Review of Tuncurry Midge Orchid

(*Genoplesium littorale* syn. *Corunastylis littoralis*) for a proposed Rezoning

Crown Lands, North Tuncurry, NSW

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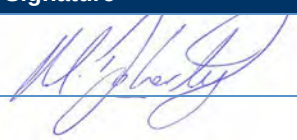
Matt Doherty		11 September 2012

Executive Summary

Introduction

RPS was requested by Landcom to prepare a comprehensive Tuncurry Midge Orchid (TMO) report that provides all the information that is presently known about the species, as ascertained from a literature review and site investigations during the period 2008 to the present. The TMO report also analyses habitat preferences and includes. an initial discussion on potential impacts on the species from a proposed rezoning of a portion of Crown Lands at North Tuncurry, NSW, hereafter referred to as the Project Site. An initial discussion on how the proposal aims to meet the 'avoid, mitigate, offset' framework is also provided.

TMO Distribution

The known extent or distribution of the species has now been determined as being approximately 20km (North Tuncurry south to Tiona) by 8 km (North Tuncurry west to Minimbah), totalling 160km2. To date the known stems of TMO recorded across this expanded distribution is 2316.

The known present distribution of the species is, however, inconsistent with that noted in the NSW Scientific Committee Final Determination for the TMO (OEH 2009) which states an area of occupancy of 8km2. The inconsistency can be explained by the fact that the Determination was solely based on the results of Paget (2008) which did not take into account the additional populations recorded by RPS in 2010 and 2011 at Green Point, Tiona and Minimbah.

TMO Habitats

TMO habitat investigations have been carried out by RPS between 2010 and 2012 with additional works completed by Paget (2008) and ERM (2010). The habitat validation surveys undertaken by RPS during 2012 flowering season as well as those of the dense Heathland searches indicate the following two main habitat preferences for the species (both on and off the North Tuncurry site):

- Artificially created low Holocene dune Heathlands (to 300mm height) in powerline easements that are regularly maintained by slashing (e.g. North Tuncurry, Green Point/Tiona populations); and
- Relatively Open Dry Sclerophyll Shrublands on Holocene dunes that have established in areas subject to historical vegetation clearing associated with dredge line excavation for mineral sands mining east of the Tuncurry Tip. The Shrublands are characterised by a thin layer of leaf litter or bare soil with 2 to 3 lichen species where the orchids have little competition for available light and do not have to germinate amongst or through thick leaf litter. It is not known whether the existing Dry Sclerophyll Shrubland habitat (main TMO colony habitat) regenerated naturally post mining or whether the area was subject to a post mine rehabilitation planting program. Regardless of the origin of the Shrubland, the historical mining activities have led to a 'sparse' vegetation cover that the species has exploited.

A third habitat preference for the TMO appears to be a Low Open Dry Sclerophyll Woodland on Pleistocene sandsheets dominated by scattered Scribbly Gum (*Eucalyptus racemosa* var *racemosa*) that RPS recorded on Crown Lands at Minimbah in 2010 and 2011. These previous records similarly occur in an area subject to historical mineral sands mining (Department of Minerals and Energy, undated).

Investigations undertaken since 2008 to the present strongly suggest the TMO is considered to be a specialist species that requires minimum competition for sunlight to survive and has clearly exploited different disturbance regimes (e.g. mineral sands mining, Pine Forestry, powerline easements) that have operated on the Project Site (and in the wider locality) since the early 1900s.

Pollination Study

Dr Colin Bower from FloraSearch Pty Ltd, a recognised orchid botanist and entomology expert in NSW, was commissioned by Landcom to undertake a pollination study of the TMO on the Tuncurry Project Site during the latter part of the 2012 flowering season. The purpose of the study was to determine the pollination mechanism of the TMO, which, in turn, would assist Landcom and its representatives in considering the potential impacts of a proposed urban development of the Tuncurry Project Site on the TMO population.

The observations of floral morphology, pollination rates and seed pod development observed in the TMO population at North Tuncurry by Dr Bower were all consistent with insect-mediated pollination (i.e. outcrossing) by small species of flies. FloraSearch (2012) concluded that a minimum viable patch size between 10 to 25 hectares is considered likely to provide sufficient habitat to maintain large population sizes of chloropoids and to provide a buffer against catastrophic events.

RBG Seedbanking

Dr Karen Somerville from The Royal Botanic Gardens & Domain Trust (RBG) in Sydney was commissioned by Landcom to undertake an *ex situ* conservation program for *Genoplesium littorale*, to both increase the knowledge base of the biology of the species (e.g. mycorrhizal fungal relationships) and to ultimately provide a safeguard for the species against future threats to its survival. The *ex situ* conservation program is comprised of the following 3 components:

- Collection of TMO seed and soil from the North Tuncurry Crown Lands Site;
- Isolation of mycorrhizal soil fungi; and
- Encapsulation of seed and isolated fungi in alginate beads for long term storage.

Seed was collected from the North Tuncurry TMO population in May 2012 by the RBG. Dr Sommerville is currently undertaking laboratory trials to isolate the mycorrhizal fungi.

Discussion of Potential Impacts

A 'high level' discussion of the potential direct and indirect impacts on the North Tuncurry TMO population was undertaken based on a proposed Notional Development Footprint (NDF). The Notional Development Footprint covers a total area of approximately 200 hectares of the site excluding the Golf Course (60 hectares) with the remaining 370 hectares being proposed for retention in conservation type tenure, notwithstanding some small linear areas for site access in the west and provision of beach amenities and access to the east.

The Notional Development Footprint (NDF) provides for the retention of the main TMO colony east of the Tuncurry Tip and for the powerline easement colony between the Tuncurry Tip and TAFE. Both these colonies are considered to form the 'core' North Tuncurry population of the TMO.

The NDF will result in the retention of 43.23 hectares of Known/Preferred TMO habitat (including the core population) and 281.8 hectares of Potential TMO Habitat, based on the TMO Habitat Map produced for this report. Of the 1643 TMO stems recorded on the Project Site, the NDF will result in the retention of a total of 1518 individuals, or 92.4% of the Project Site population.

Across the species distribution the NDF will result in the removal of 3.7% of potential TMO habitat and 5.4% of the total recorded population.

The discussion focused on the retention of the core North Tuncurry TMO population, provision of habitat buffers, plant pollinator interactions, connectivity, edge effects, human intrusion, herbivore grazing, fire and overall population viability.

Overall Conclusions

The following conclusions can be made with regards to the TMO and are based on the information available to date for the species derived from field surveys undertaken since 2008 and research begun in 2012:

1. A total of 3 TMO populations have been recorded during the 5 years of investigations of the species by RPS (2011), Paget (2008) and ERM (2010), these being North Tuncurry Crown Lands and adjoining northern lands, Green Point/Tiona (Booti Booti sandbeds) and Minimbah/Nabiac Sandbeds. For the purposes of this report, the 3 'populations' do not imply 3 genetically heterogeneous groups, rather are simply meant to infer geographic separation;

2. Habitat preferences of the TMO were confirmed to be artificially low Holocene Heathlands within powerline easements subject to regular (annual) slashing **and** relatively Open Dry Sclerophyll Shrublands and Low Woodlands that have recolonised areas subject to historical mineral sands mining;

3. The TMO does not occur in dense wallum Heathlands, Shrublands or dune Forests. Rather, the species, as a post disturbance coloniser, appears to temporarily exploit gaps or openings that may occur periodically in such habitats until such time as canopies re-establish and then likely disappear until subsequent disturbance events;

4. Two additional Genoplesium taxa (*Genoplesium rufum, Genoplesium filiforme*) have been recorded by RPS co-occurring with the TMO on the Project site and/or in the Green Point/Tiona population;

5. Results from pollination studies begun by FloraSearch (2012) have indicated that the TMO cross pollinates and is likely pollinated by tiny Chloropoid flies;

6. The Royal Botanic Gardens, Sydney has initiated an *ex situ* conservation program for the TMO to investigate long term security for the species through seedbanking processes; and

7. An urban development proposed for part of the North Tuncurry Crown Lands has been designed to retain the 'core' North Tuncurry TMO population and will provide for its protection through habitat buffers and conservation mechanisms. The Proponent has also committed to provide funding to prepare a TMO Habitat/Recovery Plan and for continued research into the species which will likely result in improved species management over the long term;

8. It is the view of RPS that, based on the information available to date, the Tuncurry TMO population would be expected to remain viable in conjunction with a proximate urban development given that:

   (a) The urban development proposal allows for the retention and conservation of both the core TMO population (Known/Preferred TMO Habitat) and adjoining habitat buffers (Potential TMO Habitat) likely required for continued plant-pollinator interactions and species recruitment. The 'northern' habitat buffer between the southern extent of the main TMO colony (Tip) and the northern NDF boundary (125 hectares) is well in excess of the 25 hectare threshold deemed by Bower (2012) to be the maximum area needed to maintain suspected TMO pollinator habitat. It is envisaged that the 'northern' habitat buffer (including the main TMO colony) will be dedicated to OEH for incorporation into the adjoining Darawank Nature Reserve. The 'western' habitat buffers fringing the powerline easement have a combined area of 55 hectares and thus also

well exceed the 25 hectare maximum threshold deemed necessary to maintain viable pollinator habitat. Bower (2012) notes that the small size of the suspected TMO pollinator(s) is such that large pollinator populations can be maintained in relatively small areas. It is also emphasised that the coastal climate assists in maintaining stable pollinator habitats compared with more inland locations and thus such pollinator habitats are likely to be less vulnerable to stochastic extinction from climatic events;

(b) The urban development proposal allows for the retention of primary linkages to the north and west to large bushland remnants which would function as continued gene flow pathways, habitat for TMO recruitment and pollinator reservoirs;

(c) The urban development proposal includes a commitment from the Proponent (as part of an indirect offsets package) to fund a continuation in 2013 of the pollination and ex situ conservation studies commenced in 2012. The pollination studies should provide further knowledge regarding the specific TMO pollinators and their habitat preferences. The ex situ conservation program should provide a viable, long term seedbank for ultimate species security in the face of stochastic extinctions. The Proponent has also committed to providing funding to OEH should the 'northern' habitat buffer lands (containing the main TMO colony) be transferred to OEH Estate. It is envisaged that the funding would be used, in part, by OEH, to implement a Habitat/Recovery Plan for the Tuncurry TMO population which would likely include a research component (e.g. population monitoring to determine life cycle dynamics and grazing impacts; response to disturbance regimes). The information gained from the research will ultimately allow for improved species management and thus improved chances for population persistence on the site, particularly in the face of a future urban development proposal. It is envisaged that the TMO Habitat/Recovery Plan would be prepared by the development Proponent in consultation with OEH and SEWPAC;

(d) The core TMO population at Tuncurry appears to have persisted in the wild since at least 1992 within 120 metres from both the residential and industrial development areas of North Tuncurry on the western side of The Lakesway and the Tuncurry Waste Management Centre and thus has shown that it can persist in concert with proximate development.

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1.0 Introduction

1.1 Background

RPS was requested by Landcom to prepare a comprehensive Tuncurry Midge Orchid (TMO) report that provides all the information that is presently known about the species, as ascertained from a literature review and site investigations during the period 2008 to the present. The TMO report also analyses habitat preferences and includes an initial discussion on potential impacts on the species from a proposed rezoning of a portion of Crown Lands at North Tuncurry, NSW (Refer to **Figure 1**), hereafter referred to as the Project Site. An initial discussion on how the proposal aims to meet the 'avoid, mitigate, offset' framework is also provided.

This TMO report was prepared in response to regulatory agency (OEH, GLC, SEWPAC) comments to the Ecological Inventory Report (EIR) (RPS 2011) and the Preliminary Impact Discussion Considerations (PIDC) (RPS 2011). The following documents were reviewed to assist in preparing this updated TMO Report:

- Great Lakes Council memo from Mat Bell (Senior Ecologist) to NSW DPI, dated 28 May 2012;
- NSW OEH letter (and Attachment) to Landcom, dated 29 May 2012; and
- SEWPAC letter to Landcom, dated 18 May 2012.

The key comment from GLC in relation to the TMO was that GLC wanted the ecological assessment to provide a *scientific and precautionary assessment as to what lands must be conserved for the protection and conservation management of the TMO*, taking into consideration habitat buffers, habitats important for pollination processes and recolonisation.

The key comment from the OEH response in relation to the TMO was that OEH would be guided by the independent orchid peer review to be undertaken by Dr Lachlan Copeland from Ecological Australia (ELA) and thus reserved any detailed TMO comments until the agency has reviewed the ELA peer review report. Dr Lachlan Copeland of EcoLogical Australia Pty Ltd (ELA) was commissioned by Landcom to undertake an independent peer review of the RPS TMO Report (RPS 2011) which outlined survey methods and results of the 2010 and 2011 TMO surveys RPS conducted for Landcom. The following issues were raised by ELA (2011) in relation to their TMO review:

- The TMO report provided no discussion of the taxonomic confusion (*Genoplesium* vs. *Corunastylis*) that exists with the TMO;
- The TMO report contained no photographs of the TMO and there was no discussion of any vouchers being submitted to any Herbaria for taxonomic confirmation;
- The TMO report contained no specific survey dates and dates of species observed flowering;
- The TMO report did not include any figures showing specific TMO survey transect locations on and off the Tuncurry Project Site;
- The TMO report did not detail previous TMO surveys undertaken by ERM (2009) and Paget (2008);
- The TMO report did not provide any discussion on the Minimbah TMO population which was identified in one of the report figures; and
- The 2011 TMO survey plots did not appear to be undertaken in the dense heath habitats as indicated in the TMO report. As such, further survey work targeting the TMO should be undertaken in dense heath habitats across the Project Site in an attempt to confirm or discount the presence of the species in this habitat type.

The full ELA (2011) review is provided as **Appendix 1**.

SEWPAC made the following key comments in relation to the TMO in their letter to Landcom:

- The Department wanted additional information to justify the TMO Habitat/Constraint Mapping for the Project Site that was presented in the updated Ecological Inventory Report (RPS 2012), including results from TMO surveys in 2012 focusing on dense Heathland habitats. The Department felt that there was an inadequate understanding of the habitat requirements of the TMO in the Ecological Inventory Report;
- SEWPAC wanted to see a consolidation of all TMO investigations to date including results from the 2012 pollination and seed banking study ;
- The Department wanted an analysis of the disturbance history on the Project Site in relation to the known occurrences of the TMO;
- The Department wanted to see further justification of the proposed development footprint based on the 'avoid' and 'mitigate' hierarchy for the TMO before offsetting for the species was considered;
- The Department wanted to see a preliminary discussion of potential direct and indirect impacts as a result of the proposed urban development; and
- The Department emphasised that the TMO rezoning documentation needs to meet the requirements prescribed in the Public Environment Report Guidelines issued by SEWPAC (to Landcom) for the proposal, dated 4 July 2011.

Notably this report will form part of the overall ecological assessment report to accompany the State Significant Study (SSS) exhibition documentation and SEWPaC reporting in response to EPBC Act (1999) matters.

1.2 Objectives of the Report

The objectives of the TMO Report are to:

- Address the comments made by GLC, Dr Lachlan Copeland of ELA, on behalf of OEH and SEWPAC;
- Provide a single, comprehensive report that provides the regulatory agencies with all known information on the species, as ascertained from both a literature review and field investigations undertaken between 2008 to date;
- Provide an initial discussion of potential impacts on the species from the proposed urban development, including a scientific rationale to inform a Notional Development Footprint (NDF) based on available information of the species; and
- Provide an initial discussion of how the proposal aims to meet the 'avoid, mitigate, offset' framework.

1.3 Structure of the Report

The report is structured as follows:

Section 2 Provides a description of the species, a discussion on its taxonomic and collection history and a discussion on its ecology;

Section 3 Details methods of TMO investigations undertaken since 2008;

Section 4 Details results of TMO investigations since 2008;

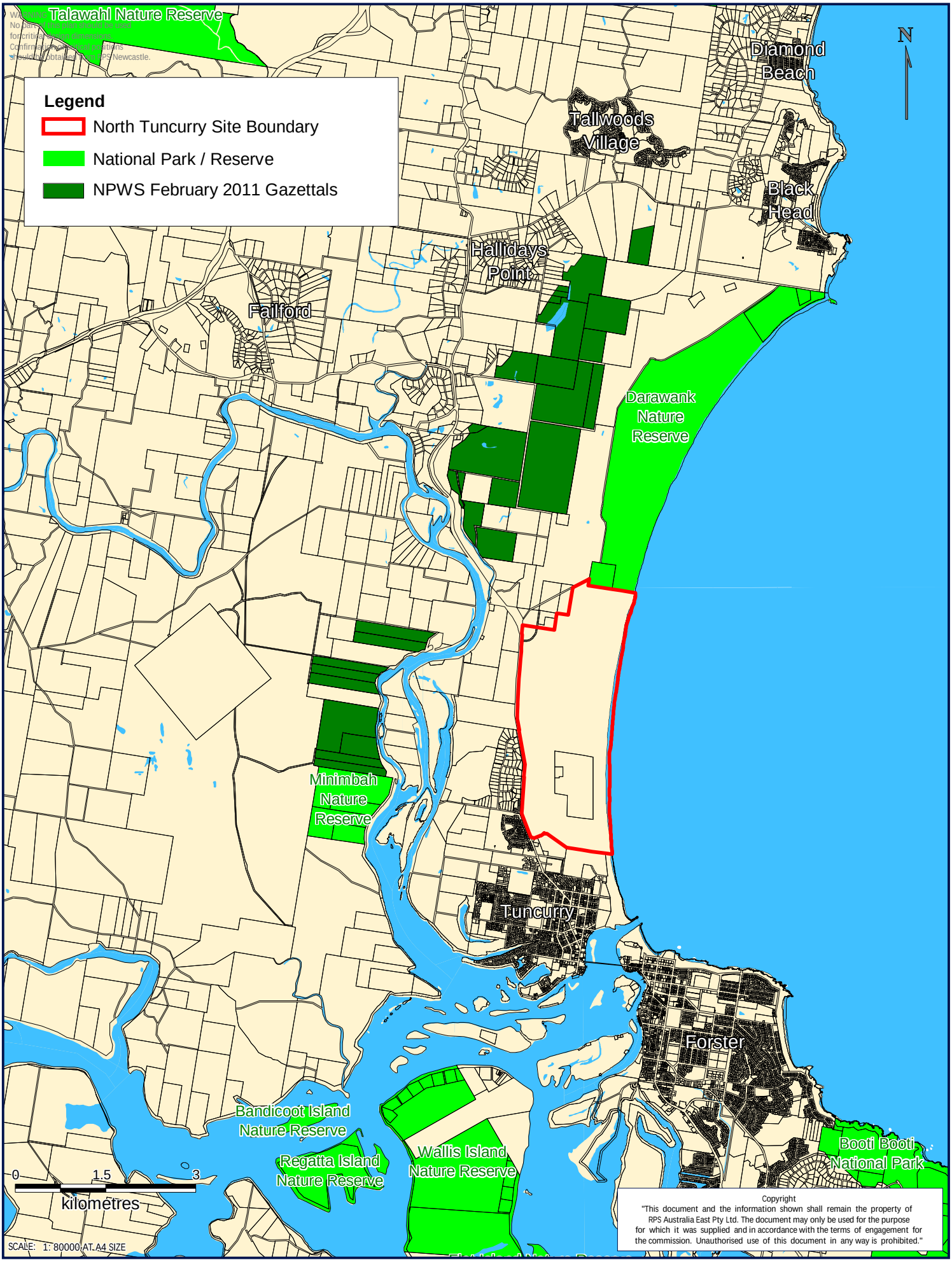
Section 5 Detail of Additional TMO Research undertaken in 2012;

Section 6 Details TMO Habitat and Distribution;

Section 7 Provides a description of the proposed urban development and Notional Development Footprint

Section 8 Provides an initial discussion of impacts on the species based on the Notional Development Footprint; and

Section 9 Provides an initial discussion of how the urban development proposal aims to meet the 'avoid, mitigate, offset' framework.



TITLE: FIGURE 1: SITE LOCATION

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 05/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces\2012 TMO Report Figures
VERSION (PLAN BY): P. HILLIER

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RPS

2.0 Species Information

2.1 Description

The Tuncurry Midge Orchid (TMO) is from a group of terrestrial orchids known as midge orchids which are known for having tiny, 'upside down' flowers, fused leaf and flower stems and concave dorsal sepals. The following description of the species is taken from Jones (2006) and from the author's field observations (in parentheses).

Leaf - 100-250mm long; free part 10-18mm long, ending below flowers; (terete, 2-3 mm wide). Spike – 10-30mm tall, 5-30 flowered. Flowers – moderately crowded, semi nodding, 5 x 4mm, green with purple-brown labellum (variation in petal and sepal colour from part green and maroon to all maroon). Dorsal sepal – 3.8 x 2.5mm; (ovate and concave); margins hairless; apex sharply pointed. Lateral sepals – deflexed, divergent, 4.5 x 1mm, base (strongly to weakly) humped; (apex often sharply pointed). Petals - 3 x 0.8mm, spreading; (ovate to lanceolate); margins hairless; apex sharply pointed. Labellum – stiffly hinged, 2.5 x 0.8mm, oblong, fleshy, margins hairless; apex sharply pointed and (strongly) recurved. Callus extending nearly to labellum apex.

A photograph of the flowering spike of the TMO observed on the Project Site east of the Tuncurry Tip is shown below as **Plate 1**.

Plate 1: Flowering spike of the TMO (Tuncurry population)

2.2 Taxonomic History

The Type specimen was first described in Bishop (1996, 2000) as *Genoplesium* sp. aff. *despectans* (Tuncurry), reflecting the TMOs apparent morphological similarity with *Genoplesium despectans*, a species known from southern NSW and Victoria. The TMO was not included in Jones's (1988) seminal publication, *Native Orchids of Australia*, given that the Type specimen was not collected until 1992. The TMO was subsequently described as a new species, *Genoplesium littoralis*, by Jones (2001). Subsequent to this, Jones *et al* (2002) published a revision of the *Genoplesium* genus whereby all but one of the *Genoplesium* taxa in Australia were placed into the *Corunastylis genus* (an old but resurrected genus), with TMO newly described as *Corunastylis littoralis (*Jones 2002; Jones 2006*)*. This major taxonomic revision was justified based on phylogenetic studies (DNA analysis) of three *Genoplesium* taxa which resulted in the re-recognition of the historic *Corunastylis* genus (Clements *et al* 2002).

The *Genoplesium*/*Corunastylis* revision has not been accepted by the NSW National Herbarium with the species still described as *Genoplesium littorale*, on the Royal Botanic Gardens (RBG) 'PlantNet' website. The NSW National Herbarium refuses to accept this major Genus revision because the revision was based on the analysis of a very small number of *Genoplesium* taxa relative to the total (48) *Genoplesium* taxa in Australia (pers comm. Dr Peter Weston, NSW National Herbarium). Further, the results of the subject phylogenetic studies used to justify the genus revision (Clements et al 2002) were contradictory to other such studies by Kores et al (2001) which concluded that the *Genoplesium* genus had more genetic affinity with the *Prasophyllum* genus (with which *Genoplesium* was historically contained within) than with the *Corunastylis* genus. The results of the study by Kores et al (2001) seem to provide an equally strong justification for re-incorporating the *Genoplesium* taxa back into the *Prasophyllum* genus (the genus was split into *Prasophyllum* and *Genoplesium* in 1989). This debate is yet to be resolved.

The taxonomic history summarised above has led to a large degree of confusion amongst consultant botanists, Australian Herbaria and regulatory authorities regarding the scientific name to be used when referring to the TMO. This confusion about the species taxonomy has resulted in, for example, the species being listed as *Corunastylis littoralis* under the EPBC Act (critically endangered) by SEWPAC and *Genoplesium littorale* (critically endangered) under the TSC Act by OEH. The Australian National Herbarium in Canberra refers to the species as *Corunastylis littoralis* (having accepted the Genus revision) whilst the RBG Sydney remains sceptical and has retained the *Genoplesium* genus to date.

For the purposes of this inventory report, botanical nomenclature follows Harden and the 'PlantNet' website and thus TMO is herein referred to as *Genoplesium littorale*.

The TMO bears the following current scientific classification:

Family: *Orchidaceae*
Tribe: *Diurideae*
Subtribe: *Prasophyllinae*

2.3 Collection History

The Australian National Botanic Garden's Australian Plant Name Index (APNI) lists the Type locality and collectors of the TMO as Tuncurry, 23 April 1992, R.G. Tunstall, G. Hillman and J. Riley. The APNI lists a Type specimen being submitted to the Canberra Botanic Gardens (**Plate 2**) (holo CANB (CBG 9709786)).

Paget (2008) notes that about 20 plants in a small group about 10m in diameter were seen when the plant was first collected and that the Type location was about 100m south of the Tuncurry Tip (based on a personal communication with a long time Tuncurry local orchid enthusiast, John Riley). Paget (2008) also

noted that the TMO has been known in the location for a long time, as it was included in an early orchid book by Rupp produced in the 1940s (John Riley per. comm.).

Since the original Type specimen was submitted to Canberra, no further specimens have been submitted until recent investigations by RPS in 2012 (refer following sections of report).

Plate 2: TMO Type Specimen Herbarium Sheet (courtesy of Dr Weston, RBG Sydney)

2.4 Ecology

2.4.1 Life Cycle

During late summer and autumn, the TMO produces a single erect stem with the flower spike emerging through the leaf near the apex of the stem, leaving a small free portion of leaf beneath the flowers. The leaves and flowering stems are essentially fused and develop simultaneously as a single unit. Individual stems have been observed by the author to flower for up to 2-3 weeks and are usually open during hot sunny days (with high humidity) to coincide with likelihood of pollinator activity.

In recent years, surveys undertaken by RPS has observed the Tuncurry population to flower from as early as mid summer (mid February) to as late as the third week of May. In the case of the Tuncurry Midge Orchid, initial observations suggest that the species flowers 4-6 weeks following good summer rainfall. The

proportion of the population that will flower in any individual year is not known and likely varies from year to year (midge orchids are often known to skip years). Successful flowering and reproduction are likely to be dependent on favourable weather conditions, however other factors may also influence flowering such as the extent of native and introduced herbivore browsing. The literature reports that midge orchid seedlings take between 3-5 years to flower, with such timing being dependent on tuber size (NSW NPWS 2002).

Bower (2001) reports that seed development and shedding occur about 3-5 weeks and 6-12 weeks, respectively, following pollination. The TMO dies back after fruiting and exists as a subterranean, dormant tuber in the winter until favourable conditions occur for germination in the following year(s).

In a comprehensive literature review of the Genoplesium genus, Bower (2001) notes that the flowers of Genoplesium are small, inconspicuous and dull-coloured, typical characteristics of myophily (fly pollination). Bower (2001) also comments that limited data suggests that nectar is present in some Genoplesium species, indicating that the pollination strategy is one of nectar reward (for the pollinators). This is consistent with Jones (2006) who notes that most species of Prasophyllum (from which the Genoplesium genus was derived) secrete nectar on the labellum and are visited by a large range of insects. Bower (2001) also states that the attraction of flies to some Genoplesium species is strong (with swarming behaviour often exhibited with fresh inflorescences for a number of species) and appears to be by odours, not all of which are detectable by humans.

Bower (2001) notes that strong evidence exists that the genus is pollinated exclusively by small flies of the closely related families Chloropidae and Milichiidae belonging to the superfamily Chloropidae. Interestingly, Bower (2001) notes that a specific pollinator was captured and identified for *Genoplesium rufum* and *Genoplesium despectans*, being *Caviceps flavipes*. *Genoplesium rufum* has been recorded on the Project Site by RPS during the 2012 flowering season in virtually identical habitat to that of the TMO (refer **Section 4.5**). *Genoplesium despectans* is considered to be morphologically similar to the TMO and may be a closely related species.

Dr Colin Bower of FloraSearch was commissioned by Landcom in May 2012 to inspect the Tuncurry TMO population and provide some initial advice on suspected pollination mechanisms used by the TMO based on flower morphology, pollination rates and seed pod development. A summary of the methods and results from Dr Bower's pollination study is provided in **Section 5.1** of this report and a copy of the full report is attached as **Appendix 2**.

2.4.2 Population Structure

At present virtually nothing is known about the age structure of plants in any of the known TMO populations, nor the life span of individuals. Current recruitment rates have not been determined, and it is not known whether recruitment occurs at a steady rate or occurs in pulses influenced by seasonal conditions.

3.0 TMO Survey Methods

3.1 Desktop Review

A desktop review of reports detailing previous investigations of the TMO on the Project Site during the period 2008-2011 was undertaken by RPS. The following reports were reviewed as part of the desktop assessment:

- Paget (2008) Results of Searches for the Tuncurry Midge-Orchid (*Genoplesium littorale,* syn *Corunastylis littoralis*) Autumn 2008 [**Appendix 3**];
- ERM (2010) Tuncurry Midge Orchid Survey, letter & map to Landcom, dated 12th January 2010 [**Appendix 4**];
- RPS (2011a) Ecological Inventory Report North Tuncurry. Report No. 26414 prepared by RPS for Landcom, Final August 2011;
- RPS (2011b) *Corunastylis littoralis* Tuncurry Midge Orchid Combined Survey Results 2010/2011 North Tuncurry Report No. 26414 prepared by RPS for Landcom, Final August 2011;

The above documents have been reviewed and summarised by this report in the following sections.

3.2 Paget (2008)

The Hunter Central Rivers Catchment Management Authority (HCRCMA) formed a working group in 2008 to investigate the TMO to provide information to the NSW Scientific Committee for its consideration of a possible listing of the TMO under the TSC Act.

Initial surveys for the TMO were undertaken by Paget (2008) during January and early February 2008 to identify and map suitable habitat areas that would be subject to detailed investigation during the flowering season (mid Feb through to mid April).

Subsequent searches early in the flowering season (18 Feb 2008) were undertaken in the following habitats:

- The Type location (100 metres south of Tuncurry Tip) - Blackbutt (*Eucalyptus pilularis*) Woodland with a shrubby understorey of Lemon-scented Tea-tree (*Leptospermum polygalifolium* ssp *cismontanum*);
- Nearby to the Type location was an almost treeless dry ridge comprising a few scattered Blackbutts *Eucalyptus pilularis*) with a sparse shrubland of *Monotoca elliptica* and *Brachyloma daphnoides*;
- Mixed Flaky-barked Teatree (*Leptospermum trinervium*) and Saw Banksia (*Banksia serrata*); and
- 100-200m south of the Tuncurry Tip and southwards towards the Tuncurry TAFE were dominated by low (<1.5m tall) dense heathland dominated by Ochrosperma lineare (syn. *Baeckea linearis*), with a range of other heathland species (e.g. *Eriostemon australasius, Dillwynia retorta)*.

The searches concentrated on 3 main areas, these being:

- the core habitat between Tuncurry Tip and Tuncurry TAFE where plants were previously known from;
- target searches in Darawank Nature Reserve immediately to the north; and
- target searches in Booti Booti National Park to the south of the Type location.

3.3 ERM (2010)

ERM (2010) undertook a 3 day targeted survey of the TMO in March 2009 across the Project Site targeting heathland vegetation. The dense structure of the heathland made it necessary for transects to be conducted parallel to the cleared transmission line easement and along the numerous sand tracks crossing the Project Site (ERM 2010). Survey effort was concentrated along four wheel drive tracks parallel to and within the electricity easement to the north of the Golf Course and along the sand track bordering the TAFE in the south of the Project Site (ERM 2010).

3.4 RPS TMO Surveys (2010 - 2012)

3.4.1 Targeted Surveys

Tuncurry Project Site

Targeted surveys for the TMO were undertaken on the Project Site in Tuncurry by RPS between 2010 and 2012. The dates of these surveys are presented in **Table 1** below. These surveys included random meanders within potential habitats within the subject site, such as power easements and tracks. Vegetation communities and habitats where the orchid had been previously recorded were also targeted. Above ground stems of the TMO were counted and mapped using a hand held GPS. **Figure 2** shows representative locations of random meander locations that were captured by the GPS. It is noted that this does not show the whole survey effort as it does not represent all revisits to the same area, where the GPS could not capture enough satellites to record positions or where two ecologists were searching in close proximity to each other with one GPS unit being shared. In short the survey intensity and coverage is greater than that displayed in the mapping.

Offsite Lands

Areas situated outside the Project Site at Tuncurry were targeted by RPS in 2010 and 2011 in order to ascertain the extent and distribution of the orchid population in the wider region. Surveys targeted Booti Booti National Park, Darawank Nature Reserve, Crown Lands at Minimbah and lands at Old Bar. The dates of these surveys are presented in **Table 1** below.

The general methodology for off-site lands consisted of two RPS ecologists' walking parallel transects spaced approximately 10 m apart and Random Meander transects within potential habitat areas. The areas surveyed and representative transects and meanders for 2010 and 2011 are presented in **Figure 3**.

Searches for TMO colonies in areas where the species was previously recorded (or considered as having a high likelihood of occurrence) outside the Project Site were also undertaken by RPS ecologists during the 2012 flowering season.

