *et al* 1994, Luo and Fox 1995, 1994). The dry sclerophyll forest on the adjacent west of Duchess Gully contained less dense groundcover consisting of ferns and Wiry Panic, offering limited refuge but is interconnected to swamp forest to the south.

The native grassland on the sandplain east of Duchess Gully offered a substantial area of open to closed cover for small terrestrial species. The densest cover consisting of *Restio tetraphyllus* and saw sedge occurred along the minor drainage line. This habitat was considered potentially suitable for the Common Planigale and was found to support the Eastern Chestnut Mouse in 2003 (Smith *et al* 1995, Strahan 2000, Luo *et al* 1994, Luo and Fox 1995, 1994). This area has not been slashed in at least 5-6yrs (pers. obs.) and is connected to the Duchess Creek riparian zone, dune scrub and littoral rainforest.

A similar size area of dense Bladey Grass occurs in the dry sclerophyll forest on the mid-west boundary, which seems to be slashed infrequently or only partially. This dense sward of vegetation adjoins a drain which has a very dense cover of sedges and grasses, as well as a very well developed shrub layer, and in total this area offers excellent habitat for the Common Planigale and Eastern Chestnut Mouse (Smith *et al* 1995, Strahan 2000, Luo *et al* 1994, Luo and Fox 1995, 1994). However, this habitat is relatively isolated from other proximate habitat with tentative connectivity to swamp forest with dense groundcover to the north, and to the central remnant when the pasture/pastoral woodland is allowed to regrow in wetter years.

(d) **Leaf litter and Soil:**

Leaf litter provides potential habitat for fungi and invertebrates, as well as potential shelter and forage for small vertebrates, particularly reptiles (Austeco Pty Ltd 1994, Smith *et al* 1995).

On the property, leaf litter was present throughout the forested areas, particularly in the Swamp Oak and southeastern area of the dry sclerophyll forest community where it was sometimes the dominant ground cover. Generally the litter was up to 5cm deep and did not appear too have not been recently burnt. This litter should be suitable for fossicking by small to medium-sized fossorial species such as bandicoots (eg *Perameles nasuta*), but the lack of connectivity to other areas and high risk of foxes being present are considered likely to preclude the threatened Long-Nosed Potoroo (*Potorous tridactylus*). Small diggings were commonly observed in the southern part of the Swamp Oak community by previous surveys (Darkheart 2006). Diggings were also frequently encountered along the fringe of the southeastern area of the Paperbark/Swamp Mahogany/Swamp Oak swamp forest.

(e) **Undergrowth:**

Throughout most of the forested areas, undergrowth was absent or present only as a sparse cover of shrubs and Lantana. Some small areas of dense low cover were present at the forest edges, particularly along the road verges. This offered a small area of potential shelter for passerine birds, but was considered to have little value for medium-sized terrestrial fauna.

The areas where undergrowth was best developed was in the southeast in the dry sclerophyll forest, swamp forest and dune scrub. These areas contained sections of well developed undergrowth containing native shrubs, grass trees and exotic species such as Lantana. Lantana was a common occurrence at times forming a dense, impenetrable thicket in the swamp forest in particular. The often dense entanglements this weed forms can provide habitat in the form of cover for threatened species (eg Common Planigale and Green-Thighed Frog), and its berries are also edible and eaten in some situations by threatened frugivorous birds such as the Rose Crowned Fruit Dove (Recher *et al* 1995).

4.3.3 Understorey Habitat

4.3.3.1 Allocasuarinas

Proposed Wetland/Filling Area:

Absent

Remainder of Property:

Forest Oak and Black Oak was present in some of the southeastern and western dry sclerophyll forest communities. It occurred as a shrub to small understorey tree.

Swamp Oak is the dominant *Casuarina* species on the property and has been reported to be used by the Glossy Black Cockatoo (Higgins 1990) though the consultants have never recorded any usage in 12yrs of survey. Clout (1989) suggests the cones of this and similar species are likely to be at best sub-optimal due to their small size which imposes difficulty in handling and seed extraction, and foraging efficiency.

Overall the low quality and limited abundance of preferred food species on the property suggested it would at most be marginal foraging habitat on the fringe of more optimal and known habitat in the nearby Queens Lake State Conservation Area (Darkheart 2006h) and around Bonny Hills (Darkheart 2004q).

4.3.3.2 Wattles

Proposed Wetland/Filling Area:

Absent.

Remainder of Property:

Wattles occurred on the property predominantly on the fringe of the southeast dry sclerophyll forest but also occurred in the wet Sclerophyll, Paperbark/Swamp Mahogany/Swamp Oak swamp forest and dune scrub communities.

Some wattles may offer potential foraging resources of gum for gliders such as Sugar Glider (*Petaurus breviceps*) and Squirrel Glider (Smith and Murray 2003, Von Chrismar 2004), and all offer a potential insect attractant for bats and passerine birds, the latter which in turn form prey for the threatened Square-Tailed Kite (Smith *et al* 1995). The wattles particularly on the fringes of the dry sclerophyll forest were considered to offer a good potential foraging resource for the species discussed above.

4.3.3.3 Melaleucas and Banksia

Proposed Wetland/Filling Area:

A solitary Coastal Banksia (*Banksia integrifolia*) occurred on the site in the pasture. This poorly formed tree offered at most a minute foraging resource for cosmopolitan nectivorous birds as part of their wider range.

Remainder of Property:

Paperbarks (predominantly Broad Leaved Melaleuca) occurred at variable densities (from uncommon to co-dominant) in the limited forested southeastern and western sections of the property, and was a co-dominant in sections of the Paperbark/Swamp Mahogany/Swamp Oak swamp forest. It occurred primarily as an immature canopy/understorey tree. Narrow-Leaved Paperbark (*Melaleuca linariifolia*) also occurred in the Paperbark/Swamp Mahogany/Swamp Oak, though it was uncommon.

Banksias were common in the eastern section of the Blackbutt dry sclerophyll forest where Swamp Banksia (*Banksia robur*), *Banksia serrata* and Old Man/Coastal Banksia all occurred. White Banksia also occurred in the riparian vegetation of Duchess Creek and as young trees in the dune scrub.

These species provide a potential flow of nectar and pollen (which may be utilised by a variety of threatened fauna including the Squirrel Glider, Eastern Blossom Bat, Grey Headed Flying Fox, Eastern

Pygmy Possum, etc) as detailed in table 3, and associated abundances of insects and birds during flowering periods. The papery bark of Broad-Leaved Melaleucas also provides excellent substrate for invertebrates, thus providing a potential prey sources for birds, arboreal mammals and some reptiles.

