Attachment H: Squirrel Glider Peer Review

DUDLEY ROAD WHITEBRIDGE
CITY OF LAKE MACQUARIE
DA/1774/2013

SQUIRREL GLIDER PEER REVIEW

REPORT TO

HUNTER AND CENTRAL COAST
JOINT REGIONAL PLANNING PANEL
JRPP# 2013HCC021

11 November 2015

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City of Lake Macquarie
DA/1774/2013
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Report prepared for

Hunter and Central Coast
Joint Regional Planning Panel

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Document History

Document No.	Prep. Date	Version	Reviewed by	Date
00349.a	6 November 2015	draft	JRPP	9 November 2015
00349.0	11 November 2015	FINAL		

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EXECUTIVE SUMMARY

A proposed development on land off 142, 144 and 146 Dudley Road and 2, 2A and 4 Kopa Street Whitebridge includes a mix of residential flat buildings, small lot housing, stormwater management facilities and Torrens title subdivision. Ecological impact assessments of the proposed development conclude the site does not contain significant habitat attributes, threatened species, populations or ecological communities listed under threatened species legislation (RPS, 2013, LMCC, 2015d).

Two detailed submissions submitted by Clulow (2014, 2015) highlighted inadequacies in the ecological assessment, and considered the site was part of a critical corridor for the threatened Squirrel Glider. The impact assessment concluded the proposed development would impact on a local population of the threatened Squirrel Glider by degradation of the critical Fernleigh Track habitat corridor. Also, the proposed development will result in a lost opportunity to restore the Fernleigh Track corridor to a more viable corridor for two important local populations of the Squirrel Glider (Clulow, 2014, 2015).

Lake Macquarie City Council report to the Hunter and Central Coast Joint Regional Planning Panel (July 2015) and concluded the proposed development would not have a significant effect on threatened species or communities. Approval of the development, subject to conditions of consent, was recommended by Lake Macquarie City Council in July 2015. However, the Assessment of Significance report (September 2015) acknowledged the requirement for enhancement of the corridor to improve connectivity for squirrel gliders in the locality. Mitigation measures to improve corridor function for the Squirrel Glider include supplementary tree planting and installation of glider poles.

This peer review undertook additional analysis of the metahabitat identified by Clulow (2014, 2015). A total of 428.5 hectares of habitat suitable for the Squirrel Glider occurs within the Glenrock patch, north of Dudley Road. The subject site off Dudley Road and Kopa Street Whitebridge belongs to this vegetation / habitat patch. The Awabakal / Jewells habitat patch is more extensive in area, with 668.1 hectares of habitat potentially suitable for the Squirrel Glider. In total, the extent of suitable habitat assessed for this peer review is 1,096.6 hectares. Based on current knowledge of habitat requirements, both the Glenrock and Awabakal / Jewells patches are of sufficient size to sustain a local population of the Squirrel Glider in the short term (<60 years).

The assessment of corridor function, based on measurement of gap widths and condition of vegetation, indicate 6 of the 14 gaps within the Glenrock patch, function poorly as movement corridors for the Squirrel Glider. Several inter-patch gaps provide good dispersal points for safe glider crossings, including the Dudley Bluff Corridor. Corridor gap analysis was also conducted on trees within the subject site off Dudley Road and Kopa Street, Whitebridge. Under the current DA, the development would result in the Fernleigh Corridor linkage narrowing to only 3 trees in a narrow linear corridor south of the unconstructed Kopa Street remnant, to trees along the Fernleigh Track corridor. Gap distances between each tree in this residual corridor indicate safe glide movements by the Squirrel Glider would be compromised. Movement through this area would require a combination of gliding and travelling along the ground.

Based on the review of both submissions, and site assessments and habitat analysis conducted for this peer review, I consider that subject to implementation of the recommendations by LMCC (2015d), which outline the above mentioned ameliorative actions, the proposed development would not likely have an adverse effect on the lifecycle of the local Squirrel Glider population.

However, if no habitat enhancement measures are incorporated into the Consent Conditions for the proposed development, then the action would likely have an adverse effect on the lifecycle of the local Squirrel Glider population, particularly the northern Glenrock sub-population. Viability analysis models for Squirrel Glider populations (Smith,

2002; Goldingay and Sharpe, 2004; Goldingay *et. al,* 2006), suggest that the northern Glenrock sub-population would not be considered viable in the longer term (>100 years). This conclusion is based on the increased fragmentation of habitat, resulting from reduced corridor connectivity, and mortality risks associated with proximity to urban settlement

It is recommended that the construction of dwellings Lots 21-24 be delayed until later stages in the proposed development. Development of proposed Lots 21-24 will result in removal of 3 mature trees in the north-eastern corner of the subject site (Tree# 18-20). These trees are situated approximately 16 metres to the west (upslope) from Tree# 15, which will be the only retained mature tree on site under the current proposed staging of works. Retention of trees 18 – 20 is recommended to retain the current Fernleigh Corridor linkage until habitat enhancement works have been completed, such as installation of glider poles and in-fill plantings.

The metahabitat identified by Clulow (2014, 2015) has tenuous linkage between the Glenrock and Awabakal – Jewells – Belmont habitat patches, the Fernleigh Track and Dudley Bluff corridors. Analysis of the Lake Macquarie Local Environmental Plan (2014) reveal that several large parcels of land immediately south of the Dudley Road area retain old land use zonings, which will require detailed consideration for ecological conservation for any future land use rezoning. Failure to consider this future land usage without significant conservation considerations, would jeopardise any ameliorative works undertaken along the Fernleigh Track Corridor, within and immediately adjacent to the subject site. A significant E2 zoned corridor, several hundred metres in width, is required to ensure long term viability of both the Glenrock and Awabakal – Jewells – Belmont Squirrel Glider sub-populations.

1.0 INTRODUCTION

A development is proposed for land off 142, 144 and 146 Dudley Road and 2, 2A and 4 Kopa Street Whitebridge (hereafter referred to as the s*ubject site*). The applicant, SNL Building Constructions Pty Ltd, lodged a development application with Lake Macquarie City Council (DA/1774/2013), which proposes construction of a mixed use development, residential flat buildings, small lot housing, stormwater management facilities and Torrens title subdivision. A subdivision plan (Reference 14_026 DA-A-012, Revision 1 dated 15-06-2015, Smith & Tzannes) illustrates the proposed layout of the development (refer to **Figure A.1** in Appendix).

An ecological assessment of the potential impact of the proposed development on flora and fauna was prepared (RPS, 2013). The assessment concluded the site does not contain significant habitat attributes, threatened species, populations or ecological communities listed under threatened species legislation. The development was not considered to have a significant effect on threatened species or communities known to occur in the locality (RPS, 2013).

Two referral responses to the development application were prepared by Lake Macquarie City Council (LMCC, 2015b, 2015c). Approval of the development, subject to conditions of consent, was recommended by Lake Macquarie City Council to the Hunter and Central Coast Joint Regional Planning Panel (LMCC, 2015a).

However, an extensive number of submissions (n = 747) were received by Lake Macquarie City Council in response to the development application. Two detailed submissions were tabled by Dr John Clulow, Lecturer in Conservation Biology, School of Environmental and Life Sciences, University of Newcastle, Callaghan (2014, 2015), relating to:

- The potential impact of the proposed development on habitat of the threatened Squirrel Glider (*Petaurus norfolcensis*), and
- Failure to adequately assess the proposed development by threatened species legislation.