3.4.2 Tuncurry Project Site Plot Surveys

The 2011 TMO survey work within the Crown Lands focused on sampling of the under-surveyed dense heath habitats to ultimately estimate the potential population size within this habitat on site. This habitat type had previously been under-surveyed due to the physical difficulty of accessing the dense heath environs.

A total of 9 random plots were established within the heath vegetation on the Project Site between 11 and 13 April 2011, with each plot having a dimension of 40m x 40m (0.16ha). Within each of the 9 plots, two RPS

ecologists walked parallel transects approximately 2m apart. Given the variability of heath vegetation within the site, RPS recorded the following data within each plot:

- species and percentage foliage cover (PFC) of each strata;
- height of vegetation;
- thickness of ground debris;
- percentage cover of ground debris; and
- disturbance levels.

The location of the 9 quadrants are shown in **Figure 2**.

3.4.3 Heathland Transect Searches

In response to ELA (2011), a survey effort was designed in collaboration with Dr Lachlan Copeland for the 2012 flowering season. The agreed methodology consisted of 37 transect searches in dense Heathland and Dune (Dry Sclerophyll) Forest habitats. This work was designed to supplement the 2011 dense heath survey work and to test previous conclusions that the species was unlikely to be present in the dense heath and if present, only in low numbers. Validation of flowering in known populations in the proximate area of transects were undertaken at the time of survey prior to commencement of transect investigations. Specific dates and transect numbers for each survey site is presented in **Table 1**. Transect locations are shown in **Figure 2, Figure 4, Figure 5 and Figure 6**.

Project Site

A total of 22 transects were undertaken in the habitats across the Tuncurry Project Site by RPS ecologists. Each transect was made by a single ecologist with efforts focussed on closely inspecting groundcover for the TMO. Additional transects were also undertaken along existing 4WD tracks to re-identify previous TMO records made by RPS in 2010 and 2011. The transect searches within the project area are provided in **Figure 2**.

Tuncurry Waste Management Facility (Tip)

A single (one) search for the TMO was made by two RPS ecologists within an area to the south-east of the Tuncurry Waste Management Centre. Habitats that were searched comprised a disturbed Blackbutt Dry Sclerophyll (Dune) Forest, characterised by a thinned canopy and underscrubbed understorey (i.e. sparse to absent mid and ground stratum). This area was targeted for surveys as it has been subject to continued site maintenance (slashing) over the past 12 to 18 months. Most notably this area is in close proximity of the Core population described by Paget (2008). The transect searches within this area are provided in **Figure 2**.

Darawank Nature Reserve

In total, eight transects were undertaken with Darawank Nature Reserve targeting TMO. Areas with past disturbance, road verges, gaps in heath and forest were targeted during the searches. The transect searches within Darawank Nature Reserve are provided in **Figure 4**.

Crown Lands, Minimbah

In total, three transects were carried out across the Crown Lands at Minimbah targeting the TMO by two RPS ecologists. Searches were biased towards those areas where the TMO was previously recorded by RPS in 2010/2011. These areas were reportedly subject to previous sand mining and generally comprised a *Eucalyptus racemosa* var *racemosa* Dry Sclerophyll Low Open Woodland showing evidence of past fire activity. The transect searches within Crown Lands at Minimbah are provided in **Figure 5**.

Booti Booti / Green Point

In total, three transects were undertaken within the Booti Booti / Green Point survey area. Searches for the TMO were undertaken by two RPS ecologists in Booti Booti National Park and Green Point Road powerline easements, access tracks and in recently burnt patches (western side of The Lakesway north of Green Point) in an attempt to record specific habitat data for these previously recorded easement populations. The transect searches within Booti Booti National Park and Green Point are provided in **Figure 6**.

Table 1 TMO Survey Effort by Date and Location

Method	North Tuncurry Development (Project) Site	Tuncurry Waste Management Facility (Tip)	Darawank NR	Crown Lands, Minimbah	Midcoast Water lands at Minimbah	Willowbend	Hallidays Point	Diamond Beach	Booti Booti / Green Point	Old Bar	Local Aboriginal Land Council (LALC) lands at Nabiac
Targeted Searches	18/02/2008 (Paget 2008) March 2009 (ERM 2010) 23/03/2010, 24/03/2010, 29/03/2010, 29/03/2010, 30/03/2010, 19/04/2010, 20/04/2010, 21/04/2010, 22/04/2010, 23/04/2010, 28/04/2010, 14/05/2010, 17/05/2010, 18/05/2010, 19/05/2010, 20/05/2010, 13/04/2011, 22/03/2012, 26/03/2012, 27/03/2012.		18/02/2008 (Paget 2008) 20/04/2010, 28/04/2010, 11/05/2010, 12/05/2010, 18/04/2011, 05/05/2011, 11/04/2011, 22/03/2012, 28/03/2012, 30/03/2012,	28/04/2010, 03/05/2010, 12/05/2010, 20/04/2011, 21/03/2012, 28/03/2012, 29/03/2012	10/05/2010, 28/04/2011, 05/05/2011, 26/03/2012, 27/03/2012	19/05/2010	10/05/2010, 12/05/2010	28/04/2010	19/05/2010, 19/03/2012, 28/03/2012, 29/03/2012	04/05/2010	28/04/2010, 11/05/2010, 21/04/2011, 28/04/2011, 04/05/2011,
Plot Surveys	11/04/2011, 12/04/2011, 13/04/2011.										
Transect	Transect No: 1 – 22 26/03/2012, 27/03/2012	Transect No: 37 26/03/2012	Transect No: 23 – 30 22/03/2012, 28/03/2012, 30/03/2012	Transect No: 34 – 36 28/03/2012					Transect No: 31 – 33 21/03/2012, 28/03/2012, 29/03/2012		

WARNING
No part of this plan should be used for critical design dimensions. Confirmation of critical positions should be obtained from RPS Newcastle.

Legend
- Site Boundary
- Tuncurry Midge Orchid Survey Quadrats
- 2010 Random Meander
- 2011 Random Meander
- 2012 Random Meander and Heath Transects

N

Note: representative macro boxes have been provided for 4 quadrat sites to illustrate that transect locations were undertaken 20 metres into Heathland/Forest habitats. Such transects were undertaken at all 9 quadrat sites.

0 0.5 1
kilometres

SCALE: 1: 20,000 AT SIZE A3

TITLE: FIGURE 2: RPS TMO SURVEY (MEANDER/TRANSECT/PLOT) LOCATIONS (2010, 2011 & 2012)

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 09/08/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces\2012 TMO Report Figures
VERSION (PLAN BY): PH (A-A3)

CLIENT: LANDCOM
JOB REF: 26414

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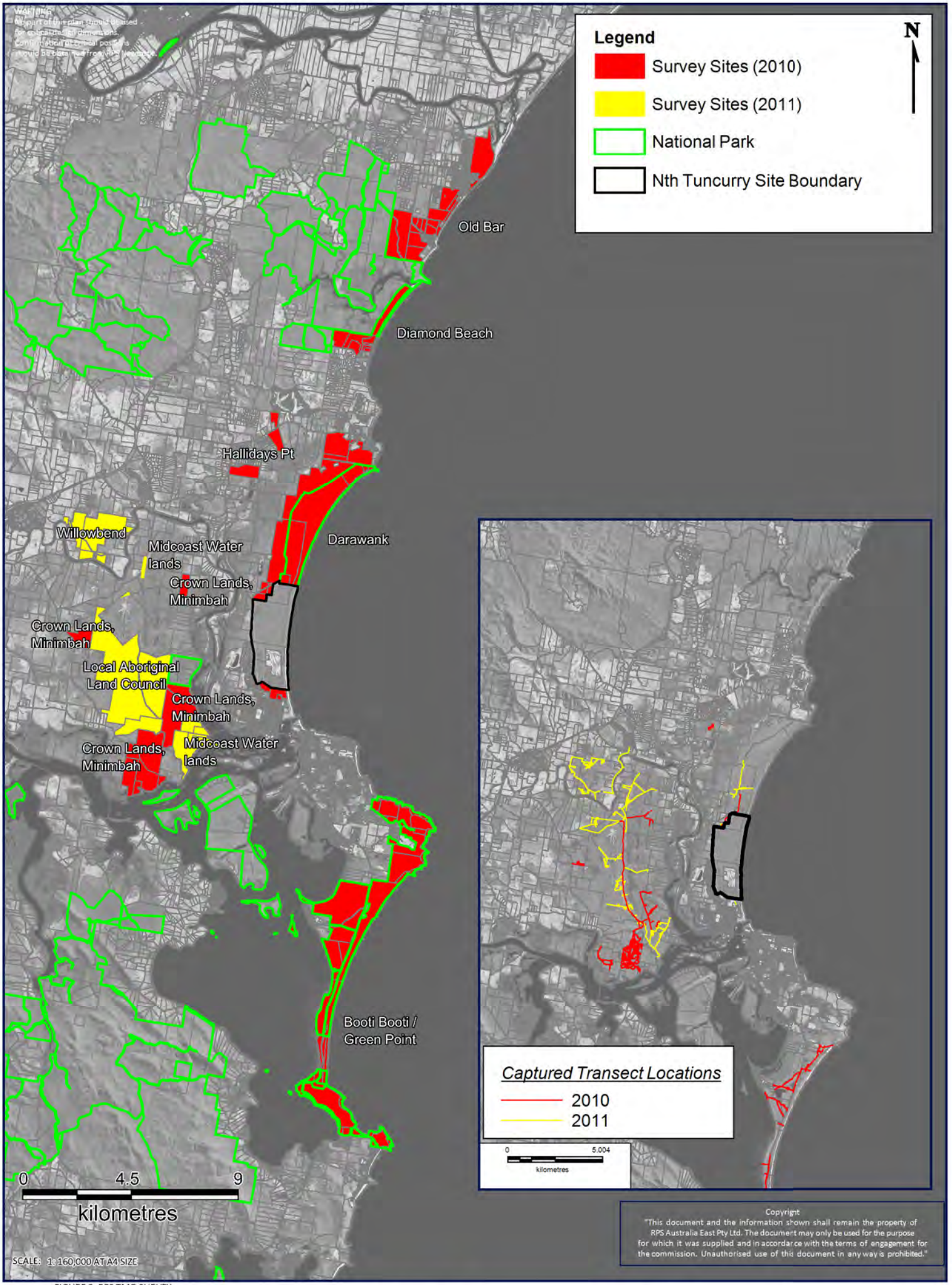

TITLE: FIGURE 3: RPS TMO SURVEY (MEANDER/TRANSECT) LOCATIONS, 2010 AND 2011 (ADDITIONAL OFFSITE AREAS)

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 09/8/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: "J:\JOBS\26k\26414 - North Tuncurry\10-Drafting
VERSION (PLAN BY): PAUL HILLIER (B-A4)

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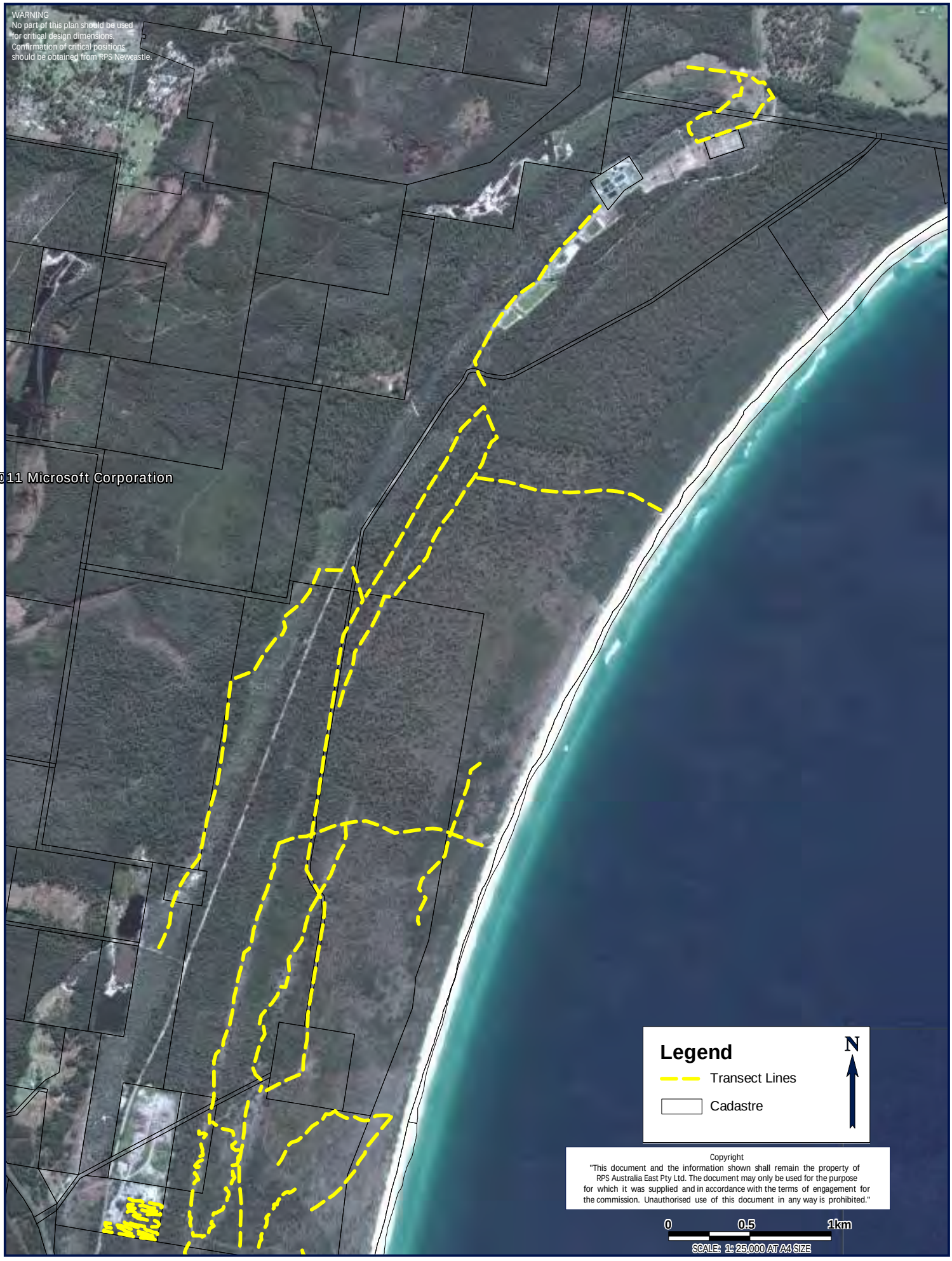

TITLE: FIGURE 4: TMO 2012 DARAWANK TRANSECT LINES

LOCATION: DARAWANK

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 26/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces
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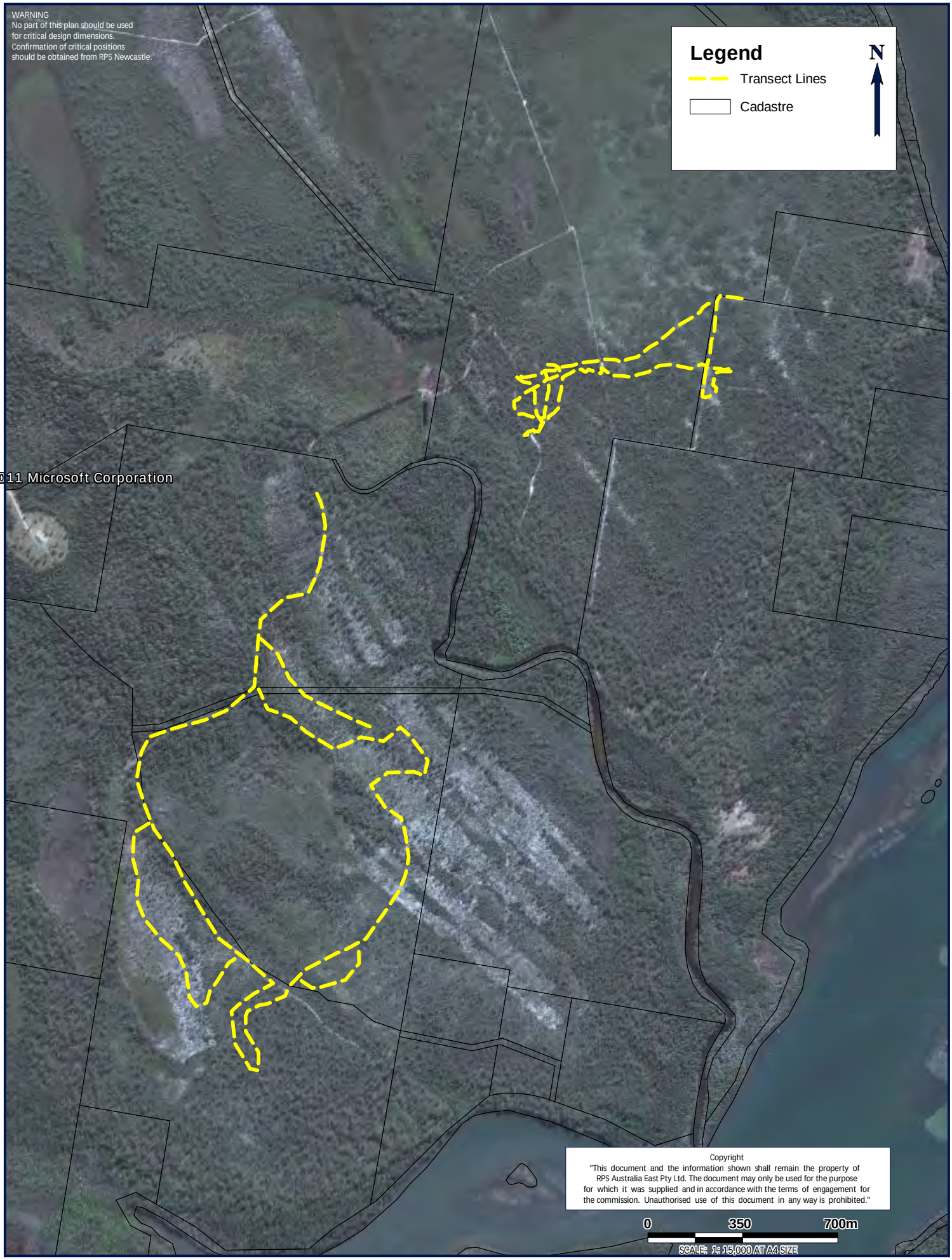

TITLE: FIGURE 5: TMO 2012 MINIMBAH TRANSECT LINES

LOCATION: MINIMBAH

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 26/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces
VERSION (PLAN BY): A A4 (AS-NW)

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TITLE: FIGURE 6: RPS TMO TRANSECT LINES GREEN POINT, TIONA, 2012

LOCATION: BOOTI BOOTI

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 26/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces
VERSION (PLAN BY): A A4 (AS-NW)

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3.5 Voucher Specimen Collection

In 2012 three voucher specimens of the TMO were collected (2 from the North Tuncurry population and 1 from the Green Point Road population) and submitted to Dr Mark Clements (Australian National Herbarium, Canberra) for confirmation.

In addition, three voucher samples were collected from the North Tuncurry and Green Point Road populations by RPS and were sent to Dr Peter Weston of the NSW National Herbarium in Sydney for confirmation.

4.0 TMO Survey Results

4.1 Paget (2008)

Paget (2008) recorded a total of 584 plants within the following 2 areas:

- A 'main colony' (512 plants) occurring in previously disturbed bushland approximately 100 metres east of the Tuncurry Tip. This area appears as two narrow 'bands' on Google Earth imagery which 'loop' east of the Tip before running parallel to each other heading northwards (outside the Crown Lands site) towards the Hallidays Point Water Treatment Plant within Midcoast Water and OEH Estate (Darawank Nature Reserve). These disturbance 'bands' generally correspond with the location of 'dredge' lines associated with historical mineral sands mining, based on a desktop review of a Land Use History Report of the Project Site and immediate surrounds, prepared by Whelans (2007) for Landcom. Paget (2008) notes the 512 plants recorded within this main colony occurred in all 4 habitat types noted in **Section 3.2**; and
- A secondary colony (72 plants) occurring within a 30 metre wide (approximate) powerline easement running parallel with The Lakesway between the Tuncurry Tip and Tuncurry TAFE and along 4WD tracks that regularly bisect the Crown Lands site. Paget (2008) notes the 72 plants recorded within this secondary colony occurred within dense *Ochrosperma lineare* Heathland (71 plants) and in Lept*ospermum laevigatum* thickets (1 plant). It is noted that based on the author's interpretation of the colony locations presented by Paget (2008), the 'dense Heathland' of Paget (2008) appears to correspond to an artificially low Heathland to 300mm height as a result of annual slashing by Essential Energy within the powerline easement which tends to favour the species.

The locations of the two colonies of TMO recorded by Paget (2008) are shown on Map 1 (page 11) within Paget's report found at **Appendix 3**.

No additional TMO colonies were recorded by Paget (2008) during his investigations.

Paget (2008) estimated a TMO population size range of 1298-1898 on the Project Site but noted this was based on crude assumptions only.

Paget (2008) also provided a brief discussion for a suite of possible threats to the TMO such as weed invasion, edge effects, rabbit browsing and residential development.

Following its consideration of the Paget (2008) study, the TMO was gazetted on 31 July 2009 as Critically Endangered under the NSW TSC Act.

The TMO locations presented in Paget (2008) have been analysed in relation to the Project Site boundary. It is estimated that approximately 161 stems of Paget's (2008) 'core population' occurs within the Project Site boundary, with the remaining 351 stems recorded to the immediate north-west. The full TMO report prepared by Paget (2008) is provided as **Appendix 3**. Of the 233 stems recorded within the project area, using the 10 metre distance threshold as described in **Section 4.3**, approximately 188 (116 within 'core population' and 72 along tracks and easement) were considered to have not been subsequently recorded by RPS. Approximately 81 of the 351 stems recorded to the immediate northwest by Paget are also considered to have not been re-recorded by RPS between 2010 and 2012. It is noted herewith that these estimates have been derived using digitisation techniques of the mapping produced in Paget (2008) and the spatial accuracy of Paget's TMO data has not been verified.

The approximate locations of the records made by Paget (2008) are provided in **Figure 7**.

4.2 ERM (2010)

ERM (2010) recorded a total of 47 individuals of the TMO on the Crown Land at varying stages of the life cycle (flowering, non-flowering stems and dying).

Refer to Figure 1 of the ERM Report provided in **Appendix 4** for the locations of the TMO plants recorded on the site.

ERM (2010) also recorded a total of 31 orchids of varying stages (flowering, non-flowering and buds) in an area with scattered Blackbutts and a sparse shrub strata dominated by *Monotoca elliptica* and *Leptospermum polygalifolium*, outside the Project Site (to the south of the Tuncurry Tip). Due to a revision in the project area boundary since the ERM surveys, the locations of these records now fall within the project area. The total number of stems recorded by ERM within the project area is therefore 78.

ERM (2010) noted that a development proposal would need to be designed to avoid, mitigate or offset impacts on the TMO through protection and buffering of the known TMO colonies.

The TMO locations presented in ERM (2010) have been analysed in relation to the Project Site boundary. ERM (2010) reported recording 31 individuals within Paget's (2008) 'core population'. Due to the close proximity of these 31 records, these are regarded as being re-recorded by Paget (2008) and RPS between 2010 and 2012. The remaining 47 stems are considered to be sufficiently separated from any subsequent records to represent unique records. It is noted herewith that these estimates have been derived using digitisation techniques of the mapping produced in ERM (2010) and the spatial accuracy of this data has not been verified. The full ERM (2010) report is provided as **Appendix 4**.

The approximate locations of the records made by ERM (2010) are provided in **Figure 7**.

4.3 RPS TMO Surveys (2010 - 2012)

All RPS TMO records were recorded with a hand held Trimble GPS unit which has sub metre accuracy post processing. To minimise the risk of count duplication, a precautionary approach, to account for GPS error, has been taken whereby RPS records were only considered to be 'new records' across the survey period if they were greater than 10 metres in distance from previous (i.e. 'old') RPS records. It is noted that there are some inconsistencies between the counts shown below and those presented in the Ecological Inventory Report (RPS 2012) and the 2011 TMO Report (RPS 2011). These inconsistencies are due to GPS referencing, wherein the counts in the present report have been derived using the 10 metre distance threshold to avoid, with absolute confidence, any risk of count duplications from the RPS surveys. The 10 metre distance threshold was not adopted in the previous RPS reports and thus would have yielded higher count numbers being tabled relative to this report.

The approximate locations of the records made by RPS between 2010 and 2012 are provided in **Figure 7**.

4.3.1 Tuncurry Project Site

Within the project site, RPS recorded a total of 1,293 individuals in 2010.

RPS recorded a total of 25 TMO individuals within the Project Site in 2011, however 11 of these stems were within close proximity to stems recorded in 2010 and have been considered possible duplicates as a precautionary approach, using the 10 metre distance threshold as described above.

Of the newly recorded 14 stems in 2011, 11 were recorded in one of the 9 quadrats, to the south of the Golf Course. The structure of the vegetation was low (1.2m) heath with clear gaps and exposed area. There was also some evidence of past fire exposure. The vegetation within this plot was dominated by *Banksia serrata*, *Leptospermum laevigatum*, *Dillwynia retorta*, *Boronia pinnata*, *Ricinocarpos pinifolius* and *Lissanthe strigosa*. The remaining three individuals were recorded along a 4WD access track west of the powerline easement (east of Chapmans Road).

The 2012 targeted transect surveys did not record any TMO in dense Heathland or Forested habitats across the subject site.

One TMO colony (comprised of 6 flowering stems) was recorded within a 'gap' in the Heathland to the north-east of the Golf Course close to an access track (**Figure 2**). The main floristic differences observed in this area were an absence of Banksia and lower density of Monotoca and Leptospermum, resulting in a sparse groundcover and sandy patches due to lack of leaf litter. Furthermore there were no obvious indications of disturbance (human or other).

In addition to the six individuals recorded within the gap in Heathland, a total of 95 new TMO stems were also recorded along the edges of the dense Heathland, and along existing 4WD access tracks, the easement and within Paget's (2008) 'core population'.

As such the 2012 surveys undertaken by RPS recorded 309 stems, with 101 of these considered to be newly recorded individuals.

The overall total stems recorded by RPS within the Project Site between 2010 and 2012 are 1,408 stems.

The results of 2012 transect surveys provided verification of the previous conclusions in relation to preferred TMO habitat on the Tuncurry Project Site and earlier hypothesis regarding the potential habitat offered within the dense heath environs across the Project Site (refer to Section 6 for further discussion).

4.3.2 Offsite lands

An additional 436 individuals were recorded to the immediate northwest of the Project Site adjacent to the Tuncurry Tip in 2010. The large number of orchids, which were detected within and to the northwest of the Crown Lands Tuncurry site, potentially extends Paget's (2008) 'core population'.

In 2010, 90 plants were also recorded in Booti Booti NP, whilst an additional 59 plants were recorded on Crown Lands at Minimbah.

In 2011, seven plants were recorded to the immediate northwest of the Project Site adjacent to the Tuncurry Tip. The visit to this location at that time was undertaken to briefly verify the presence of flowering stems at the Project Site of a known large population, prior to the commencement of the plot surveys. Due to the close proximity to records made in 2010, these seven plants were not considered to represent new records.

An additional 4 plants were recorded on Crown Lands at Minimbah.

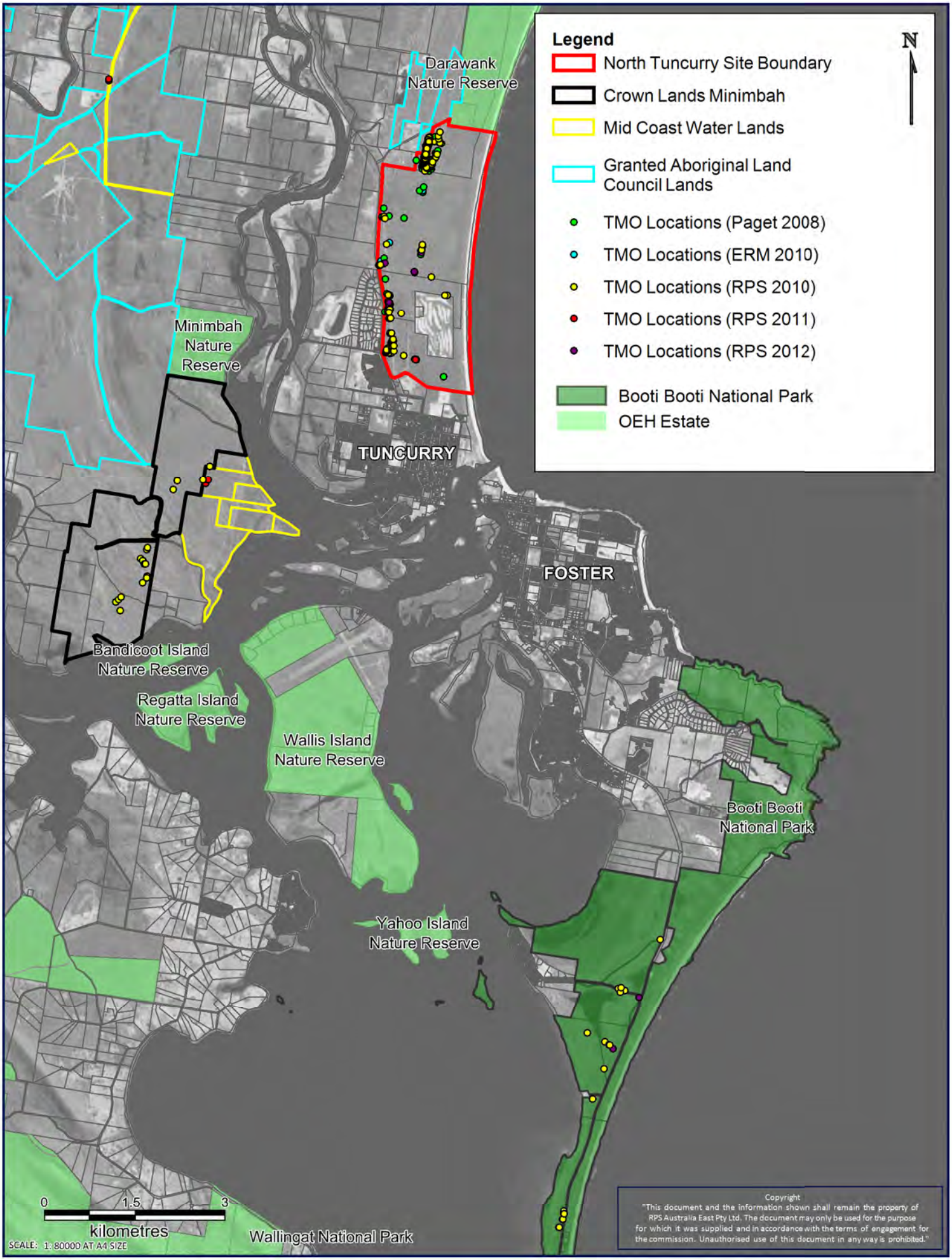
Locations of TMO recorded by RPS during the 2010-12 surveys for both the North Tuncurry and Offsite Areas are shown in **Figure 7.** Notably validation of existing populations in Minimbah during 2012 did not observe any of the previously recorded plants or any new individuals. This is concurrent with flowering patterns observed in many orchid species and the information on TMO presented in **Section 2**.

4.4 Overall Population Count Summary

Results from TMO population counts undertaken by Paget (2008), ERM (2010) and RPS in 2010-2012 across the known distribution of this species are provided below in **Table 2**. These results have been derived by using the 10 metre distance threshold as described in **Section 4.3** above. When considering duplicate records, priority has been given to RPS records, followed by Paget (2008) and lastly ERM (2010). The order of priority was decided based on knowledge of accuracy of RPS records and/or the availability of stem counts per point location available in Paget (2008).

Table 2 RPS TMO Population Count Summary

Location	Paget (2008)	ERM (2010)	RPS (2010)	RPS (2011)	RPS (2012)	Total TMO Records
Project Site	188	47	1,293	14 (includes 11 stems from quadrat searches)	101 (includes 6 TMO recorded within gap in dense heathland)	1,643
Area adjacent to the Project Site (to the north)	81	-	436	-	1	518
Crown Lands, Minimbah	-	-	59	2	-	61
Midcoast Water Lands, Minimbah	-	-	-	2	-	2
Green Point, Tiona (Booti Booti)	-	-	90	-	2	92
Total	**269**	**47**	**1,878**	**18**	**104**	**2,316**



TITLE: FIGURE 7: OVERALL SURVEY RESULTS (NORTH TUNCURRY AND ADDITIONAL OFFSITE AREAS)

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 09/08/2012
PURPOSE: TMO REPORT 2012

J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\2012 TMO Workspaces

VERSION (PLAN BY): P. HILLIER

CLIENT: LANDCOM
JOB REF: 26414

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4.5 Voucher Specimen Confirmation

4.5.1 Australian National Herbarium

All three specimens submitted to the Australian National Herbarium were confirmed to be *Corunastylis littoralis* by Dr Mark Clements. The confirmation received from the Australian National Herbarium is provided as **Appendix 5**.