4.3.4 Arboreal Habitat

4.3.4.1 Hollows

Tree hollows occurred only in the pastoral woodland and dry sclerophyll forest, and the southeastern Paperbark/Swamp Mahogany/Swamp Oak swamp forest.

(i) Pastoral Woodland:

In the pastoral woodland, hollows predominantly occurred in Forest Red Gums. Well over 20 hollow-bearing trees (actual observable cavities) and potential hollow-bearing trees (upturned notches, etc which may contain hollows or develop into hollows) were noted throughout this community, with opening aperture diameter ranging from 5-30cm. One hollow was observed being utilised by a pair of Galahs, and numerous Rainbow Lorikeets were also noted, but no indications of arboreal mammal use such as scratch marks were observed. Lorikeets and rosellas have been observed nesting in these trees, and exotic species such as Starlings and Indian Mynas are also likely to nest here (pers. obs).

A vertical pipe observed in a large stag may be suitable for access by Glossy Black Cockatoo (*Calyptorhynchus lathami*), but the internal dimensions of the hollow were considered unlikely to be sufficient for this bird to utilise the hollow for nesting (Cameron 2006, Birds Australia 2008).

None of the hollows appeared to be occupied by feral Honey Bees, however utilisation of these tree hollows by arboreal mammals is likely to be very limited due to the isolation of the trees from similar habitat on the property (Gibbons and Lindenmayer 2002). The failure to detect any of these species in the pastoral woodland during the 2006 survey also indicates a low potential occurrence of the species.

These hollows overall offer potential mostly to common agricultural woodland species of birds, though some threatened Microchiropteran bats have been recorded in isolated trees (Law *et al* 2000, Gibbons and Lindenmayer 2002) and the Masked and Barking Owls have been recorded using such trees for nest sites (Gibbons and Lindenmayer 2002, Dr Stephen Phillips pers. comm., Birds Australia 2008). Arboreal mammals and reptiles are considered unlikely to use these hollows due to lack of other habitat (eg understorey) and effective isolation from other arboreal habitat by open pasture.

(ii) Dry Sclerophyll Forest:

Hollow-bearing trees were also observed in the southeast dry sclerophyll forest most commonly in Needlebark Stringybark. Hollows were estimated to range in diameter between 10-25cm, with a few trees having small hollows with apertures <5cm. Several larger hollows were also observed in this community; however these are infested by feral honey bees.

The patch of dry sclerophyll in the head of the northern corridor contained 6 mature trees which contained hollows with entrances 5-10cm diameter. One of the six trees also contained a vertical pipe 15-20cm diameter. Other small hollows may also be present but were not visible from below due to the upward angle of stub branches. Several hollows appeared to have been utilised by fauna as indicated by wear marks around the entrances and such trees were noted to be well scratched. None of the hollows appeared to be occupied by feral Honey Bees. The entrance to the vertical pipe may be suitable for access by Glossy Black Cockatoo (*Calyptorhynchus lathami*), but the internal dimensions of the hollow were considered unlikely to be sufficient for this bird to utilise the hollow for nesting. This habitat is directly connected to the Swamp Oak swamp forest where this habitat component is absent.

The western patches of dry sclerophyll forest contained a similar abundance and types of hollows to the above community, mostly in large senescent Forest Red Gums.

The isolated patch of dry sclerophyll forest in the mid-north contains the most hollows; most of which are small to medium in opening aperture and occurred in paperbarks and gums. These were noted to be dominated by Galahs, Eastern Rosellas and Lorikeets.

In general these hollows provided good potential roost/nest habitat for Antechinus, possums, gliders (eg Sugar Glider, Squirrel Glider, Yellow-Bellied Glider), other mammals (eg Brushtail Phascogale) and Microchiropteran bats (Gibbons and Lindenmayer 2002, Debus 1993,1995, NPWS 1999, DECC 2008b, Churchill 1998). However, apart from the southeast dry sclerophyll, most of these hollows occur in isolated or limited extent arboreal habitats hence usage is most likely to be by birds and bats (Gibbons and Lindenmayer 2002, Law *et al* 2000).

(iii) Swamp Forest:

A few small hollows occur in the far southwestern remnant, offering potential roost sites perhaps for Microchiropteran bats and small birds (Gibbons and Lindenmayer 2002). As for most of the hollows on the property however, these key habitat components occur in isolated pockets away from main bodies of arboreal habitat hence only very mobile species such as birds and bats are likely to make any substantial use of them.

4.3.4.2 Raptor Roosts

Diurnal and nocturnal raptors utilise large emergent trees as perches, roosts and nest sites (Birds Australia 2008, DECC 2008b, Smith *et al* 1995, Debus 1993, 1995).

The various scattered trees in the pastoral woodland over property provided an excellent vantage point for diurnal raptors as demonstrated by the resident Whistling Kite. These could also be used by hunting owls.

Two emergent stags were present in the dry sclerophyll forest and in the southern area of the Swamp Oak swamp forest community in the northwest corridor. These were both potential perches for raptors. The senescent trees in the western dry sclerophyll forest, western and southern Paperbark/Swamp Mahogany/Swamp Oak swamp forest also offered vantage points.

Potential diurnal roosts sites for owls were limited to the denser dry sclerophyll forest along Duchess Creek adjacent to the site as other areas were considered too open or exposed.

4.3.4.3 Pollen and Nectar Sources

The following table lists the main flowering periods of potential nectar/pollen sources on the property.