Dr Clulow identified that the subject site is located immediately adjacent to a critical habitat corridor for a local population of the threatened Squirrel Glider. He identified two large patches of habitat (or meta-habitat) suitable for the Squirrel Glider, the Glenrock (north of Dudley Road) and Awabakal / Jewells (south of Dudley Road) habitat patches, which have very poor habitat connectivity. Dr Clulow identified only 2 very narrow potential corridor linkages between each habitat patch, the Fernleigh Track corridor and the Dudley Bluff corridor. The Fernleigh Track corridor is located along the eastern boundary of the subject site, whilst the Dudley Bluff corridor is located approximately 2.6 km's to the south-east, at the end of Goulburn Street and Debs Parade, Dudley. Urban growth within the Whitebridge / Dudley locality over the past 50 years has resulted in extensive fragmentation and isolation of remaining patches of remnant vegetation and habitat.

Dr Clulow concluded the proposed development would impact on a local population of the threatened Squirrel Glider by degradation of the critical Fernleigh Track habitat corridor. Also, the proposed development will result in a lost opportunity to restore the Fernleigh Track corridor to a more viable corridor for two important local populations of the Squirrel Glider. Dr Clulow also presented in his submissions that this impact has not addressed in the ecological impact assessment prepared for the development application. Dr Clulow prepared an impact assessment for the proposed development and concluded the proposal would have a significant impact on a local population of the threatened Squirrel Glider, and that a SIS (Species Impact Statement) be prepared (Clulow, 2015).

In response to the submissions from Dr Clulow, LMCC prepared an additional impact assessment of the subject site by application of the Assessment of Significance test (the 7 part test). The conclusion by LMCC is "…*that the application is*

unlikely to result in significant negative impact on a local population of squirrel glider and a species impact statement is not required…" (LMCC, 2015d, p. 12).

(Please note: the DA/1774/2013 – Assessment of Significance report (LMCC, 2015d) has no page numbering).

However, the Assessment of Significance report (LMCC, 2015d) acknowledged the ecological significance of the existing Fernleigh Track corridor, and the requirement for enhancement of the corridor to improve connectivity for squirrel gliders in the locality. The LMCC Assessment of Significance acknowledged the issues raised by Dr Clulow in his submissions, but "*…disagrees on his application of the seven part test and the scale of impact that would occur as a result of the application…*" (LMCC, 2015d, p. 12)

In addition to the LMCC Assessment of Significance test, consideration of the draft Lake Macquarie Squirrel Glider Planning and Management Guidelines (LMCC, 2015e) was presented. A general discussion including suitable mitigation measures to improve corridor function for the Squirrel Glider is presented LMCC (2015d). The mitigation measures to improve and enhance the existing Fernleigh Track corridor include supplementary tree planting and installation of glider poles. The Fernleigh Corridor adjacent to the subject site is currently very narrow and requires widening in tree canopy to improve the corridor quality and viability for the Squirrel Glider. Installation of glider poles at specific locations is designed to reduce the gap between existing canopy cover. Gaps of greater than 35 metres are considered to prevent the Squirrel Glider gliding between forested patches of habitat (Smith, 2002).

2.0 SCOPE OF THIS PEER REVIEW

Michael Murray of Forest Fauna Surveys Pty Ltd was engaged by the Hunter & Central Coast Joint Regional Planning Panel to undertake a peer review of the ecological findings at 142 Dudley Road Whitebridge. This peer review will consider the impact of the proposed development on the threatened Squirrel Glider (*Petaurus norfolcensis*), and to consider the submissions by Dr Clulow and response by Lake Macquarie City Council.

3.0 BACKGROUND

The Squirrel Glider range extends from northern Victoria to central northern Queensland near Cairns (Quin, 1993). The status of the species is not consistent across this range. In Victoria, the species is listed as Endangered on the *Flora and Fauna Guarantee Act 1988*. In NSW, the Squirrel Glider is listed as Vulnerable on the NSW *Threatened Species Conservation (TSC) Act 1995*. Two endangered populations of the species are listed in NSW under the TSC Act 1995, but none are listed for the lower Hunter and Central Coast region. The species is not listed as threatened under the *Nature Conservation Act 1992* in Queensland. The Squirrel Glider is not threatened, nor any endangered populations or critical habitat listed, on the Federal *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999.*

Extensive literature has been published about the ecology of the species, with a detailed synopsis summary in the Draft Squirrel Glider Management Plan (LMCC, 2015e). Within NSW, the Squirrel Glider occurs in a patchy distribution in forest and woodlands along the coast, ranges and inland slopes (refer to **Figure 1** below). Within this range, there are regions with higher concentration of records, particularly the Central Coast and lower Hunter, and northern NSW. Within the central slopes and plains region, the species is patchy due to the extensive clearing and fragmentation of native vegetation.

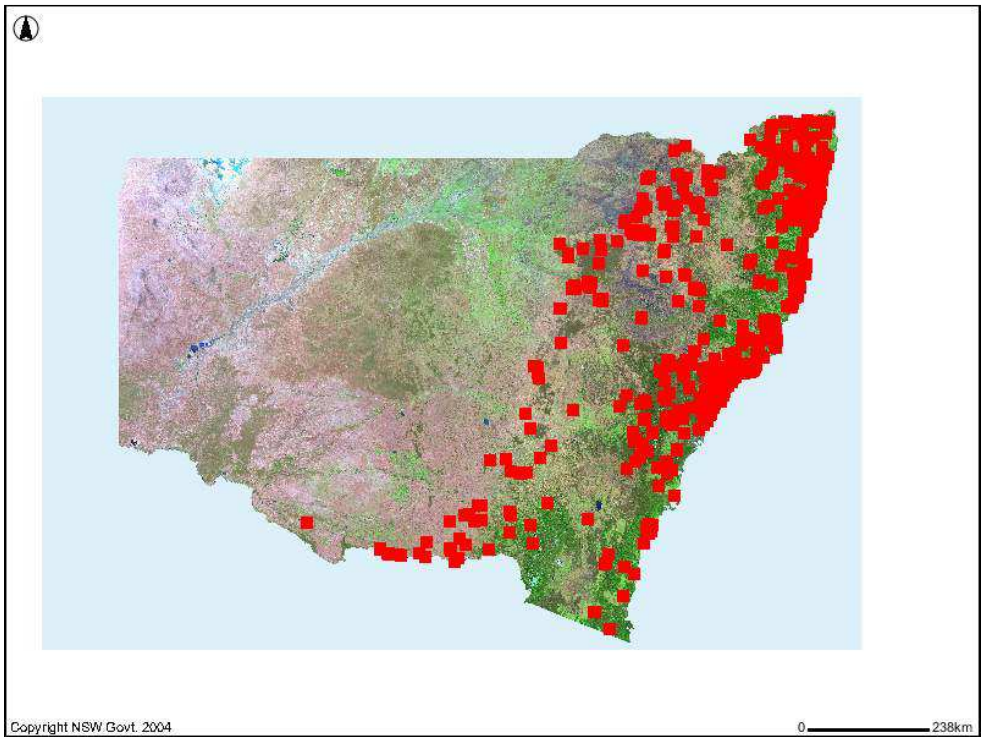

Figure 1. Squirrel Glider distribution, New South Wales (OEH, 2004).