4.5.2 National Herbarium of NSW

All specimens submitted to the NSW National Herbarium were identified as *Genoplesium rufum* by Dr Peter Weston. The letter of confirmation received from the NSW National Herbarium is provided as **Appendix 6**.

4.5.3 Discovery of co-occurring *Genoplesium* taxa

In addition to the NSW National Herbarium identification of *Genoplesium rufum* from the North Tuncurry and Green Point Road populations, a further *Genoplesium* species, namely *Genoplesium filiforme*, was also recorded during the 2012 surveys within the low Heathland (Green Point Road powerline easement) habitat within the TMO Green Point/Tiona population adjoining Booti Booti National Park. This record was later validated by Dr Lachlan Copeland via photographs taken from the Green Point Road population.

Both newly identified *Genoplesium* species were observed in the immediate vicinity (<50mm) of flowering TMO stems at the North Tuncurry and Green Point/Tiona populations.

A description of the two additional *Genoplesium* taxa is provided below. This had been taken from Jones (2006) with additional author observations noted in parentheses.

Genoplesium rufum

Leaf - 100-160mm long; thin; free part 10-20mm long, ending below flowers. Spike – 15-30mm tall, 5-25 flowered. Flowers – moderately crowded, nodding, 3.5-4.5mm x 4-5mm, pinkish or reddish. Dorsal sepal – 2.5mm x 2.0mm, sometimes with dark bands; margins hairless. Lateral sepals – divergent, 3.5-4.0 x 1mm, base (strongly) humped; apex sharply pointed or with tiny vestigial gland (gland often appears as a tiny white or translucent ball). Petals - 2-2.3 x 0.9mm, margins hairless; apex sharply pointed. Labellum – stiffly hinged, obovate, 2.5 x 1.3mm, fleshy, whitish or pinkish with black callus; margins slightly irregular; apex sharply pointed and (strongly) recurved. Callus – oblong, constricted, extending nearly to labellum apex.

A photograph of the flower spike of *Genoplesium rufum* recorded on the Project Site (taken by RPS in 2012) is provided below as **Plate 10**. Note the conspicuous apical glands on the lateral sepals.

Genoplesium filiforme

Leaf - 150-300mm long; free part 10-20mm long, ending well below flowers. Spike – 10-45mm tall, 5-30 flowered. Flowers – moderately crowded, projecting, 6.5 x 5mm, greenish to purple with reddish purple to purple labellum. Dorsal sepal – 4.5 x 2mm; margins with short hairs; apex sharply pointed. Lateral sepals – widely divergent, 6 x 1mm; (apex often sharply pointed or acute and curved upwards). Petals - 3.5 x 1mm, margins with short hairs (cilia); apex sharply pointed. Labellum – tremulous, obovate, 3.5-4 x 1.8mm, thin textured, margins with numerous short hairs (often along the entire margins); apex pointed (acuminate). Callus – not extending near labellum apex (appears as a dark red marking covering half to two thirds of the labellum).

A photograph of the flower spike of *Genoplesium filiforme* recorded at Green Point (taken by RPS in 2012) is provided below as **Plate 11**. Note dark Callus marking on the labellum and short hairs (cilia) along the margins of the labellum (appear in photo as tiny white hairs).

Plate 1 Flower spike of *Genoplesium rufum*

Plate 2 Flower spike of *Genoplesium filiforme*

A comparison of the morphological features between *Genoplesium littorale, Genoplesium rufum* and *Genoplesium filiforme* is provided in **Table 3** below.

Table 3 Comparison between *Genoplesium littorale* and *G. rufum, G. filiforme*

Character	*G. littorale*	*G. rufum*	*G. filiforme*
Lateral sepal	4 mm long, relatively narrow, no apical glands, slight hump towards base	3.7 mm long, relatively broad, whitish glands at tip, strongly humped close to base	5mm long, no apical glands, often widely divergent; apex often curved upwards
Dorsal sepal	Shallowly concave, relatively narrow with a straight acuminate tip	Deeply concave, relatively broad with an acute deflexed tip	Ovate; margins with cilia
Petal(s)	Lanceolate, drawn out to an acuminate point	Ovate, drawn out to an acuminate point	Ovate; margins with cilia
Labellum	Thick and fleshy when fresh, purple coloured, callus occupies most of the lamina and has a shallow central groove that is smooth and shiny	Thin labellum lamina with a broad deeply furrowed callus occupying most of the lamina surface	Obovate; margins with cilia; acuminate tip; callus occupying half to two thirds of labellum
Overall	Key features are the fleshy purple labellum, rather narrow drawn out petals and sepals, the lack of apical glands on the lateral sepals and	Key features are the lateral sepal apical glands (often appearing as conspicuous white or semi translucent	Key features are the dark markings on the labellum and short hairs on the margins of the labellum, petals and dorsal sepal.

Character	*G. littorale*	*G. rufum*	*G. filiforme*
	the obscure lateral sepal hump.	balloons) and prominent hump on (at the base of) the lateral sepals, the relatively broad petals and sepals and the deep furrow in the labellum callus.	

The TMO habitat validation works undertaken by the RPS in the 2012 survey season did not include detailed counts of the additional co-occurring *Genoplesium* taxa. Such counts would have required the close inspection (10x hand lens) of all *Genoplesium* spp. flowering stems across the TMO populations to determine population size and extent. Rather, the Proponent has decided to take a precautionary approach and consider all *Genoplesium* spp. records to date on the Project site as that of the TMO.

5.0 Additional TMO Research

5.1 FloraSearch (2012) Pollination Study

Dr Colin Bower from FloraSearch Pty Ltd, a recognised orchid botanist and entomology expert in NSW, was commissioned by Landcom to undertake a pollination study of the TMO on the Project Site during the latter part of the 2012 flowering season. The purpose of the study was to increase the knowledge base of the ecology/biology of the species, which, in turn, would assist Landcom and its representatives in considering the potential impacts of a proposed urban development of the Project Site on the TMO population.

The specific study objectives, noted by FloraSearch (2012), were as follows:

- To determine the pollination mechanism employed by *Genoplesium littorale*, i.e. whether it be by outcrossing, selfing (autogamous) or apomixy (i.e. producing seed without fertilisation);
- To determine whether the flowers of *G. littorale* emit an odour and/or produce nectar to attract pollinators; and
- If the species is autogamous, to determine the mechanism of autogamy via microscopic examination of flowers at different stages of development.

A summary of the methods and results of the pollination study undertaken by FloraSearch (2012) is produced below. The full FloraSeach (2012) report is provided as **Appendix 2**.

The pollination study was undertaken under licence approval from both OEH and SEWPAC.

Results

Odour and nectar

No nectar was detected on the labellum of *G. littorale* flowers from the powerline easement colony. These flowers were relatively old, however, and may no longer have been functional.

No flowers were available for examination from the main colony (as defined by Paget (2008)).

Seed set

The proportions of flowers developing seed pods varied widely from zero to 100 percent, with an average (mean) of 34.6 percent. Similar levels of seed set were present at both the main colony and power line easement colonies. Of the 18 inflorescences inspected, a total of 16 had at least one developing seed pod whilst a total of 7 inflorescences had at least 30% of its flowers developing seed pods (indicating relatively high seed set levels on about 40% of the inflorescences inspected).

Flower Dissection

Results from the flower dissection indicated high levels of pollinaria removal (77 and 95 %) from the *G. littorale* flowers that were examined from the main colony and powerline easement colonies, respectively. However, the powerline easement colony exhibited much higher pollination (74% vs. 15%) and seed pod development (68% vs. 23%) than the main colony.

It is not clear why such low levels of pollination occurred in the Tip colony when the levels of pollinaria removal were relatively high. FloraSearch (2012) surmise that the weather conditions may have inhibited pollinator activity when the flowers were at their most receptive, and that by the time suitable weather

conditions (i.e. sunny, warm/hot) arrived for pollinator activity, the flowers were aging such that the stigma was less receptive (drying out), even though pollinaria was available for removal.

In contrast, the high level of pollination and seed set observed in the powerline easement plant appears to have been due to a combination of optimal flower function coinciding with suitable weather conditions for pollinator activity.

No evidence of self-pollination was found in any flowers examined amongst the two colonies. There was no indication of growth of the anthers or stigmas towards each other nor the dropping of pollen onto the stigma from an anther. All observed pollinaria maintained their coherence and separation from the stigma, thereby precluding autogamy.

FloraSearch (2012) noted that the results from the flower dissection did not support the occurrence of apomixy amongst the TMO population. Although two flowers on the main colony plant appeared to develop seed pods without pollination, it is possible the pollen had been fully absorbed into the stigma by the time the flowers were closely examined.

The observations of floral morphology, pollinaria removal and pollen deposition in *G. littorale* were all consistent with insect-mediated pollination.

Study Limitations

It is noted that the majority of the 18 inflorescences inspected for seed pod development had no remaining open flowers (had gone to fruit) and thus could not be distinguished between the 2 Genoplesium species that appear to be co-occurring on the Tuncurry Project Site, these being *Genoplesium littorale* and *Genoplesium rufum* (due to the delay in the start of the study until the end of the 2012 flowering season).

Whilst this limitation could have affected the interpretation of the seed pod development data, it is emphasised that the pollination results from the flower dissections were derived from *G. littorale* specimens and thus have no doubt associated with them. Furthermore, the pollination results from the flower dissections are generally consistent with the interpretation of the field observations and that on balance such a limitation is unlikely to have greatly affected the pollination conclusions reached in the report.

A continuation of pollination research proposed for 2013 will help to address this limitation.

Conclusion

FloraSearch (2012) concluded that observations of floral morphology, pollination rates and seed pod development in *G. littorale* were all consistent with insect-mediated pollination (i.e. outcrossing).

Discussion of suspected TMO Pollinators

Suspected pollinator species

In a discussion of the life cycle ecology of the TMO provided in **Section 2** of this report, it was noted that the existing literature on the *Genoplesium* genus stated that the pollinators are likely to be tiny flies of the families Chloropidae and Milichiidae in the superfamily Chloropidae. FloraSearch (2012), in its discussion of suspected TMO pollinators, noted that, according to existing literature, the adults of Chloropidae '*are of almost ubiquitous occurrence, and the larvae inhabit a wide range of habitats, though still little known*. *It is likely that the Chloropid or Milichid pollinators of G. littorale are abundant at the Tuncurry Project Site, especially given the very high pollination percentages that were observed on some of the plants*'.

FloraSearch (2012) also remarked that all insect pollinated *Genoplesium* species that have been investigated to date appear to secrete copious amounts of nectar from the labellum callus and that such plants that reward their pollinators with food tend to attract multiple pollinator species. FloraSearch (2012) thus concluded that '*it was likely that G. littorale is pollinated by a suite of chloropoids, rather than a single species, although at any particular site, one species may be greatly dominant'*.

Patch size requirements of suspected pollinators

FloraSearch (2012) also provided a brief discussion on the likely patch size requirements of the suspected TMO pollinator(s) which is summarised below.

The pollinators of *Genoplesium* are very small species of flies, so small that they have been observed to move through insect mesh screen doors. Whilst little is known about minimum viable areas for insect conservation, insects of this size are unlikely to require very large areas in order to maintain viable populations. Areas in the vicinity of 25 to 100 hectares have been recommended for some of the larger invertebrates thus it is reasonable to consider that insects as small as chloropoids are likely to maintain viable populations in smaller areas than this. FloraSearch (2012) concluded that a minimum viable patch size between 10 to 25 hectares is considered likely to provide sufficient habitat to maintain large population sizes of chloropoids and to provide a buffer against catastrophic events.

Notably the core TMO population at Tuncurry appears to have persisted in the wild since at least 1992 within 120 metres from both the residential and industrial development areas of North Tuncurry on the western side of The Lakesway and the Tuncurry Waste Management Centre. The human incursion in close proximity to TMO does not appear, from RPS investigations, to have impacted on the viability of this population or its pollinators.

Recommendations for further research in relation to TMO pollination is outlined in **Section 9.3** of this report.

5.2 RBG Seedbanking

Dr Karen Somerville from The Royal Botanic Gardens & Domain Trust (RBG) in Sydney was commissioned by Landcom, on the advice of RPS, to undertake an *ex situ* conservation program for *Genoplesium littorale*, to both increase the knowledge base of the biology of the species (e.g. mycorrhizal fungal relationships) and to ultimately provide a safeguard for the species against future threats to its survival. The *ex situ* conservation program is comprised of the following 3 components:

- Collection of TMO seed and soil from the Tuncurry Project Site;
- Isolation of mycorrhizal soil fungi; and
- Encapsulation of seed and isolated fungi in alginate beads for long term storage.

Ultimately, the alginate beads can be used to establish an *ex situ* population of the TMO which, in turn, can be planted out within (and used to supplement) the *in situ* TMO populations.

Seedbanking using the encapsulation-dehydration method is a recognised and proven technology for orchid conservation (Somerville *et al* 2008).

The *ex situ* conservation study was undertaken under licence approval from both OEH and SEWPAC.

Results

A Progress Letter Report outlining works undertaken to date by Dr Somerville (RBG 2012) is provided as **Appendix 7**.

A total of 13 mature and immature pods were collected from 6 Genoplesium plants within the Tuncurry Tip and powerline easement colonies by Dr Somerville on 18 April 2012. Soil samples were also collected from the base of at least 2 plants from each colony.

The pods and soil collected from the Project Site were transported to the Mt Annan Botanic Gardens on 20 April 2012. Following transport, the mature pods were placed in a drying room to ripen whilst the stem with immature pods was placed in a vase of tap water at room temperature to facilitate pod maturation.

Seeds were subsequently extracted from the pods and inspected under a microscope to determine seed quantity and quality (i.e. viability). Good quality seed from the Tuncurry Tip colony was subsequently sown onto site soil in Petri dishes, placed in incubators and is presently being monitored fortnightly (over a few months) for germination of seedlings. The base of germinated seedlings (called the protocorm) would then be used to try and isolate the mycorrhizal fungus necessary for orchid seed germination. Should the soil fungus be successfully isolated, both seed and fungal material would be encapsulated in alginate beads and stored indefinitely at low temperature.

Study Limitations

In their report RBG (2012) note that insufficient seed was collected in the 2012 fruiting season for which to undertake the encapsulation component of the *ex situ* conservation program.

It is also noted that results from the 2012 seed collection should, as with the pollination study, be treated with caution and considered as 'Preliminary Only' at this stage. This is due to the fact that RBG was not able to determine whether seed pods collected on the Project Site were from *Genoplesium littorale* or from *Genoplesium rufum* as flowering had ceased by the time Dr Somerville had visited the site.

Further seed pod collections earmarked for the 2013 autumn season should help to address these limitations.

6.0 TMO Habitat and Distribution

6.1 Habitat Validation Surveys

6.1.2 Method

The collection of specific habitat data for all known TMO populations was considered a priority for the 2012 TMO investigations as this information was considered to be lacking in both the TSC and EPBC Scientific Committee Determination listings for the species and in some of the previous investigation reports. The collection of specific habitat data was considered essential to assist in assessing potential impacts on the species from the proposed urban development of the Tuncurry Project Site.

An NPWS Threatened Plants Proforma was completed by RPS ecologists during 19-22 March 2012 at each of the following three TMO populations where flowering stems were observed and identified to be the TMO with a 10x hand lens:

- North Tuncurry population, comprising Paget's (2008) northern and southern colonies;
- Green Point Road population; and
- Booti Booti NP population at Tiona.

The habitats for a fourth TMO population at Minimbah on both Crown Lands and Mid Coast Water Lands have been assessed. Whilst no TMO flowering stems were recorded during the 2012 validation surveys, habitat information was nevertheless collected from this population during previous seasonal surveys undertaken by RPS in 2010 and 2011.

Information recorded on the proforma included:

- Locational details including GPS grid references (+/- 5-10 metre accuracy);
- Time and data;
- Vegetative Community description to sub-formation level;
- Vegetative Structure (projected foliage cover and height of all strata);
- Associated plant species (vascular and non vascular);
- Soils and geology;
- Disturbance (e.g. mining, fire, weeds); and
- Adjoining vegetation communities/habitats.

6.1.3 Results

6.1.3.1 East of Tuncurry Tip ('main colony' of Paget 2008)

The core population situated approximately 120 metres due east of the Tuncurry Tip occurs within a horseshoe-shaped former mineral sands strip mining area in Dry Sclerophyll Shrubland on a Holocene-aged dunefield on moist to well drained podsolised sands. Vegetative structure and floristics of this TMO habitat is outlined below.

Emergents (5% Projected Foliage Cover; to 10 metres height) - *Eucalyptus pilularis*;

Small Trees (5-10% Projected Foliage Cover; to 6 metres in height) – *Banksia serrata, Callitris endlicheri*;

Shrubs (15-40% Projected Foliage Cover; to 4 metres in height) – *Monotoca elliptica, Acacia sophorae, Leptospermum laevigatum, Persoonia lanceolata, Bossiaea rhombifolia* subsp*. rhombifolia, Leptospermum polygalifolium* subsp*. cismontanum, Dillwynia retorta, Conospermum taxifolium, Leucopogon lanceolatus var gracilis, Acacia ulicifolia, Acacia suaveolens, Leucopogon parviflorus, Zieria laxiflora, Gompholobium latifolium*.

Groundcover (10-30% Projected Foliage Cover; to 1.5 metres in height) – shrub seedlings, *Hibbertia obtusifolia, Pteridium esculentum, Gonocarpus teucrioides, Dianella revoluta, Platysace lanceolata, Eragrostis brownii, Macrozamia communis, Astroloma pinifolium, Euryomyrtus ramosissima* subsp*. ramosissima*.

Lichens (0-15% cover; to 50mm height) - Cladia *aggregata, Heterodea muelleri, Cladonia spp*.

Leaf litter (0- 70% cover) – Comprised predominantly of *Monotoca elliptica, Leptospermum laevigatum, Acacia sophorae, Persoonia lanceolata*.

Miscellaneous Notes - The TMO was often observed in the drip zone of *Monotoca elliptica* (+/- leaf litter and lichen spp.).

Plate 3 Dry Sclerophyll Shrubland east of Tuncurry Tip (habitat for main TMO colony)

Plate 4 Typical TMO groundcover at Tuncurry population with TMO seedlings

Note in Plate 4 above typical leaf litter with a sparse to moderate cover of lichen indicating a moist soil surface. (Also note macropod scat next to reference pen).

6.1.3.2 Crown Lands Minimbah Population

The population is situated approximately 6 to 8 kilometres south-west of the Tuncurry Core TMO population described by Paget (2008) on the Minimbah/Nabiac Sandbeds , occurring as generally scattered records throughout a former mineral sands strip mining area.. Habitat preference for the TMO in this location appears to be a Low Open Dry Sclerophyll Woodland (**Plate 5**) on Pleistocene sandsheets dominated by scattered Scribbly Gum (*Eucalyptus racemosa* var *racemosa*). All areas were noted to have been burnt in recent years, with some locations exhibiting a lower, Heath like appearance (**Plate 6**), whilst other areas were found to have retained a woodland canopy. The disturbance regimes that may have contributed to these vegetative structures are believed to be a combination of past mineral sand mining, as well as fire, however the composition of flora is similar throughout. Vegetative structure and floristics of this TMO habitat is outlined below.

Emergents (5% Projected Foliage Cover; to 8 metres height) - *Eucalyptus racemosa* var *racemosa*;

Small Trees (5-10% Projected Foliage Cover; to 6 metres in height) – *Banksia serrata*;

Shrubs (15-40% Projected Foliage Cover; to 4 metres in height) – *Leptospermum polygalifolium* subsp*. cismontanum, Dillwynia retorta, Bossiaea rhombifolia* subsp*. rhombifolia, Acacia ulicifolia* and *Leucopogon parviflorus*.

Groundcover (10-30% Projected Foliage Cover; to 1.5 metres in height) – shrub seedlings, *Caustis flexuosa*, *Platysace lanceolata, Eragrostis brownii, Euryomyrtus ramosissima subsp. ramosissima*.

Leaf litter (0- 10% cover) – Comprised predominantly of *Eucalyptus racemosa* var *racemosa* and *Banksia serrata*.

Plate 5 Scribbly Gum Woodland Habitat

Plate 6 Heath Habitat

6.1.3.3 Midcoast Water Lands Minimbah Population

This population is situated 6.8km north of the Crown Lands Minimbah population within an electricity easement which intersects Elliots Rd. The vegetation is not dissimilar to that of the Crown Lands Minimbah population located to the south, although the disturbance regime associated with the maintenance of the easement has altered the structure of this vegetation, including the removal of the canopy layer. The TMO individuals recorded within the Midcoast Water Lands occur within this easement (see **Plate 7**). Vegetative structure and floristics of this TMO habitat is outlined below.

Shrubs (15-40% Projected Foliage Cover; to 2 metres in height) – *Leptospermum polygalifolium* subsp*. cismontanum, Dillwynia retorta, Bossiaea rhombifolia* subsp*. rhombifolia, Acacia ulicifolia* and *Leucopogon parviflorus*.

Groundcover (10-30% Projected Foliage Cover; to 1.5 metres in height) – shrub seedlings, *Caustis flexuosa*, *Platysace lanceolata, Eragrostis brownii, Euryomyrtus ramosissima subsp. ramosissima*.

Plate 7 Heathland in Midcoast Water Lands Electricity Easement

Plate 8 Heath Habitat adjacent to easement

6.1.3.4 Powerline Easement between Tuncurry Tip and Tuncurry TAFE (southern colony of Paget 2008)

The southern portion of the core population of Paget (2008) was recorded within the 30 metre wide and 3.2km long powerline easement that runs parallel to The Lakesway from the Tip Road south to the Tuncurry TAFE. Within the powerline easement, the TMO occurs amongst a periodically slashed (regenerating) Dry Heathland community on well drained podsolised sands of Holocene origin. Some sections of the easement appeared to have been recently slashed (within the last 3 months). Vegetative structure and floristics of this TMO habitat is outlined below.

Heathy Shrubs (15-70% Projected Foliage Cover; to 0.5 metres in height) – *Caustis recurvata* var *recurvata, Boronia pinnata*, *Dillwynia retorta*, *Monotoca scoparia, Monotoca elliptica, Brachyloma daphnoides, Phyllota phylicoides, Acacia sophorae, Bossiaea heterophylla, Leptospermum polygalifolium* subsp. *cismontanum, Dillwynia retorta, Ricinocarpus pinifolius, Allocasuarina littoralis, Conospermum taxifolium, Leucopogon muticus, Leucopogon parviflorus, Zieria laxiflora, Hypolaena fastigata, Lomandra glauca, Leptospermum laevigatum, Calytrix tetragona, Ochrosperma lineare, Leucopogon ericoides, Hibbertia obtusifolia, Hibbertia linearis, Astroloma pinifolium*.

Lichens (0-15% cover; to 50mm height) - *Cladia aggregata, Heterodea muelleri, Cladonia spp*.

This periodically slashed Heathland habitat grades slightly upslope into a *Banksia aemula-Leptospermum polygalifolium* subsp*. cismontanum* Dry Heathland fringing the eastern side of the easement and slightly downslope into a *Leptospermum laevigatum* Dry Sclerophyll Shrubland fringing the western side of the easement.

Plate 9 Slashed heathland in Tuncurry Powerline Easement (note recently slashed heath in left of plate)

6.1.3.5 Powerline easement along Green Point Road, Green Point

The Green Point Rd population is also situated within a powerline easement that runs within the road reserve on the northern side of Green Point Rd between The Lakesway and Green Point. Within the powerline easements, the TMO occurs amongst a periodically slashed (regenerating) Intermediate Dry Heathland community on moist to well drained podsolised sands of Holocene origin. Vegetative structure and floristics of this TMO habitat is outlined below. There appears to be some habitat affinity with the 'southern' (powerline easement) TMO population at Tuncurry although with a greater composition of sedges compared to the Tuncurry population. The dunes along the Green Point Rd easement may be somewhat deflated with a shallow water table occurring following periods of high rainfall (Griffith et al 2000).

Heathy Shrubs (30-50% Projected Foliage Cover; to 0.3 metres in height) – *Caustis recurvata* var *recurvata, Boronia pinnata*, *Monotoca scoparia, Phyllota phylicoides, Bossiaea heterophylla, Leptospermum polygalifolium* subsp*. cismontanum, Conospermum taxifolium, Leucopogon muticus, Zieria laxiflora, Hypolaena fastigata, Calytrix tetragona, Hibbertia linearis, Lepyrodia scariosa, Goodenia heterophylla, Bossiaea ensata, Epacris obtusifolia, Melaleuca nodosa, Acacia linifolia, Eriostemon australasius, Dillwynia floribunda, Acacia brownei, Gonocarpus teucrioides, Actinotus helianthi, Pimelea linifolia, Leptocarpus tenax, Tatraria capillaris, Isopogon anemonifolius, Baeckia imbricata*.

Lichens (0-15% cover; to 50mm height) - *Cladia aggregata, Heterodea muelleri, Cladonia spp*.

This habitat grades slightly upslope into a *Banksia aemula-Leptospermum trinervium* Dry or Intermediate Dry Heathland fringing the northern side of the easement.

Plate 10 Slashed heathland within Green Point Rd Powerline Easement

6.1.3.6 Powerline easement Booti Booti NP (Tiona)

The Booti Booti population is similarly situated within a powerline easement that runs parallel with The Lakesway (20-25 metres west of the road edge) approximately 4km south of the Green Point Road population. The TMO occurs amongst a periodically slashed (regenerating) Intermediate Dry Heathland community on moist to well drained podsolised sands of Holocene origin. Vegetative structure and floristics of this TMO population is essentially as per the Green Point Road population. The perennial grass weed Whisky Grass (*Andropogon virginicus*) has invaded portions of the easement and will ultimately impact upon the availability of habitat for the TMO without adequate control.

This habitat grades slightly upslope into a *Banksia aemula-Leptospermum trinervium* Dry Heathland fringing the eastern and western sides of the easement.

Plate 11 Booti Booti Powerline Easement (note band of whisky grass in centre of photo)

6.2 Disturbance Regimes

The North Tuncurry Project Site has been subject to a range of human disturbances dating back to at least 1911. These include forestry, mineral sands mining and bushfires. A clear relationship between the occurrence of TMO and particular disturbances are apparent from desktop studies and site investigations. A description of each disturbance is provided below.

Pine Plantation

Historic planting of *Pinus radiata* has occurred across the Project Site since 1913 (Bailey 1931). Native vegetation growing on targeted compartment lots was either “cleared and burnt”, “felled and burnt” or

"brushed, mattocked and planted" to make way for Pine plantations (Bailey 1931). Forestry plantation operations continued on the Project Site until 1938.

The TMO may have exploited the disturbance associated with staged vegetation clearing and logging, as this is consistent with anecdotal reports of the species presence on the Project Site since the 1940s (Paget 2008). Tracks still present today, which contain TMO, are likely to have been created as part of the compartmentalisation of the forestry areas.

Areas dominated or co-dominated by exotic Pines are still present on the Project Site and are typically associated with a relatively thick leaf litter of pine needles. Such areas are thought to generally limit the recruitment potential of the TMO as the leaves of dormant tubers may struggle to penetrate the litter in order to photosynthesise. The compartment layout, digitised from historic maps (Bailey 1931) is provided in **Figure 8**.

Mineral Sands Mining

The main TMO colony at North Tuncurry (east of the Tuncurry Tip) appears to have exploited historical vegetation clearing associated with dredge line excavation for mineral sands mining undertaken on the Project Site in the 1960s and 1970s. It is not known whether the existing Dry Sclerophyll Shrubland habitat (main TMO colony habitat) regenerated naturally post mining or whether the area was subject to a post mine rehabilitation planting program. Regardless of the origin of the Shrubland, the historical mining activities have led to a 'sparse' vegetation cover that the species has exploited.

A population of the TMO was recorded by RPS on Pleistocene sandsheets within Crown Lands at Minimbah by RPS in 2010 and 2011. The Minimbah population occurs within a *Eucalyptus racemosa* var *racemosa* Dry Sclerophyll Low Open Woodland in an area that was also subject to mineral sands mining (Department of Minerals and Resources, undated). The mineral sands mining in this area is represented by the red areas on **Figure 9**.

Powerline Easements

The North Tuncurry TMO population is also concentrated within the main powerline easement situated between the Tuncurry Tip and the Tuncurry TAFE. The easement was established sometime prior to 1952 based on our review of the earliest available (1952) aerial photograph of the site. The Green Point and Tiona TMO populations are also contained primarily within existing operational powerline easements which are regularly (typically annually) slashed to maintain a vegetative height of the relevant Heathland communities of less than 1 metre. This slashing regime appears to favour the species by maintaining an artificially low Heathland habitat with high sunlight exposure. However, vegetation slashing at inappropriate times during the TMOs flowering and fruiting season can have detrimental effects on the seed production of the species for one or more years.

Bushfire

The north-eastern section of the Project Site was subject to a high intensity bushfire in 2007. The fire reportedly started in the Tuncurry Waste Management Centre west of the main TMO colony and proceeded to burn northwards into Darawank Nature Reserve but also crept into the north- eastern portion of the North Tuncurry site. Surveys by RPS in recent years have failed to locate any TMO flowering stems in these burnt areas. Recently burnt *Banksia aemula* Heathland in Booti Booti National Park near Green Point was also searched for the TMO by RPS in 2012. No TMO stems were recorded during the search.

TITLE: FIGURE 8: PINE FORESTRY OPERATIONS, NTH TUNCURRY

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 26/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\Workspaces\TMO Report Figures\2012 TMO Report Figures
VERSION (PLAN BY): P. HILLIER

CLIENT: LANDCOM
JOB REF: 26414

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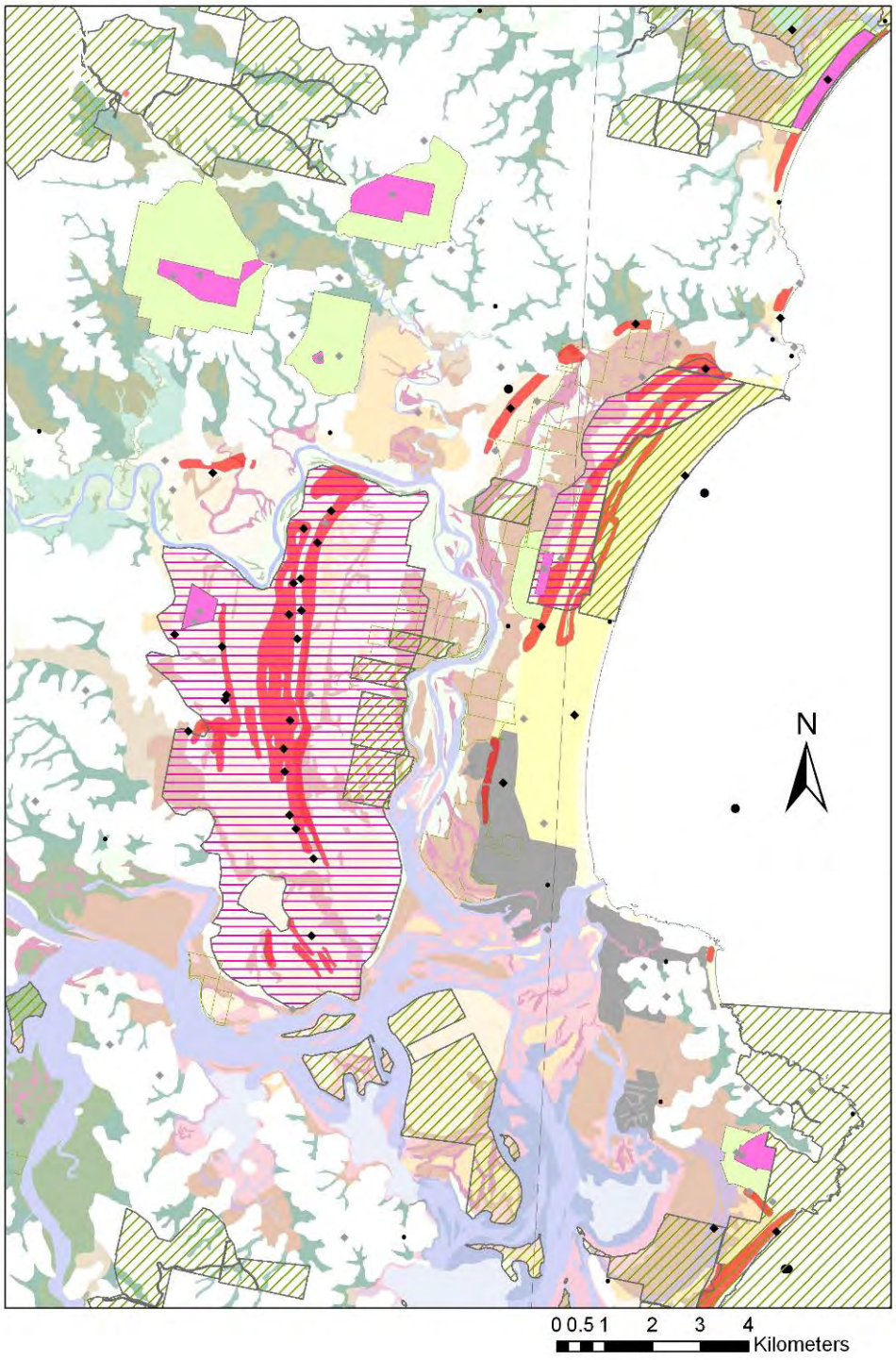


Figure 9: Mineral Sands Mining - Nth Tuncurry and Minimbah.