Table 3: Main flowering periods of pollen and nectar sources
(Beadle 1982, pers. obs):

TREE SPECIES	FLOWERING PERIOD	COMMUNITY	FREQUENCY
Corymbia intermedia	Summer-early Autumn	Dry sclerophyll, Paperbark/Swamp Mahogany/Swamp Oak swamp forest	Uncommon (limited area)
C. citriodora	Winter	Pasture, nursery escapees	Uncommon
Eucalyptus robusta	Winter-Spring (sometimes Autumn)	Dry sclerophyll, Paperbark/Swamp Mahogany/Swamp Oak swamp forest, pastoral woodland	Common in specific area
E. saligna	Winter-Spring	Wet sclerophyll	Uncommon

E. tereticornis	Winter-Spring	Pastoral woodland, dry sclerophyll, Paperbark/Swamp Mahogany/Swamp Oak swamp forest	Dominant in specific area, uncommon
E. pilularis	Summer (sometimes Winter)	Dry sclerophyll	Dominant in specific area
E. planchoniana	Summer	Dry sclerophyll	Common in specific area
E. microcorys	Winter-early Summer	Dry sclerophyll	Uncommon
E. propinqua	Summer-Autumn	Dry sclerophyll	Uncommon to common in specific area
E. siderophloia	Winter-Spring	Dry sclerophyll	Uncommon to common in specific area
Lophostemon confertus	Summer	Wet sclerophyll	Occasional in specific area
Melaleuca quinquenervia	Autumn to Winter (sometimes mid-Summer)	Dry sclerophyll, Paperbark/Swamp Mahogany/Swamp Oak swamp forest, Swamp Oak, pastoral woodland	Common in specific area
M. linariifolia	Spring-Summer	Paperbark/Swamp Mahogany/Swamp Oak swamp forest	Uncommon
Lophostemon confertus	Summer	Dry sclerophyll	Uncommon to common in specific area
Callistemon pachyphyllus	Spring-Autumn	Paperbark/Swamp Mahogany/Swamp Oak swamp forest	Uncommon
Banksia integrifolia	Year round (mostly Winter)	Pasture, dry sclerophyll, Wet Sclerophyll, dune scrub	Uncommon-Common in specific areas
Banksia serrata	Summer	Dry sclerophyll	Uncommon
Banksia robur	Late Summer	Dry sclerophyll (localised)	Uncommon

Winter flowering species are particularly critical for arboreals, due to the shortage of other food resources in this period (Eby 2002, 2000a, Menkhorst *et al* 1999, Quinn 1995, Olivier 2000, Smith *et al* 1995, Smith and Murray 2003, etc). As shown in the table above, the property overall contains a range of flowering species which collectively flower at some time in the year. Most important of these are six of the canopy tree species in some areas of the dry sclerophyll forest which flower in Winter and/or Spring; Forest Red Gum in the pastoral woodland and western dry sclerophyll forest; and the Swamp Mahogany and Broad-Leaved Paperbark in the swamp forest areas.

Collectively these species offer a diverse range of opportunities for nectarivores, however this may not be a reliable year-round resource due to variations in flowering resulting from climatic factors (Law *et al* 2000). Furthermore these resources are arranged over the property in a manner that only the most mobile species such as bats and birds may be able to utilise this resource over the entire property. For more restricted species, the mosaic of dry sclerophyll and swamp forest around the STP in the southeast is likely to be most productive and useful area, and hence the greatest potential value to arboreal mammals such as the Squirrel Glider which has often been by recorded by Biolink in this area (Biolink 2003) and in a similar species/community mix in the North Coast Bioregion (eg Berrigan 2002c, Darkheart 2004l, 2006i, Berrigan 2000a, 2000b, 2000c, Smith and Murray 2003, etc).

The Winter-Spring flowering Swamp Mahogany and Forest Red Gum are considered a particularly significant preferred food resource for several threatened species including the Squirrel Glider, Grey-Headed Flying Fox, Swift Parrot and Regent Honeyeater (Eby 2002, 2000a, Menkhorst *et al* 1999, Quinn 1995, Olivier 2000). These species are also noted to be locally common in the adjacent Queens Lake State Conservation Area (Darkheart 2006h), and Swamp Mahogany is also relatively common on private land to the southwest around Queens Lake (Darkheart 2004q, 2007c, pers. obs.).

Foraging resources of nectar and pollen below the canopy were limited by the poor development of the understorey, shrub and groundcover vegetation throughout the majority of the property. Banksias in the southeast are the most significant especially for Squirrel Gliders (Smith and Murray 2003, DECC 2008b).

4.3.4.4 Other Foraging Resources

(a) Sap:

Pink Bloodwood, Forest Red Gum, Red Mahogany, Tallowwood, Blackbutt, Flooded Gum and Grey Gum are potential sap sources for the Yellow-Bellied Glider (DIPNR 2004, Lindenmayer 2002, NPWS 1999, Smith *et al* 1995, NPWS 2003b, DECC 2008b). Squirrel Glider and the common Sugar Glider also tap eucalypts for sap (Smith and Murray 2004, DECC 2008b), with Grey Ironbark and Pink Bloodwood observed to be a very significant sap source at Crottys Lane, Kempsey (Berrigan 1999a), and Scribbly Gums and Pink Bloodwoods at South West Rocks (Berrigan 2000a, 2000b, 2000c, Darkheart 2004).

These species occur in the dry sclerophyll forest communities and pastoral woodland. However, in most of these areas, Squirrel Gliders are unable to access this resource due to isolation from proximate habitat (ie isolated remnants) and high predator exposure (eg pastoral woodland).

(b) Decorticating Bark:

Bark-shedding species on the property were limited to Broad-Leaved Melaleuca, Grey Gum, Blackbutt, Flooded Gum, Brushbox and Forest Red Gum. These may provide potential substrate for invertebrates and thus potential foraging substrate for a variety of mammals (eg Antechinuses, gliders and possums) and common birds (Braithwaite *et al* 1984, Goldingay 1991, Quinn 1995).

Again most of these species occur in isolated remnants which are unable to be used by arboreal mammals. This habitat component is likely to be most valued in the southeast dry sclerophyll forest.

(c) Edible Fruits, Seeds and Foliage Species:

Proposed Wetland/Filling Area:

Absent.

Remainder of Property:

Rainforest plant species which produce edible fruits are foraging resources used by a variety of birds including threatened pigeons such as the Wompoo Fruit-Dove (Recher *et al* 1995, Date *et al* 1994, Smith *et al* 1995, DECC 2008b, Birds Australia 2008).

The minute area of wet sclerophyll along Duchess Creek contained a very marginal potential fruiting resource in trees such as Lilly Pilly (*Acmena smithii*) and Guioa (*Guioa semiglauca*), as well as vines and climbers, (*Cissus antarctica, C. australis, *Lantana camara*) and shrubs (eg *Cordyline stricta*). However, this was only a minor resource due to the small area present and it was considered unlikely to provide a significant proportion of the requirements of locally occurring frugivorous such as rainforest pigeons. It could possibly (but rather unlikely) offer a minor 'stepping stone' habitat for any such transient fauna moving between areas of more suitable habitat such as the littoral rainforest to the east and northeast (Parker 2002, Biolink 2005c) which is known to be utilised seasonally by the Wompoo Fruit-Dove (Berrigan 2003h).