The high concentration of records in the central coast / lower hunter valley and north coast regions reflects the higher quality habitat for the species, but also the higher survey effort conducted for the species. Within the central coast / lower hunter region, the Squirrel Glider is widely distributed, with the population extending from north Wyong to Lake Macquarie identified as nationally significant due to the high concentration of records of the species (Smith, 2000; 2002; Smith and Murray, 2003). The Lower Hunter Regional Conservation Plan refer the Lower Hunter population as of state significance due to the area supporting extensive, high quality coastal habitat (DECC, 2009).

Predictive modelling of Squirrel Glider habitat in the lower Hunter has revealed areas to the north of Lake Macquarie, including Port Stephens and Cessnock LGA's, also support high quality habitat for the species (refer to **Figure 2** below).

Within the City of Lake Macquarie, recent habitat modelling for the Squirrel Glider sought to identify key habitat areas and degree of connectivity between forested remnants. The mapping of habitat within the City utilised recent vegetation mapping (Bell and Driscoll, 2014), overlayed with Squirrel Glider records. The modelling sought to identify key habitat areas that would support significant populations of the species, in addition to identification of areas where fragmentation of habitat reduces the viability of populations within the City (refer to **Figure 3** below).

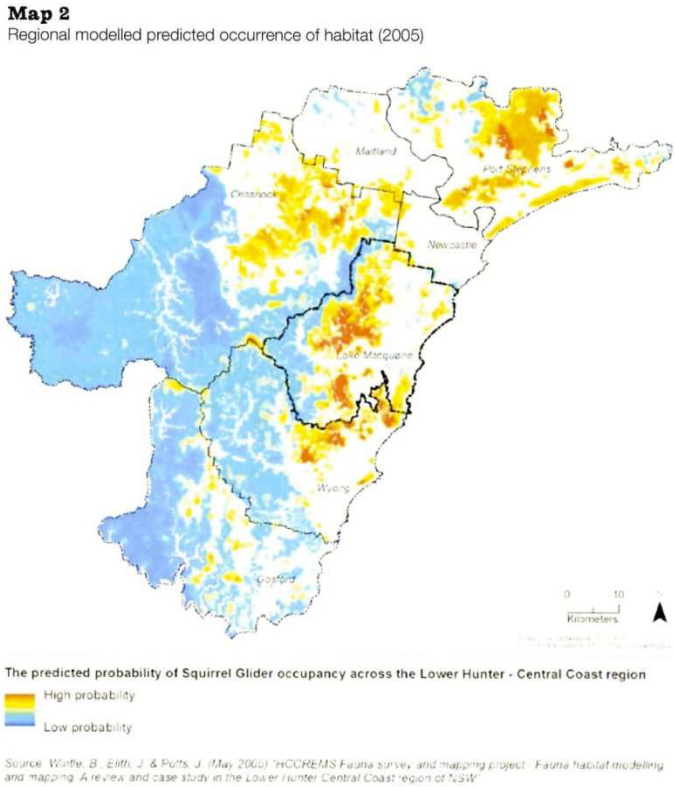

Figure 2 Lower Hunter Central Coast Squirrel Glider habitat modelling (reproduced from Wintle *et. al.* 2005).

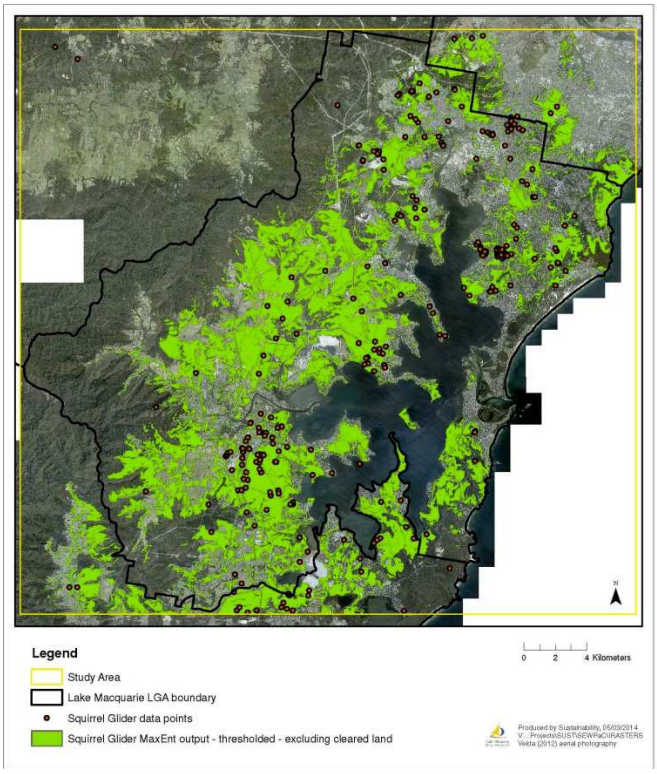

Figure 3 MaxEnt predictive modelling, Squirrel Glider Habitat, City of Lake Macquarie (LMCC, 2015)

Within the City, it is estimated that 40% of the original habitat has been lost since 1750, and that habitat remaining is poorly protected within existing conservation reserves. The majority of records of the species have been recorded on private land (LMCC, 2015e). Mapping of City wide habitat for the Squirrel Glider identified 5 major forested remnants, the North-east (Charlestown – Jewells – Belmont – Warners Bay), South-east (Wallarah peninsula), west (Killingworth – West Wallsend) and south-west (Morisset - Wyee). The modelling reveals extensive fragmentation of habitat within the City, and all viable populations should be considered important populations (LMCC, 2015e).

Two key characteristics have been identified that influence Squirrel Glider distribution:

- Habitat suitability, and
- Habitat size and spatial arrangement.

Smith (2000) identified that the density and probability of occurrence of Squirrel Gliders in forested remnants increases significantly with

- Increasing remnant size,
- Reduced distance to the adjoining remnant, and
- Increasing size of the adjoining remnant.

Within a fragmented landscape, such as the north-east population in the City, major factors that influence species presence within forested patches include the presence of adequate corridor linkages between remnants. Within these corridors, canopy gaps greater than the length of a single glide are potentially a barrier to the movement of the species. Gliding mammals have evolved an efficient and highly specialised way of locomotion, where the gliding membrane (or patagium) is converted into an air-foil when extended between the fore and hind limbs (Jackson, 1999; cited in van de Ree, *et. al,* 2010). This enables gliders to efficiently cross gaps up to 70m in width in a single glide, although typical glides are closer to 20 – 35 metres in length (van der Ree *et. al.* 2003; Goldingay and Taylor, 2009). In comparison, they are quiet cumbersome when traversing at ground level. Gliders will move along the ground if necessary, and long distances have been documented (Suckling, 1984; van de Ree, 2000). However, gliders that are forced to travel along the ground and over roads to move among forested areas are prone to high levels of mortality (i.e. predation, road-kill)(Goldingay and Sharpe, 2004).

Gap crossing is an important consideration in assessment of the potential impact of an action, such as a residential development, which may either reduce the size of habitat patches, or remove or degrade connectivity between patches. Squirrel Glider population viability in smaller habitat patches is highly dependent on connectivity, especially the ability to cross cleared gaps (LMCC, 2015e). These gaps can include major and minor roads, powerline easements, and open space such as parklands.

Movement of gliders between habitat patches is critical for regular, and also infrequent traverses of the local landscape. Gliders can move extensive distances (>400m) in one night to obtain foraging resources (van de Ree, 2000; Goldingay and Sharpe, 2004; van de Ree, *et. al.* 2010). Periodic, or irregular movements may be undertaken by juvenile and adult individuals in response to social (dispersal) or stochastic events (fire).