Note: Red indicates location of Mineral Sands Mining Activities.

6.3 Observed Habitat Preferences of the TMO

Results from the habitat validation undertaken by RPS during the TMOs 2012 flowering season as well as those of the dense Heathland searches indicate the following two main habitat preferences for the species (both on and off the North Tuncurry site):

- Artificially created low Holocene dune Heathlands (to 300mm height) in powerline easements that are regularly maintained by slashing (e.g. North Tuncurry, Green Point/Tiona populations); and
- Relatively Open Dry Sclerophyll Shrublands on Holocene dunes that have established in areas subject to historical vegetation clearing associated with dredge line excavation for mineral sands mining east of the Tuncurry Tip. The Shrublands are characterised by a thin layer of leaf litter or bare soil with 2 to 3 lichen species where the orchids have little competition for available light and do not have to germinate amongst or through thick leaf litter. It is not known whether the existing Dry Sclerophyll Shrubland habitat (main TMO colony habitat) regenerated naturally post mining or whether the area was subject to a post mine rehabilitation planting program. Regardless of the origin of the Shrubland, the historical mining activities have led to a 'sparse' vegetation cover that the species has exploited.

A third habitat preference for the TMO appears to be a Low Open Dry Sclerophyll Woodland on Pleistocene sandsheets dominated by scattered Scribbly Gum (*Eucalyptus racemosa* var *racemosa*) that RPS recorded on Crown Lands at Minimbah in 2010 and 2011. These previous records similarly occur in an area subject to historical mineral sands mining (Department of Minerals and Energy, undated).

As discussed in **Section 4.3.1**, results from the TMO surveys undertaken by RPS in 2011 and 2012 on the Tuncurry Project Site confirmed that the species occurs on the edges of, or in gaps within, the dense Heathland habitat and only in very low numbers in comparison to populations occurring in open areas or previously disturbed areas such as the Project Site Power Easement and core population described by Paget (2008), occurring in the northern Project Site area. The dense vegetation cover and thick leaf litter associated with the Heathland habitat would be expected to preclude the use of this habitat for the TMO based on its known habitat preferences, at least until such time as a disturbance event takes place (eg. fire) which 'opens' up the vegetation for the species to temporarily exploit.

As such, the TMO is considered to be a specialist species that requires minimum competition for sunlight to survive and has clearly exploited different disturbance regimes (e.g. mineral sands mining, Pine Forestry, powerline easements) that have operated on the Project Site (and in the wider locality) since the early 1900s. It is unknown whether the TMO occurred on the Project Site prior to the disturbance activities. If present, it is thought that the species would have been dependent on natural fires and storms to create gaps or openings in the Heathland, Shrubland (scrub) and (to a lesser extent) dune Forest canopy for germination and that a particular colony would subsequently disappear once the canopy re-established creating unfavourable conditions for germination. Dispersal of seed and establishment of a soil seedbank would be required by the species to exploit subsequent disturbance events.

Such post disturbance, sun worshiping colonisers are relatively common amongst the Orchidaceae, including a number of Threatened orchids that are restricted to regularly maintained (i.e. slashed) powerline easements on the lower North Coast such as *Diuris arenaria*, *Diuris praecox and Diuris flavescens* (Espallargos 2005; Orogen 2009; Mamott 2011).

Hence, the species appears to favour dry to moist dunal habitats (of both Holocene and Pleistocene age) that have been subject to disturbance (clearing and slashing) and for which the historical or current disturbance event maintains a microenvironment characterised by bare soil or a thin layer of leaf litter and a relatively open vegetation structure for maximum light penetration to the groundcover stratum.

6.4 Potential Habitat

Results from the TMO investigations undertaken in 2012 by RPS were used to prepare a habitat map for the species on the Tuncurry Project Site. Habitat categories used for the species comprised:

- Known/Preferred Habitat (50.24 hectares) – areas where TMO has been recorded + areas presently having a high likelihood of occurrence of the species (e.g. cleared 4WD tracks). Records were afforded a 20m buffer around them and classed as Known/Preferred Habitat;
- Potential Habitat (472.7 hectares) – areas not presently providing known/preferred habitat but have the potential to provide preferred habitat (at least temporarily) for species exploitation following a natural or anthropogenic disturbance event (e.g. fire, storm, clearing). This habitat category makes an assumption that the species has the ability to temporarily recruit into or exploit favourable habitats based on seed dispersal from the core population; and
- Not Habitat (107.06 hectares) – areas not presently providing preferred or potential habitat (e.g. Foredune Complex).

The 9 targeted quadrats completed across the Project Site in 2011 coupled with a further 22 transects across the heath and forested environs during 2012 provide strong evidence to support the habitat findings outlined in **Section 6.3** above and the quantum of known/ preferred habitat and potential habitat determined across the project site.

The TMO habitat map for the Project Site is provided as **Figure 10.**

Consideration has also been given to the potential habitat that may exist outside of the project area. **Figure 11** shows the areas mapped as Potential TMO Habitat in the Forster-Tuncurry locality, outside of the Project Area. In a similar fashion to the Project Site, Known / Preferred Habitat has been determined based on a 20m buffer around individual TMO. Notably the total area of Preferred habitat is greater given this area does not include tracks or areas of similar type disturbance occurring on the project site such as mineral sand extraction. Potential habitat has been considered as those areas that contain vegetation types which are commensurate to those which are known to contain TMO and where those vegetation types, as mapped, are directly linked to the recorded TMO populations. The area of potential habitat, as shown in **Figure 11**, has been derived from the newly released Draft Greater Hunter Vegetation Mapping data layer (Sivertsen D, *et al.* 2011) using the following vegetation types described in the Draft Greater Hunter Vegetation Mapping (2011):

- MU185 Wallum Banksia / Monotoca scoparia heath on coastal sands of the Central Coast and lower North Coast (3,383ha);
- MU128 Smooth-barked Apple/ Blackbutt/ Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1,079ha); and
- MU 119 Scribbly gum/ Wallum Banksia/ Prickly-leaved Paperbark heathy coastal woodland on coastal lowlands (155ha).

The total area of potential TMO habitat occurring outside of the Project Site has therefore been calculated to be approximately 4,618ha of which 4.28ha is Known/ Preferred Habitat and 4613.72ha Potential Habitat.

6.5 Distribution

Based on the 2012 validated TMO populations detailed above, the known extent or distribution of the species is approximately 20km (North Tuncurry south to Tiona) by 8 km (North Tuncurry west to Minimbah).

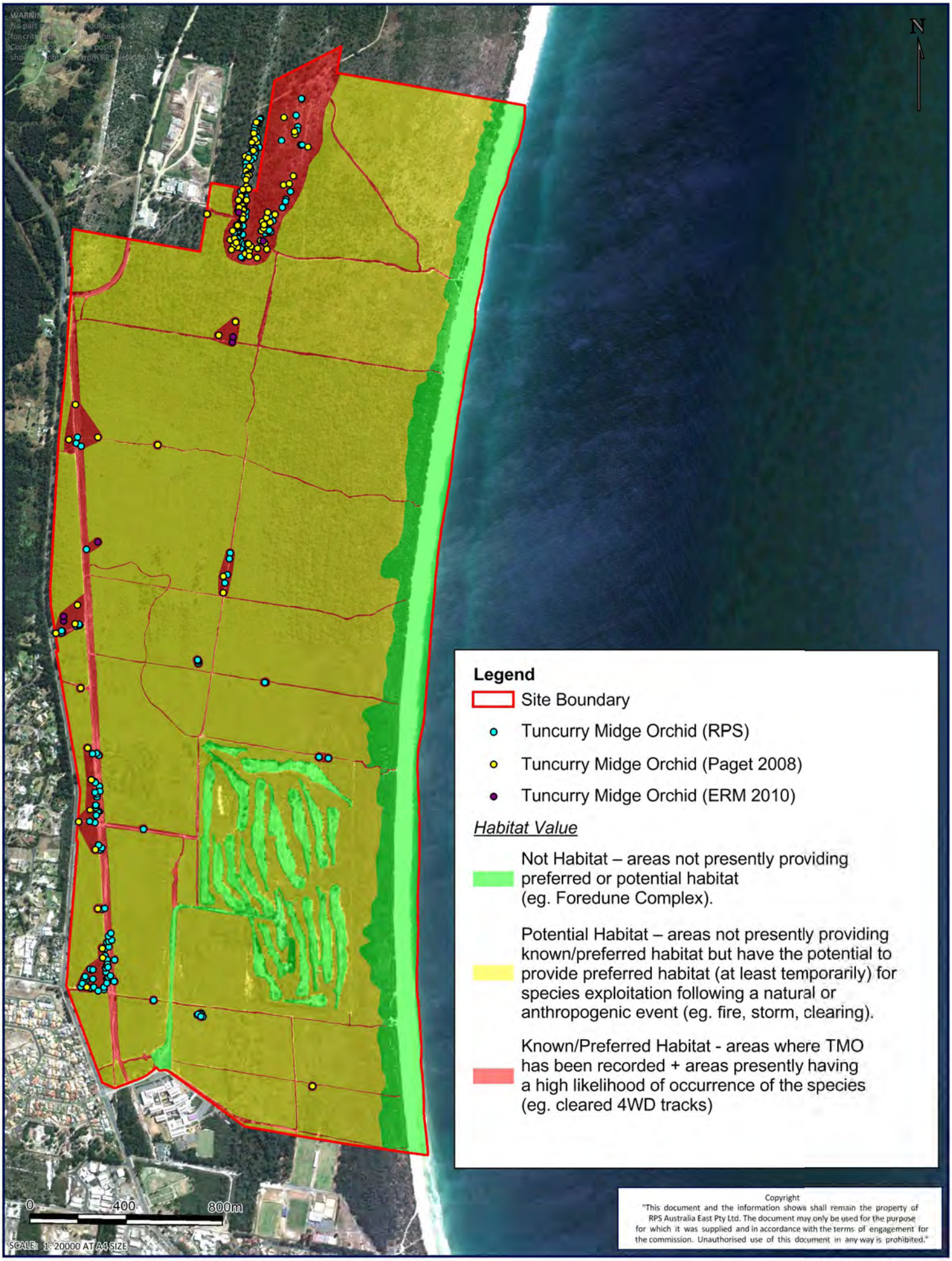
The land area generally spanning between the Midcoast Water Lands Minimbah population and the Crown Lands Minimbah population is considered to be form part of the regional distribution of TMO habitat. Furthermore there is a high likelihood that TMO individuals / sub populations exist within this area. This is supported by the following:

- The area between these two recorded populations is covered by a continual tract of native vegetation;
- Habitat between these two recorded populations are considered to be suitable habitat for TMO;
- The two populations are occupied by the same historic mineral sands mining operations, which is expected to have contributed to their success in this area.

There is a high likelihood that TMO exists within the area between the Crown Lands Minimbah population south of Aerodrome Road and the population discovered within Midcoast Water Minimbah lands for the above reasons.

The known present distribution of the species is consistent with that noted in the current Commonwealth Listing Advice for the TMO (SEWPAC 2011).

The known present distribution of the species is, however, inconsistent with that noted in the NSW Scientific Committee Final Determination for the TMO (OEH 2009) which states an area of occupancy of 8km^2. The inconsistency can be explained by the fact that the Determination was solely based on the results of Paget (2008) which did not take into account the additional populations recorded by RPS in 2010 and 2011 at Green Point, Tiona and Minimbah.



TITLE: FIGURE 10: TUNCURRY MIDGE ORCHID HABITAT MAP

LOCATION: NORTH TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 26/07/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26K\26414 - North Tuncurry\10-Drafting\Orchid Investigations\2012 TMO Report Figures
VERSION (PLAN BY): PH / MD (A-A4)

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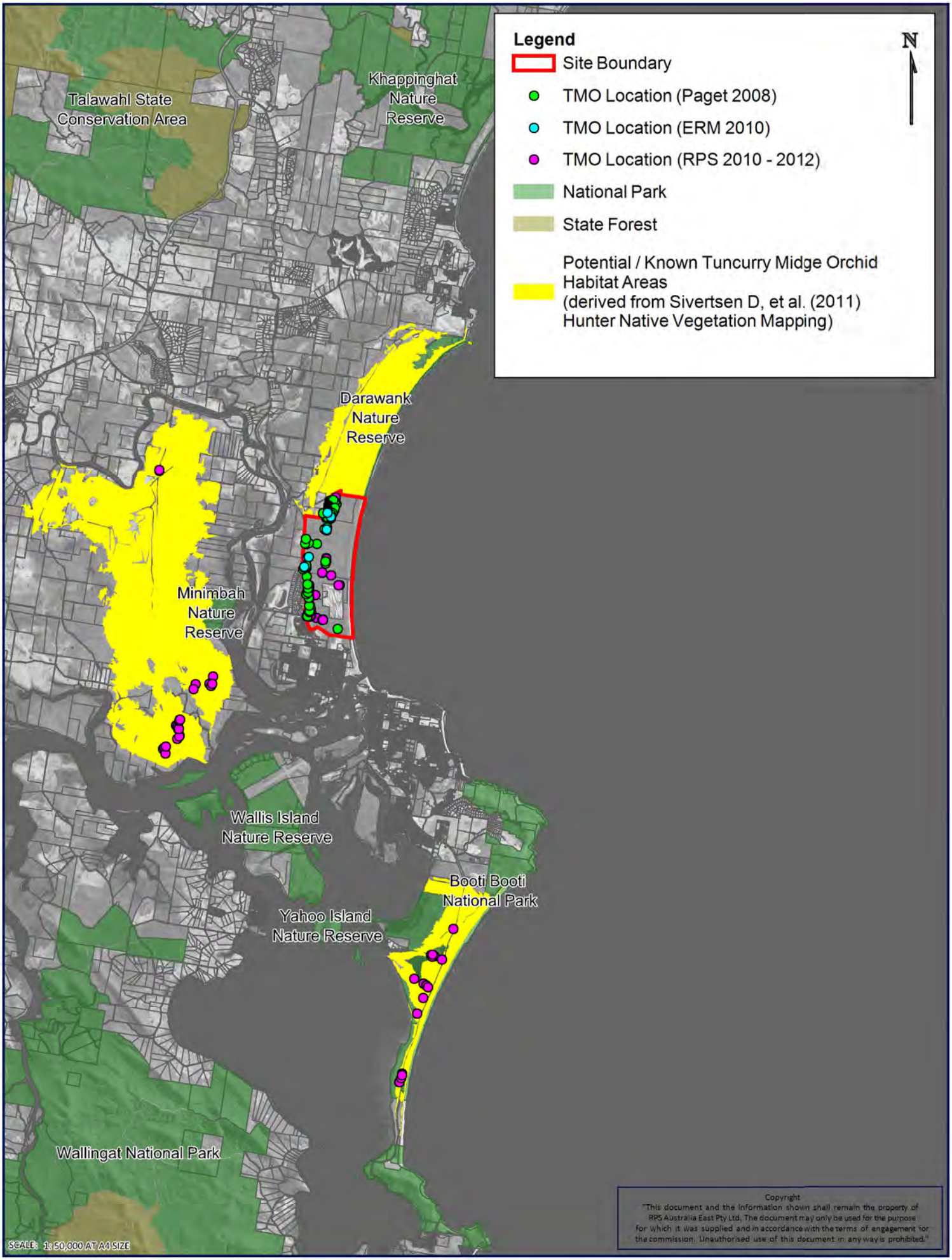

FIGURE 11: POTENTIAL TMO HABITAT IN FORSTER-TUNCURRY LOCALITY | LOCATION: NORTH TUNCURRY | DATUM: DATUM | PROJECTION: MGA ZONE 56 (GDA 94) | DATE: 21/08/2012 | PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26k\26414 - North Tuncurry\10-Drafting\Workspaces\TMO Report Figures\2012 TMO Report Figures
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7.0 Description of the Proposal

The Crown Lands Division of the NSW Department of Primary Industry and Landcom are proposing to deliver a mixed use development at North Tuncurry that meets the State Governments' objectives to increase housing supply, provide community benefits and create jobs.

The North Tuncurry project is the key plank for the future urban expansion of Tuncurry, providing up to 75% of planned growth. It has been earmarked for residential rezoning in Great Lakes Council's strategic planning documents for over 30 years and is shown as future urban release in the NSW Department of Planning's Mid North Coast Regional Strategy.

Detailed planning of the Project is yet to commence but is likely to incorporate the following components:

- Approximately 1500-2000 dwellings, pending the outcomes of a master planning process;
- Incorporation of retail, commercial, industrial, educational and community infrastructure and facilities;
- Provision of open space and drainage areas, environmental conservation lands, and local active and passive recreation facilities;
- Road network and utilities (including power, telecommunications and gas); and
- Appropriate conservation of Aboriginal heritage located on the site.

A variety of housing types is proposed to be delivered to cater to social / demographic diversity and provide a proportion of dwellings at affordable price points. It is envisaged that retail and other employment-generating uses would be predominantly located at the southern end of the site, adjacent to the existing Tuncurry Township. The project provides the opportunity for new localised retail facilities to service the new residential population. There is a clear opportunity to provide a high quality and aesthetically pleasing development which connects to and interfaces with the existing development to the south and the foreshore to the east. The project provides an excellent place-making opportunity on a key, well-located site where demand for additional dwelling stock and mix of residential types is relatively high. The proposed mixed uses provide a rational extension of the existing adjoining land uses on to the Project Site with a reasonable yield in terms of strategic planning for both housing and employment targets.

A plan showing an Indicative Concept Plan layout was prepared at the commencement of discussions with the NSW Government and put forward within the Preliminary Environmental Assessment Report, which is essentially the trigger for study requirements to be generated. Furthermore around the same time this Indicative Concept Plan was put to the Commonwealth department under an EPBC Act referral. It was noted at the time of lodgement at both levels of governance that the Indicative Concept Plan was for illustration purposes only and would be subject to further refinements following the completion of relevant technical investigations and stakeholder consultation.

A refined Notional Development Footprint has now been developed primarily in response to detailed ecological studies across the Project Site coupled with further input from technical studies including cultural heritage and hydrology (**Figure 12**). The Notional Development Footprint covers a total area of approximately 200 hectares of the Project Site excluding the Golf Course (60 hectares) with the remaining 370 hectares being proposed for retention in conservation type tenure, notwithstanding some small linear areas for site access in the west and provision of beach amenities / access to the east.

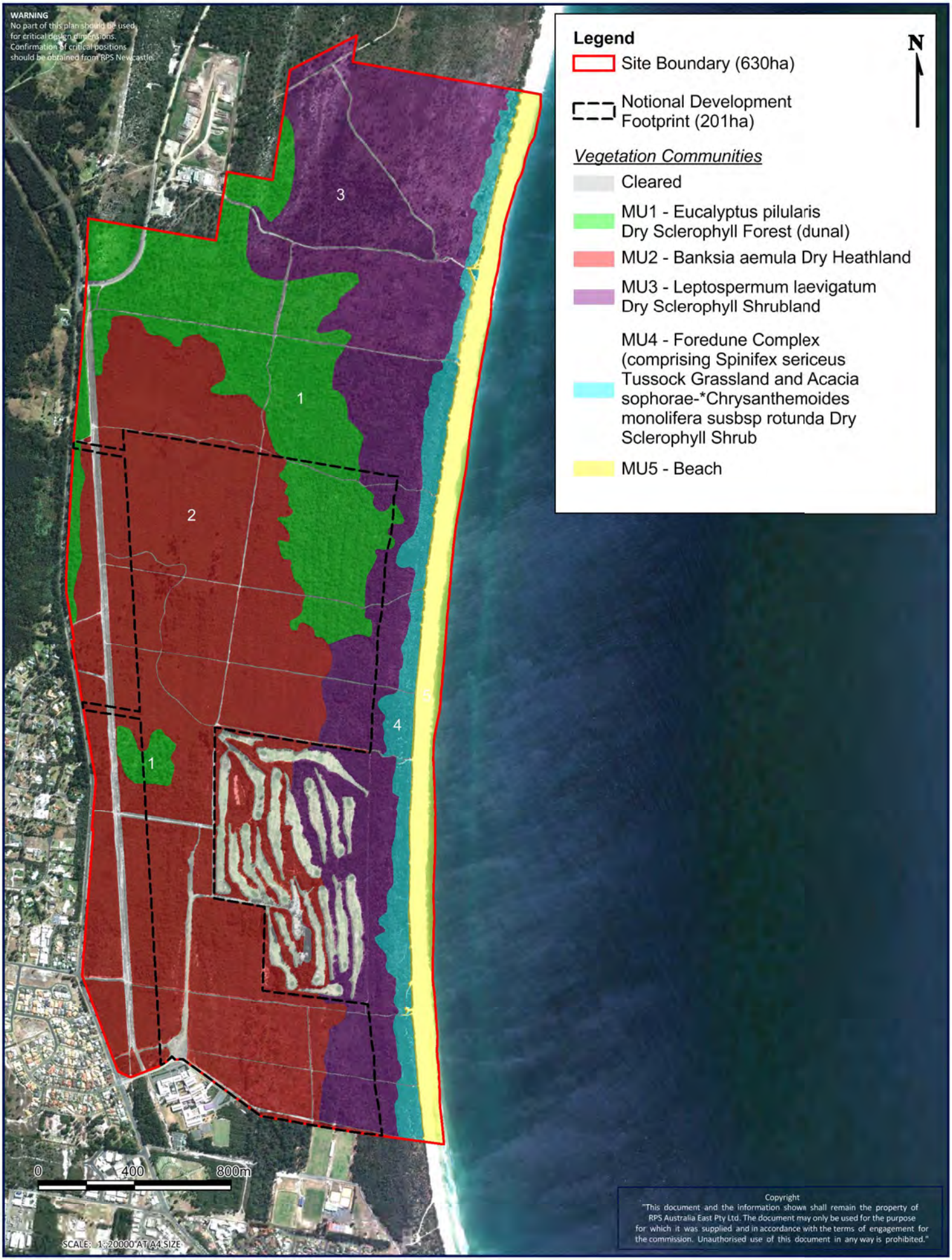
The proposal provides for the following conservation outcomes on site:

- A large portion of the northern Project Site area will be dedicated to conservation reserves (likely an extension of the Darawank National Park).
- It is envisaged the western perimeter habitat considered for retention should be in the order of 200 – 300 metres wide and will be managed in a conservation type tenure.
- It is envisaged the eastern perimeter habitat considered for retention should be in the order of approximately 200 metres from the mean high water mark (as delineated on DP1104340) as confirmed via future survey and managed in a conservation type tenure.
- Maintenance of connectivity to the west and north.
- In relation to vegetation, the Notional Development Footprint seeks to develop approximately 200 hectares of which 192 hectares are vegetated. Vegetation types and their areal extent on the Project Site are presented in **Table 4** shown below.

Table 4 Delineated Vegetation Community

Delineated Vegetation Community	Area Developed (ha) approx	Area retained (ha/%) approx on site*
Eucalyptus pilularis Dry Sclerophyll Forest (dunal)	26 (26.5%)	72 / 73.5%
Banksia aemula Dry Heathland	143 (65%)	76 / 35%
Leptospermum laevigatum Dry Sclerophyll Shrubland	23 (15%)	128 / 85%
Foredune Complex	0	32 / 100%

*Not including the Golf Course



TITLE: FIGURE 12: PROPOSED NOTIONAL DEVELOPMENT FOOTPRINT

LOCATION: TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 09/08/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26K\26414 - North Tuncurry\10-Drafting\Orchid Investigations\2012 TMO Report Figures
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8.0 Discussion of Potential Impacts

The following is a 'high level' discussion of the potential direct and indirect impacts on the Tuncurry TMO population based on the Notional Development Footprint introduced in **Section 7**. The discussion should not be viewed as a detailed and formal assessment of impacts based on a specific development proposal or Master Plan.

The combined TMO records have been displayed with the Notional Development Footprint in **Figure 13**.

8.1 Potential Direct Impacts

The Notional Development Footprint (NDF) provides for the retention of the main TMO colony east of the Tuncurry Tip and for the powerline easement colony between the Tuncurry Tip and TAFE. Both these colonies are considered to form the 'core' North Tuncurry population of the TMO.

The NDF will result in the retention of 43.23 hectares of Known/Preferred TMO habitat (including the core population) and 281.8 hectares of Potential TMO Habitat, based on the TMO Habitat Map produced for this report.

Of the 1643 TMO stems recorded on the Project Site, the NDF will result in the retention of a total of 1518 individuals, or 92.4% of the Project Site population. The NDF in relation to the TMO records is provided in **Figure 13**.

The Tuncurry Tip TMO 'main' colony in the northern portion of the Project Site is contiguous (to the north) with Darawank Nature Reserve. It is thus envisaged that this colony (and an associated 'northern' buffer area) would be dedicated by the Proponent to OEH and incorporated into OEH Estate (Darawank NR) for long term conservation and management. The 'northern' habitat buffer is situated between the southern extent of the main (Tip) TMO colony and the northern boundary of the NDF and equates to approximately 125 hectares in area.

The balance of the core population (the Powerline easement colony) situated between the Tuncurry Tip and the Tuncurry TAFE would be contained within a 300m wide corridor (approximate) and be subject to a conservation agreement with management funded by the project. Any Management Plan for this corridor would require collaboration with Essential Energy who currently manage an easement (through this corridor). Based on the current NDF, the 300 metre wide corridor is comprised of 2 non-contiguous habitat buffers (on both the western and eastern sides of the Powerline easement), with these 2 'western' habitat buffers approximating 55 hectares in area (excluding the easement). Whilst the 2 'western' habitat buffers are physically separated by an access road that leads into the western portion of the proposed development, off The Lakesway, they are essentially considered as one contiguous buffer given the mobility of the suspected TMO pollinators.

Based on the TMO Habitat Map produced for the Project Site (see **Section 6.4**), the NDF will result in the loss of 7 hectares of Known/Preferred TMO habitat and 190.9 hectares of Potential TMO Habitat on the Tuncurry Project Site (**Table 6**). This represents the removal of approximately 14% of Known/Preferred TMO Habitat and 40% of Potential TMO habitat on the Project Site.

The removal of 7 ha of Known/ Preferred TMO habitat within the NDF will result in a 12.8% habitat reduction across the known species distribution, noting that the quantum of regional known/ preferred habitat across the species distribution will be greater than that reported herewith as the area outside the project site

reported in **Table 6** below does not include tracks or areas of past disturbance such as easements and mineral sands extraction in the Minimbah Sand Bed area. Furthermore the loss of 190 hectares of Potential TMO Habitat on the Project Site represents approximately 3.7% of the Total Potential TMO habitat delineated in **Figure 11** (**Table 6**).

Based on investigations to date, the NDF has the potential to result in the loss of 125 TMO individuals through direct disturbance (i.e. removal). This amounts to a potential loss of 7.6% of the Project Site population and 5.4% of the total known population (**Table 5**). It is emphasised that a precautionary assumption has been made in this report that all Genoplesium counts were of the TMO. Given the co-occurring *Genoplesium rufum* recorded on the Project Site in 2012, this assumption may have overestimated the number of TMO individuals that will be subject to removal based on the proposed NDF.

A summary of potential direct impacts to the known TMO population and habitat as a result of the NDF is provided in **Table 5** and **Table 6** below.

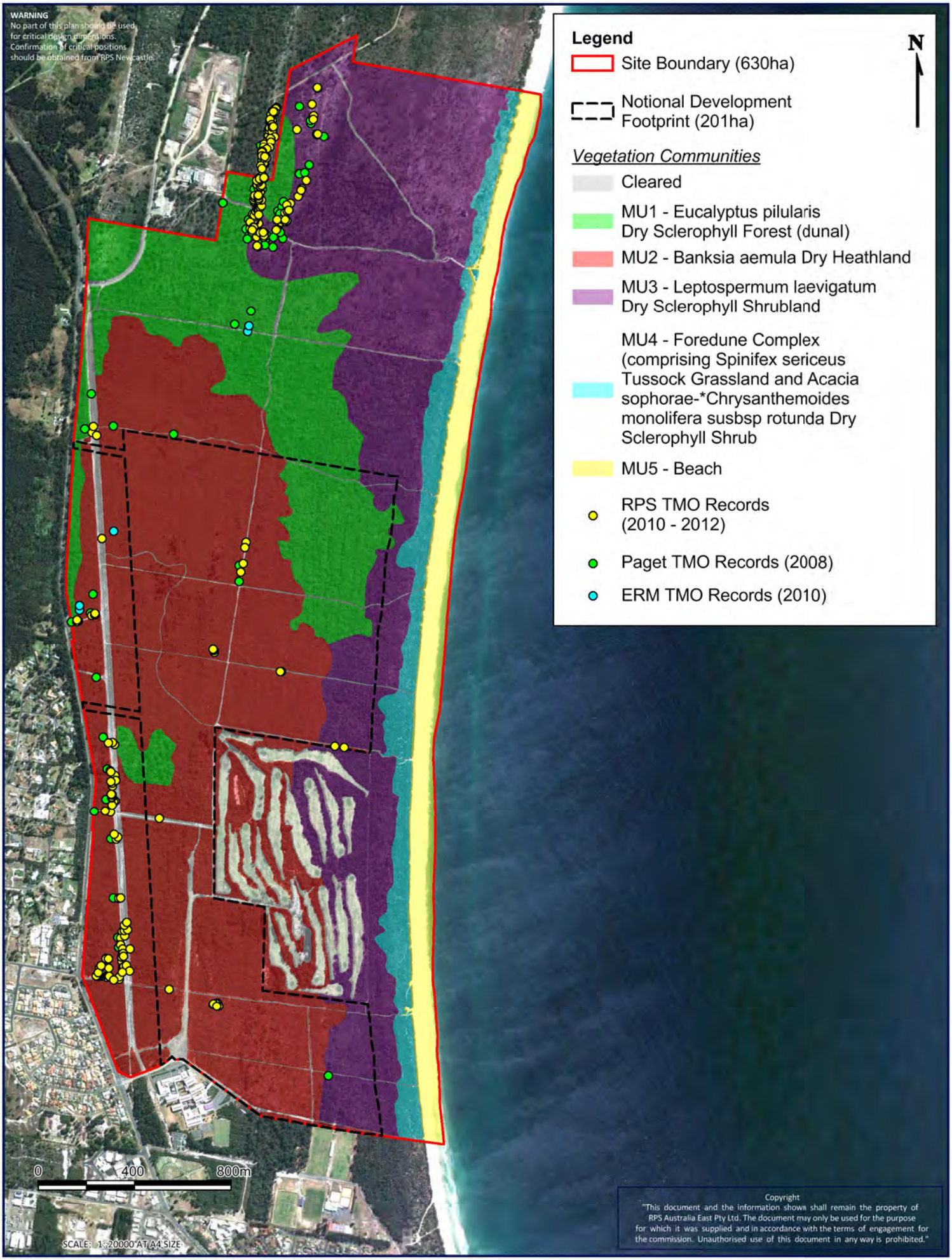
Table 5 Summary of TMO Impacts

	Project Site	Project Site Notional Development Footprint	Outside Project Site	Total TMO Population (Project Site + offsite)	TMO stems proposed for disturbance in NDF as % of Project Site Population (%);	TMO stems proposed for disturbance in NDF as % of Total TMO Population (%)
Total # stems recorded	1643	125	673	2316	7.6%	5.4%

Table 6 Summary of TMO Habitat Impacts

	Project Site (Ha)	Project Site Notional Development Footprint (Ha)	Outside Project Site (Ha)	Total (Project Site + offsite) (Ha)	Disturbance in NDF as % of Project site	Disturbance in NDF as % of Total Area
Area of Known/Preferred Habitat (ha)	50	7	4.28	54.28	14%	12.8%
Area of Potential TMO Habitat (ha)	472	190	4613.72	5085.72	40%	3.7%

Section 9 outlines measures to salvage these individuals earmarked for disturbance so as to target a 'no net loss' outcome to the Tuncurry TMO population.