(d) Koala Browse Species:

Study Site and Property:

Swamp Mahogany, Tallowwood and Forest Red Gum were the only Primary Preferred Koala Food Species as listed in Schedule 2 of SEPP 44 on the property. Core Koala Habitat has been identified by Biolink to occur in the southeast corner of the property, and in the adjacent STP.

4.3.5 Bats

4.3.5.1 Megachiroptera (frugivores and nectarivores)

4.3.5.1.1 Foraging opportunities

The main threatened species considered likely to occur in the area is the Grey-Headed Flying Fox (*Pteropus poliocephalus*) which is listed as Vulnerable under the TSCA 1995 and EPBCA 1999. The Grey-Headed Flying Fox has been recorded in the locality and in close proximity to the site (Atlas of Wildlife 2008, Bionet 2008, Darkheart 2005a, 2005b, 2004q, 2006h, etc). It has been personally observed foraging on locally occurring species such as Tallowwood, Broad-Leaved Paperbarks and Bloodwood. The eucalypts, Broad-Leaved Paperbark, Coast Banksia, Saw Banksia, Brushbox and fruiting rainforest trees present on the property offer a potential foraging resource for the species, with Winter and Spring species being most significant during regional food shortages (Eby 2000a, 2000b, Tideman 2000, DECC 2008b) and these are relatively common over the limited extent of forest present. Overall the property offers a good area of potential year-round foraging habitat for this species with the consistency of flowering varying according to climatic factors (Laws *et al* 2000).

The Black Flying Fox (*P. alecto*) is extending its range, and has been recorded roosting with other Flying Fox species in Kooloonbung Creek Nature Reserve (Port Macquarie FAWNA pers. comm.). This species is listed as Vulnerable under the TSCA and also use the property as part of its expanding range (with individuals recorded as far south as Melbourne and regularly in Sydney).

Overall for both species, the property has potential as a seasonal foraging resource with the extent of its utilisation depending on the distance from roost camps and the abundance of similar resources locally.

The Eastern Blossom Bat (*Syconycteris australis*) is listed as Vulnerable under the TSCA. This bat has a preference for heath and swamp forest, but also forages on Myrtaceous species (Churchill 1998, Smith *et al* 1995, Law 1993). The eucalypts, Lilly Pilly, callistemon and melaleucas on the property thus provide some limited seasonal foraging potential. Given the limited extent of habitat on site and extent of more optimal habitat in nearby Lake Innes Nature Reserve, the site was considered to offer minimal potential to attract this species with the best habitat being the southeast dry sclerophyll forest and associated swamp forest around the STP.

4.3.5.1.2 Roosting opportunities

Grey-Headed Flying Foxes and the Black Flying Foxes tend to roost according to life cycle period and food availability (Eby 2000a, Churchill 1998, Eby 2002, Smith 2002, Palmer *et al* 2004). In poorer periods, the Grey-Headed Flying Fox may roost temporarily close to the food source, or range wide from a larger colonial roost (mainly within a 20km radius). In normal periods, they tend to aggregate in roosts with a long history of usage, and such areas are generally well known (eg a large Summer roost was noted west of Kendall in late 2005-2006). The characteristics that determine choice of roost site are unknown, though in NSW, most are located near water (rivers or creeks), with dominant vegetation being subtropical rainforest, wet sclerophyll forest, Melaleucas, Casuarinas or Mangroves (Eby 2000a, 2002, Tideman 2002). Colonial roosts of the Grey-Headed Flying Fox are known to occur locally at Dunbogan,

west of Kendall and in Port Macquarie (Eby 2002, pers. obs), and the Black Flying Fox is known to share roosts with this species (Tideman 2002, Eby 2002).

Queens Lake State Forest/Nature Reserve may also contain some potential roosting habitat at for a small number of individuals moving throughout their seasonal range. The Swamp Oak forest on the property may have (at best) marginal potential as a roost camp, but there does not appear to be any historical or landowner accounts to suggest that the property has ever been a colonial roost.

The Eastern Blossom Bat requires wet sclerophyll or rainforest, or melaleuca swamp forest with a rainforest understorey to roost within flying range (usually about 4km with a home range of about 5ha) of foraging areas (Richards 1991, DECC 2008b). Roost selection is highly specific, with preference for foliage of the sub-canopy and daily and seasonal changes of site (NPWS 1999, Richards 1991, Churchill 1998, Smith *et al* 1995, Law 1993, DECC 2008b).

The wet sclerophyll on the property contained some dense foliage, but only in a small area without structural diversity that would allow changes of roost site to reflect climatic/seasonal conditions. It was considered unlikely that the Eastern Blossom Bat would roost on the property other than as a rare vagrant. This species has been recorded roosting in the SEPP 26 Littoral Rainforest to the northeast of the property (Parker 2002), hence it considered likely to roost off-site.

4.3.5.2 Microchiroptera (insectivores)

4.3.5.2.1 Foraging opportunities

Due to the complex range of habitats, there is an associated range of potential foraging habitats and structures as follows:

(i) *Supra canopy zone*: The extent of relatively continuous canopy over larger areas of forest on the property at times contiguous with communities on adjacent land, is suitable for aerial intercept species flying over the canopy. Threatened species that could forage in this stratum are: Yellow-Bellied Sheathtail Bat (*Saccolaimus flaviventris*), Common Bent-Wing Bat (*Miniopterus schreibersii*), Little Bent-Wing Bat (*M. australis*) and Eastern Freetail Bat (*M. norfolkensis*) (Churchill 1998, pers. obs). These species have all been recorded in the LGA (Bionet 2008, DECC 2008a, Darkheart 2006a, 2006b, 2006c, 2006d, etc).

(ii) *Sub-canopy zone*: The open nature of the canopy and understorey in the dry sclerophyll forest, and most of the Paperbark/Swamp Mahogany/Swamp Oak swamp forest in the west, south and centre, and tracks under the canopy provide potential foraging habitat for more manoeuvrable species or those that prefer more open habitats eg Common Bent-Wing Bat, Little Bent-Wing Bat, Eastern Freetail Bat and Greater Broad-Nosed Bat (*Scoteanax rueppellii*) (Churchill 1998, pers. obs).