The Lake Macquarie Squirrel Glider management plan identified that the North-east area, which includes the subject site, is highly fragmented with a habitat area of 1,767 hectares, comprising mostly small habitat patches and conservation reserves (LMCC, 2015e). Connectivity in this area is affected by linear infrastructure such as roads (both major and minor), electricity easements and residential areas.

3.1 Summary of Subject Site Submissions relating to the Squirrel Glider

The submissions from Clulow (2014, 2015) identified a number of significant issues that were not addressed by the initial ecological assessment of the subject site, such as the:

- extent of existing habitat within the locality,
- location and adequacy of corridor linkages, and
- viability of the local glider population.

Dr Clulow identified a major metapopulation east of the Pacific Highway, which extends from Glenrock SCA in the north to Belmont Wetlands State Park in the south. He also identified that corridor linkage within this area is tenuous at specific points, which includes the subject site off Dudley Road and Kopa Street, Whitebridge. The extent of habitat within this single metapopulation was not quantified, but estimated to be 1,000 – 2,000 hectares (Clulow, 2014, p.3). Clulow (2014) identified that only 2 narrow corridors, the Fernleigh Track and Dudley Bluff linkages, remain within this large metahabitat. The submission indicates that the proposed development on the subject site will *"permanently degrade the Fernleigh Track corridor at the point where it forms the narrow bottleneck, and if implemented as currently proposed, will severely limit the options for adequately restoring the Fernleigh Track corridor at its most vulnerable point…"* (p. 5).

Contrary to this viewpoint, the response from Lake Macquarie City Council indicates the proposed development would result in the loss of "…*eight trees and one shrub from the corridor would not sever movement habitat for squirrel glider, as all trees on the subject site in E2 zone, including those adjacent to the Fernleigh Track, and all trees identified within Lot 102 DP 843703, the Fernleigh Track would be protected. Post development, the LMCC native vegetation corridor would retain native vegetation and habitat and would continue to allow for north-south movement of squirrel gliders although this might be at greater risk given the number of alternative routes are reduced and loss of critical trees in the future could interrupt movement…".* Furthermore, "…*The application is therefore considered unlikely to have an adverse effect on the lifestyle of squirrel glider such that a viable local population of the species is likely to be placed at risk of extinction…"* (LMCC, 2015d; page 4, although un-numbered).

However, the LMCC response does acknowledge "*there is, however, an impact to the native vegetation corridor, which exposes the existing corridor to a higher risk of impact from natural storms, etc., which justify recommended conditions of consent to enhance and improve connectivity…"*(LMCC, 2015d; page 4, although un-numbered).

4.0 PEER REVIEW METHODOLOGY AND RESULTS

Given the two opposing viewpoints in relation to the potential impact on the Fernleigh Track corridor by the proposed development of the subject site, this peer review sought to identify a number of matters which relate to the following:

1. What is the size of the Glenrock – Belmont metahabitat specific to the Squirrel Glider?
2. How suitable is the corridor linkages between the Glenrock and Awabakal / Jewells metapopulation?
3. Will the proposed development impact on the Fernleigh Track corridor and Squirrel Glider metapopulation?
4. Will the proposed habitat enhancement measures recommended by LMCC assist in improvement of corridor quality and condition?

4.1 Habitat Patch Size Analysis.

The city wide vegetation mapping (Bell and Driscoll, 2014) was utilised as a template to extrapolate those communities that are known to support Squirrel Glider habitat. The study defined for this peer review was consistent with the metahabitat area described by Clulow (2014, 2015). All vegetation communities east of the Pacific Highway, extending from the northern boundary with the Newcastle LGA, south to the Belmont Wetlands, were captured by GIS software for subsequent analysis. Vegetation communities west of the Pacific Highway were excluded, despite suitable connectivity for gliders located at a number of points near Jewells and Belmont North.

The vegetation community polygons were overlayed on recent aerial photographs of the City, to identify any mapped polygons that have been cleared since completion of the mapping in 2014. Those vegetation communities that are considered to not support resident Squirrel Glider populations were extracted from the GIS layer (Manifold GIS v.8.29). The residual polygons were amalgamated to generate a composite layer termed “habitat patch”.

An arbitrary barrier was generated by the GIS mapping, with the barrier defined as Dudley Road extending from Charlestown in the west, to the end of Goulburn Street and Debs Parade in Dudley (refer to **Figure 4**). Mapped polygons were defined as occurring either to the north or south of this barrier. As a consequence, two metahabitats were described for this exercise, the **Glenrock patch** and the **Awabakal / Jewells patch**, in an attempt to retain consistency in definitions between this peer review, and descriptions in the submissions by Dr Clulow, and also LMCC.

A summary of the LMCC mapped vegetation communities within the larger Glenrock – Belmont metahabitat is presented below in **Table 1**. The analysis indicates a total of 428.5 hectares of habitat suitable for the Squirrel Glider occurs within the Glenrock patch. The subject site off Dudley Road and Kopa Street Whitebridge belongs to this vegetation / habitat patch. The Awabakal / Jewells habitat patch is more extensive in area, with 668.1 hectares of habitat potentially suitable for the Squirrel Glider. However, this patch appears to be more fragmented due to combination of past clearing and areas of non-suitable Squirrel Glider habitat, for instance, wet heath. It must be recognised that these habitat estimates have been generated by GIS analysis, with no ground validation to ensure accuracy of habitat suitability. In total, the extent of suitable habitat assessed for this peer review is 1,096.6 hectares.

The draft Lake Macquarie Squirrel Glider Planning and Management Guidelines indicate the North-east area of the City supports an area of 1,767 hectares (LMCC, 2015e). The reduced area examined for this peer review is due to habitat fragments west of the Pacific Highway (Tingira Heights, Bennetts Green, Belmont North, Green Point) being excluded from the GIS analysis.

Table 1. Patch Analysis of LMCC City wide Vegetation Mapping (Bell and Driscoll, 2014)

GLENROCK PATCH (north of Dudley Road, east of Pacific Highway)		
LMCC_MU	**LMCC_NAME**	**Area (ha)**
1a	Coastal Warm Temperate Rainforest	3.8
6	Coastal Narrabeen Moist Forest	0.3
9	Coastal Ranges Open Forest	1.0
11	Coastal Sheltered Apple-Peppermint Forest	70.4
12	Hunter Valley Moist Forest	29.1
15	Coastal Foothills Spotted Gum - Ironbark Forest	119.3
15h	Lake Macquarie Spotted Gum Forest	11.3
30	Coastal Plains Smooth-barked Apple Woodland	70.3
30e	Coastal Plains Stringybark - Apple Forest	6.7
30j	Sugarloaf Lowlands Bloodwood-Apple-Scribbly Gum Forest	12.4
31	Coastal Plains Scribbly Gum Woodland	0.0
48	Coastal Clay Heath	67.5
51	Coastal Headland Complex	0.4
119	Kahibah Snappy Gum Forest	36.0
	TOTAL AREA (Glenrock Patch)	**428.5**