TITLE: FIGURE 13: PROPOSED NOTIONAL DEVELOPMENT FOOTPRINT AND TMO

LOCATION: TUNCURRY

DATUM: DATUM
PROJECTION: MGA ZONE 56 (GDA 94)

DATE: 09/08/2012
PURPOSE: TMO REPORT 2012

LAYOUT REF: J:\JOBS\26K\26414 - North Tuncurry\10-Drafting\Orchid Investigations\2012 TMO Report Figures
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8.2 Potential Indirect Impacts

Edge Effects

Murcia (1995), in one of the most comprehensive reviews undertaken to date on the subject of edge effects, identifies both abiotic and biological edge effects. Abiotic edge effects are those that relate to changed environmental conditions within a bushland remnant and include changes to air moisture and temperature, solar radiation levels, soil moisture and temperature as well as changes to wind speed and pattern. Biological edge effects involve changes in species abundance and distribution, either directly due to changed environmental conditions at the remnant edge or indirectly through changes in species interactions such as pollination and seed dispersal (Murcia 1995).

Whilst forest edges are sometimes associated with high species diversity (grassland/forest habitats), it is now understood that edge effects are detrimental to a wide range of flora and fauna (Murcia 1995; Laurance, 1991; Laurance, 2000). Murcia (1995) and Laurance (2000) also note that edge effects vary considerably in the distances of penetration into a remnant, depending on such factors as the type of edge effect measured, the vegetation community being affected, the characteristics of the surrounding environment (e.g. pasture, cropland, urban) and the age of the remnant edge (time since edge was created).

Murcia (1995) noted that, in most instances, most edge effects were reported to have disappeared within 50 metres of the remnant edge. A review by Laurance (2000) concluded that most empirical studies of edge effects reported distances of penetration of effects (into a bushland remnant) of less than 150 metres.

The urban development proposal has the potential to indirectly impact upon the Tuncurry TMO population through a variety of edge effects such as weed invasion. The Tuncurry Tip colony and sections of the powerline easement colony inspected by the author in 2012 were essentially weed free. Without adequate buffers between the TMO population and the NDF boundary, the rezoning proposal may result in the recruitment of weeds into the TMO population from garden escapees, car tyres and rubbish associated with a proximate residential development.

The NDF allows for the following bushland buffers between the TMO colonies and NDF boundaries:

- an 840 metre (approx) buffer between the southern edge of the Tip colony and the northern NDF boundary; and
- a 120 metre buffer between the powerline easement colony and the western boundary of the NDF.

The northern conservation lands buffer proposed appears to well exceed the maximum disturbance distance thresholds reported for edge effects in the scientific literature. The western buffer appears to be generally in line with the threshold edge effect distances.

It should also be noted that, in general, large deleterious edge effects are not typically associated with Wallum vegetation as the dense and impenetrable nature of the dense Heathland tends to mitigate against weed invasion and human intrusion.

Measures are proposed in **Section 9** of this report to further mitigate the potential for edge effects on the Tuncurry TMO population.

Increase in Herbivore Grazing

Opportunistic grazing of native terrestrial orchids by both exotic (e.g. rabbits) and native herbivores (e.g. kangaroos, wallabies) is well documented and is thought to occur on the Tuncurry Project Site. A number of inflorescence stalks appeared to have been grazed during the author's inspection in March 2012. Fresh and old macropod scats (suspected Swamp Wallaby) were observed RPS during the 2012 site inspections amongst the TMO colonies. Surprisingly, the small, dull coloured and relatively inconspicuous character of the TMO does not seem to evade the foraging ability of the macropods. Macropods are suspected to be attracted to the Tuncurry Project Site, in general, due to the golf course which provides an ideal grazing/shelter interface for these mammals.

A reduction of potential herbivore grazing habitat as a result of the urban development proposal has the potential to put added grazing pressure on the Tuncurry TMO population, especially if the locally occurring herbivore populations are already at their carrying capacities on the Project Site and immediate surrounds. The added grazing pressure could impact upon seed set for one or more seasons, and, if the reduction in seed set is large enough, could ultimately impact upon population recruitment and dispersal.

The establishment of open lawns associated with future housing development will also likely attract feral rabbits to the Project Site and immediate surrounds.

Section 9 outlines measures to mitigate potential adverse impacts on the Tuncurry TMO population from herbivore grazing.

Increase in Human Intrusion

The rezoning proposal will allow for a future 1500-2000 lot residential subdivision of the Project Site pending the outcomes of a master planning process, which roughly equates to an estimated population influx for Tuncurry of 4000 over a 25 year period. The subdivision may place added 'human intrusion' pressure on retained TMO habitats, from trail bike riders, dog walkers, bush walkers and beach going residents.

Section 9 outlines measures to mitigate potential adverse impacts on the Tuncurry TMO population and habitat from an increase in human intrusion associated with future residential subdivision.

Plant-Pollinator Interactions

The rezoning proposal has the potential to indirectly impact upon the Tuncurry TMO population through potential impacts to the life cycle requirements of the TMOs pollinator(s). Habitat fragmentation can disrupt plant-pollinator interactions for many reasons. Existing literature generally shows a decline in pollinator abundance and diversity with habitat fragmentation and reduction (Rathcke and Jules 1993). Declines in pollinator communities can lead to reduced pollination success and subsequently lower seed set in plant populations. However, due to the complexity of interaction pollination webs, it has not yet been possible to predict which plant species will prove most susceptible to habitat fragmentation through detrimental affects to their pollinator. However, literature relating to the susceptibility of a plant population to habitat fragmentation or reduction generally states that the degree of susceptibility is often attributed to the level of specialisation exhibited by both the plant and pollinator(s) (Rathcke and Jules 1993). Plant and pollinator habitat generalists with broad ecological tolerances may be less susceptible to habitat fragmentation or reduction relative to plant-pollinator relationships requiring specialist niches to survive (Rathcke and Jules 1993).

FloraSearch (2012) concluded in its TMO pollination study that whilst little is known about minimum viable areas for insect conservation, chloropoid insects suspected of pollinating the TMO are likely to maintain viable populations with minimum viable patch (MVP) sizes between 10 to 25 hectares, although no

discussion on specific vegetation types or habitats needed by the insects for their life cycle requirements was provided. Nevertheless, areas on the Project Site proposed for retention (acting as buffers between the TMO population and the NDF boundaries) well exceed this predicted MVP size threshold for the suspected TMO pollinators. In addition, the NDF does not support any 'unique' habitats that would not be found in the habitat buffer areas proposed for retention on the Tuncurry Project Site. As such, no key pollinator habitats (e.g. breeding) would be expected to be lost as a result of the rezoning proposal (only a reduction in areal extent).

FloraSearch (2012) also note that connectivity between retained habitats on the Project Site and adjoining and proximate bushland in the locality would be important to allow the re-establishment of pollinator populations through immigration in the event of localised pollinator extinctions on the site. It is emphasised that the Project Site is situated at the southern terminus of an existing coastal bushland corridor with primary linkages to coastal dune forests and heathlands to the north and west across the Wallamba River to the Nabiac sandbeds. The NDF would not be expected to adversely impact upon the integrity of these primary linkages and as such should provide source pollinator populations should pollinator decline on the site be experienced as a result of the proposed rezoning.

FloraSearch (2012) provides the following two concluding statements in its TMO pollination study:

1. The TMO pollinators are likely to be abundant at North Tuncurry owing to the high pollination levels that occurred on some plants; and

2. A minimum reserve size of 10-25 hectares is likely to conserve pollinator populations sufficiently large to be viable in the long term, provided local corridors of pollinator habitat exist.

Further pollination research of the TMO is recommended in **Section 9** of this report to provide added confidence in these initial discussions regarding potential pollinator impacts on the Tuncurry TMO population.

8.3 Fire

To date, the TMO has been found in dunal Dry Sclerophyll Shrubland and Heathland communities that are fire prone, often with repeated inter fire intervals of less than 10-15 years. As such, it would be reasonable to assume that the TMO would have evolved to adapt to a frequent and hot fire regime. Jones (1988) notes that *Prasophyllum rufum (*syn *Genoplesium rufum*), occurring in identical habitat to the TMO on the North Tuncurry Crown Lands site, is listed as a species that is often inhibited by fire, noting that the absence or reduction in flowering of a population generally lasts for only one season following a fire. Whilst such fire response could be extrapolated to the TMO based on similar habitat type, there is no specific information on the response of the TMO to fire.

Fire may assist the species by increasing the availability of habitat through the removal of large areas of dense Heathland habitat with which the Tuncurry population adjoins, reducing competition for light and water and temporarily increasing soil nutrient levels. Many *Genoplesium* spp., *Diuris* spp., and other terrestrial orchids are considered to be post disturbance colonisers and generally respond favourably to fire. Alternatively, a high intensity fire could kill some (or all) of the orchid tubers of a population and destroy the lichen dominated ground cover which may play an important role in the life cycle of the species. Should a fire burn a flowering or fruiting TMO population, such an event would destroy the reproductive effort for that year and perhaps weaken the tubers by reducing the photosynthetic period for the growing season, possibly also resulting in reduced flowering the following season (NSW NPWS 2002). RPS did not record any TMO plants in areas of recently burnt heath in Booti Booti National Park during the 2012 site investigations nor were any plants found in burnt dune scrub on the North Tuncurry Crown Lands site.

It is difficult to predict what changes to the present fire regime (if any) would occur on the North Project Site as a result of the proposed urban development. The Project Site is presently subject to relatively frequent fires as a result of lightning strikes and arson which are typically extinguished quickly by the local Tuncurry Rural Fire Service (RFS). The permanent residential presence that the development brings may help to reduce arson events within retained bushland habitats (habitat buffer conservation lands). The presence of 'life and property assets' associated with the proposal would likely result in a continuation of (rapid) fire suppression practices by the RFS for fires that ignite in the retained habitat buffers. Should the 'northern' habitat buffer conservation lands become part of Darawank Nature Reserve, it is unlikely that OEH will undertake any hazard reduction burns in the adjoining OEH Estate, amounting to little change from the present regime.

8.4 TMO Population Viability

The key issue arising from the NDF and overall urban development proposal is whether the Known/Preferred and Potential TMO Habitat areas proposed for retention (and conservation) on the Project Site are adequate for the Tuncurry TMO population to persist in the future and meet its life cycle requirements (e.g. recruitment/dispersal, reproduction) in conjunction with a proposed (and proximate) 'large scale' mixed use development.

Studies have shown that 3 main variables typically determine the occurrence of a species of a population in a fragmented landscape, these being:

- Patch size (as surrogate of population size);
- Connectivity; and
- Habitat quality.

These 3 variables are generally related to key ecological processes which drive local and regional population dynamics, these being:

- The increase of stochastic extinctions (e.g. resulting from random catastrophic events such as fire, drought, inbreeding depression) with decreasing patch size; and
- The decrease of (re)colonisation probability of a species within suitable habitats with increasing isolation.

Based on these 2 ecological processes, theoretical models typically predict a smaller probability of occupancy of a species for small and isolated patches relative to large and well-connected ones. Not surprisingly, the consensus from the literature on population viability and dynamics to date is simply that 'larger' plant populations have a much better chance for survival relative to 'smaller' populations in the face of demographic and environmental catastrophic events (i.e. stochasticity).

In recent times, Population Viability Analysis (PVA) using software programs have been used by some academic researchers in an attempt to define Minimum Viable Population and Patch Size (MVP) requirements for Threatened plant and animal populations both in Australia and overseas (e.g. Possingham 2009). Although providing initial indications of population (and patch) sizes needed for species or population persistence across a range of scenarios, results are treated with much caution as the raw data with which they depend is often limited and typically can take years (or even decades) to obtain in order to achieve a more accurate set of MVP results. No PVAs have been undertaken for the TMO, Genoplesium taxa or Australian Orchidaceae in general and thus it is difficult to make a definitive comment regarding likely patch (and population) size requirements necessary for the persistence of the TMO, particularly in the face of an urban development proposal.

Nevertheless, it is the view of RPS that, based on the available information to date, the Tuncurry TMO population would be expected to remain viable in conjunction with a proximate urban development given that:

- The urban development proposal allows for the retention and conservation of both the core TMO population (Known/Preferred TMO Habitat) and adjoining habitat buffers (Potential TMO Habitat) likely required for continued plant-pollinator interactions and species recruitment. The 'northern' habitat buffer between the southern extent of the main TMO colony (Tip) and the northern NDF boundary (125 hectares) is well in excess of the 25 hectare threshold deemed by Bower (2012) to be the maximum area needed to maintain suspected TMO pollinator habitat. It is envisaged that the 'northern' habitat buffer (including the main TMO colony) will be dedicated to OEH for incorporation into the adjoining Darawank Nature Reserve. The 'western' habitat buffers fringing the powerline easement, have a combined area of 55 hectares and thus also well exceed the 25 hectare maximum threshold deemed necessary to maintain viable pollinator habitat. Bower (2012) notes that the small size of the suspected TMO pollinator(s) is such that large pollinator populations can be maintained in relatively small areas. It is also emphasised that the coastal climate assists in maintaining stable pollinator habitats compared with more inland locations and thus such pollinator habitats are likely to be less vulnerable to stochastic extinction from climatic events;
- The urban development proposal allows for the retention of primary linkages to the north and west to large bushland remnants which would function as continued gene flow pathways, habitat for TMO recruitment and pollinator reservoirs;
- The urban development proposal includes a commitment from the Proponent (as part of an indirect offsets package) to fund a continuation in 2013 of the pollination and ex situ conservation studies commenced in 2012. The pollination studies should provide further knowledge regarding the specific TMO pollinators and their habitat preferences. The ex situ conservation program should provide a viable, long term seedbank for ultimate species security in the face of stochastic extinctions. The Proponent has also committed to providing funding to OEH should the 'northern' habitat buffer lands (containing the main TMO colony) be transferred to OEH Estate. It is envisaged that the funding would be used, in part, by OEH, to implement a Habitat/Recovery Plan for the Tuncurry TMO population which would likely include a research component (e.g. population monitoring to determine life cycle dynamics and grazing impacts; response to disturbance regimes). The information gained from the research will ultimately allow for improved species management and thus improved chances for population persistence on the site, particularly in the face of a future urban development proposal. It is envisaged that the TMO Habitat Management Plan would be prepared by the development Proponent in consultation with relevant stakeholders (e.g. OEH and SEWPAC);
- The core TMO population at Tuncurry appears to have persisted in the wild since at least 1992 within 120 metres from both the residential and industrial development areas of North Tuncurry on the western side of The Lakesway and the Tuncurry Waste Management Centre and thus has shown that it can persist in concert with proximate development.

9.0 Avoid, Mitigate, Offset

The following is a discussion of how the urban development proposal meets the avoid, mitigate and offset framework and has been taken (and revised) from the Preliminary Impact Considerations Report prepared by RPS in March 2012.

9.1 Avoid

In terms of the 'Avoid' approach, RPS considers that the highest priority areas of the Project Site have fundamentally been incorporated into the development design and been avoided as outlined below.

The design of the development footprint and resultant conservation outcomes has resulted in the following:

- Conservation of a large and ecologically significant block of land at the northern part of the site. This block of land:
  - Provides direct local offsets for the project for local threatened species populations;
  - Provides continuity of habitat in a northerly direction for known threatened species and populations;
  - Has a low edge to area ratio, assisting in providing future environmental management of the land;
  - Retains the core Tuncurry population of TMO;
  - Retains a majority of the Blackbutt Forest, which is recognised as being of the highest importance for a majority of the threatened fauna recorded on the site;
  - Retains an area that appears to be critical to regional (and local) habitat connectivity in the future; and
  - Immediately adjoins the existing Darawank Nature Reserve, making it suitable for an addition to this Reserve if this is desired by the Office of Environment and Heritage (OEH).
- Conservation of the western strip of land and associated buffer .This block of land:
  - Provides direct local offsets and associated buffers for the project for most importantly the TMO;
  - Provides supplementary habitat and buffers for local threatened species populations;
  - Retains part of the core Tuncurry TMO population;
  - Has a high edge to area ratio, requiring more investment in management to exclude impacts detrimental to TMO and threatened species habitats;
  - Retains an area that appears to be critical to local habitat connectivity in the future; and
  - May be suitable for a local conservation reserve (management mechanism to be determined). It is recognised that OEH are not likely to want to take ownership of this land.
- Conservation of the eastern strip of land and associated buffer. This block of land;
  - Provides direct local offsets and associated buffers for the;
  - Provides supplementary habitat and buffers for local threatened species populations;
  - Has a high edge to area ratio, requiring more investment in management to exclude impacts detrimental to TMO and threatened species habitats;
  - Retains an area that appears to be critical to local habitat connectivity in the future; and
  - May be suitable for a local conservation reserve (management mechanism to be determined). It is recognised that OEH are not likely to want to take ownership of this land directly.

9.2 Mitigate

Mitigation measures are proposed to include:

- TMO plants recorded within the NDF and thus earmarked for removal shall be translocated (i.e. salvaged) to the main colony within the proposed northern conservation lands under a detailed Salvage Program to be prepared by the Proponent;
- Provision of dedicated pedestrian boardwalks to the beach from the development to minimise human intrusion into the conservation lands;
- Incorporation of informative environmental and access signage for the community;
- Consideration of fencing the core North Tuncurry TMO population and habitat buffers to minimise human intrusion into the conservation lands;
- A Masterplan design that ensures runoff does not enter into or impact upon the conservation lands (TMO habitat buffers) and that any change in Project Site hydrology does not result in a significant water table drawdown or change in the conservation areas;
- Preparation and implementation of a TMO Habitat Management Plan for the conserved TMO populations which would include appropriate slashing regimes and weed control methods to assist Essential Energy (and the western corridor land manager) in maintaining the easement whilst not adversely impacting upon the TMO colony. It is envisaged that the Proponent would prepare the TMO Habitat Management Plan;
- Provision of a perimeter road wherever possible to provide a hard line interface between the built and retained environs. This will also act as a passive management tool to control illegal dumping of items such as garden refuse;
- Sensitive establishment and ongoing management of bushfire Asset Protection Zones adjacent to areas of conserved lands. This may be in the form of groundcover height upon slashing to assist in the control of weed seed dispersal and water dissipation into conserved areas;
- Site access points from The Lakesway will avoid known TMO individuals; and
- Landscaping at the interface of conserved lands to the east, west and north shall use locally sourced native species.

9.3 Offset

It is recognised that a combination of direct and indirect offsets is required to compensate for the balance of the impacts likely to result from development of the nominated development area.

The offset package is likely to contain the following:

- Dedication of northern areas of the Project Site outside the NDF (including main TMO colony) to OEH for incorporation into the adjoining Darawank Nature Reserve.
- Conservation of the western corridor including a funding mechanism for in perpetuity management.
- Additional direct compensatory habitat lands located off-site but within the local area, and that complies with the agreed offset requirements.
- Additional indirect offsets including:
  - Continuation in 2013 of the pollination and ex situ conservation studies commenced in 2012 by Dr Colin Bower (FloraSearch) and Dr Karen Sommerville (RBG);
  - Provision of funding to OEH if part or all of the offered conservation lands are incorporated into OEH Estate (i.e. Darawank Nature Reserve). It is envisaged funding would be used, in part, to implement a

Habitat Management Plan for the main Tip TMO colony which would likely include a research component (e.g. response to disturbance events, browsing impacts, life cycle dynamics) to assist in improving the knowledge base of the species for improved species management. It is envisaged that the Habitat Management Plan would be prepared by the development Proponent and would likely address the Tuncurry TMO population as a whole (main and powerline easement colonies).

10.0 Conclusions

The following conclusions can be made with regards to the TMO and are based on the information available to date for the species derived from field surveys undertaken since 2008 and research begun in 2012:

1. A total of 3 TMO populations have been recorded during the 5 years of investigations of the species by RPS (2011), Paget (2008) and ERM (2010), these being North Tuncurry Crown Lands and adjoining northern lands, Green Point/Tiona (Booti Booti sandbeds) and Minimbah/Nabiac Sandbeds. For the purposes of this report, the 3 'populations' do not imply 3 genetically heterogeneous groups, rather are simply meant to infer geographic separation;

2. Habitat preferences of the TMO were confirmed to be artificially low Holocene Heathlands within powerline easements subject to regular (annual) slashing **and** relatively Open Dry Sclerophyll Shrublands and Low Woodlands that have recolonised areas subject to historical mineral sands mining;

3. The TMO does not occur in dense wallum Heathlands, Shrublands or dune Forests. Rather, the species, as a post disturbance coloniser, appears to temporarily exploit gaps or openings that may occur periodically in such habitats until such time as canopies re-establish and then likely disappear until subsequent disturbance events;

4. Two additional Genoplesium taxa (*Genoplesium rufum, Genoplesium filiforme*) have been recorded by RPS co-occurring with the TMO on the Project site and/or in the Green Point/Tiona population;

5. Results from pollination studies begun by FloraSearch (2012) have indicated that the TMO cross pollinates and is likely pollinated by tiny Chloropoid flies;

6. The Royal Botanic Gardens, Sydney has initiated an *ex situ* conservation program for the TMO to investigate long term security for the species through seedbanking processes; and

7. An urban development proposed for part of the North Tuncurry Crown Lands has been designed to retain the 'core' North Tuncurry TMO population and will provide for its protection through habitat buffers and conservation mechanisms. The Proponent has also committed to provide funding to prepare a TMO Habitat/Recovery Plan and for continued research into the species which will likely result in improved species management over the long term;

8. It is the view of RPS that, based on the information available to date, the Tuncurry TMO population would be expected to remain viable in conjunction with a proximate urban development given that:

   (e) The urban development proposal allows for the retention and conservation of both the core TMO population (Known/Preferred TMO Habitat) and adjoining habitat buffers (Potential TMO Habitat) likely required for continued plant-pollinator interactions and species recruitment. The 'northern' habitat buffer between the southern extent of the main TMO colony (Tip) and the northern NDF boundary (125 hectares) is well in excess of the 25 hectare threshold deemed by Bower (2012) to be the maximum area needed to maintain suspected TMO pollinator habitat. It is envisaged that the 'northern' habitat buffer (including the main TMO colony) will be dedicated to OEH for incorporation into the adjoining Darawank Nature Reserve. The 'western' habitat buffers fringing the powerline easement, have a combined area of 55 hectares and thus also well exceed the 25 hectare maximum threshold deemed necessary to maintain viable pollinator habitat. Bower (2012) notes that the small size of the suspected TMO pollinator(s) is such that

large pollinator populations can be maintained in relatively small areas. It is also emphasised that the coastal climate assists in maintaining stable pollinator habitats compared with more inland locations and thus such pollinator habitats are likely to be less vulnerable to stochastic extinction from climatic events;

(f) The urban development proposal allows for the retention of primary linkages to the north and west to large bushland remnants which would function as continued gene flow pathways, habitat for TMO recruitment and pollinator reservoirs;

(g) The urban development proposal includes a commitment from the Proponent (as part of an indirect offsets package) to fund a continuation in 2013 of the pollination and ex situ conservation studies commenced in 2012. The pollination studies should provide further knowledge regarding the specific TMO pollinators and their habitat preferences. The ex situ conservation program should provide a viable, long term seedbank for ultimate species security in the face of stochastic extinctions. The Proponent has also committed to providing funding to OEH should the 'northern' habitat buffer lands (containing the main TMO colony) be transferred to OEH Estate. It is envisaged that the funding would be used, in part, by OEH, to implement a Habitat/Recovery Plan for the Tuncurry TMO population which would likely include a research component (e.g. population monitoring to determine life cycle dynamics and grazing impacts; response to disturbance regimes). The information gained from the research will ultimately allow for improved species management and thus improved chances for population persistence on the site, particularly in the face of a future urban development proposal. It is envisaged that the TMO Habitat/Recovery Plan would be prepared by the development Proponent in consultation with OEH and SEWPAC;

(h) The core TMO population at Tuncurry appears to have persisted in the wild since at least 1992 within 120 metres from both the residential and industrial development areas of North Tuncurry on the western side of The Lakesway and the Tuncurry Waste Management Centre and thus has shown that it can persist in concert with proximate development.

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Appendix 1

ELA (2011)

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Michael Pring
Development Director
Landcom - Tuncurry
PO Box 718
Forster NSW 2428

Project No: 11SUTECO-0104

12th December 2011

Dear Mr Pring

RE: Independent review of Tuncurry Midge Orchid Investigations – North Tuncurry Investigation Area.

I refer to your request to undertake the above review, specifically to comment on:-

1. the adequacy of the survey effort to date for the Tuncurry Midge Orchid (TMO), the survey methodology and compliance with relevant survey guidelines;
2. Great Lakes Council (GLC) and the NSW Office of Environment & Heritage (OEH) submissions in relation to the State Significant Site study (SSS study) requirements and their "reasonableness" in regards to additional survey required for the TMO; and
3. to provide strategic advice in relation to negotiating a practical and commercially viable offset package and development footprint that also provides certainty of outcome for future development.

In undertaking this review the following documents have been considered:-

1. Preliminary ecological review and comments to study requirements – proposed Landcom North Tuncurry Development (Great Lakes Council memo to Department of Planning and Infrastructure 7th November 2011);
2. North Tuncurry State Significant Site Study Requirements (Letter from NSW Office of Environment & Heritage to Department of Planning & Infrastructure 7th November 2011);
3. Landcom – Key Ecological Constraints Investigation Brief – North Tuncurry, February 2010
4. Letter from Landcom to DP&I, 19th January 2011, State Significant Site listing and Part 3A request – North Tuncurry.

5. ERM (2005) North Tuncurry – Ecological Constraints & Opportunities, Report to Landcom dated 20th October 2005;
6. ERM (2010a) Crown Land off the lakes way, North Tuncurry – Ecological Assessment. Report to Landcom dated 12th January 2010;
7. ERM (2010b) Tuncurry Midge Orchid Survey, letter & map to Landcom, dated 12th January 2010;
8. RPS (2011a) Ecological Inventory Report North Tuncurry. Report No. 26414 prepared by RPS Newcastle for Landcom, Final August 2011;
9. RPS (2011b) *Corunastylis littoralis* Tuncurry Midge Orchid Combined Survey Results 2010/2011 North Tuncurry Report No. 26414 prepared by RPS Newcastle for Landcom, Final August 2011;
10. Letter from RPS to OEH, 18 August 2011 (2011c), Proposed Offset Strategy for North Tuncurry Study Area, North Tuncurry, NSW
11. 26414 Credit per hectare table 281011 - summary of biodiversity credits required to offset proposed impacts of Concept Plan – 2 options

In summary, the review has found that a significant amount of survey effort has been undertaken for the TMO both in the study area, adjacent to the study area and elsewhere over the past 4 years and the ecological knowledge of the species has improved. This survey effort has been quantified but is not shown spatially in either the orchid combined survey report or the flora and fauna inventory. Further, some of the survey effort is not yet documented in RPS 2011 (i.e. Paget 2008, ERM 2010)

The current development footprint has been designed to avoid impacts as far as practi.cal to the areas of highest abundance of TMO individuals but has not quantified this in terms of the area of confirmed habitat being impacted (within the study area and across the species range) nor the area of potential habitat (either of high, moderate or low potential). It is therefore difficult at this point in time to provide an opinion whether the magnitude of impact proposed would be supported by the various regulators.

An offset strategy has been proposed for the impact to around 5% of the currently known TMO population within and immediately adjacent to the study area. The current offset strategy has largely focussed on direct offset measures i.e. the identification of areas to protect the TMO, rather than additional or complementary indirect measures i.e. contribution to ecological studies to improve the knowledge and management requirements of the species. Whilst the proposed offset strategy has achieved the protection of a significant proportion of the on-site and local TMO population, the long term viability of the proposed offset area is likely to be low due to its linear nature and inevitable edge effects. Further consideration is required to identify an on-site offset area that has a better conservation design and/or further information should be provided regarding the management of the area.

If you have questions about any aspect of this review, please contact me on (02) 8536 8620.

Yours sincerely

Robert Humphries

Robert Humphries

Manager Biobanking and Offset Programs, Eco Logical Australia Pty Ltd

INDEPENDENT REVIEW OF NORTH TUNCURRY ECOLOGICAL ASSESSMENT AND OFFSET STRATEGY

Tuncurry Midge Orchid Survey and Impact Assessment

The Tuncurry Midge Orchid combined survey results report (RPS 2011) was reviewed by Dr Lachlan Copeland, a renowned orchid expert who is familiar with the species and the previous work by Paget (2008) and Robert Humphries of Eco Logical Australia Pty Ltd.

It is assumed that the Ecological Inventory report would provide a summary of the more detailed findings of the TMO survey report, however, there is information in the Ecological Inventory Report (survey dates, photograph, figures of plant densities etc) that are not in the detailed TMO survey report. This information should be added to the TMO report for completeness.

Taxonomy

Given that there is current uncertainty and debate as to the most appropriate name for this critically endangered species, it would have been appropriate to at least address this issue in the report. RPS has chosen to use the name "*Corunastylis littoralis*" which is the recommended name by Jones (2006) and is the name under which this species is listed under the federal *EPBC Act 1999*. In NSW, however, the most commonly applied name for this species is *Genoplesium littorale*, as recommended by the National Herbarium of NSW and their Plantnet website. This is also the name under which this species is listed under the NSW *TSC Act 1995*. Ideally this should have been spelt out in the introduction section of the report so as to avoid any future confusion.

Lack of any vouchers and/or photographs

Given the significance of this species, and the importance of getting its identification correct, it is surprising that there are no photographs of the species have been included within the TMO combined survey results report or photographs of the different populations (although a photograph is included in the RPS Ecological Inventory Report). Likewise no mention is made of any vouchers of this species being collected and lodged at a relevant herbarium such as the National Herbarium of NSW or the Australian National Herbarium in Canberra, particularly for the new populations west of the Wallamba River and Booti Booti National Park. As with most native ground orchids it is possible to gently and cleanly cut off the top of the orchid above ground level and use this as a voucher, while effectively leaving the underground part of the orchid (tuber) unharmed.

Although we assume that the ecologists from RPS have correctly identified the species during all their surveys, a single close-up photograph in the report would have been an obvious addition. There are other similar-looking species which grow in sandy coastal habitats e.g. an undescribed member of the *Genoplesium rufum* complex from less than 40 km away in Myall Lakes NP. Both grow in very similar sandy habitats close to the ocean.

Genoplesium littorale

Genoplesium rufum complex (Myall lakes)

Detail of Survey effort, dates and flowering observations

Midge orchids are notorious for their highly variable flowering time as they often flower best in response to seasonal conditions (e.g. 5-7 weeks after significant rainfall events) within their broader flowering period. Most spring-flowering orchids, in contrast, have a more consistent, reliable flowering period. Given that one of the goals of the report was to "*Provide insights into the ecology of this poorly understood species*" it would have been prudent to list the dates on which it was observed flowering. Table 2-2 in RPS 2011 Ecological Inventory includes a table of survey dates which indicates that targeted TMO surveys were conducted on 22-25th/3/2010, 29/3-1/4/2010, 19-22nd/4/2010, 3-7th/5/2010, 10-14th/5/2010, 11-13th/4/2011, 18-21st/4/2011, 27-29th/4/2011 and 3-5th/5/2011 equating to 34 days of random meanders, of which, 24 of these days (according to Table 2-1 in the Ecological Inventory Report) were within the subject site.

Table 2-2 of the Ecological Inventory Report should be included in the Orchid Report with an indication of which dates the species was detected flowering and which population/s were flowering. A figure should be included that shows the locations of the 24 days of „random meanders" within the subject site (easily obtained by the GPS tracks function) and provide an indication of the number of person hours allocated to this task i.e. was most of this effort concentrated around the margins of tracks and easements or in the heart of the heath areas.

There is no reference in the TMO survey report of the 3 days of survey undertaken by ERM in March 2009 in which 15, 47 and 31 orchids were recorded within and/or adjacent to the site (ERM 2010). The 2010 ERM report also includes information on habitat preferences and flowering times. Similarly, this information and the effort by Paget (2008) is not included in Table 2-1 of the Ecological Inventory report.

Ambiguous number of populations

Most of the text in the report infers that there are "three" populations/locations of the species: Tuncurry North, Booti Booti NP and "West of Wallamba River". The distribution map presented in Figure 3-1 however, clearly shows a fourth distinct area of occurrence (i.e. a population north east of Minimbah Nature Reserve in addition to the area south of the nature reserve some 8-10km distant. It is unclear whether the far north-western pink point is what is referred to as the "West of Wallamba River" population, or whether the greater number of both pink and yellow points further south are representative of this population. Clearly the number of known locations is of great importance and this information should be explicitly clear with no contradictions between the distribution map and the text presented in the report.

Further the legend on Figure 3-1 refers to Crown Lands North and South as well as Mid Coast Water Lands without actually labelling these areas. It is unclear which of the 3 populations these areas refer to.

Adequacy of survey effort

It appears that a relatively high level of effort has been made to search for *Genoplesium littorale* on the study site. The combined survey effort and coverage (Paget, ERM & RPS) for this species should be included in the Orchid Report as described above.

Four consecutive years of targeted survey by Paget (2008), ERM (2009) and RPS (2010 and 2011) have probably accounted for the considerable range of variation that is often present in the number of flowering plants in different seasons in a typical population of a midge orchid. RPS should be commended in finding and documenting the two or three additional new populations which represent highly significant range extensions of an otherwise poorly understood and highly restricted species, including a population occupying several sites over a 5km range in a secure conservation reserve (Booti Booti National Park).