(iii) *Forest interface*: The scattered pockets of forest and linear strips offers extensive interface habitat between cleared land and forest. This provides suitable structure for species that forage on the interface between forest and open areas, or hovering/gleaning species, such as Eastern Freetail Bat, Greater Broad-Nosed Bat, Common Bent-Wing Bat, and Little Bent-Wing Bat.

(iv) *Dams, Lagoons, Drains and Creek*: As detailed previously, these habitats offer varying quality foraging habitat for the Southern Myotis (*Myotis adversus*) which has been recorded in the locality (DEC Atlas of Wildlife 2008, Bionet 2008, Darkheart 2004i). Other species may also forage over these waterbodies eg Greater Broad-Nosed Bat.

4.3.5.2.2 Roosting opportunities

There are no ruins/abandoned dwellings, caves, cliffs, or overhangs on or directly adjacent to the property, which precludes species depending on such resources to breed or roost in, unless they are known to forage widely from such habitat components, or utilise alternative roosts during non-breeding stages (and hence not depending on key maternity sites eg the Bent-Wing Bats). Some bats have been recorded in occupied dwellings (eg Eastern Freetail Bat), thus the buildings and sheds on the property offer some marginal potential as roosts. The nearest potential caves/crevices may be at Jolly Nose to the west or in headlands at Bonny Hills. Culverts on the property and under the adjacent Ocean Drive may offer marginal potential for roost sites.

Bark-shedding tree species provide potential roost sites for some Microchiropteran bats (Churchill 1998). Most of these species occurred in the small scattered remnants or in the pastoral woodland. The best potential for such roosting may occur in the southeast dry sclerophyll where Blackbutt occurs.

The most suitable and relatively abundant potential roosts are the tree hollows scattered over various communities on the property, but most abundant in the pastoral woodland. These offer a range of opportunities which could potentially include key seasonal or lifecycle roosts.

4.4 KEY THREATENING PROCESSES

The following NSW TSCA Key Threatening Processes operate in the general area (www.npws.nsw.gov.au accessed 7/7/08):

1. **Predation by the Feral Cat and European Red Fox**: Feral cats and foxes have been recorded in the locality (Berrigan 2001a, Berrigan 2001b, Darkheart 2004q, AMBS 2003). Large dog tracks have been previously recorded in the central swamp forest as well. These species compete with and prey on native fauna (NSWSC 2000a, 2000b, Dickman 1996, NPWS 2001), and are likely to occur at least periodically on the property.

2. **Clearing of native vegetation**: Previous logging, clearing and pastoralism of the property have significantly modified the property's vegetation associations ie virtually all forest is regrowth and extensive areas of former forest have been removed or modified. Urban and rural developments as well as agriculture have also lead to clearing of native vegetation in the general locality with substantial impacts on connectivity (NSWSC 2001d).

3. **Removal of dead wood, dead trees and logs**: This includes processes such as firewood collection, removal of forest/woodland logging wastes, on-site burning, mulching and "cleaning up" activities. This process threatens a range of hollow obligate species of invertebrates, microbial species and vertebrates, including the following threatened species which may occur in the locality: Regent Honeyeater, Pale Headed Snake, Stephens's Banded Snake, Red-Tailed Black Cockatoo, Glossy Black Cockatoo, Barking Owl, Powerful Owl, Masked Owl, Hoary Bat, Spotted-Tail Quoll, Yellow-Bellied Glider, Squirrel Glider and Brush-Tailed Phascogale (NSWSC 2004h). Firewood collecting potentially occurs on the property given proximate rural and residential development.

4. **Invasion of native plant communities by exotic perennial grasses**: A number of exotic perennial grasses invade native plant communities and compete or displace many native species, eg *Cenchrus ciliaris* (Buffel Grass) *Eragrostis curvula* (African Lovegrass), *Nassella trichotoma* (Serrated Tussock), *Phalaris aquatica* (Phalaris), *Andropogon virginicus* (Whisky Grass), *Chloris gayana* (Rhodes Grass), *Cortaderia* spp. (Pampas Grasses), *Ehrharta erecta* (Panic Veldgrass), *Melinis minutiflora* (Molasses Grass), *Panicum repens* (Torpedo Grass), *Paspalum urvillei* (Vasey Grass), *Pennisetum clandestinum* (Kikuyu), *Setaria sphacelata* (South African Pigeon Grass), *Sporobolus fertilis* (Giant Parramatta Grass), *etc* (NSWSC 2003a). Torpedo Grass dominates

virtually all of the low lying plains, and other grasses (eg Whisky Grass and Rhodes Grass) dominate the remainder of the pasture/pastoral woodland. These grasses are also common within most of the vegetation communities west of Duchess Gully.

5. **Infection of frogs by amphibian chytrid causing the disease chytridiomycosis**: This disease may occur in the locality and hence affect the viability and distribution of local frog populations (NSWSC 2002b).

6. **Competition from feral honeybees**: Feral bees compete with native fauna for hollows and pollen/nectar resources (NSWSC 2003b). Several hives were observed in the southeast dry sclerophyll which is detrimental given this habitat has the best potential for arboreal threatened species.

7. **Predation by the Plague Minnow (*Gambusia holbrooki*):** This species has been recorded preying upon the eggs and tadpoles of both common frog species and the threatened Green and Golden Bell Frog (*Litoria aurea*), and has also been linked to the decline of the New England Bell Frog (*L. castanea*), Southern Bell Frog (*L. raniformis)* and the Southern Tablelands Bell Frog (*Litoria spp*). Breeding of *L. aurea* is now almost restricted to water entities where the Plague Minnow is absent (NSW Scientific Committee 1999a). Plague Minnow were abundant in the large lagoons, the small western dam, and in Duchess Creek and associated drains where they posed a substantial limitation to frogs.

8. **High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition:** Fire appears to have been absent for a significant period from the property. The isolation of remnant habitats on the property places populations of small terrestrial species at significant risk of extinction if fire (or complete slashing) were to remove all of their habitat at once time eg the Bladey Grass grassland east of Duchess Gully and the shrub dominated drain and adjacent dry sclerophyll supports an isolated population of Common Planigale and Eastern Chestnut Mouse (Berrigan 20003h).

9. **Infection by Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species and populations:** This species may potentially occur in the locality and affect populations of psittacine species (NSWSC 2002c).

10. **Herbivory and environmental degradation caused by feral deer:** Stray deer are present in the locality and a dead stag had been recorded in the western side of the property. Numerous tracks have also been observed in the muddy drains in the west.