AWABAKAL / JEWELLS PATCH (south of Dudley Road, east of Pacific Highway)		
LMCC_MU	**LMCC_NAME**	**Area (ha)**
5	Alluvial Tall Moist Forest	2.4
9	Coastal Ranges Open Forest	4.2
11	Coastal Sheltered Apple-Peppermint Forest	66.1
12	Hunter Valley Moist Forest	53
15h	Lake Macquarie Spotted Gum Forest	65.4
30e	Coastal Plains Stringybark - Apple Forest	36.9
30j	Sugarloaf Lowlands Bloodwood-Apple-Scribbly Gum Forest	12.9
33	Coastal Sand Apple-Blackbutt Forest	16.1
33a	Coastal Sand Apple-Blackbutt Forest (redefined)	63.0
33c	Pelican Bangalay Forest	0.9
37	Swamp Mahogany - Paperbark Forest	14.1
37e	Coastal Sand Swamp Forest	142.8
37j	Dune Swale Swamp Forest	66.2
38c	Foreshore Redgum-Ironbark Forest	3.8
43a	Estuarine Paperbark Scrub Forest	10.9
44a	Munmorah Grasstree Wet Heath	5.5
44m	Coastal Plains Wet Heath	17.4
50b	Coastal Sand Banksia Scrub	3.8
51c	Coastal Headland Low Forest	7.0
100a	Swamp Paperbark Thicket (Floodplain Alluvials)	1.5
119	Kahibah Snappy Gum Forest	74.2
	TOTAL AREA (Awabakal / Jewells Patch)	**668.1**

Table Legend: **LMCC_MU** Column – refers to Map Unit Vegetation Community Number; **LMCC_Name** column –vegetation community description by Bell and Driscoll (2014)

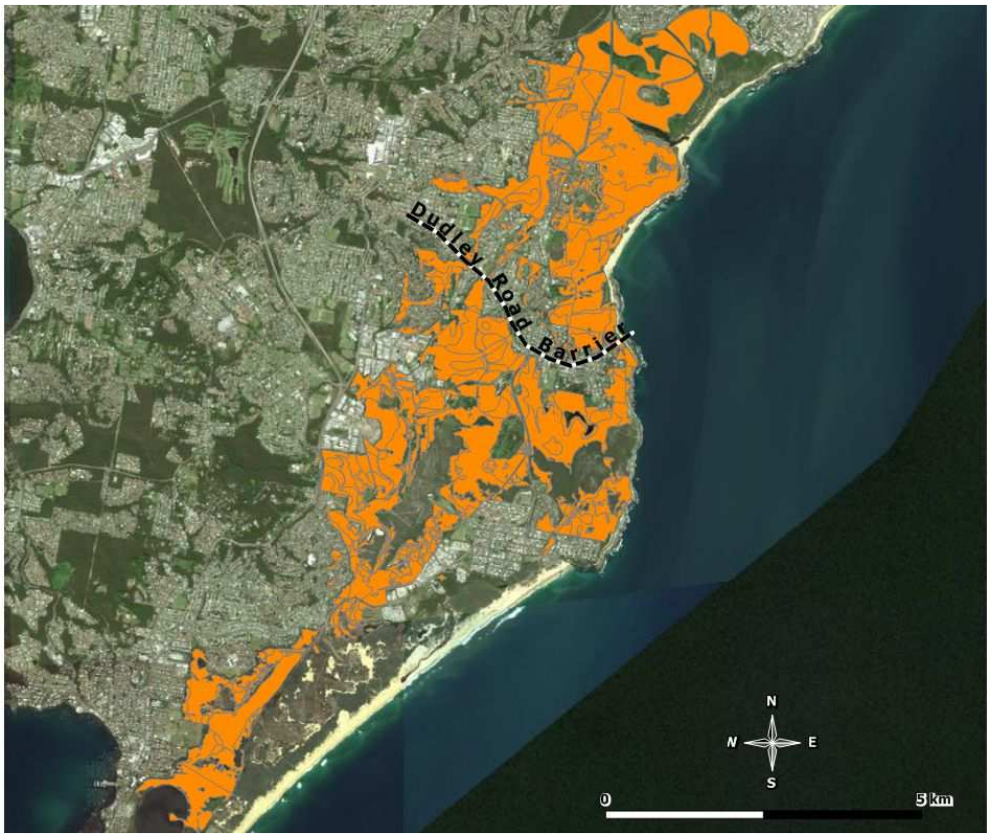

Figure 4 Habitat Patch Mapping, Glenrock and Awabakal / Jewells Remnants

Smith (2002) developed a minimum habitat size / population viability model based on the Wyong Squirrel Glider studies. Occupation of major habitat patches, 100 – 1,000 hectares, are considered at low risk of local extinction in the short term (50 – 100 years), and low to moderate risk in the longer term. Additionally, remnant habitat patches >250 hectares in area, or populations of more than 90 individuals, should have close to 100% probability of survival in the short term (40 – 60 years).

Other workers have suggested that a remnant patch of habitat would need to exceed 400 ha to ensure continued survival of a viable population (Goldingay *et al.,* 2006).

Based on current knowledge of habitat requirements, both the Glenrock and Awabakal / Jewells patches are of sufficient size to sustain a local population of the Squirrel Glider in the short term (<60 years). Whilst the Glenrock patch is smaller in total habitat area, it supports large patches of continuous habitat with good corridor connectivity. It is therefore considered that the removal of trees associated with the proposed development, and the resultant reduction in width of the Fernleigh Corridor, would not constitute a significant effect on the viability of the local Squirrel Glider population in the short term (40 – 60 years as per Smith, 2002).

4.2 Corridor Linkages.

Clulow (2014, 2015) identified that the Glenrock – Awabakal – Jewells - Belmont metahabitat area supported only 2 linkages, the Fernleigh Track and Dudley Bluff corridors. However, he noted both corridors were tenuous due to narrow width. This viewpoint was supported by LMCC in the response (2015d). As noted previously, the proposed development of land off Dudley Road and Kopa Street was considered by Clulow to "*permanently degrade the Fernleigh*

Track corridor at the point where it forms the narrow bottleneck, and if implemented as currently proposed, will severely limit the options for adequately restoring the Fernleigh Track corridor at its most vulnerable point…(Clulow, 2014; p.5). However, there were no detailed measurements of tree height or gap widths in either assessment.

The Corridor Linkages were also examined in detail by LMCC (2015d). The gap widths and tree heights were measured at the two linkage points to assess their adequacy for the Squirrel Glider. The Fernleigh Track corridor was identified to narrow from approximately 50 metres in width at the Kopa Street unconstructed road reserve, to less than 5 metres on the subject site in the centre of Lot 2A. At this point, the corridor is limited to only 1 young Scribbly Gum *Eucalyptus racemose* tree on the boundary of Lot 2A and the Fernleigh Track. This single tree would be retained, but a number of additional trees in this corridor would be removed by the proposed development (LMCC, 2015d).

The Dudley Bluff corridor is described by Clulow (2014) as "*…a narrow vegetation corridor at the end of Dudley Bluff that connects Glenrock to Awabakal that may support some movement of squirrel gliders between the systems (Fig 2). However, the quality of that corridor is questionable. It is very narrow, exposed to strong winds from the ocean (unlikely to favour glider activity) and much of it consists of low, stunted eucalypt vegetation identified by Smith and Murray (2003) as poor quality habitat…*" (p.4).

For this peer review, the corridor linkages within and between the Glenrock patch (north of Dudley Road) were examined in detail to assess the potential of this patch to support a local Squirrel Glider population in the medium to long term (>60 years, based on Smith 2002 criteria). All potential corridor linkages within and between the Glenrock patch were identified by examination of recent aerial photographs. All gaps between patches of habitat were identified and location coordinates extracted into a GIS file, then uploaded to a GPS for field validation. A total of 14 potential crossing points were identified from this analysis, and their locations shown in **Figure 5** below. The location description of each point is listed in **Table 2**.