Whilst the number of plants in the North Tuncurry Crown lands site represent a significant proportion of the total estimated population size, it is difficult to compare the relative survey effort in these new populations. The 2 or three additional sites appear to have had a total of 10 days survey effort (including recording abundance) over two years compared to 24 days by RPS, plus Paget (2008) and ERM (2010) at the subject site. If the other sites had a similar level of survey effort per unit area as the subject site, the proportional distribution of the total population size may well be quite different i.e. the North Tuncurry site may represent significantly less than 92% of the population.

Most of the documented plants within the North Tuncurry Crown land site appear to be within a few metres of existing tracks and this is likely to result from the ease for which these areas can be traversed/surveyed. RPS claim that it is also a function of these areas having been more disturbed/opened up and this is also likely to be largely true. From Dr Copeland's experience most midge orchids prefer areas of microhabitat that are relatively open and have relatively high levels of sunlight and air flow. Alongside vehicle tracks are often the most productive areas to search for these orchids (*Genoplesium* spp. in general) and this is also consistent with Dr Copeland's previous encounters with *Genoplesium littorale* in 2008 and 2009. In slashed areas beneath powerlines is another favoured habitat of this (and other) *Genoplesium* species.

A possible scenario that has not been explored is that the orchid is still present in the undisturbed areas but may not flower regularly in these areas and is therefore not detectable. This phenomenon is well documented for various other ground orchids (e.g. *Caladenia* and *Prasophyllum*) whereby the individual plants may only flower for a few years following a fire or some other form of disturbance, then will cease to flower for several years until a suitable disturbance regime opens up the habitat once again allowing the species to flower. It is poorly known to what extent *Genoplesium* spp. cease

to flower in increasingly dense habitats, but assuming that *Genoplesium littorale* is absent from dense areas where it is not observed may be an erroneous assumption. However, further survey effort in these areas is likely to have similar results unless the surveys are undertaken following a natural disturbance such as a bushfire. In the absence of being able to wait until a fire goes through the area, the habitat should still be regarded as being "potential" habitat and cautious assumptions on the likelihood of orchids being present made. This may enable the abundance of the TMO population to be expressed as the number of confirmed individuals as well as the area of confirmed and potential habitat as well as being able to quantify the impacts of development using the same categories. If there is good information regarding the disturbance history of parts of the heath area (e.g. previous sand mining and/or clearing for agro-forestry), it may be possible to assign probabilities of the orchid occurring in various parts of this "potential" habitat based on an analysis of the characteristics of the areas where it has been recorded.

Alternatively, ecological studies into the response of the TMO to various disturbances (e.g. hot and cool autumn/spring burns and/or slashing in small areas of known/confirmed and potential habitat) could be undertaken in parallel to the impact assessment to provide guidance in the management of retained areas for the TMO.

Given that other *Genoplesium spp* have been recorded flowering in the first few years following fire, it is surprising that there is no mention of the survey effort in the burnt heath area in the north east of the subject site. Of the nine quadrats that were surveys for Genoplesium, none were in the burnt heath and as the location of random meanders is not shown, it is difficult to comment whether any of the random meanders included this area

In spite of the above limitations, additional survey effort in the denser, heathy areas would still be appropriate. The methodology employed in 2011 (looking intensely in nine large quadrats) only yielded plants in a single quadrat – it would be preferable to look closely at a much larger number of smaller, widely-spaced quadrats. This would have only taken slightly more survey effort but would have given a clearer picture of the presence/absence of the species across the whole site in the dense areas of heath. On page 8 of the report it is stated that the 40 x 40 metre quadrats were "randomly placed" but looking at the map of these quadrats (Figure 2-2) they can hardly be interpreted as being random as all but one are adjacent (or very close) to an existing vehicle track. The question of whether or not the orchid occurs in good numbers in dense areas of heath away from disturbed areas still remains largely unanswered.

Given the now known extent of the population and areas occupied, it should be possible to update the area of occupancy (documented as 8 km² in the NSW Scientific Committee listing) and range of occupancy (reported in the EPBC Act listing as 20km north-south and 9km east-west) and undertake more refined impact assessment calculations whereby in addition to the proportion of the population abundance being impacted, information is provided on the proportion of the area of occupancy impacted.

Further survey work and ecological information

Figure 2-2 in the Orchid Report makes reference to the identification of "suspected optimal habitat" although this is not defined as to whose definition of optimal habitat these areas relate to (i.e. Paget (2008), ERM (2010), NSW Scientific Committee or EPBC Act listing). The text in the report refers to areas where the TMO has been recorded including previously mined areas, previously burnt areas, vegetation communities with open understoreys, low and wet heaths, however the report does not include a figure which shows these features with an overlay of orchid records. The closest figure is that within the offset proposal report. It would be useful to include a similar figure in the orchid report.

In ATTACHMENT A of the requested SSS study requirements by OEH, it is requested that "*Further targeted surveys, impact assessment and understanding long-term management requirements of this*

species are required". It is difficult to argue with this statement and it is agreed that further surveys in the heath area would be desirable,, but research into the "long-term management requirements of this species" is likely to be a very difficult, long-term process. Similarly, there is a recommendation in ATTACHMENT B stating that "*research into the species ecology, lifecycle, and habitat preferences would need to be subject to further consideration*…". Once again this additional information would obviously be beneficial but acquiring such data may be easier said than done. The lifecycle of *Genoplesium* spp. is probably well understood enough in this context but it is agreed that further information on its habitat preference and response to fire/disturbance could be sought.

Subject to any development being approved, it is likely that the development would proceed over many years (10-20 years)) This provides plenty of opportunity to initiate long term ecological studies at both the potential development site and retained areas on and off-site as part of an indirect offset package. Further, a number of recommended research priorities are included below.

Likely impacts of the proposed development on *Genoplesium littorale*

At this stage, a detailed impact assessment appears not to have been undertaken as a final development layout has not been finalised. The indicative Concept Plan will result in the loss of approximately 5% of the known population, will marginally affect the extent of occurrence and more significantly affect the area of occupancy. The survey data to date should be able to quantify the area and proportion of "confirmed" habitat being potentially impacted as well as the area and proportion of potential (yet to be confirmed) habitat being affected. It should also be possible to provide a level of "probability" of occurrence, based on the results obtained to date i.e. whilst the "heath" has been identified as "potential" habitat, how likely is it that the species occurs there given the survey effort to date, the characteristics of the habitat where it has been found and the type and extent of disturbance in these areas. In addition, as pointed out by the OEH and GLC preliminary reviews, the Concept Plan and resulting retained areas will have other indirect impacts on the species which may include disruption of the pollination mechanisms (i.e. negative impacts on the small vinegar flies that pollinate *Genoplesium* spp.), and greatly increased edge effects to the species and its habitat given that the proposed offset areas are very long thin, linear areas. Such areas will no doubt be prone to weed invasion and control of these invasive herbs using traditional herbicide techniques may also have a serious effect on the remaining plants of *Genoplesium littorale*. It is likely that an increased incidence of feral animals (e.g. rabbits) following the development may also increase the grazing pressure on the species.

Recommendations for future study

The main recommendation for future study is to more accurately quantify the number of plants and area of habitat occurring in the proposed development area. While this has already been done to a reasonably high standard along the vehicle tracks it is still possible that large, additional subpopulations occur in the dense heathy areas but have simply not flowered (and were therefore not detected) during the past 4 years of survey.

Given the timeframes for any development in the area there is also scope for a range of further scientific studies into the ecology and management of the species on site and in other recently documented populations. These studies could form part of a staged approval and comprise part of a direct and indirect offset package.

The highest priority for research is to conduct slashing and/or burning of some small areas of heath where the species has not been recorded to see if *Genoplesium littorale* is observed flowering in these areas in subsequent years. A proper experimental design should also include slashing and/or burning areas with confirmed individuals during autumn and spring to see how these areas respond.

If any approval includes the loss of individuals, these plants should be salvaged for propagation and mycorrhizal fungi association trials.

A suitably qualified expert with experience in managing threatened species of *Genoplesium,* such as John Briggs of OEH Queanbeyan, should be consulted in the design of any such research program.

The data to undertake such an assessment is contained in the ecological inventory report or can be derived from the studies already undertaken and thus be used to meet GLC and OEHs request in this regard.

Impact Assessment

The need for further targeted survey in the heath areas for the TMO is consistent with the gap analysis undertaken by Dr Copeland. The "*understanding of long term management requirements*" for the TMO is a requirement difficult to meet within a reasonable development assessment timescale, however, assuming that proposed impacts are considered acceptable (i.e. less than 5% of the on-site population) can be addressed in parallel and subsequent to development decisions as part of a direct and indirect offset package, using both on and off-site populations, to inform management of the offset areas.

Offset Strategy

A biodiversity offset strategy has been proposed for the preliminary Concept Plan and a variation on this plan. The offset strategy includes both on-site and off-site conservation areas with these areas either being managed under suitable conservation covenants or as dedication to the NPWS Estate.

At this stage, the proposed offset strategy has concentrated on a secure outcome for a significant proportion of the TMO population and has not documented how it addresses the other threatened species whose habitat will be impacted.

The offset includes 254.14 ha of on-site habitat and an adjacent area of land owned by the Foster LALC. The area and vegetation communities on this parcel are not described but believed to be around 9.2 ha.

The offset strategy does not discuss how it addresses the principles for offsets in NSW (DEC 2008) or the Commonwealth Draft Offset Principles (DEWR 2007) or whether it meets an improve or maintain outcome. It does however address to an extent the measure taken to avoid and mitigate impacts and a range of development options.

The SSS study requirements requires the offset strategy to be prepared in line with the OEH Interim Policy on assessing and offsetting impacts of Part 3A, State Significant Development and State Significant Infrastructure projects (OEH June 2011). This policy provides for a three tiered approach to addressing offset requirements, with the preferred outcome (Tier 1) being fully meeting an Improve or Maintain Outcome (no impacts to red flags), followed by a Tier 2 outcome (no net loss, meets the IoM quantum of offsets but impacts to Red Flags allowed) or Tier 3 (a negotiated offset that as a minimum meets a 2:1 ratio).

RPS has undertaken some initial improve or maintain (IoM) calculations for various development scenarios using the Biobanking Credit Calculator..

There is no information whether these assessments have used any biometric plot data or whether it has been assumed that the vegetation communities are in benchmark condition.

It is noted that only the TMO has been identified as a „Red Flag" issue.

It is noted that both OEH and GLC have commented on the configuration of the proposed offset lands and have described part of the proposed offsets as inappropriate due to their high edge to area ratios (i.e. they are essentially long narrow strips of vegetation that would be subject to significant edge effects thereby diminishing their value as offsets. These statements are supported and consideration needs to be given to improving the design of the proposed offsets lands to reduce edge effects and improve their ability to achieve long term viability.

OEH also raises the issue of „additionality" as to whether Crown Land can participate as an offset. OEH points to Principle 12 in the Lower Hunter Regional Conservation Plan (LHRCP) that states "*areas already managed by the Government, for example.....crown reserves, cannot be used as offsets"*. It is noted that Principle 12 in the LHRCP is inconsistent with the same offset principle on the OEH website (Attachment 1) and OEHs Policy on "additionality" in the Biobanking Scheme (*Additionality and its affect on credit creation DECCW 2010)).* This policy states that unless the "*Act"* does not specifically require certain management actions to be undertaken, the management actions are not to be taken as existing conservation obligations. In the case of Crown land, the Crown Lands Act states that „*Crown Reserves must generally be managed consistently with their public purpose, the principles of crown land management and <u>any</u> adopted Plan of Management"*. Unless a parcel of Crown land has been dedicated as a reserve under section 87 of the Crown Lands Act and a Management Plan has been prepared, there is no legal requirement to manage the land for a particular purpose. Land reserved for a public purpose, as notified in the Government gazette, can be changed to another public purpose simply by a gazettal notice. The Tuncurry Crown lands are reserved for "public purposes". The Tuncurry Crown land therefore can be used as an offset.

References

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Great Lakes Council (2003) Draft Great Lakes Council Vegetation Strategy, Great Lakes Council, Forester NSW

Paget, A (2008) Results of searches for the Tuncurry Midge-Orchid (*Genoplesium littorale*, syn *Corunastylis littoralis*), CMA, Autumn 2008

Attachment 1: NSW Offsetting Principles

These offset principles are from the DECCW website (30/5/2010):

1. Impacts must be avoided first by using prevention and mitigation measures.

Offsets are then used to address remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

2. All regulatory requirements must be met.

Offsets cannot be used to satisfy approvals or assessments under other legislation, e.g. assessment requirements for Aboriginal heritage sites, pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

3. Offsets must never reward ongoing poor performance.

Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

4. Offsets will complement other government programs.

A range of tools is required to achieve the NSW Government"s conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks and incentives for private landholders.

5. Offsets must be underpinned by sound ecological principles.

They must:

- include the consideration of structure, function and compositional elements of biodiversity, including threatened species
- enhance biodiversity at a range of scales
- consider the conservation status of ecological communities
- ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

6. Offsets should aim to result in a net improvement in biodiversity over time.

Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.

Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset against the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.

Offsets may include enhancing habitat, reconstructing habitat in strategic areas to link areas of conservation value, or increasing buffer zones around areas of conservation value and removal of threats by conservation agreements or reservation.

7. Offsets must be enduring & they must offset the impact of the development for the period that the impact occurs.

As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or a private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

8. Offsets should be agreed prior to the impact occurring.

Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

9. Offsets must be quantifiable & the impacts and benefits must be reliably estimated.

Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- the area of impact
- the types of ecological communities and habitat/species affected
- connectivity with other areas of habitat/corridors
- the condition of habitat
- the conservation status and/or scarcity/rarity of ecological communities
- management actions
- level of security afforded to the offset site.
- the best available information/data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:
- they protect land with high conservation significance
- management actions have greater benefits for biodiversity
- the offset areas are not isolated or fragmented
- the management for biodiversity is in perpetuity (e.g. secured through a conservation agreement).
- management actions must be deliverable and enforceable.

10. Offsets must be targeted.

They must offset impacts on the basis of like-for-like or better conservation outcome. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats. Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

11. Offsets must be located appropriately.

Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

12. Offsets must be supplementary.

They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space cannot be used as offsets.

13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.

Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

Appendix 2

Flora Search (2012) Pollination Study

PRELIMINARY REPORT ON POLLINATION OF THE TUNCURRY MIDGE ORCHID (*Genoplesium littorale*)

Report prepared for Landcom
by Colin C Bower PhD

April 2012

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INTRODUCTION

FloraSearch was commissioned by Landcom to investigate the pollination mechanism of the Tuncurry Midge Orchid, *Genoplesium littorale*, on the site of a proposed future housing development at North Tuncurry, NSW. One day (15 April 2012) was spent on site at North Tuncurry during which three inflorescences were collected for dissection of flower parts. Unfortunately, it was too late in the flowering period for other aspects of the research plan to be implemented. Unusually intense rainfall in previous months brought forward the flowering season of *G. littorale*, such that most plants flowered about a month earlier than expected.

The objectives of collecting, preserving and dissecting flowers were to:

1. To determine the pollination mechanism employed by *Genoplesium littorale*, i.e. whether it is outcrossing, selfing (autogamous) or apomictic.
2. Determine whether the flowers of *G. littorale* emit an odour and/or produce nectar to attract pollinators.
3. If the species is autogamous, determine the mechanism of autogamy via microscopic examination of flowers at different stages of development.

METHODS

Collection and preservation of flowers

Two populations of *G. littorale* were inspected, east of the Tuncurry Tip and in the powerline easement east of Chapman Road. The inspections revealed that flowering had finished and the inflorescences of most plants had withered. Two inflorescences, one at Tuncurry Tip and one opposite Chapman Road, still had a few open flowers. The two inflorescences with open flowers were collected and inspected for the presence of nectar on the labellum using a 10X magnification hand lens. They were also smelt to determine if a detectable odour was present. A third inflorescence, with recently closed flowers that were still green, was also collected. After examination for nectar and odour, the three inflorescences were placed in 70 percent ethanol in separate vials.

Seed set data

Eighteen post flowering inflorescences were scored for the presence of developing seed pods, ten at Tuncurry Tip and eight at Chapman Road. Each finished flower was examined sequentially from the bottom of the inflorescence to the top and scored as to whether or not the ovary was swollen, indicating seed pod development.

Flower examination

Flowers of preserved *G. littorale* were examined individually with a binocular dissecting microscope at magnifications up to 40 times. The following information was recorded for each flower:

- whether the pollinarium (viscidium plus pollinia) was present in the anther sacs or had been removed by a pollen vector
- whether any pollen had been placed on the stigma, and if so, whether it was a small, medium or large amount
- whether the ovary was swollen
- if the pollinarium remained in situ, whether there was any evidence of self-pollination, such as growth of pollen tubes into the stigma from the anthers, or the spilling of pollen from the anthers onto the stigma, or outgrowth of the stigma to contact the pollinia.

RESULTS

Genoplesium species present

Examination of the three preserved inflorescences revealed there were two *Genoplesium* species present; *G. littorale* (2 specimens) and a species that appears to be *G. rufum* (1 specimen) (Plate 1). Both *G. littorale* specimens had high numbers of flowers that were mostly finished, 13 and 19, while *G. rufum* carried only six flowers, three open and three still in bud. This suggests that *G. rufum* flowers later than *G. littorale*. It is considered that all but two of the *Genoplesium* plants seen were *G. littorale*. Table 1 summarises the contrasting characteristics of the two species. Plate 1 shows *G. rufum*; no photograph of *G. littorale* flowers was obtained.

Table 1
Characteristics of *Genoplesium littorale* and *G. rufum*

Character	*G. littorale*	*G. rufum*
Lateral sepal	4 mm long, relatively narrow, no apical glands, slight hump towards base	3.7 mm long, relatively broad, whitish glands at tip, strongly humped close to base
Dorsal sepal	Shallowly concave, relatively narrow with a straight acuminate tip	Deeply concave, relatively broad with an acute deflexed tip
Petal	Lanceolate, drawn out to an acuminate point	Ovate, drawn out to an acuminate point
Labellum	Thick and fleshy when fresh, purple coloured, callus occupies most of the lamina and has a shallow central groove that is smooth and shiny	Thin labellum lamina with a broad deeply furrowed callus occupying most of the lamina surface
Overall	Key features are the fleshy purple labellum, rather narrow drawn out petals and sepals, the lack of apical glands on the lateral sepals and the obscure lateral sepal hump.	Key features are the apical glands and prominent hump on the lateral sepals, the relatively broad petals and sepals and the deep furrow in the labellum callus.

Odour and nectar

No nectar was detected on the labellum of *G. littorale* flowers on the specimen from the power line easement. However, these flowers were relatively old and may no longer have been functional. By contrast, a row of nectar droplets was present in the labellum furrow of the *G. rufum* flowers, which is shown in Plate 2. These flowers were freshly opened and fully functional.

Seed set

The proportions of flowers setting seed were determined on 18 plants of *G. littorale* in the field (Table 2). The proportions of flowers developing seed pods varied widely from zero to 100 percent, with an average of 34.6 percent (Table 2). Similar levels of seed set were present at both the Tuncurry Tip and power line easement sites.

Plate 1. *Genoplesium rufum*, North Tuncurry, NSW

Plate 2. Nectar droplets in the furrow of the labellum callus, *Genoplesium rufum*, North Tuncurry, NSW

It was noticed that some plants had lost their inflorescences altogether, the top parts of others were missing and that the tops of still others had shrivelled. The likely cause of these flower losses is herbivory by macropods in the case of completely missing flower heads. Partial loss of inflorescences and shrivelling are most likely caused by hot, dry weather conditions. It seems likely that the early flowering of *G. littorale* stimulated by above average rainfall in summer 2012, made the population susceptible to subsequent periods of high temperatures in early autumn. Nevertheless, the early flowering strategy was successful, with seed set occurring on most plants, in some cases at very high levels (Table 2).

Table 2
Counts of Seed Pods on *Genoplesium littorale*, North Tuncurry, NSW

Plant No.	Location	Total flowers	Total seed pods	Percent seed pods	Notes
1	Tuncurry Tip	8	2	25.0	Top of inflorescence lost (not counted)
2		10	1	10.0	Top of inflorescence withered (not counted)
3		13	0	0.0	All flowers withered
4		15	3	20.0	
5		8	1	12.5	Some flowers missing (counted in 8)
6		16	3	18.8	
7		17	7	41.2	
8		16	5	31.3	
9		12	12	100.0	Plate 3
10		25	22	88.0	
11	Power line	14	3	21.4	
12		8	2	25.0	
13		10	5	50.0	
14		22	3	13.6	18 of flowers shrivelled above
15		11	0	0.0	
16		16	4	25.0	
17		16	11	68.8	Four open flowers. This plant collected for dissection.
18		7	5	71.4	
Total		244	89		
Mean		13.6	4.9	34.6	

Plate 3. An inflorescence of *Genoplesium littorale* with 100 percent seed set.

Flower examinations

Three inflorescences were collected and preserved for microscopic examination of the pollination mechanism. All flowers on each inflorescence were examined for the presence of the pollinarium in the anthers, the presence of pollen on the stigma, and whether a seed pod had developed. The results are summarised in Table 3.

Table 3
Results of flower dissections

Species	***G. rufum***	***G. littorale***	***G. littorale***
Location	Tuncurry Tip	Tuncurry Tip	Power line easement
Total flowers	3	13	19
No. of pollinaria removed	0	10	18
% pollinaria removal	0	76.9	94.7
No. with pollen on the stigma	0	2	14
% pollinated	0	15.4	73.7
No. of seed pods	0	3	13
% seed pods	0	23.1	68.4

The plant of *G. rufum* had only three fresh flowers in which no pollinaria removal or pollination had taken place.

By contrast, high levels of pollinaria removal, 77 and 95 percent, had occurred in both *G. littorale* inflorescences. However, only the power line plant also had high pollination (74%) and seed pod (68%) levels. Only three seed pods formed on the Tuncurry Tip plant and there was very little evidence of pollen deposition in these three flowers. Very small amounts of pollen were present in two of the flowers and no pollen was detectable in the third. Pollen was also absent from the stigmas of all flowers that did not develop seed pods. It is not clear why such low levels of pollination occurred in this plant when the levels of pollinaria removal were relatively high. It may be that weather conditions inhibited pollinator activity when the flowers on this plant were at their most attractive, and that by the time suitable conditions arrived, the flowers were aging such that the stigma was less receptive (drying out) even though pollinaria could still be removed.

In contrast, the peak of attractiveness of the power line easement plant appears to have coincided with both a good pollinator population and suitable weather for pollinator activity. Consequently, this plant and several others (Table 2, Plate 3) were very successfully pollinated. Most flowers on this plant had both their pollinaria removed and pollen deposited on the stigma (13 flowers). It is worth noting that the four open flowers on this plant had their pollinaria removed, but no pollen deposited. Only one flower still retained its pollinarium, and despite this, was heavily pollinated.

No evidence of self-pollination was found in any flower. There was no indication of growth of the anthers or stigmas towards each other, or the dropping of pollen onto the stigma from an anther. All observed pollinaria maintained their coherence and separation from the stigma, thereby precluding autogamy. Nor did the evidence support the occurrence of apomixy. Although two flowers on the Tuncurry Tip plant appeared to develop seed pods without pollination, it is possible the pollen had been fully absorbed into the stigma.

The evidence from the power line plant overwhelmingly points to insect pollination owing to:

- the complete removal of pollinaria from the anthers (also evident in the Tuncurry Tip plant)
- the deposition of pollen onto the stigma in flowers from which the pollinaria had been removed
- development of seed pods only in flowers that had pollen deposited on their stigmas

DISCUSSION

Genoplesium species present

Two species of *Genoplesium*, *G. littorale* and *G. rufum*, occur at North Tuncurry. *G. littorale* is by far the more common species and flowers earlier than *G. rufum*. On 15 April, *G. littorale* had all but finished flowering with only one plant, out of 40 or more observed, having any open flowers. By contrast, flowering in *G. rufum* was only just starting; the one plant collected had three fresh flowers with active nectar secretion and seven unopened buds. A further plant with only early bud development was found and is also likely to have been *G. rufum*.

Pollination mechanism of *G. littorale*

The observations of floral morphology, pollinaria removal and pollen deposition in *G. littorale* are all consistent with insect-mediated pollination. The evidence does not support the existence of autogamy or apomixy in *G. littorale*. If the species was obligately autogamous, all flowers developing seed pods would have retained their pollinaria and a mechanism would be present for transfer of pollen onto the stigma. No such mechanism is present. If the species was facultatively autogamous, flowers from which pollinaria had not been removed by insects and which had not been pollinated by insects, would have a mechanism for transfer of pollen from the anthers to the

stigma. No evidence for such transfer was found. Similarly, although two flowers appeared to develop seed pods on the Tuncurry Tip plant without pollination, suggesting apomixy, a more likely explanation is that the flowers on this plant were relatively old and the pollen had been fully absorbed into the stigma. In addition, if the pollination mechanism was apomixy, all flowers would go on to develop seed pods, which is not the case.

Pollinators

No pollinators of *G. littorale* were able to be collected, owing to the lack of suitable flowering material. However, the pollinators are likely to be tiny flies of the families Chloropidae and Milichidae in the superfamily Chloropoidea (see review by the author in Attachment 1). According to Colless and McAlpine (1991), the adults of Chloropidae '*are of almost ubiquitous occurrence, and the larvae inhabit a wide range of habitats, though still little known*'. It is likely that the Chloropid or Milichid pollinators of *G. littorale* are abundant at North Tuncurry, especially given the very high pollination percentages that occur on some plants. Such high pollination levels are likely to be achieved when inflorescences at the peak of their attractiveness coincide with favourable weather conditions for chloropoid activity. These are likely to be sunny days with temperatures in the high 20s and high relative humidity. The circumstantial evidence suggests that *G. littorale* is stimulated to flower by high rainfall in late summer and early autumn, which is also likely to stimulate emergence of adult chloropoids, thereby achieving synchrony between plant and pollinator.

All insect pollinated *Genoplesium* species that have been investigated appear to secrete copious amounts of nectar from the labellum callus (Attachment 1). In general, plants that reward their pollinators with food do not tend to attract only a single pollinator species (Attachment 1). There is evidence that *Genoplesium* species have multiple pollinators (Attachment 1). Consequently, it is likely that *G. littorale* is pollinated by a suite of chloropoids, rather than a single species, although at any particular site, one species may be greatly dominant. Accordingly, it is expected that several chloropoid species are likely to pollinate *G. littorale* and that the composition of the pollinator pool may vary from site to site. It is clear from the two sites inspected for this report that pollinators are sufficiently abundant at North Tuncurry to achieve quite high pollination levels in some plants and some level of pollination in most plants. The pollination levels found in this study compare very favourably with those recorded in orchids generally, which are often quite low. The low levels of pollination in most orchids are compensated by the very high numbers of seeds that are produced, which is likely to be several hundred per pod in *Genoplesium*.

Habitat requirements of pollinators

The pollinators of *Genoplesium* are very small species of flies, so small that they have been observed to move through insect mesh screen doors (Attachment 1). Insects of this size are unlikely to require very large areas in order to maintain viable populations. Very little is known about minimum viable areas for insect conservation. However, areas in the vicinity of 25 to 100 hectares have been recommended for some of the larger invertebrates. It is reasonable to consider that insects as small as chloropoids are likely to maintain viable populations in smaller areas. Ten to 25 hectares is considered likely to provide sufficient habitat to maintain quite large population sizes of chloropoids and to provide a buffer against catastrophic events. It would also be important to provide corridors of suitable vegetation between reserves for *G. littorale* and large reservoir areas to allow re-establishment of pollinator populations through immigration should local extinction occur.

CONCLUSIONS

1. Two species of *Genoplesium* occur at North Tuncurry, the Tuncurry Midge Orchid, *G. littorale* and the Red Midge Orchid, *G. rufum*. *G. littorale* flowered earlier than *G. rufum* in 2012, and is much more abundant on the two sites examined.

2. The proportion of flowers setting seed on 18 inflorescences varied from zero to 100 percent, averaging 34.6 percent. Similar levels of seed set occurred at the Tuncurry Tip and power line populations.

3. Some plants were adversely affected by macropod grazing and others by hot, dry weather conditions.

4. Microscope examination of flowers on two preserved inflorescences of *G. littorale* showed:

    a. They had high levels of pollinaria removal by insects, 77 (Tuncurry Tip) and 95 (power line) percent.

    b. The power line flowers had higher levels of pollination of the stigma (74%) and seed pod development (68%) than the Tuncurry Tip flowers (15 and 23 percent, respectively).

    c. The high variation in pollination percentages is considered to be attributable to whether the peak attractiveness of flowers to pollinators coincides with the occurrence of suitable weather for pollinator activity.

5. Observations of floral morphology, pollinaria removal and pollen deposition in *G. littorale* are all consistent with insect-mediated pollination.

6. The evidence does not support the existence of self-pollination (autogamy) or apomixy in *G. littorale*.

7. The pollinators of *G. littorale* were not identified, but are considered likely to be tiny flies of the superfamily Chloropoideae.

8. The pollinators are considered likely to be abundant at North Tuncurry owing to the high pollination levels that occurred on some plants, and the fact that most plants had at least some flowers pollinated.

9. It is considered that for very small insects such as Chloropoideae a minimum reserve size of 10 to 25 hectares is likely to conserve populations sufficiently large to be viable in the long term, provided corridors of undisturbed habitat link reserves for *G. littorale* to larger reservoirs of pollinator species.

REFERENCE

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ATTACHMENT 1

GENERA ORCHIDACEARUM

Volume 2

Orchidoideae (Part 1)

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(although not formally) within subfamily Spiranthoideae. Szlachetko (1991) maintained Prasophyllinae as a monogeneric taxon, preferring instead to treat it as a subtribe within Diurideae, Thelymitroideae. He later transferred Prasophyllinae to his tribe Microtideae (Szlachetko 1995) by broadening the circumscription of the tribe.

Prasophyllinae have been confirmed as members of Diurideae by Clements (1995) with embryological studies and later by Clements *et al.* (in preparation) using analyses of ITS sequences of rDNA, in which *Microtis*, *Genoplesium*, and *Prasophyllum* form a distinct clade, indicating a relationship originally proposed by Schlechter (1926). **(MAC)**

49. GENOPLESIUM

Genoplesium R.Br., *Prodr.*, 319 (1810). Type species: *Genoplesium baueri* R.Br.

Prasophyllum R.Br. sect. *Bifida* G. Don, in Loudon's *Hortus Brittanicus*, 369 (1830). Type species: *Prasophyllum rufum* R.Br.

Prasophyllum R.Br. sect. *Genoplesium* Hook.f., *Fl. Tasm.*, **2**, 10 (1858). Type species: *Prasophyllum brachystachyum* Lindl.