11. **Human-induced climate change:** This global process is occurring in the area from a variety of sources ie industrial, residential and agricultural (NSWSC 2000d).

12. **Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands:** This process (NSWSC 2002e) has occurred widely in the LGA as part of flood mitigation and pasture improvement practices. Drainage on the property has been significantly altered via a network of drains which now channel flow from drainage lines in the southwest to the main lagoons and to Duchess Gully, and reduce standing time. This is likely to have assisted vegetation shifts eg from sedgeland to pastoral land in the southwest, and hence contributed to degradation of EECs.

13. **Invasion and establishment of exotic vines and scramblers**: Exotic vines and scramblers may transform habitats by their tendency to: smother existing vegetation, suppress native flora, alter the fire regime, restrict fauna movement, alter rates of litter decomposition and compete for nutrients and water. Listed species present in the mid-north coast include: *Anredera cordifolia, Araujia sericifera, Asparagus sp., Cardiospermum grandiflorum, Ipomoea sp., Macfadyena*

unguis-cati, and *Passiflora sp.* A few of these species were present on the property but were in low abundance and hence did not constitute a substantial threat at this time to EECs.

14. **Invasion and establishment of the Cane Toad**: On the mid-north coast the Cane Toad is recorded at Lake Innes Nature Reserve and has potential to occur elsewhere. Cane Toads prey on native fauna and compete with native carnivores. They are toxic to some predators such as Quolls and their tadpoles can dominate water bodies. The Cane Toad has been recorded at Port Macquarie and has potential to occur in the area.

15. **Invasion of Native Plant Communities by *Chrysanthemoides monilifera***: Some minor infestations occur in the southeast dry sclerophyll and in the dune scrub. These could be easily removed to ensure they do not become a significant weed as they currently are in the adjacent STP.

16. **Invasion of native plant communities by *Lantana camara***: Lantana invades disturbed sites and communities (NSWSC 2005b). It suppresses less competitive native vegetation by shading, nutrient removal, smothering and allelopathy. It has been identified as a threat to a number of threatened species and endangered ecological communities. Lantana is a generally common species throughout most of the vegetation remnants especially in the southeast where it may dominate the edges of the forest.

17. **Loss of hollow-bearing trees**: The loss of hollow-bearing trees is listed as a key threatening process as, in the opinion of the Scientific Committee as (NSWSC 2007a):
    - It adversely affects threatened species, populations or ecological communities, and/or
    - Could cause species, populations or ecological communities that are not threatened to become threatened.

    This process will occur via natural attrition as the hollow-bearing Forest Red Gums in the pastoral woodland are declining. The proposed wetland and filling on the property, as well as future urban development (as per the Concept Plan Application) will also see the loss of all hollows in the pastoral woodland. Hollows will remain in the dry sclerophyll remnants.

4.5 HABITAT LINKS AND WILDLIFE CORRIDORS

4.5.1 Habitat Links and Corridors

Habitat links are evaluated in this report as links from habitat on the property directly to similar habitat on adjacent land. These would be used by fauna which depend solely or at least partially on the site/property for all of their lifecycle requirements, and/or dispersal. Wildlife corridors are the collection of habitat links that facilitate genetic flow and seasonal movements over a wider area supporting the local population (Fisher and Lindenmayer 2006).

While the following discussion is primarily on fauna, movement of plant genetic material is likely to be similarly patterned given animals are responsible for transfer of genetic materials (eg seeds, pollen, etc) for many plant species, and water may also be a major dispersal agent.

4.5.1.1 Proposed Wetland/Filling Area

With reference to figures 8 and 9, it is clear that the majority of the property and all of the proposed wetland/fill area is composed of pasture/pastoral woodland. This thus poses a substantial barrier to movement of species requiring canopy/understorey tree cover or dense shrub and/or ground vegetation will therefore be unable to traverse the site. Hence the site is only an interlink for large macropods, birds and bats and a barrier to other less mobile species.

4.5.1.2 Overall Property

(a) Links within/across the property:

As noted above, the majority of the property is pasture or being progressively modified into pasture. This has resulted in any remaining habitat links between the pockets of remnant habitat as being extremely tenuous, at best, for species dependant on dense groundcover or continuous forest. The only intra-property links are the fragmented vegetation along Duchess Creek, which links the southeast dry sclerophyll and swamp forest to the Swamp Oak swamp forest and northwest patch of dry sclerophyll; and the linear swamp forest regrowth along the main drain in the southwest, which links the central swamp forest regrowth to the western dry sclerophyll and swamp forest regrowth. Both links are considered very tenuous for arboreal mammals and small terrestrial fauna, due to lack of refugia (eg tree hollows, fallen logs, dense groundcover, etc), fragmentation, and high exposure to predators.

The major drainage line which dominates the south of the property supports substantial surface flows following heavy rainfall or local flooding from the west and southwest to the east to Duchess Gully. During substantial flow events, this would allow dispersal of frogs and other small mammals across the property, and also onto the property from upstream habitats.

(b) Links to habitat adjacent to the property:

(i) General:

Adjacent habitat to the east, southeast and marginally to the southwest is linked to habitat on the property. Such links may allow fauna to use habitat on the property and adjacent to meet their lifecycle needs and maintain genetic viability via dispersal, etc.

Other proximate remnants on adjacent land to the northwest and north are considered isolated from the property via pastoral land and Ocean Drive for all but flying species and large macropods.

(ii) Coastal Links:

The best coastal habitat link is the dune complex to the east which includes dune scrub on former sand mine areas to littoral rainforest. This link terminates to the north in Lake Cathie due to residential development, hence is not a significant link in this direction.

This link also runs south to Bonny Hills where it is extensively fragmented and thinned by residential and tourist development, and alters to low coastal scrub, before linking to dry sclerophyll forest south of Grants Head and west of Bonny Hills. An important linkage especially for Koalas also occurs through fragmented habitat along Beach St to a drainage line south of the Bonny Hills Tavern (Darkheart 2005a, 2005b).

Duchess Gully and associated vegetation around the STP also adjoins this link, with habitat around the southern end of Duchess Gully and the STP forming the most substantial body of vegetation in northeast Bonny Hills. Habitats include Blackbutt-dominated dry sclerophyll, paperbark swamp forest and dune scrub which provide a broad range of habitats for fauna including the Koala and Squirrel Glider (Biolink 2003).

