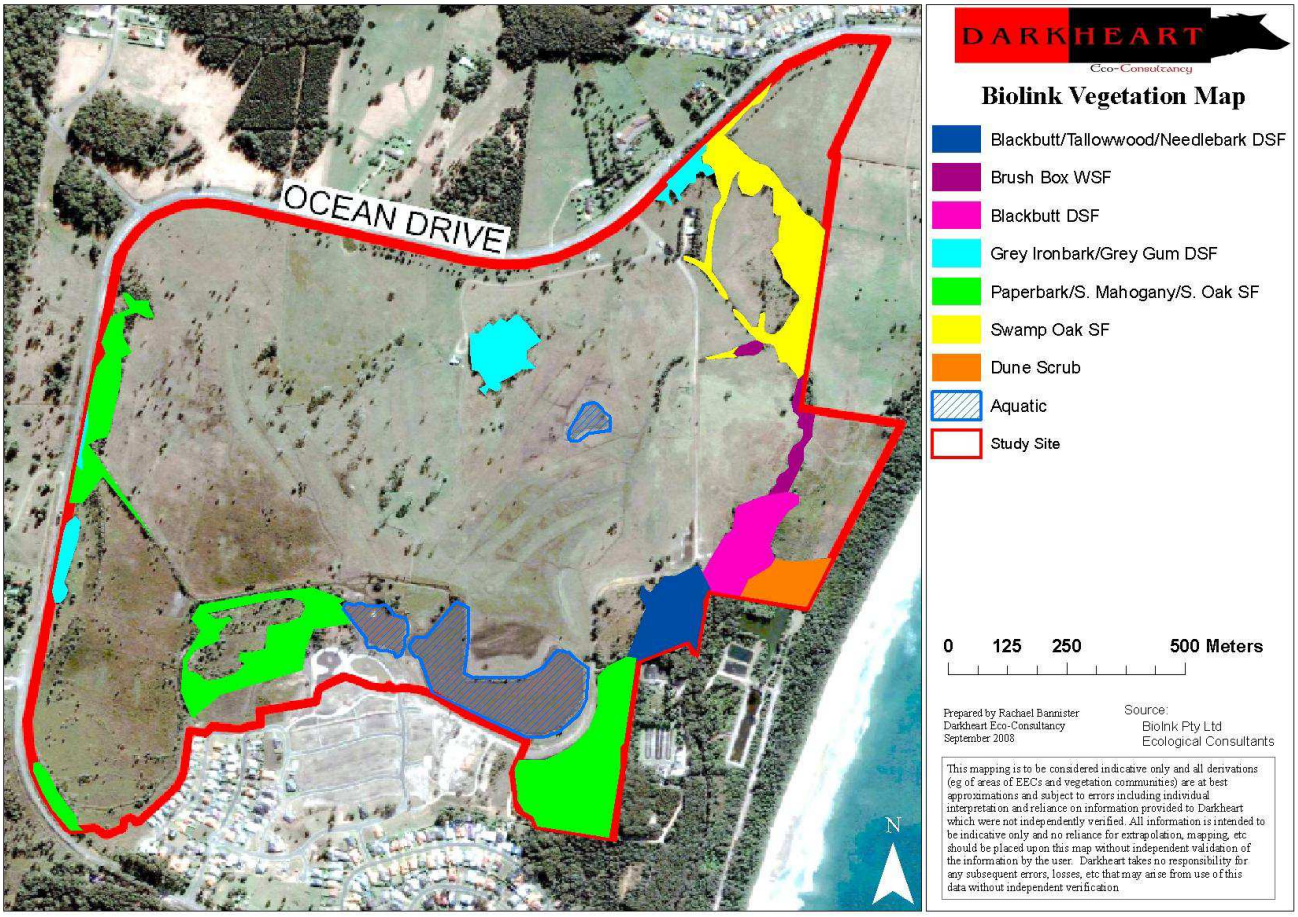
Figure 8: Biolink's vegetation map over aerial photo
(Source: Biolink 2005c)



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:

- 0.4ha in the northwestern end of the northwest corridor. This area also has about 0.15ha of nursery escapees.
- 1.4ha comprising the isolated remnant in the mid-north of the property.
- 0.1ha 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