Corunastylis Fitzg., *Austral. Orch.* **2**, back cover (Mar. 1888), *nom. illeg.*

Anticheirostylis Fitzg., *Austral. Orch.* **2** (4), back cover (Mar. 1888), *nom. illeg.*

Antichirostylis Kuntze, in Post & Kuntze, *Lex. Gen. Phan.*, 36 (1903), *orth. var.*

Prasophyllum R.Br. sect. Micranthum Rupp, *Victorian Naturalist*, **66**, 75–9 (1949), *nom. illeg.*

Derivation of name

From the Greek *genos*, race or kind, and *plesios*, near, referring to the close relationship these orchids have with *Prasophyllum*. **(DJ)**

Description (Plates 60, 61; Fig. 49.1)

Perennial geophytic *herbs*. *Roots* filamentous. *Tubers* globose to subglobose, paired, fleshy, naked; replacement tubers formed on the end of short droppers; daughter tubers absent; vertical shoots with membranous cataphylls at each node. *Leaf* single, basal, sessile; leaf of sterile plants hollow, cylindrical, longer than wide, erect, glabrous, with an obscurely developed apical lamina; leaf of fertile plants similar but solid in section, the peduncle and most of the leaf (? petiole) fused together, the apical lamina free, with involute margins. *Inflorescence* racemose or spicate, 1–many flowered, erect, terminal, developing simultaneously with the leaf; scape slender, without sterile bracts; floral bracts reduced, closely sheathing, often unequally emarginate. *Flowers* non-resupinate, dull-coloured, often with a fruity fragrance, subsessile to sessile; perianth entire or the margins adorned with cilia or hairs, the apex with an apical gland or vestigial. *Dorsal sepal* free, broader than the lateral sepals. *Lateral sepals* free or basally fused. *Petals* free, dissimilar in size, shape, and coloration to the sepals. *Labellum* free, attached by its base to the apex of the column foot, freely mobile, markedly dissimilar in shape, size, and coloration to the sepals and petals, ecalcarate; lamina not lobed, the margins entire, denticulate, erose, glandular or ciliate; callus consisting of a raised fleshy central plate, often covering most of the lamina, usually grooved, smooth, or papillate; nectar present. *Column* short; column wings fused basally to column base, erect and free distally, usually bilobed, the anterior lobe often well developed and papillate; column foot shorter than the column, ligulate, the apex erect or incurved; anther porrect, prominently rostrate; pollinia four, in two pairs, yellow, sectile, attached to a terminal viscidium via a ligulate hamulus; pollen grains in tetrads; stigma entire, quadrate, rostellum apical. *Ovary* elongate, ribbed, glabrous. *Capsules* dehiscent, erect, glabrous, usually ribbed; pedicels not elongated in fruit; in some species the peduncle elongates considerably in fruit. *Seeds* numerous, light-coloured, winged. **(DJ)**

Distribution (Fig. 49.2)

A genus of about 45 species distributed in Australia, New Zealand, and New Caledonia, including Isle des Pines. **(DJ)**

Palynology

Tetrads of *Genoplesium baueri*, treated as *Prasophyllum baueri* (R.Br.) Poir. by Ackerman and Williams (1981), are similar to those of *Prasophyllum gibbosum* R.Br. (*q.v.*). **(AP)**

Ecology

Genoplesium is primarily an Australian genus with a single species, *G. calopterum* (Rchb.) D. L. Jones & M. A. Clem., from New Caledonia. Two other species, *G. pumilum* (Hook.f.) D. L. Jones & M. A. Clem. and *G. nudum* (Hook.f.) D. L. Jones & M. A. Clem., also occur in New Zealand. Within Australia *Genoplesium* is distributed from about 17° south in Queensland to about 43° south in Tasmania. In New Zealand it occurs between about 35° south and 44° south and in New Caledonia between about 20° south and 22°50′ south. These orchids are terrestrials and reproduce solely from seed, growing as individuals or widely spaced in colonies. They grow in seasonal climates and have periods of active growth and dormancy. The plants survive extremes of heat and dryness as dormant fleshy tubers partly encased in a resistant fibrous sheath, which extends to the soil surface and through which each new shoot develops. The leaves of sterile plants are hollow, but in fertile plants the leaf and flowering stem are fused and develop simultaneously as a single unit. The buds mature and flower as this fused unit elongates; in some species such as *G. nudum* substantial elongation continues prior to seed dispersal. Flowering occurs principally over summer, autumn, and winter, and seeds begin to be shed 6–12 weeks after pollination.

Species of *Genoplesium* are most abundant in coastal and near-coastal lowlands and extend to montane and subalpine regions. The genus reaches its greatest development in temperate south-eastern Australia and has few representatives within the tropics. Moss beds and accumulations of shallow soil over rock plates and rock sheets, particularly sandstone, are favoured habitats in Australia. Others

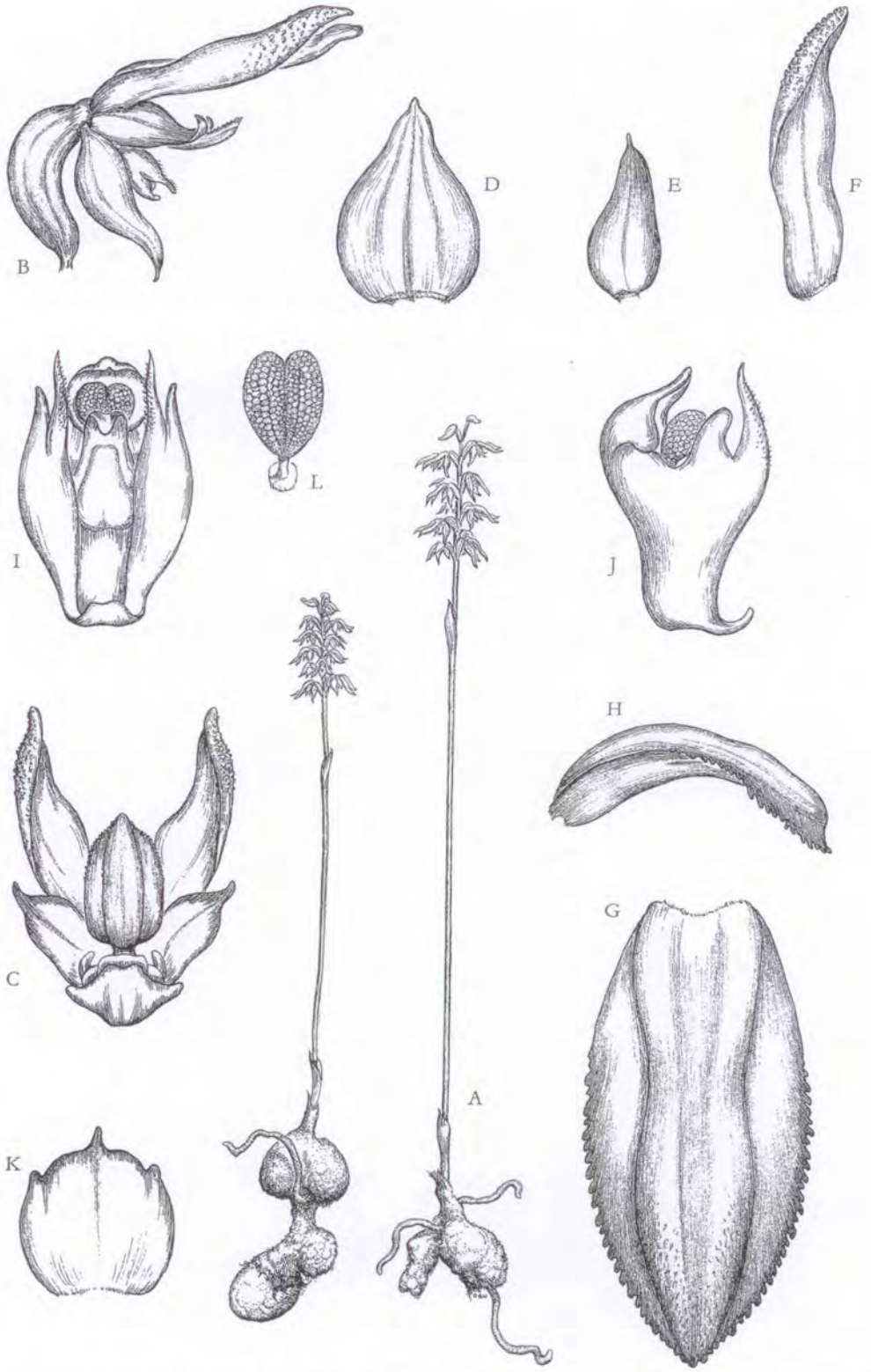

Fig. 49.1. *Genoplesium brachystachyum* (Lindl.) D. L. Jones & M. A. Clem. A. Habit, ×1; B. Flower from side, ×9; C. Flower from front, ×9; D. Dorsal sepal, ×9; E. Petal, ×9; F. Lateral sepal, ×9; G. Labellum from above, ×30; H. Labellum from side, ×21; I. Column from front, ×21; J. Column from side, ×21; K. Floral bract, ×15; L. Pollinarium. Drawn by Oliver Q. Whalley.

Fig. 49.2. Distribution map of *Genoplesium*.

include sclerophyll forest and woodland; montane grassy forests; heathland over sand or limestone; mallee shrubland over limestone and subalpine bogs. In New Zealand *Genoplesium* species occur in moist grassy areas, swamps, and bogs. In New Caledonia *G. calopterum* grows in stunted maquis developed on ultrabasic soils. **(DJ)**

Pollination

Formal scientific studies on the pollination of *Genoplesium* are lacking, but there have been a number of anecdotal reports by naturalists which provide some insights (Garnet 1940; Jones 1970*d*; Bates 1981*a*, 1988). The flowers of *Genoplesium* are small, inconspicuous, and dull-coloured in shades of reddish brown, purple, and green. The perianth may be fringed with cilia, the latter hanging loosely and waving freely in the breeze in some species. These characteristics conform most closely to myophily (fly pollination; van der Pijl and Dodson 1966), which is borne out by the limited data indicating that *Genoplesium* is pollinated exclusively by small, compact flies of the superfamily Chloropoidea. Garnet (1940) reported the presence of nectar in some *Genoplesium* species, indicating that the pollination strategy is one of nectar reward. A few species are autogamous (Jones 1972*a*, 1998*d*), and one is apomictic (Jones 1977; Jones and Clements 1989)

Jones (1972*b*) reported that *Genoplesium nudum* (as *Prasophyllum beaugleholei* Nicholls) and *G. pumilum* (as *P. aureoviride* Rupp) are autogamous. He also noted (Jones 1998*e*) that populations of *G. archeri* (Hook.f.) D. L. Jones & M. A. Clem. in south-west Tasmania are autogamous, whereas the species is entomogamous throughout the rest of its large range. *Genoplesium nudum* has a suite of characteristics typical of autogamous orchids (Jones 1972*b*). The flowers are short-lived, lasting only two to three days. The pollinia lack coherence, even in the bud, and are only weakly attached to the viscidium, which lacks a viscid secretion and is unlikely to be removed by an insect. Ovaries on all plants swell and contain viable seed by contrast to outcrossing species in which many ovaries do not produce seeds.

The mechanism of self-pollination in *G. nudum* is simple but does not commence until the flower has opened (Jones 1972*b*). The anther is located behind the narrow upper half of the stigma and is separated from it by the rostellum in the early bud. Two days before the flower opens the rostellum moves forward of the anther, the pollinia are incoherent, and the stigma has become moist but not sticky. After the flower opens the anther sacs split wide open, the pollinia rest on the back of the rostellum, which has bent further forward in front of the stigma to an angle of 45°or less, and pollen grains begin to fall on the now-sticky stigmatic surface. As flowering progresses pollination appears to involve two processes; the loose pollen grains crumble over the rostellum onto the stigma, and the stigma grows around the rostellum to meet them. The stigma ultimately becomes swollen and distorted.

The dominant pollination mechanism in *Genoplesium* appears to be xenogamy or geitonogamy mediated by small flies. The early observations of Garnet (1940) remain the most thorough and complete pollination study of the group so far. He studied four species near Melbourne in Victoria, although their exact identity is uncertain due to recent taxonomic revisions (Jones and Clements 1989; Jones 1991; Jones and Jeanes 1996; Jones 1998*e*). Over several seasons he observed the behaviour of flies visiting *G. morrisii* (Nicholls) D. L. Jones & M. A. Clem., *G. archeri* (but possibly *G. ciliatum* (Ewart & B. Rees) D. L. Jones & M. A. Clem.), *G. nigricans* (R.Br.) D. L. Jones & M. A. Clem. (probably an undescribed species related to *G. rufum*; Backhouse and Jeanes 1995), and *G. despectans* (Hook.f.) D. L. Jones & M. A. Clem. Other observations are those of Jones (1970*d*) on five species and Bates on *G. ciliatum* (as *Prasophyllum archeri*; Bates 1981*a*) and *G. acuminatum* (R. S. Rogers) D. L. Jones & M. A. Clem. (Bates 1988).

The attraction of flies to some *Genoplesium* species is very strong, and it is common for several to many flies to swarm over fresh inflorescences (Garnet 1940; Bates 1981*a*, 1988). Flies respond rapidly to bait flowers placed in the field. Bates (1981*a*) noted a response by seven flies within one minute of exposing a pot of *G. ciliatum* flowers. Such rapid responses are similar to those of pollinators sexually attracted by pseudo pheromones (Peakall 1990). Attraction to *Genoplesium* appears to be by odours, not all of which may be detectable by humans. Garnet (1940) could detect an odour in *G. despectans* but not *G. morrisii*, *G. archeri* or *G.* aff. *rufum*. *Genoplesium fimbriatum* has a strong lemon scent, which increases in intensity with rising temperature (Jones 1970*d*). Blaxell (1970) reported that *G. apostasioides* (as *Prasophyllum anomalum* Rupp) has a faint lemon scent, *G. archeri* smells of sour milk, *G. citriodorum* D. L. Jones & M. A. Clem. (as *P. morrisii*) has a strong lemon fragrance (see also Jones 1991), and *G. simulans* D. L. Jones (as *G. morrisii* var. *intermedium*) has a weak lemon scent mixed with an ant-like aroma, though Jones (1991) indicated *G. simulans* lacks a lemon fragrance. Blaxell detected no odour in *G. nudiscapum* (Hook.f.) D. L. Jones & M. A. Clem. (as *P. densum*), *G. pumilum* (Hook.f.) D. L. Jones & M. A. Clem. (as *P. aureoviride*) and *G. nudum* (as *P. beaugleholei*); the latter two species are autogamous, so the lack of an odour is not surprising. Although flowers of *G. acuminatum* (R. S. Rogers) D. L. Jones & M. A. Clem. were actively visited by flies, no odour could be detected (Bates 1988).

The available records of visitors to *Genoplesium* species all involve flies of the closely related families Chloropidae and Milichiidae of the superfamily Chloropoidea, indicating that *Genoplesium* is specifically adapted to these fly families as pollinators. Specimens collected by Garnet (1940) were identified as belonging to four or five species in three genera and two families, but only three were named, all chloropids, as follows: *Caviceps flavipes*, *Oscinosoma subpilosa*, and an undescribed species of *Oscinosoma*. The specific orchid species visited by each fly species were not given. A photograph in Cady and Rotherham (1970) shows a chloropid bearing pollinia on the labellum of *G. archeri* (as *Prasophyllum archeri*) and captioned as *Conioscinella becker*. The reliability of the identification cannot be assessed because no details of the observation are given in the text. The identities of the insects observed by Jones (1970*d*) and Bates (1981*a*, 1988) were not given, but the flies collected by D. L. Jones were subsequently identified by D. Colless (unpublished) as follows: species of *Caviceps* on *G. nigricans*, *G. despectans*, *G. morrisii*, and *G. rufum*; *Caviceps flavipes* was also collected on *G. rufum*. As an additional unpublished record, flies caught by A. E. Logan on *G.* aff. *rufum* at Carabost, New South Wales, were identified by D. K. McAlpine of the Australian Museum as chloropids of the genus *Lioscinella* and milichiids of the genus *Stomosis*.

The mechanism of insect-mediated pollination in *Genoplesium* was described in detail by Garnet (1940). Attracted flies landed on the inflorescence and moved to the downward-hanging labellum, which they gradually walked up, probing with their proboscis as they went. He noticed the prominent raised callus plate of the labellum appeared to exude droplets of nectar, which the flies seemed to imbibe. Once on the labellum the flies became totally absorbed and were unperturbed by close observation with a hand lens or even inversion of the flowers (Garnet 1940; Bates 1981*a*). The flies moved to the base of the labellum (Garnet 1940), forcing their way below the rostellum by jerking movements of the legs (Bates 1981*a*, 1988), where they spent up to several minutes. In this position the fly's thorax contacted the viscidium. Garnet proposed that the stout hairs on the fly's thorax punctured a thin membrane over the viscidium releasing the glue, although it is more likely the sticky viscidium simply stuck to the insect's dorsum (Plate 61). Once the pollinarium has been removed, the stipe connecting the pollinia to the viscidium bends through 90° to bring the pollinia into a position above the fly's head, where they would contact the stigma of the next flower visited.

After flies have finished on one flower they may move to others on the same raceme (Garnet 1940), raising the possibility of geitonogamous pollination. This behaviour also indicates that the flies are deriving a reward for their efforts (Bates 1988). An unusual observation by Bates was that flies responded to flowers of *G. acuminatum* taken inside a house after dark. The flies, one of which was carrying pollinia, were small enough to pass through the mesh on a screen door.

The available data do not allow definite conclusions to be made about the degree of pollinator specificity in *Genoplesium*. Garnet (1940) did not report which species of flies were attracted to each *Genoplesium* species but stated that pollinators were shared among species, allowing the possibility of hybridization. However, hybrids were not apparent in mixed populations of *Genoplesium* species that he examined. By contrast, observations by Jones (1970*d*) and Bates (1988) indicated that some level of specificity may occur. Jones observed that small flies behaved differently toward five species of potted *Genoplesium* placed together. The flies removed the pollinaria of only one species, *G. morrisii*, but also actively worked the flowers of *G. despectans*. They landed on the inflorescence of *G. fimbriatum* but did not enter the flowers and showed little interest in *G. nigricans* (as *Prasophyllum fusco-viride* Reader). The flies ignored *G. filiforme* (as *P. nublingii* R. S. Rogers) altogether. Similarly,

Bates (1981*b*) observed that larger flies visited *G. ciliatum*, then went to *G. nigricans* and *G.* aff. *rufum* in the same glasshouse over the same time period. However, Bates (1988) also found that the same unidentified fly species visited *G. acuminatum* and *G. ciliatum* in the glasshouse. It should be noted that *G. acuminatum* and *G. ciliatum* do not occur sympatrically; the former is found in coastal northern New South Wales and Queensland, and the latter in southern Victoria and South Australia. It appears that allopatric *Genoplesium* taxa, which have no opportunity to hybridize, may attract the same pollinators.

Hybrids have been reported among some *Genoplesium* species, indicating that pollinator specificity is incomplete. Hybrids between *G. ciliatum* (as *Prasophyllum archeri*) and *G. despectans* (as *P. despectans*) have been reported by Bates and Weber (1979), and Backhouse and Jeanes (1995) reported that *G. archeri s.s.* also hybridizes with *G. despectans*. Jones (1991) reported that hybrids may occur between *G. citriodorum* and *G. simulans*, two closely related species in the *G. morrisii* complex, but only in disturbed sites. **(CCB)**

Uses

None recorded. **(DJ)**

Cultivation

Genoplesium is not widely cultivated because of limited appeal and difficulty in culture.

Mix: basic with extra drainage material such as coarse sand. Light: 50% shade. Watering: from summer to early autumn, depending on the species, until late spring. Flowering: from summer to late autumn. Propagation: best propagated from seed sown around parent plants. **(HR)**

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50. MICROTIS

Microtis R.Br., *Prodr.*, 320 (1810). Type species: *Microtis rara* R. Br.

Goadbyella R. S. Rogers, *Trans. & Proc. Roy. Soc. South Australia* **51**, 294 (1927). Type species: *Goadbyella gracilis* R. S. Rogers.

Derivation of name

From the Greek *mikros*, small, and *ous, otos*, ear, in reference to the small column wings that subtend the anther. **(DJ)**

Description (Plates 62, 63; Fig. 50.1)

Perennial geophytic *herbs*. *Roots* filamentous. *Tubers* globose to subglobose, paired, fleshy, naked; replacement tubers formed on the end of short droppers; daughter tubers formed on the end of slender root-like stolons; vertical shoots with membranous cataphylls at each node. *Leaf* single, basal, sessile; lamina much longer than wide, erect, cylindrical, terete, hollow, glabrous. *Inflorescence* racemose or spicate, few–many flowered, erect, terminal, emergent through a membranous point on the upper part of the leaf; scape wiry, without sterile bracts; floral bracts reduced, closely sheathing. *Flowers* resupinate, green, subsessile to sessile. *Dorsal sepal* free, much broader than the lateral sepals, cucullate over the column. *Lateral sepals* free, often recurved. *Petals* free, smaller than the sepals. *Labellum* free, attached by its base to the anterior column base, markedly dissimilar in shape, size and coloration to the sepals and petals, ecalcarate; lamina not lobed, the margins entire or with irregular clusters of callus cells, the apex entire, emarginate or notched; callus consisting of a raised fleshy basal plate which is sometimes lobed or notched, often with an accessory apical granular callus, rarely the callus entirely absent; nectar present. *Column* short; column wings fused basally to column, erect and free distally, the free parts closely subtending the anther; column foot absent; anther erect, parallel to the axis of the column, rostrate or not; pollinia four, yellow, granular, attached via a short hamulus to a dorsal viscidium; stigma entire, quadrate; rostellum apical. *Ovary* elongate, ribbed, glabrous, swelling rapidly during anthesis. *Capsules* dehiscent, erect, glabrous; pedicels not elongated in fruit. *Seeds* numerous, light-coloured, winged. **(DJ)**

Distribution (Fig. 50.2)

A genus of about 18 species distributed in Australia, New Zealand (including Stewart Island and Chatham Island), Indonesia, Malaysia, Philippines, Japan, Taiwan, and China. **(DJ)**

Appendix 3

Paget (2008)

Results of Searches for the Tuncurry Midge-Orchid
(*Genoplesium littorale, syn Corunastylis littoralis*)

Autumn 2008

Photo Copyright A Paget 1981-

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Catchment Action Plan Implementation Officer – Vegetation
Hunter-Central Rivers CMA, Taree Office (PH 6551 8994)

The Australasian Native Orchid Society was contacted by the NSW Scientific Committee for comments about a proposed listing of this orchid under the NSW Threatened Species Conservation Act (1999), and contacted Andrew Paget regarding any information the Hunter-Central Rivers Catchment Management Authority had about this orchid.

Very little was known about the orchid except for the following:

- About 20 plants in a small group about 10m in diameter were seen when the plant was first collected in 1993, and subsequently described as a new species (as distinct from G. despectans to which it had been referred previously). This type location was about 100m south of the Tuncurry Tip (John Riley pers comm).
- Some additional plants had been seen near the Tuncurry TAFE and on the edges of tracks between Tuncurry TAFE and the Tuncurry Tip by Bill Brinsley (John Riley, pers comm).
- Some plants had also been seen by Isaac Mamott in 1995-6, approx 300-500m north of the Tuncurry Rock Pool (Wallamba River mouth) (Isaac Mamott pers comm). This area is now very degraded habitat and plants have not been seen there recently.
- The orchid has been known in the location for a long time, although it is uncertain as to when it was first discovered. Bill Brinsley has known the plants at Tuncurry for around 30-40 years (John Riley pers comm).

It was decided that a collaboration would be formed between a range of workers (including Australasian Native Orchid Society volunteers and Hunter-Central Rivers Catchment Management Authority staff) in the local area to undertake a survey for this orchid during Autumn 2008 (when it was expected to be in flower). This purposes of this survey were to determine:
1. The distribution range for this species
2. A better description of the range of habitats in which the species could be found
3. The estimated total population size for this species

This report contains the results of these surveys. This information has been submitted to the NSW Scientific Committee for their consideration in deliberations on the listing of this species.

Acknowledgements

A range of individuals and organisations combined their efforts to compile this report, and the report reflects observations of the following: Andrew Paget (HCR CMA), Barry Ralley (Private), Great Lakes Council Staff, Isaac Mamott, John Riley, Bill Brinsley, and Di Brown (DECC). Thanks also go to Mark Clements for information about this species and confirmation of its identification, and to Mt Annan Botanic Gardens staff who collected seed off plants for long-term storage. Thanks also to Shawn Cappararo (HCR CMA) for comments on the draft report.

Nomenclature

The Midge-orchids were all previously included in the genus *Prasophyllum*. Then the smaller flowered (mainly autumn-flowering) species were split off *Prasophyllum* and named *Genoplesium*s. Recently the work of Mark Clements and David Jones at the Canberra Centre for Plant Biodiversity Research has proposed that many of the *Genoplesium*s become a new genus *Corunastylis*. The NSW State Herbarium in Sydney (on their PlantNET website) has yet to accept the use of this new name, hence this report still refers to the orchid as *Genoplesium littorale* rather than *Corunastylis littoralis*.

Habitats Found in

Initial surveys were undertaken during January and early February 2008 to survey the general location and map out suitable habitat for detailed investigation during the flowering season (mid Feb through to mid April). The following habitat types were considered possible locations for this orchid:

1. The type location was described in the literature as being Coast Teatree Thickets but on revisiting the site it was determined to be Blackbutt (*Eucalyptus pilularis*) Woodland with a shrubby understorey of Lemon-scented Tea-tree (*Leptospermum polygalifolium ssp cismontanum)*.
2. Nearby to the type site was a dry ridge which was considered to be even better habitat, and this ridge was almost treeless (only a few scattered Blackbutts *Eucalyptus pilularis*) with a sparse shrubland of *Monotoca elliptica* and *Brachyloma daphnoides*.
3. Some parts of the site contained a mixed Flaky-barked Teatree (*Leptospermum trinervium*) and Saw Banksia (*Banksia serrata*).
4. Other parts of the site 100-200m south of the Tuncurry Tip and southwards towards the Tuncurry TAFE were dominated by low (< 1.5m tall) dense heathland dominated by *Ochrosperma lineare* (syn. *Baeckea linearis)*, with a range of other heathland species (eg. *Eriostemon australasius, Dillwynia retorta)*

Subsequent searches early in the flowering season (18 Feb) located plants in all of these habitat types, so further hunts were then conducted in each of these 4 potential habitat types in the locality, and in broader areas to the north and south to determine if the orchid was also found elsewhere nearby.

The survey concentrated on 3 main searches:
1. The core habitat between Tuncurry Tip and Tuncurry TAFE where plants were previously known from.
2. Target searches in similar habitat to the north, in particular searches in Darawank Nature Reserve immediately to the north to check if they occurred there.
3. Target searches in similar habitat to the south, in particular searches in Booti Booti National Park.

Similar suitable habitat was identified from a combination of local knowledge and the use of vegetation maps and aerial photos to identify similar sparse shrubland communities known to be the preferred habitat of this species.

The results of these surveys are presented in the following tables (Tables 1-3).

Table 1: Tuncurry – Core Area Surveys

Location	**Likely habitat?**	**Approx. Extent of habitat?**	**Condition?**	**Any seen? Qty?**
Darawank Nature Reserve	Some *Leptospermum laevigatum* thickets and some *Monotoca/Brachyloma* shrubland. The Blackbutt forests appear unsuitable due to their frequent burning.	10-15 ha within 826 ha reserve	Good to Poor (mostly poor due to frequent fire regime, but some good areas amongst shrubs with lichen/moss beds)	No, despite extensive search
E & SE of Tuncurry Tip	All 4 habitat types found in this area	21 ha	Excellent	Yes, 510
W of Tuncurry Tip	Some *Leptospermum laevigatum*	4-6 ha	Good	No
N of Tuncurry TAFE	Mainly *Ochrosperma lineare* dense heathland	~500 ha	Moderate to Good, but difficult to survey due to density	Yes, 71 (not fully searched

				due to veg density)
NE of Tuncurry TAFE	*Leptospermum laevigatum* thickets	20-30 ha	Moderate. Dense shady.	Yes, 1
			TOTAL PLANTS	582

Table 2: North of Tuncurry

Location	**Likely habitat?**	**Approx. Extent of habitat?**	**Condition?**	**Any seen? Qty?**
Bonny Hills South	Some *Leptospermum laevigatum* thickets	5-6 ha	Poor (due to windfall, adjacent Bitou control and tracks)	No
Charm Haven Nth	Similar to Blackbutt but with some Bastard Tallow-wood (*E. planchoniana)*	2-3 ha	Good	No
Charm Haven	Some *Lepto laevigatum* thickets but poor quality due to weeds and Bitou invasion/control	5-6 ha	Poor (due to windfall, adjacent Bitou control and tracks)	No
Pt Perpendicular Kattang NR	Some *Leptospermum laevigatum* thickets	2 ha	Moderate	No
Dunbogan Sth	Some *Leptospermum laevigatum* thickets, and *Euc. planchoniana* with heathy understorey, and Monotoca-Brachyloma shrubland and Ochrosperma lineare heathland.	~20 ha	Good	No
Crowdy Bay Nth	Eucalyptus planchoniana – E pilularis woodland	~30 ha	Moderate	No
Crowdy Head to Harrington	Some *Leptospermum laevigatum* thickets,	~100-120 ha	Good to Excellent	No
Old Bar Park	Some *Leptospermum trinervium* thickets but appears too moist (with *Melaleuca nodosa*)	10-20 ha	Moderate to Poor – due to being considered to moist.	No
Saltwater	*Leptospermum laevigatum* and *Monotoca elliptica* thickets, with some *Melaleuca nodosa* (indicating it may be too wet in some parts)	5-6 ha	Good	No
North Diamond Beach	None suitable seen	0	Poor	No
Red Head	Mainly littoral rainforests	0	Poor	No
Black Head	Mainly littoral rainforests	0	Poor	No

Table 3: South of Tuncurry

Location	**Likely habitat?**	**Approx. Extent of habitat?**	**Condition?**	**Any seen? Qty?**
Pebbly Beach	*Leptospermum laevigatum* and *Monotoca elliptica* thickets	< 0.5 ha	Moderate	No
Booti Booti NP – 7 mile beach area	*Leptospermum laevigatum* and *Monotoca elliptica* thickets	2-3 ha	Moderate-Poor	No
Booti Booti NP – SE of Green Point turnoff	*Leptospermum laevigatum* and *Monotoca elliptica* thickets with *Angophora costata* and *Banksia ?serrata*	3-4 ha	Moderate	No
Booti Booti NP – 300m N of Camp Elim	Slashed power easement	1-2ha	Moderate	No
Booti Booti NP – 300m SSE of Camp Elim	*Leptospermum laevigatum* and Bitou Bush infested	1 ha	Poor	No
Booti Booti NP – Santa Barbara Picnic Area	Slashed powerline easement	1-2 ha	Moderate	No
Booti Booti NP – Boomerang Point Reserve Area	*Leptospermum laevigatum* and *Monotoca elliptica* thickets with *Angophora costata* and *Banksia ?serrata*	<0.5 ha	Poor. Too shady and weedy.	No
Mungo Brush south – East of Robinsons Fire Trail	*Leptospermum laevigatum* with scattered *Banksia integrifolia*.	< 2-4 ha	Moderate	No
Mungo Brush south – 100m SSW of Stewart and Lloyd Campground	*Leptospermum laevigatum* dense thickets	5-10 ha	Poor. Too shady.	No

Pipetrack Disturbed Habitat

During the survey it was apparent that the main colony was on some type of previously disturbed habitat, and MidCoast Water (Brendan Guiney) was consulted about possible reasons for this disturbed habitat. Their knowledge and records indicate a number of other recent disturbances in that area related to the new sewerage treatment plant to the NW of the Darawank Nature Reserve, but there was no knowledge or explanation for the old disturbed area on which the orchid was found. It appears that this area is old disturbance of at least 20-30 years ago (as evidenced by large (3-4m) old shrubs of *Monotoca elliptica* found in this area – which is a slow-growing heathland species).

Estimation of Total Geographic Range

From the results of this survey, and from earlier records, it appears that the Tuncurry Midge-Orchid (*Genoplesium littorale*) is very restricted in its distribution and found in an area of only 5km north-south and 1.4km east-west. This includes the records near the Wallamba River mouth at Tuncurry, which have not been seen since about 1995-6. The area in which plants were found in during this survey is only 4.1km north-south (ie without the southern records the range is reduced from 5km to 4.1km).

The historic records (I. Mamott, 1995-6) of plants East of the Tuncurry Caravan Park are in habitat which has been very disturbed and invaded by weeds (in particular Panic Veldt-grass, **Ehrharta erecta*) and no plants have been found recently in this location. Further survey work will be undertaken to try to locate plants in this area, but it is likely they are precarious and may not survive long-term due to the massive disturbances in that area and active threats.

Known Population Size

The known total population size from plants found in this detailed survey is 582 plants. Of the 582 plants found in this survey, 510 of these were found in the area east and south-east of the Tuncurry Tip. This main colony occupies an area of 21 ha and contains 87% of the known plants. As a minimum this area needs to be protected as core habitat. Also the pipetrack location on which the colony is growing needs to be investigated to determine if future disturbance of the underground infrastructure through maintenance or removal is likely, as this could have a devastating impact on the orchid. Similarly the expansion and management of the nearby Tuncurry Tip needs to be done in a way which does not further impact on the orchid. Clearing to the south of the tip has already modified the type location for this species (John Riley, pers comm), and any expansion, fire prevention clearing, or weed invasion eastwards from the tip may dramatically impact on this orchid.

Estimation of Population Size

An estimation of the likely total population size is made based on a number of calculations. The main colony SE and E of the Tip is considered well surveyed and likely to be a fairly accurate count of numbers, with an allowance of 25% increase factor for plants which may not have been seen during the survey (ie an error factor). The larger densely vegetated habitat between the Tuncurry Tip and Tuncurry TAFE is less well surveyed, however. This is due to the density of the vegetation, as the 1-1.5m tall dense shrub layer makes surveying both extremely difficult physically to push through this dense layer for hours on end, but also very difficult in terms of spotting small orchids 20cm tall when the surveyors' visibility to this level is blocked by the dense shrub layer. For this habitat, therefore, the population size has been estimated:

The calculation of estimated population size is as follows:

21/ha main colony of 582 plants x 25% increase	= 698 plants (with allowance for missed)
500/ha with approx 200 ha suitable habitat x 3-6 plants per ha (estimation)	= 600 - 1200 plants
Nil allowance for other locations, since none have yet been found outside of the Tuncurry area	

TOTAL = 1298 – 1898 total population (estimate)

Threats

This orchid occurs in very limited specific habitats, and prefers only open dryish low sand ridge sites with little ground cover (ground cover of moss and lichens or leaf litter beneath shrubs). This preference for open habitat makes the orchid vulnerable to a range of threats, particularly weeds which can colonised and dominated these bare areas and thus render suitable habitat not suitable for this orchid.

A number of threats were observed during this survey, and are as follows (listed in ranked priority order with most potentially devastating first, and more minor down the list).