Collectively both links and the cluster of habitat around the STP provide a range of habitats with sufficient means to provide for movement of a diverse range of species and hence contribute to the biodiversity of the property.

(iii) Northern Corridor:

The UIA 14 Structure Plan (Richards 2004) identifies Duchess Gully and the Swamp Oak swamp forest in the upper reaches of this watercourse as a northern corridor to be incorporated into future urban development. Ocean Drive however prevents this proposed corridor from being effective due to the physical and mortality barrier it poses, and there is no substantial link on currently vacant (but proposed for urban expansion) land on the other side of the road to connect the property's habitat to Lake Innes Nature Reserve.

As noted previously, the riparian vegetation along Duchess Gully is highly fragmented, and lacks key habitat components such as hollow-bearing trees or preferred food trees (eg Koala browse species). Hence this corridor is thus at best of limited value as anything more than linear habitat with associated high level of edge effects, etc which limit its long term effectiveness in its current state.

(iii) Southwest-East Corridor:

The UIA 14 Structure Plan (Richards 2004) identifies a substantial corridor running from the southwest of the property to the east, interlinking habitat to the southwest on adjacent rural land to the STP and adjoining habitat and the dune complex vegetation.

At present, this link is at best conceptual for most species as the majority of vegetation is merely pasture (periodically slashed) with scattered young/stunted trees. However, as demonstrated by the high component of native species, it has good potential to recover if slashing and grazing were to cease. With weed management and supplementary plantings required to accelerate recovery, this could form a good linkage for a range of species using swamp forest habitats eg Squirrel Gliders and Koalas, but may not be of use to species dependant on dry or wet sclerophyll forest. Again Ocean Drive is a physical barrier to the south, with only low culverts providing a potential safer access to adjoining habitat especially for frogs washed down during peak flow events.

The remnant swamp forest and dry sclerophyll on the western boundary is tentatively linked via woodland trees to the west of Ocean Drive (again a physical barrier though a major culvert under the road at this point may assist movement of some species). The drainage line continues west from the site to Queens Lake Conservation Area via the culvert under Ocean Drive, and is generally vegetated with sedges. This offers the best linkage to the west for frogs and perhaps rodents and reptiles.

Overall however, arboreal movement to the southwest and west is presently considered very limited.

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

4.5.2 DECC Wildlife Corridors and Key Habitats

4.5.2.1 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.

4.5.2.2 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.

4.5.2.3 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.

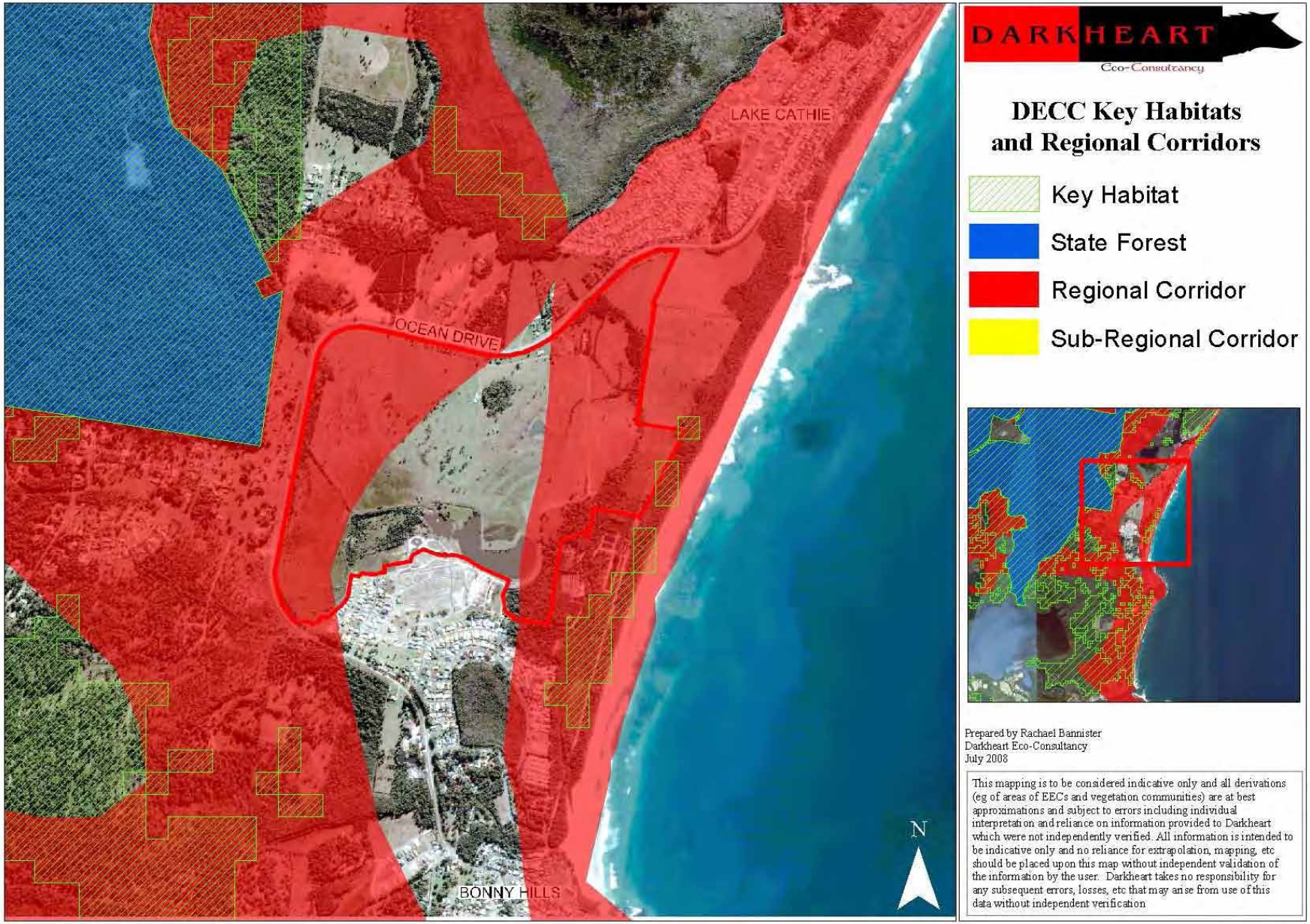
4.5.2.4 Local Corridors

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: DEC 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).

4.5.2.5 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 2008c, 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.