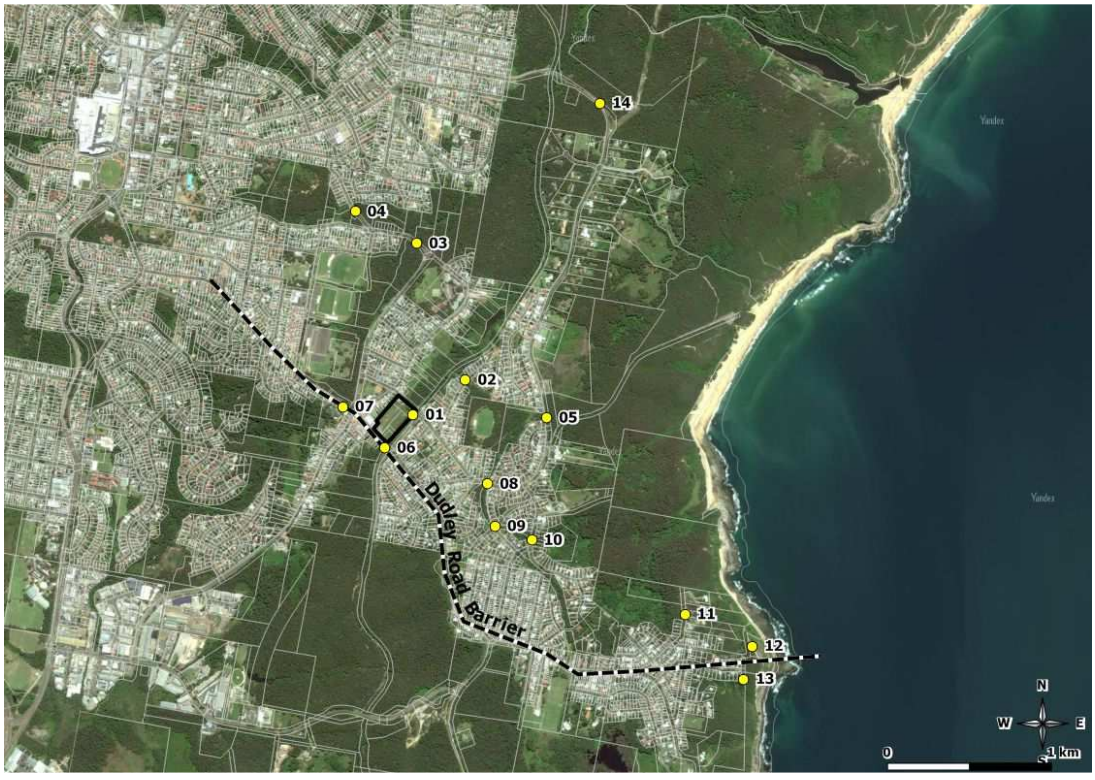

Figure 5 Gap Locations, Glenrock Patch

At each potential crossing point, the following details were recorded:

- Gap ID
- Location (street name)
- Gap width (in metres)
- Tree height side 1 and location (east, west, north or south)
- Glide width (m)
- Tree height side 2 and location (east, west, north or south)
- Suitability index (assessment of condition and function)
- Barriers to movement by gliders

The glider width is calculated using the equation formulated by Jackson (1999). The formulae is:

Glide distance = (tree height (m) x 1.8) – 2.0

Where 2.0 refers to the height in metres above the ground at which a glider typically lands on a tree at completion of a glide. Note also that glide width was calculated from tree height on both sites of the gap, to account for presence of a high launch height on one side, and a low launch side on the opposite side. The narrowest glide width at each potential crossing point is utilised to determine the suitability index, which is scored as either:

- Good (glider can safely cross gap)
- marginal (gap width at limit of glide angle, may require glider to land at base of tree), or
- poor (gap is too wide to enable glider to land on tree, must move across ground).

The results of the gap analysis is presented below in **Figure 6** and **Table 2**.

Table 2 Gap Analysis, Glenrock Patch

Point ID	Location Description	Gap width (m)	Tree Height side 1	Glide Width (m)	Side 1 Bearing	Tree Height Side 2	Glide Width (m)	Side 2 Bearing	Suitability Index	Barriers
1	Subject Site / Fernleigh Track	30	13	21.4	south	14	23.2	north	poor	cleared gap, loss of trees 18-20 + 21-27 will restrict corridor
2	Baroonba Street	30	14	23.2	west	8	12.4	east	poor	3 x powerlines @ 5, 7, 8m
3	Kaleen Street	18	15	25	north	20	34	south	good	powerline @ 5m, single strand
4	Guna Street	20	13	21.4	east	17	28.6	west	good	powerlines @ 4, 5m
5	Burwood Road	25	14	23.2	east	15	25	west	marginal	3 x powerlines @ 5, 7, 8m
6	Dudley Road / Fernleigh Track	27	7	10.6	north	6	8.8	south	poor	road, powerlines, clearing, fence on southern side
7	Dudley Road	81	11	17.8	north	13	21.4	south	poor	powerlines @ 5, 9m, houses
8	Burwood Road	35	17	28.6	north	12	19.6	south	poor	large cleared gap, powerlines, narrow corridor
9	Ashby Street	42	11	17.8	west	10	16	east	poor	large cleared gap, powerlines, open parkland
10	Seacourt Avenue	20	13	21.4	west	21	35.8	east	good	powerlines
11	Bombala Street	10	14	23.2	west	14	23.2	east	good	good crossing point, some cleared patches for houses
12	Goulburn Street	no gap	13	21.4	west	No gap, continuous trees			good	continuous trees, natural gaps in canopy
13	Debs Parade	no gap	10	16	east	No gap, continuous trees			good	tree height reduces to 2-3m on cliff line
14	Burwood Road	20	15	25	north	15	25	south	good	powerlines @ 9m, busy road

A colour coded rating was applied to each crossing point, where
Yellow indicates good crossing width
Aqua is marginal and
Red is Poor.