1. Habitat Loss through development

The primary habitat for this orchid is identified in the Draft Mid North Coast Regional Planning Strategy (Department of Planning) for investigation for possible future residential development. This proposal could eliminate all known habitat of this orchid. It would be important for the survival of this orchid that a large proportion of its habitat be set aside for conservation purposes, and that active management of the spread of weeds and other impacts from expanding habitation to the south is instituted to ensure its long-term survival.

2. Habitat Loss through impacts of adjacent landuses clearing, firebreaks, edge effects

There have been a number of developments in and adjacent the habitat of this orchid which have caused habitat loss or habitat degradation. These include the Tuncurry Tip and associated expansions (and clearing to the south), The Tuncurry TAFE (and clearing to the north and east), and the clearing to the east of the Tuncurry Caravan Park. Not only have these developments and associated clearing removed habitat, but they have caused 'edge effects' like light penetration, nutrient increases, and weed invasion into adjacent habitat, thus causing degradation to nearby habitat of this orchid. This disturbance may also include any infrastructure maintenance or removal for the underground pipeline on which the main colony grows. The creation of pipetracks in the vicinity needs also to be done in a way which reduces the disturbances being a vector for the invasion of exotic grasses, as recent pipetracks created have caused the rapid spread and colonisation of the disturbed areas by *Eragrostis curvula* in particular. Works should include protocols to reduce the risk of spread of seed, and also include follow-up to eradicate any exotic grasses which establish. The slashing of the clearings under the existing power easement approximately 75m east of The Lakes Way needs also to be slashed outside of the flowering-seeding season of this orchid (1 February to 10 May) to avoid this slashing impacting on the orchid's reproduction.

3. Habitat modification by weed invasion by Loblolly Pines (*Pinus taeda*)

Scattered Loblolly Pines (*Pinus taeda*) in the area between the Tuncurry Tip and the Tuncurry TAFE, are causing modification of the orchid habitat through shade, competition, and dense pine needle leaf litter deposition.

4. Habitat modification by weed invasion by Exotic Grasses (including *Andropogon virginicus, Ehrharta erecta, Eragrostis curvula*, and others)

A number of exotic grasses are now well established around the edges, and scattered through, the orchid habitat. They have the potential to modify the habitat by invading and occupying the bare moss/lichen crust areas where the Tuncurry Midge-Orchid grows. This invasion of native plant communities by exotic perennial grasses is a listed Key Threatening Process under the Threatened Species Conservation Act. The track north of the main colony of the orchid is of particular concern as it is lined on each side with a 10-15m wide dense infestation of African Lovegrass (*Eragrostis curvula*) which could dramatically impact on this orchid if it was to spread southwards into the area of the main colony.

5. Habitat modification by weed invasion by Bitou Bush (*Chrysanthemoides monilifera ssp rotundata*) and by Bitou Bush control works.

Invasion of coastal vegetation by Bitou Bush is a major problem and degradation factor for the habitat of the Tuncurry Midge-Orchid, but so also is damage to habitat caused by weed control works for control of Bitou Bush.

6. Habitat modification by weed invasion by Asparagus Fern (*Protoasparagus aethiopicus*)

The Tuncurry Midge-Orchid is found close to the ocean, and parts of it's habitat along the coastal fringe area liable to invasion and modification by Asparagus Fern. This fern has the capacity to create a dense mat of vegetation and underground tubers, and can occupy and modify areas which would have been suitable habitat for this orchid. This weed can therefore modify and render suitable habitat unsuitable for this orchid.

7. Habitat modification by weed invasion by Bryophyllums (*Bryophyllum* spp.)

The Tuncurry Midge-Orchid likes to grow in open areas where bare spaces between shrubs are dominated by lichen/moss crusts. These habitats are open to weed invasion because of their open nature, but in particular they are open to invasion by exotic grasses and succulents. Mother of Millions/Bryophyllums (*Bryophyllum* spp, including *B. delagoense, B. pinnatum*) are succulents which are common in many coastal reserves and have the potential to rapidly colonise the habitat of this orchid.

8. Predation by Rabbit browsing

East of the Tuncurry Caravan Park there is a great deal of evidence of a large rabbit population (between the fore dune and hind dune) and the rabbit population has the potential to impact on the orchid population through browsing.

9. Habitat modification by weed invasion by Lantana (*Lantana camara*)

Most of the habitat of this orchid is on sand ridges, however the adjacent moist low-lying areas have some scattered Lantana in them, and in a few locations these Lantana infestations are forming thickets which are a risk to the ridge areas due to their spread.

10. Habitat modification by weed invasion by Camphor Laurels (*Cinnamomum camphora*)

Most of the habitat of this orchid is on sand ridges, however the adjacent moist low-lying areas have some scattered Camphor Laurels in them, and in a few locations these infestations are forming moderate sized plants which are a risk to the ridge areas due to their shading and the allelopathic chemicals they exude from their roots, and dense leaf litter they deposit.

11. Habitat modification by disturbances caused by rubbish dumping, especially garden refuse.

The majority of the orchid's habitat is crown land which is being used for illegal rubbish dumping and occassional four-wheel driving and beach access. These uses are a threat to the orchid through the direct impact on habitat from physical damage from vehicles (crushing). As well as this the dumping of rubbish (especially garden refuse) also impacts on the orchid by the changes that can result to the orchid's habitat. Rubbish can smother areas where the orchid would otherwise grow, chemically alter the soil (eg iron, concrete) or introduce garden weeds which can compete with the orchid.

12. Habitat modification by disturbances caused by Vehicles

The physical damage to vegetation by illegal and uncontrolled vehicle access to the crown land which is the main habitat of this orchid is a threat to it. The orchid likes to grow around the bases of shrubs, which provide a competitive root zone which may harbour the symbiotic fungi which the orchids live in association with, and also provide a dry area through the root competition they provide. The removal of shrubs by them being run over by vehicles has the potential to alter the habitat of this orchid and render it unsuitable for them. Some shrubs may regrow from occasional damage, but repeated traffic could stop shrubs growing in some areas. Given about 70 of the 120 known orchids are found within 5-10m of a track, the damage by vehicles has the potential to threaten a large proportion of this orchid's population.

Reproductive Success

From observations towards the end of the flowering season, during this survey, it was evident that the pollination rate of this orchid was good, as most plants were observed forming at least some seed pods. There appeared to be around 2-12 seed pods forming on most plants observed. This indicates that the pollinators (likely to be fungal gnats – John Riley pers comm and on-site observations by Andrew Paget and Barry Ralley) were present and performing pollination successfully. This is likely to result in good levels of seedling establishment, and most groups of more that a couple of plants had small seedlings and non-flowering plants present, indicating a good range of age-classes of plants were present within the population.

Seed Colletion

During seeding Mt Annan Botanic Gardens staff visited the population and collected seed to put into long-term storage as a safeguard against loss of plants in the wild.

Conclusion

The nomination of the Tuncurry Midge-Orchid (*Genoplesium littorale*) appears warranted, from the results of this survey, due to a number of factors:

1. The total range of this species is very restricted, being 4.1-5km north-south and 1.4km east-west.

2. The population size of this species appears to be around 1200-1800 plants.

3. There are active threats which if not addressed could lead to the extinction of this species.

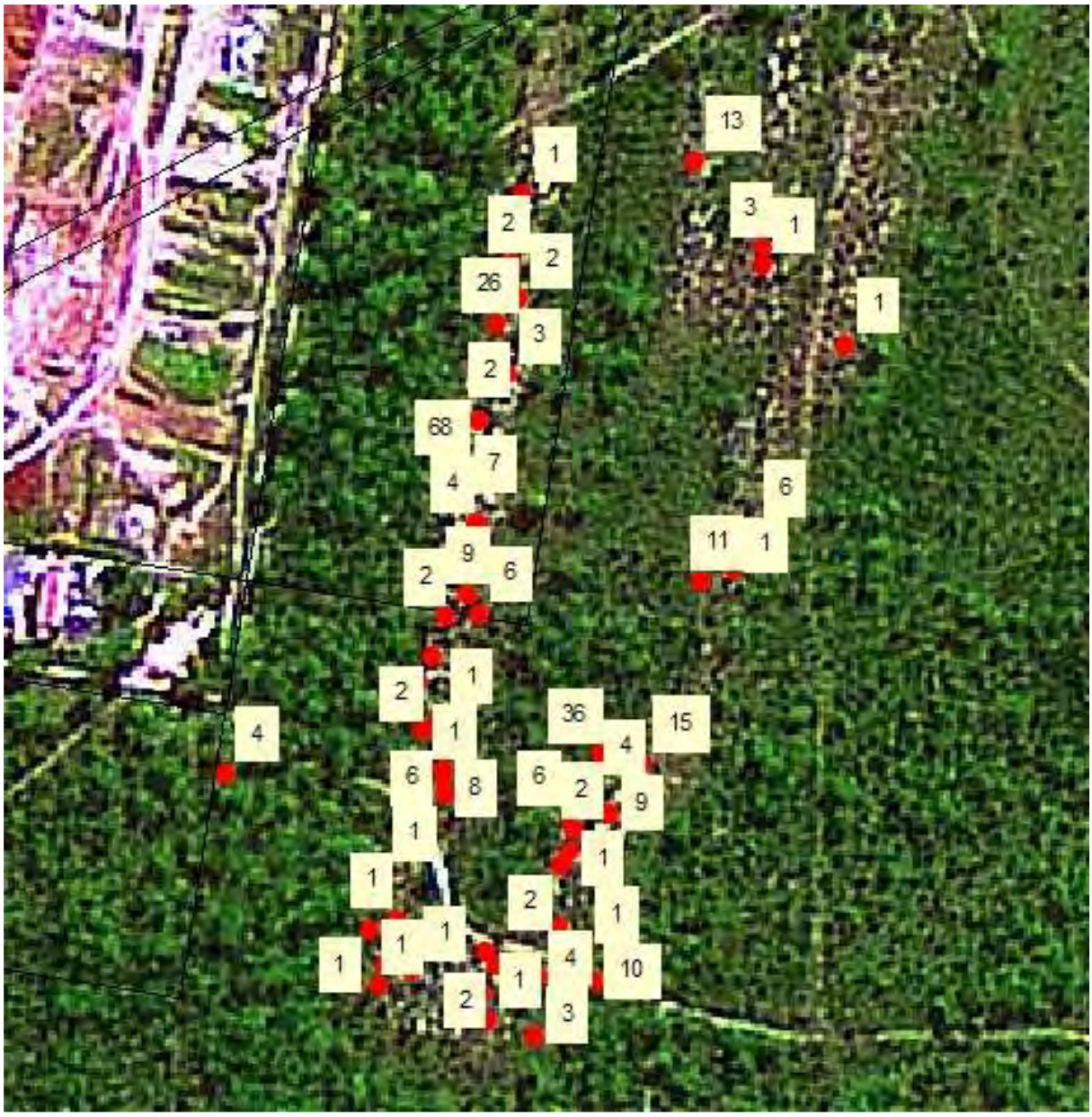
LOG OF SURVEY EFFORT

Mon 18 Feb 2008	Meeting between Andrew Paget, John Riley and Barry Ralley at original type location for hunt. First flowering plant found, and 4 others in bud. 3 people x 1 day at type location and several other likely nearby locations (based on earlier habitat mapping). Also met Isaac Mamott re location near Tuncurry river mouth. 5 plants found
Fri 22 Feb 2008	Andrew Paget 1 person x 1 day. Search for in areas to north of known habitat from Bonny Hills to Crowdy Bay National Park.
Fri 29 Feb 2008	Andrew Paget 1 person x 1 day. Searching cor habitat area found last week to count number in 1 ha sample, then expand search to find extent of main colony. 106 plants found.
Wed 5 Mar 2008	Andrew Paget 1 person x 1 day. Search for in areas to north of known habitat from Crowdy Bay National Park to North Diamond Beach.
Fri 7 Mar 2008	Andrew Paget & Barry Ralley and Di Brown (half day) searching in Darawank Nature Reserve and South from main colony. 2.5 people x 1 day. 9 plants found.
Fri 14 Mar 2008	Andrew Paget & Barry Ralley searching in Booti Booti National park to Mungo Brush south (near Tea Gardens)
Fri 28 Mar 2008	Andrew Paget & Barry Ralley searching area between Lakes Way and power easement from Tuncurry TAFE to Tuncurry Tip. 2 people x 1 day. Approx 70 plants found.
Tue 1 Apr 2008	Andrew Paget & Barry Ralley searching main colony area E of Tuncurry Tip. 2 people x 1 day. 270 plants found.
Fri 4 Apr 2008	Andrew Paget & Barry Ralley searching coastal fringe of main area between Tuncurry TAFE and Tuncurry Tip, and checking track edges in main area east of the power easement. 14 plants found.

Map 1: All Current Locations of the Tuncurry Midge-Orchid (*Genoplesium littorale*)

Map 2: Enlargement of main colony of the Tuncurry Midge-Orchid (*Genoplesium littorale*)

Map 3: Northern Quantities of the Tuncurry Midge-Orchid (*Genoplesium littorale*)



Map 4: Southern Quantities of the Tuncurry Midge-Orchid (*Genoplesium littorale*)

Appendix 4

ERM (2009)

Environmental Resources Management Australia

53 Bonville Avenue
Thornton NSW 2322
PO Box 71
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Telephone (02) 4964 2150
Facsimile (02) 4964 2152
www.erm.com

12 January, 2010

John Sorby
Landcom
PO Box 33
NEWCASTLE NSW 2300

Our Reference: 0092575L04JS_V2.DOC

Attention: John Sorby

Dear John,

RE: ECOLOGY ASSESSMENT OF CROWN LAND AT NORTH TUNCURRY - TUNCURRY MIDGE ORCHID SURVEY

Introduction

Environmental Resources Management Australia Pty Limited (ERM) were engaged by Landcom to conduct an ecological assessment of Crown Land at North Tuncurry on the Mid-North Coast of New South Wales.

An outcome of the Ecological Assessment in early 2009 was the identification in consultation with the Department of Environment and Climate Change (DECC) of the likely occurrence of the Tuncurry Midge Orchid (*Genoplesium littorale*). At that time, the Tuncurry Midge Orchid had been given preliminary determination by the NSW Scientific Committee for listing as critically endangered under the *Threatened Species Conservation Act 1995* (TSC Act). This conservation status was finalised with gazettal of the Tuncurry Midge Orchid as critically endangered on 31 July 2009.

The purpose of this report is to describe the Tuncurry Midge Orchid and provide the results of field investigation undertaken in 2009.

Tuncurry Midge Orchid

The Tuncurry Midge Orchid is a terrestrial perennial orchid with a single leaf and flower spike 10 to 30 mm tall supporting between five and 30 flowers. The life-cycle is poorly understood with flowering period from March to May (DECC 2008). It has a very restricted distribution and only occurs at Tuncurry between the Wallamba River mouth at Tuncurry and the Tuncurry Tip (Paget 2008).

Preferred habitat is well-drained, open sand ridge sites in sparse shrubland of *Monotoca elliptica* and *Brachyloma daphnoides*, sparse shrubland of *Leptospermum* spp or in low dense heath dominated by *Ochrosperma lineare* (syn *Baeckea linearis*) (DECC 2008). Within these habitats, the orchid appears to grow under the shrubs in the root zone where there is little or no groundcover excepting lichen, moss and leaf litter (Paget 2008).

The Crown Land at North Tuncurry supports suitable habitat in the low dense heathland dominated by *Ochrosperma lineare* (see *Figure 1*). The Crown Land investigation area also contains the majority of the known range of the Tuncurry Midge Orchid.

Survey Methodology and Results

Survey methodology included consultation with Andrew Paget of Hunter Central Rivers Catchment Management Authority and field investigations over three days in the known flowering period.

Andrew Paget was consulted to identify a reference site that was readily accessible to confirm that flowering had commenced. With confirmation of the reference site, an inspection was undertaken on 19 March 2009 to verify that the orchid was flowering. This was combined with targeted searches on site to confirm that that the orchid was present and flowering on site and in sufficient numbers to be detectable. During this inspection 15 orchids were identified on site in heathland habitat.

Two day survey was conducted across the site targeting heathland vegetation. The survey technique incorporated intensive searches along transects with inspections in the root zone under low shrubs at approximately two metre intervals or where suitable microhabitat features were noted in the dense heathland. The dense structure of the heathland made it necessary for transects to be conducted parallel to the cleared transmission line easement and along the numerous sand tracks crossing the Crown Land.

Locations of *Genoplesium littorale* identified during searches over the three days are shown in *Figure 1*. In total only 47 individuals were identified in the Crown Land at varying stages of the life cycle (flowering, non-flowering stems and dying). In response to the low success rate searches were also conducted external to the site to the southeast of the Tuncurry Pit to confirm technique. In this area four locations of a total of 31 orchids of varying stages (flowering, non-flowering and buds) were readily identified within less than 30 minutes of searching. These orchids were recorded in an area of disturbed Blackbutt (*Eucalyptus pilularis*)

open forest with scattered Blackbutts and a sparse shrub strata dominated by *Monotoca elliptica* and *Leptospermum polygalifolium*. Only one of the orchid records was from within the disturbed electricity easement.

Survey effort was concentrated along four wheel drive tracks parallel to and within the electricity easement to the north of the Golf Course and along the sand track bordering the TAFE in the south of the site. Survey coverage of the site was not complete due to the slow nature of the targeted survey largely attributed to the density of the vegetation and the cryptic nature and size of the orchid hindering detection. This resulted in intensive search effort over a reduced area of the site.

Previous Surveys

Surveys have previously been conducted in 2008 over the Crown Land investigation area and an area to the north of the Crown Land and east of the Tuncurry Pit by an officer of the Hunter Central Rivers Catchment Management Authority and members of the Australasian Native Orchid Society (Paget 2008). The 2008 survey within the Crown Land investigation area identified 72 individuals of *Genoplesium littorale* in 21 locations scattered throughout the heathland and one individual in *Leptospermum laevigatum* thickets to the northeast of the TAFE and south of the Golf Course (Paget 2008).

510 individuals were identified in an area east to southeast of the Tuncurry Tip and north of the Crown Land investigation area. The area to the east and southeast of Tuncurry Tip has been described as the main colony of *Genoplesium littorale*, while the area between the Tuncurry Tip and the Tuncurry TAFE is identified as the core habitat (Paget 2008).

In addition to the core habitat, investigations of suitable habitat were conducted in 2008 in Darawank Nature Reserve and Booti Booti National Park. No individuals were identified within either reserve.

Implications for the Proposal

Tuncurry Midge Orchid has been confirmed within the Crown Land investigation area. *Figure 2* illustrates the distribution of known records from the survey conducted in 2009. While the number of locations of *Genoplesium littorale* was low this is largely due to the difficulty of detecting the small orchid underneath shrubs in the dense heathland where the shrub cover limits visibility. It is likely that orchid numbers are higher in the Crown Land investigation area

in particular within the heathland areas where *Ochrosperma lineare* dominates. Paget (2008) estimates that the heathland in the Crown Land is likely to support between 600 to 1200 plants.

Any development proposal over the Crown Land investigation area will be constrained by the need to protect the population and core habitat of *Genoplesium littorale*. It is likely that the development would impact on the population of *Genoplesium littorale* through clearing habitat, fragmentation of habitat and indirectly through habitat modification resultant from weed invasion of potential habitat. Development proposal would need to be designed to avoid or mitigate or offset impacts on this species by:

- protecting and managing a buffer to the main congregation of records of *Genoplesium littorale* to the north of the Crown Land investigation area; and
- protecting and managing population within the Crown Land investigation area.

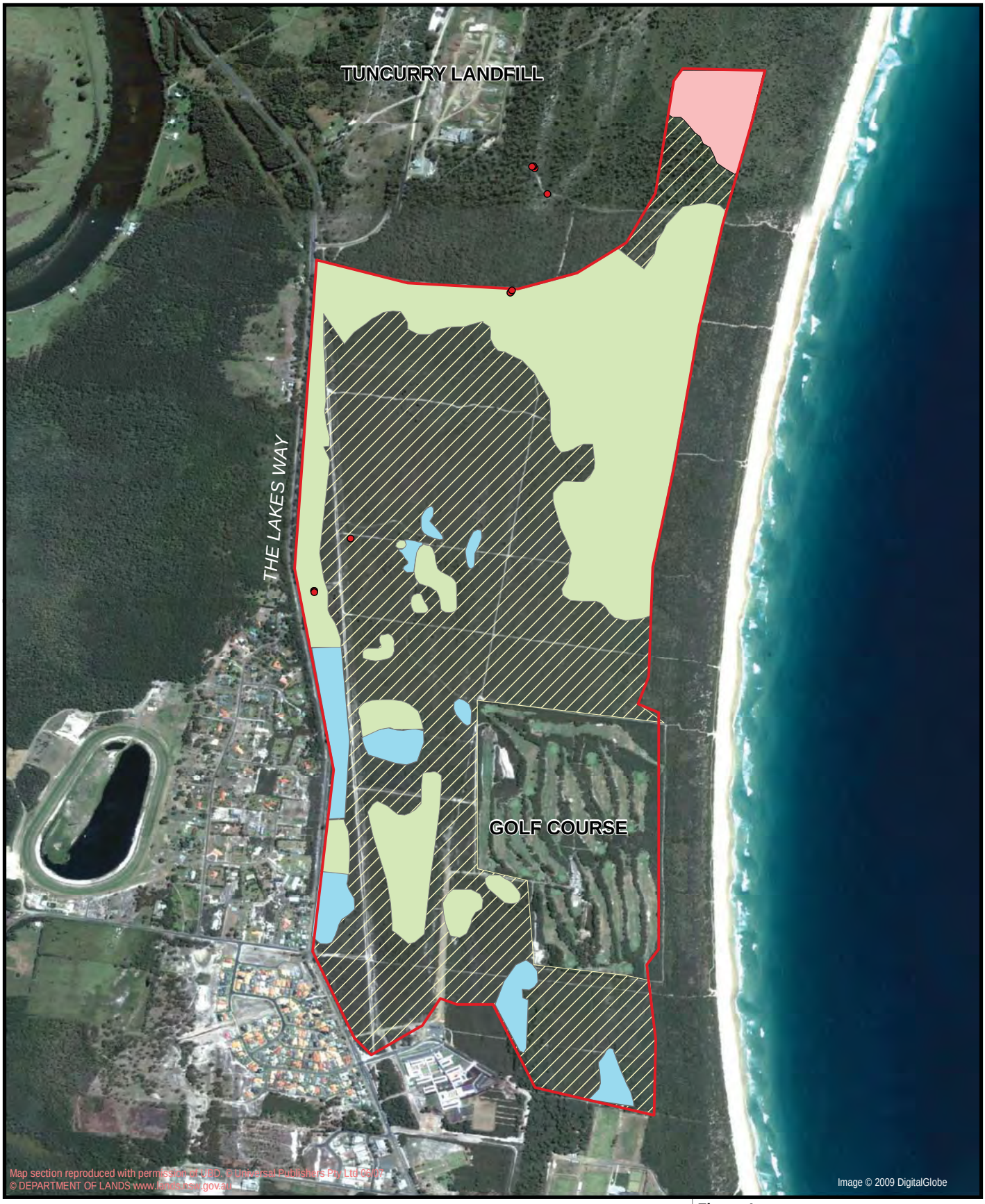
It is likely that any development application for the site would require preparation of a Species Impact Statement.

Should you have any questions please do not hesitate to contact myself or Paul Douglass on 4964 2150.

Yours sincerely,
for Environmental Resources Management Australia Pty Ltd

Naomi Buchhorn
Project Manager

Paul Douglass
Partner



Legend

- Genoplesium littorale Locations 2009
- Site Boundary
- Blackbutt Open Forest
- Banksia Woodland
- Conifer Stands
- Heathland

Source:
© 2007 Google TM

Figure 1
Vegetation Communities

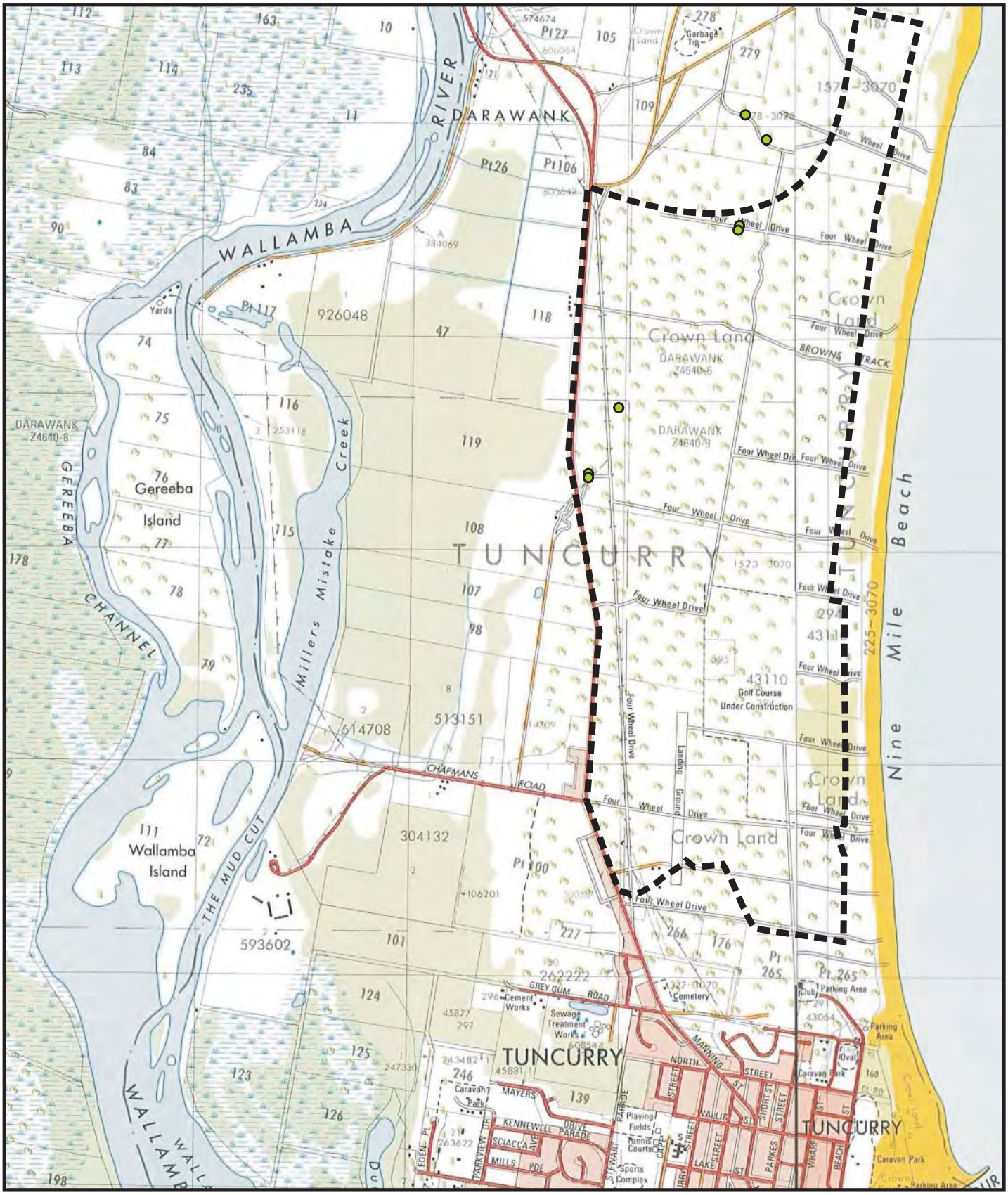
Client:	Landcom	
Project:	North Tuncurry Ecology	
Drawing No:	0092575Orchid_GIS01	
Date:	01/05/2009	Drawing size: A4
Drawn by:	TH	Reviewed by: NB
Scale:	Refer to Scale Bar	

N

0 200 400 600m

Environmental Resources Management Australia Pty Ltd
Suite 3, 146-148 Gordon St, Port Macquarie, NSW 2444
Telephone +61 2 6584 7155

ERM



Legend

Site Boundary

Location of *Genoplesium littorale* ERM 2009

Figure 2

Distribution of *Genoplesium littorale*

Client:	Landcom		
Project:	North Tuncurry Ecology		
Drawing No:	0092575hv_orchid_2010_02		
Date:	08/01/2010	Drawing size:	A4
Drawn by:	JD	Reviewed by:	NB
Source:	1:25000 Topo Series Coolongolook & Forster		
Scale:	Refer to Scale Bar		

N

0 250 500 750m

Environmental Resources Management Australia Pty Ltd
53 Bonville Avenue, Thornton, NSW 2322
Telephone +61 2 4964 2150

ERM

Appendix 5

Confirmation Letter from Australian National Herbarium

Matt Doherty

From: Mark.Clements@csiro.au
Sent: Thursday, 12 April 2012 10:55 AM
To: Matt Doherty
Cc: Andrew C. Smith
Subject: Tuncurry orchids

Hi Andrew & Matt,

Thank you for the specimens of the orchid from Tuncurry. I can confirm that all of them are:

Corunastylis littoralis (D.L.Jones) D.L.Jones et M.A.Clem., Orchadian 13(10): 461 (30 Jan. 2002). Basionym: *Genoplesium littoralis* D.L.Jones, Orchadian 13(7): 297-299, f. 3, t. (2001). Type: New South Wales; Tuncurry, 23 Apr. 1992, *R.G.Tunstall, J.Riley and G.Hillman* (*D.L.Jones 9310)* (holo CANB (CANB 9709786); iso NSW).

Dist: Nnc.

The collections have been entered into our collections data base, all under the number ORG 6501. We have taken material for DNA analysis from two of these specimens.

Regards

Mark

Dr Mark A. Clements
Research Scientist
Centre for Plant Biodiversity Research
GPO Box 1600
Canberra ACT 2601
Australia
ph: 61 02 6246 5503
Fax: 61 02 6246 5249

Appendix 6

Confirmation Letter from Royal Botanic Gardens, Sydney

The Royal
BOTANIC GARDENS
& Domain Trust

National Herbarium of New South Wales

Isaac MAMOTT
RPS Group Australia
Level 12,
92 Pitt Street
Sydney, NSW 2000
AUSTRALIA

Enquiry No: 17236
Botanical.Is@rbgsyd.nsw.gov.au
Fax No: (02) 9251 1952
Ph No: (02) 9231 8111
Date: 30 March 2012

Dear Isaac MAMOTT,

Thank you for your enquiry of 26-Mar-12. We are happy to provide the following information:

Both specimens have been identified by Dr Peter Weston as *Genoplesium rufum*. An invoice for this identification will be sent when you provide an ABN for your company.

Thank you for your enquiry.

Yours sincerely

Barbara Wiecek
Identification Botanist
Botanical Information Service

Appendix 7

Seedbanking Progress Letter from Royal Botanic Gardens, Sydney

Mount Annan Drive
Mount Annan NSW 2567 Australia
Tel +61 2 4634 7900
Fax +61 2 4634 7950
www.rbgsyd.nsw.gov.au

Mr Michael Pring
Landcom
PO Box 718
Forster NSW 2428

20 June 2012

The Australian
BOTANIC GARDEN
Mount Annan

Dear Michael,

As discussed on Friday 15th, here is an outline of the work undertaken to date to conserve *Genoplesium littorale*:

23 03 2012 – Received approval for collection from OEH
16 04 2012 – Received approval for collection from SEWPAC
18 04 2012 – Visited two populations of *G. littorale* at Tuncurry with Michael Pring

- Collected 4 mature pods from 3 plants in the population behind the Waste Management facility (collection number KDS 017)
- Collected 3 mature pods from 2 plants in the population beside the electricity easement, and 6 immature pods on a single stem from an additional plant (collection number KDS 018)
- No other fruiting plants were found on the day of collection. The majority of the population appeared to have finished fruiting and had already died back
- Soil samples for each site were taken from around the base of two or more of the sampled plants

20 04 2012 – Pods and soil were transported to The Australian Botanic Garden

- Mature pods were placed in a drying room (15 °C and 15% RH) to allow afterripening
- The stem with immature pods was held at room temperature in a vase of tap water to enable maturation of the pods

08 06 2012 – Seed was extracted from the pods and inspected under a microscope

- Collection KDS 017 contained several thousand good quality seeds
- Collection KDS 018 consisted of mostly empty seed from the mature pods, and good quality, but possibly not fully developed, seed from the pods collected before maturity

08 06 2012 – Seed from collection KDS 017 was sown over site soil in Petri dishes

- Petri dishes were placed in incubators at 20 °C, 20/10 °C and 20/5 °C.
- Seed is being monitored fortnightly for germination and any germinating seed will be used to attempt to isolate the mycorrhizal fungus.

The seed obtained this year was sufficient to commence work on mycorrhizal isolation but insufficient (in number and quality) to constitute an adequate ex situ collection. Further collections will be made earlier in the season in 2013. An invoice for the work undertaken to date will be forwarded shortly.

Yours sincerely,

Karen Sommerville
Scientific Officer