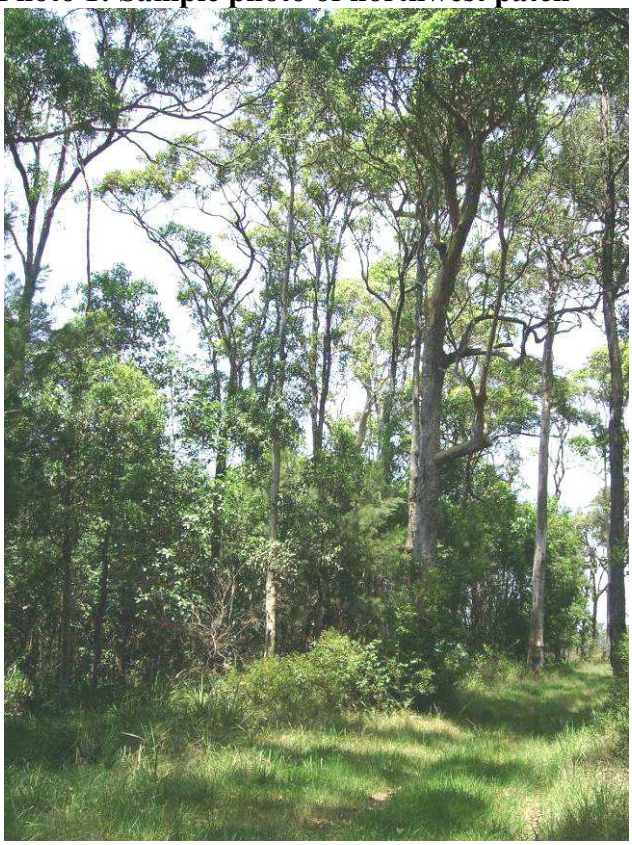


Photo 2: Sample photo of nursery escapees

2. *Mid-North Remnant*:

Distribution and Extent: The isolated community occurs adjacent to the central dwelling on the property and covers an area of 1.4ha. 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 0.6ha 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 over 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 10.4ha 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, totalling 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. Also 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). *Subtropical Floodplain Forest on Coastal Floodplain – Identification Guide*. NSW DECC. Available at http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.
- DECC (2008b). *River-Flat Eucalypt Forest on Coastal Floodplain – Identification Guide*. NSW DECC. Available at http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.
- *Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209*
- 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 (2008). Letter to the President of the NSW Ecological Consultant's Association, in regard to interpretation of the Final Determination for *River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast Sydney Basin and South East Corner bioregions* EEC .
- NSWSC (2007). Letter to Mr Jim Charley, Honorary Fellow, Faculty of Science, University of New England, Armidale, in regard to interpretation of the Final Determination for *River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast Sydney Basin and South East Corner bioregions* EEC.
- NSWSC (2004a). *Subtropical coastal floodplain forest of the NSW North Coast bioregion - endangered ecological community listing: final determination*. www.npws.nsw.gov.au.

- NSWSC (2004b). *River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing: final determination*. www.npws.nsw.gov.au.

- 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, Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209)*, 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, 2004b) 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 2009a). 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, Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209* and *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 36.*

As detailed in his judgement on *Motorplex vs Port Stephens Council* and *Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209*, Justice 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. Justice 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 three cases which deal with the Coastal Floodplain EECs. Each systematically evaluates the primary and supplementary descriptors eg landform, soils and vegetation. Each 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, Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209 74*, Keith and Scott 2005, 2004, DECC 2009b, 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*"). This is most clearly defined by Justice Preston in *Gales Holdings Pty Limited v Tweed Shire Council [2008] NSWLEC 209 74*:

> "*64 This description has three components that are linked: an edaphic (soil) component ("silts, muds or humic loams"), a topographical component ("depressions, flats, drainage lines, backswamps, lagoons and lakes") and a locational component ("associated with coastal floodplains"). The soils are "in" the topographical features identified, which are in turn "associated" with the coastal floodplain, as defined by the Scientific Committee. This suggests that these topographical features are formed by the fluvial processes referred to in the definition of floodplains, namely, "active erosion and aggradation by channelled and overbank stream flow with an average recurrence interval of 100 years or less". So too the soils which are in such topographical features will be formed by such fluvial processes*".

In *CBD Prestige Holdings Pty Ltd v Lake Macquarie City Council [2005] NSWLEC 367*, Justice 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 determined in all three legal precedents) 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 Justice's Bly and Preston is on the issue of "*associated with coastal floodplains*". Justice 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). Justice Preston and the NSW Scientific Committee (in communication to Justice 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 Justice 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 10.4ha 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 relic 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 indicates 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 2009b, 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 2009, 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 and Scaley Breasted 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 2009).

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 2009). 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 2009b, 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 2009, DECC 2009b, 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, Little Lorikeet, 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 2009b).

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 2009b). Squirrel Glider and the common Sugar Glider also tap eucalypts for sap (Smith and Murray 2004, DECC 2009b), 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 2009b, Birds Australia 2009).

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 2009, 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 2009b) 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 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 tend to roost according to life cycle period and food availability (Eby 2000a, Churchill 1998, Eby 2002, Smith 2002). 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).

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 2009b). 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 2009b).

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 2009, DECC 2009a, 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 2009, 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 HABITAT LINKS AND WILDLIFE CORRIDORS

4.4.1 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.

4.4.1.1 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.

4.4.1.2 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) <u>General</u>:

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.