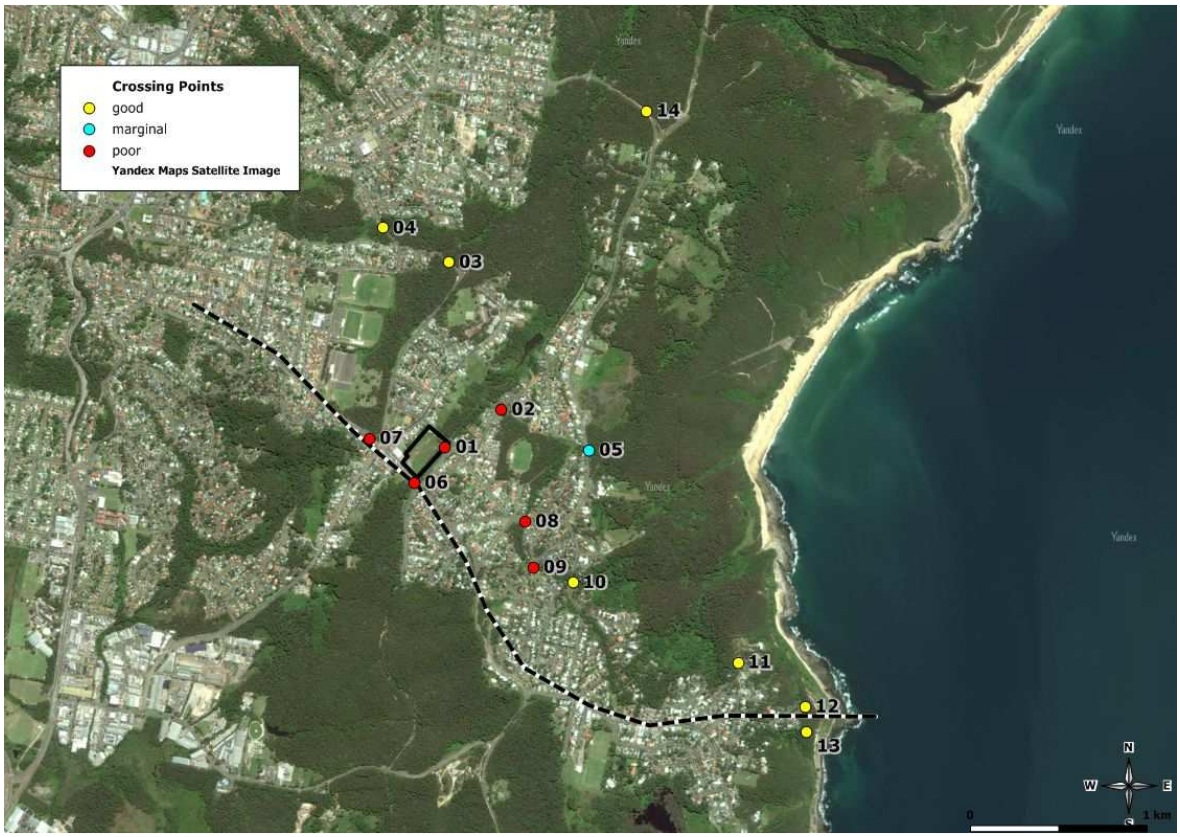

Figure 6 Gap Analysis, Glenrock Patch

The assessment of corridor function, based on measurement of gap widths and condition of vegetation, indicate 6 of the 14 gaps identified in this peer review, function poorly as movement corridors for the Squirrel Glider. Several inter-patch gaps provide good dispersal points for safe glider crossings (Numbers 3, 4, 10, 11, 12, 13 and 14). The Dudley Bluff Corridor (numbers 11, 12 and 13) are considered suitable movement corridors for the Squirrel Glider, with tree heights to 13 metres, and limited gaps in canopy cover. However, as noted by Clulow (2014, 2015), the height of the tree canopy at points 12 and 13 (Goulburn Street and Debs Parade, Dudley) reduce to 2-3 metres at the cliff edge. However, the corridor width (at least 30 metres) has sufficient canopy structure to enable movements of gliders at this narrow point.

Following is a discussion on the issues relating to a number of the crossing points, particularly Points 1, 6 and 7, which are located in close proximity to the Fernleigh Track corridor.

4.2.1 Location Point 1 (Figure 6)

Location Point 1 (Fernleigh Track corridor) is located in the north-eastern corner of the subject site. Within this area, trees identified for removal by the proposed development include:

- Trees #18 – #20 within Lot 1 DP436503) and
- Trees #21 - #27 in the Kopa Street un-constructed easement.

The plan DA-SP-04 Version D (Mansfield Urban, 2015) illustrating the location of each tree is presented in **Appendix B**.

This action will result in the corridor linkage narrowing to 1 tree width for a distance of 80 metres, from the remaining trees north of the unconstructed Kopa Street remnant, to trees along the Fernleigh Track corridor. The 80m gap would

retain 4 trees, in a linear sequence from south to north, Tree# 12, 13, 14 and 15. Analysis of glide distance between each tree in this residual corridor is summarised below in **Table 3**.

Table 3. Glide Distance Estimates, trees retained on Subject Site.

Tree ID	Tree Description	Tree Height	Gap width to next tree (m)	Maximum Glide Width (m)	Suitability Index
12	Angophora costata	13	32m to Tree 13	21.4	poor
13	Eucalyptus racemosa	7	8m to Tree 14	10.6	good
14	Eucalyptus racemose	7	12m to Tree 15	10.6	poor
15	Eucalyptus racemosa	13	28m to Kopa St remnant	21.4	poor

Note: Tree ID refers to the numbering illustrated on Plan DA-SP-04 Version D 20.02.2015 (Mansfield Urban, 2015).

The analysis reveals that although trees would be retained within the north-eastern corner of Lot 1 DP436503, the gaps are sufficiently wide to restrict normal glide movements of the Squirrel Glider. Movement through this area would require a combination of gliding and ground traverse.

4.2.2 Location Point 6 (Figure 6)

Location Point 6 is located at the Dudley Road overpass above the Fernleigh Track. The cleared gap at this point is 27 metres at the most narrow point. The gap is unsuitable for gliding by the Squirrel Glider, with a large cleared expanse and low tree height (7 metres) on either side of the road. The maximum glide distance is estimated at 10.6 m, whilst the gap is 27m at the narrowest point. However, the trees at this point are unsuitable for glider, and the distance between trees more suited for the Squirrel Glider is 44m. In addition to this large cleared gap, a number of additional obstacles are present, including Dudley Road with high traffic volumes (particularly at dusk in winter), overhead powerlines and barrier fencing.

Clulow (2014) discusses in detail the issue of this location. Squirrel Glider records have been recorded historically and more recent (Clulow, 2015) to the north and south of this location, but assumes this point would not enable gliders to cross between remnants either side of Dudley Road. This point is identified in the LMCC response for remediation works to restore connectivity for the Squirrel Glider, including installation of glider poles and tree plantings to the reduce the gap.

4.2.2 Location Point 7 (Figure 6)

This point is also located along Dudley Road, situated 190 metres to the west of the subject site. A substantial vegetated remnant occurs to the north and south of Dudley Road, being separated by a cleared gap measuring 81 metres. Residential housing and Dudley Road break this corridor, with a number of barriers likely to prevent gliders crossing between remnants. There is no opportunity for restoration of any corridor links at this location due to existing land uses within this gap.

The remaining Location points assessed for this peer review were assessed to determine the quality of crossing points within the Glenrock patch. Connectivity within the larger remnants in this habitat is good, with small gaps in canopy cover, tall tree heights and minimal barriers. However, the smaller fragmented patches have poor connectivity (Crossing points 2, 8 and 9), and unlikely to support populations of the Squirrel Glider.

4.3 Summary

4.3.1 Assessment of Effect

Part (a) of the 7-part test of significance test is the most relevant test relating to the proposed action:

> *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the lifecycle of the species such that a viable local population of the species is likely to be placed at risk of extinction*

Analysis of the metahabitat area defined by Clulow (2014, 2015) reveals that both the northern Glenrock patch, and southern Awabakal – Jewells – Belmont patch are of sufficient size to support sub-populations of the Squirrel Glider in the short to medium term (40 – 60 years, as defined by Smith, 2002). This assessment is based on maintenance of the existing 2 (although tenuous) corridor linkages. The submissions by Clulow (2014, 2015) indicate the proposal would have a significant effect on the local Squirrel Glider population. However, the response prepared by LMCC (2015d) dispute the impact assessment by Clulow (2014, 2015), indicating the proposed action would not have a significant effect on the local population. The response by LMCC (2015d) is subjective to implementation of ameliorative actions, including tree plantings within the E2 zoned part of the subject site, additional plantings along Station Street to the east of the Fernleigh Track, and installation of glider poles at specific locations to improve corridor connectivity.