4.6 FAUNA SURVEY RESULTS

4.6.1 Trapping

4.6.1.1 Elliot B

4.6.1.1.1 2006

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

4.6.1.1.2 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.

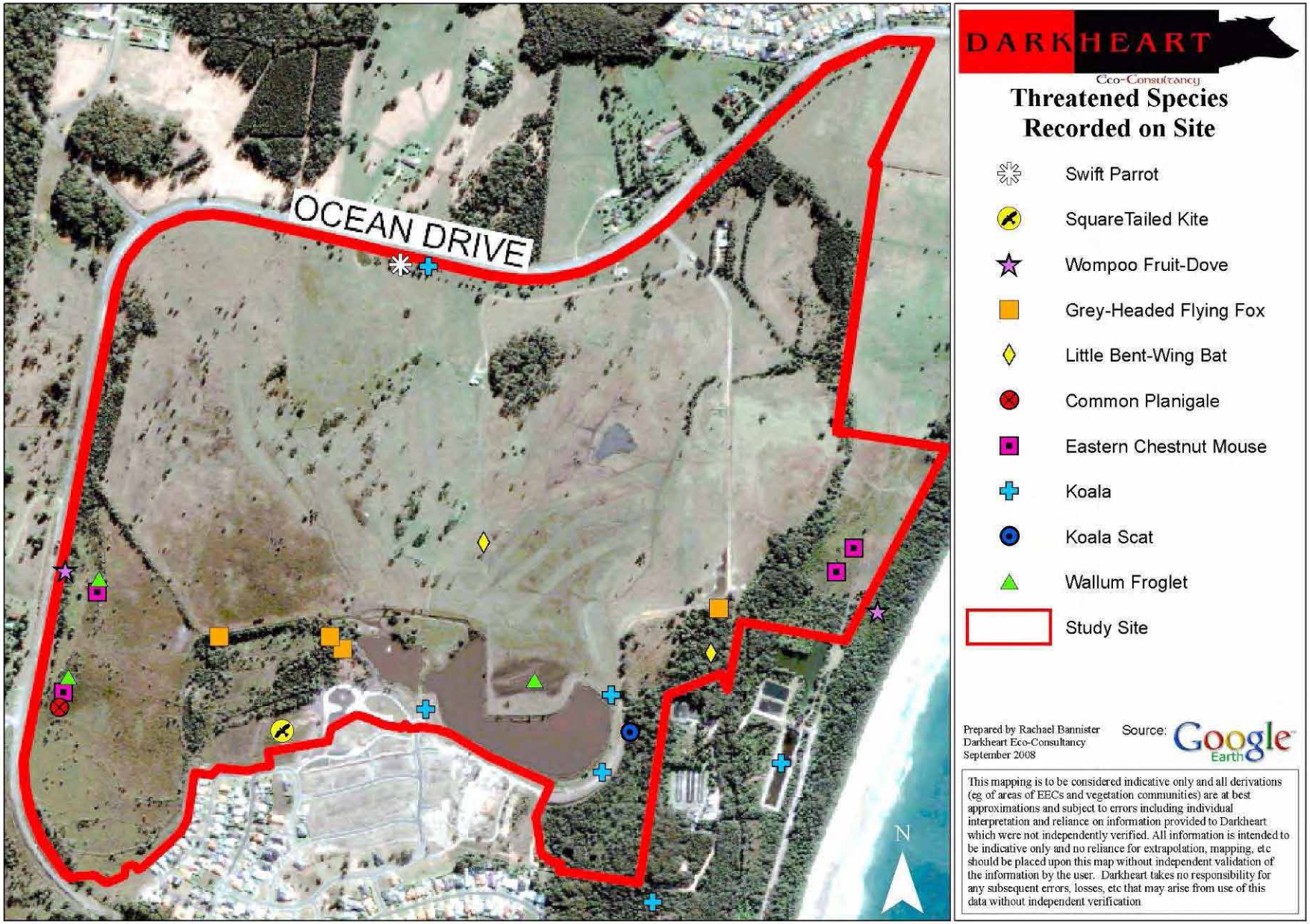
4.6.1.2 Elliot A

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.

4.6.1.3 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.

4.6.2 Spotlighting

4.6.2.1 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.

4.6.2.2 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.

4.6.3 Call Playback and Recording

4.6.3.1 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.

4.6.3.2 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.

4.6.3.3 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.

4.6.3.4 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*)

4.6.4 Secondary Evidence and Opportunistic Observation

4.6.4.1 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*).

4.6.4.2 Scats and tracks

4.6.4.2.1 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.

4.6.4.2.2 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 (NPWS 2003a). 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.

4.6.4.3 Feeding signs

4.6.4.3.1 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.

4.6.4.3.2 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).

4.6.4.3.3 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*).

4.6.4.3.4 Bones, etc

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

4.6.4.4 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

4.6.4.4.1 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).

4.4.4.4.2 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.

4.6.4.4.3 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*

4.7 DISCUSSION OF FAUNA SURVEY FINDINGS

4.7.1 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.

4.7.2 General

4.7.2.1 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.

4.7.2.2 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.

4.7.3 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.

4.7.3.1 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).

4.7.3.1.2 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 2008a, Bionet 2008).

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.

4.7.3.2 Eastern Chestnut Mouse

4.7.3.2.1 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).

4.7.3.2.2 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.

4.7.3.2.3 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 2008b, Bionet 2008, Darkheart 2004q, 2005a, 2005b, 2007c, Parker 2002, Berrigan and Bray 2002).

4.7.3.3 Common Planigale

4.7.3.3.1 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.

4.7.3.3.2 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.

4.7.3.3.3 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.

4.7.3.4 Little Bent-Wing Bat

4.7.3.4.1 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).

4.7.3.4.2 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.

4.7.3.5 Wallum Froglet

4.7.3.5.1 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).

4.7.3.5.2 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.

4.7.3.5.3 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 2008b), 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.

4.7.3.6 Wompoo Fruit-Dove

4.7.3.6.1 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.

4.7.3.6.2 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).

4.7.3.7 Swift Parrot

4.7.3.7.1 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).

4.7.3.7.2 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 2008a, 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.

4.7.3.8 Koala

4.7.3.8.1 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).

4.7.3.8.2 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 2008a, Bionet 2008, 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).

4.7.3.9 Grey-Headed Flying Fox

4.7.3.9.1 Ecological Profile

Refer to section 4.3.5.1

4.7.3.9.2 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).

4.7.4 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.

4.7.5 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.