Based on the review of both submissions, and site assessments and habitat analysis conducted for this peer review, I consider that subject to implementation of the recommendations by LMCC (2015d), which outline the above mentioned ameliorative actions, the proposed development would not likely have an adverse effect on the lifecycle of the local Squirrel Glider population. However, if no habitat enhancement measures are incorporated into the Consent Conditions for the proposed development, then the action would likely have an adverse effect on the lifecycle of the local Squirrel Glider population, particularly the northern Glenrock sub-population.

Viability analysis models for Squirrel Glider populations (Smith, 2002; Goldingay and Sharpe, 2004; Goldingay *et. al,* 2006), suggest that the northern Glenrock sub-population would not be considered viable in the longer term (>100 years). This conclusion is based on the increased fragmentation of habitat, resulting from reduced corridor connectivity, and mortality risks associated with proximity to urban settlement.

At present, two corridors have been identified as potentially providing connectivity within this metahabitat area. This review has identified that only the Dudley Bluff corridor provides a suitable movement corridor for the Squirrel Glider, whilst the Fernleigh Track corridor is compromised by cleared gaps and barriers at both the subject site and Dudley Road overpass location. Whilst glider movements are considered possible at the subject site locations (crossing points 1 and 6; refer to Figure 6 above), the risk to gliders is considered higher than other crossing points identified within the metahabitat patch.

4.3.2 Ameliorative Actions

The recommendations to improve the Fernleigh Track corridor, which include additional in-fill plantings within and adjacent to the subject site, and installation of glider poles at specific locations, would increase the potential of gliders to utilise this crossing point in the future. At present, the probability of gliders crossing Dudley Road within the Fernleigh Track corridor, is considered very low.

The action of infill planting within the subject site is restricted to the E2 zone along the eastern boundary. This strip is approximately 10 metres in width. At present, the Fernleigh Track corridor is restricted to a narrow corridor of 1 – 3

tree widths. The Fernleigh Track corridor, including plantings within the subject site, would increase the width to at least 3-4 crown widths. Additional in-fill planting along a cleared strip of Station Street, located to the east of the Fernleigh Track, has the potential to expand the corridor to 4 - 5 tree crowns in width, or approximately 40 – 50 metres. A corridor of this width, whilst not ideal as a regional corridor, is considered sufficient for the length of the corridor (260 metres) between the northern boundary of the subject site and Dudley Road.

The recommendation for installation of glider poles at specific locations by LMCC (2015d), both within the subject site and adjacent to the Dudley Road crossing point, is supported. Glider poles have the benefit of providing instant restoration of launch sites for gliders across previously cleared gaps, and remain viable structures for long periods of time (40+ years). In contrast, tree plantings require a minimum period of 15-20 years to attain sufficient height to be functional for gliders. However, this time period until established, may be compromised by stochastic events such as high winds, disease and even tree maintenance for public safety.

Depending upon the engineering requirements, an additional structure is recommended for consideration at the Dudley Road overpass location (Point 6 on **Figure 6** above). The installation of a rope spanning the gap between glider poles is recommended. Such structures are commonly constructed as fauna overpasses along major highways and significant minor roads. The rope bridge enables additional arboreal fauna such as possums, to walk along the structure overhead from the carriageway. In comparison, poles are specific to glider species.

The development is proposed to be constructed in six stages, with the initial Stage 1 including construction of four small lot housing dwellings on proposed Lots 21-24. It is recommended that the construction of dwellings Lots 21-24 be delayed until later stages in the proposed development. Development of proposed Lots 21-24 will result in removal of 3 mature trees in the north-eastern corner of the subject site (Tree# 18-20). These trees are situated approximately 16 metres to the west (upslope) from Tree# 15, which will be the only retained mature tree on site under the current proposed staging of works. Retention of trees 18 – 20 is recommended to retain the current Fernleigh Corridor linkage until habitat enhancement works have been completed, such as installation of glider poles and in-fill plantings.

Approval for Lots 21-24 are recommended to be with-held until ameliorative actions recommended by LMCC (2015d) and in the discussion above, are implemented.

4.3.3 Future Strategic Land Use Considerations

The submissions by Clulow (2014, 2015) identified that the local metahabitat patch, and local population of the threatened Squirrel Glider population, has tenuous linkage between the Glenrock and Awabakal – Jewells – Belmont habitat patches. Connectivity within this metahabitat patch is restricted to 2 narrow and tenuous vegetation corridors, the Fernleigh Track and Dudley Bluff. Analysis of the Lake Macquarie Local Environmental Plan (2014) reveal that several large parcels of land immediately south of the Dudley Road area retain old land use zonings, which will require detailed consideration for ecological conservation for any future land use rezoning.

Under the current land use zones, a narrow corridor of E2 conservation zoned land approximately 100 metres in width, and extending 1.8 kilometres, extend from the Dudley Road crossing point near the subject site, south to Oakdale Road at Gateshead / Bennett's Green. This narrow corridor is the old RTA East Charlestown Bypass land, which has been rezoned to conservation. This E2 corridor stops short of Oakdale Road Gateshead by existing light industrial land. Land to the east and west of the E2 corridor currently retains old land use zonings, which are incompatible with conservation objectives (refer to **Figure 7** below).

Figure 7 LMCC Land Use Zonings south of Dudley Road (LMCC LEP, 2014).

Future land use zonings that support land development, without significant conservation considerations, would jeopardise any ameliorative works undertaken along the Fernleigh Track Corridor, within and immediately adjacent to the subject site. A significant E2 zoned corridor, several hundred metres in width, is required to ensure long term viability of both the Glenrock and Awabakal – Jewells – Belmont Squirrel Glider sub-populations.

5.0 CONCLUSION

A proposed development on land off 142, 144 and 146 Dudley Road and 2, 2A and 4 Kopa Street Whitebridge includes a mix of residential flat buildings, small lot housing, stormwater management facilities and Torrens title subdivision. The subdivision plan (Reference 14_026 DA-A-012, Revision 1 dated 15-06-2015, Smith & Tzannes) is presented in Appendix A. An initial ecological assessment of the proposed development concluded the site does not contain significant habitat attributes, threatened species, populations or ecological communities listed under threatened species legislation (RPS, 2013).

Two detailed submissions were submitted by Clulow (2014, 2015) following exhibition of the Development Application. The submissions highlighted inadequacies in the ecological assessment, and considered the site was part of a critical corridor for the threatened Squirrel Glider. Dr Clulow prepared an impact assessment based on the 7-part test and concluded the proposed development would impact on a local population of the threatened Squirrel Glider by degradation of the critical Fernleigh Track habitat corridor. Also, the proposed development will result in a lost opportunity to restore the Fernleigh Track corridor to a more viable corridor for two important local populations of the Squirrel Glider.

Lake Macquarie City Council prepared a report to the Hunter and Central Coast Joint Regional Planning Panel (July 2015) and concluded the proposed development would not have a significant effect on threatened species or communities. Approval of the development, subject to conditions of consent, was recommended by Lake Macquarie City Council (LMCC, 2015a).

Following preparation of the Joint Regional Planning Panel in July 2015, LMCC prepared a detailed Assessment of Significance report (September 2015)(LMCC, 2015d). The report acknowledged the issues raised by Dr Clulow in his submissions, but "*…disagrees on his application of the seven part test and the scale of impact that would occur as a result of the application*…". The Assessment of Significance report concluded "*…the application is unlikely to result in significant negative impact on a local population of squirrel glider and a species impact statement is not required*…" (LMCC, 2015d, p. 12).

However, the Assessment of Significance report (LMCC, 2015d) acknowledged the requirement for enhancement of the corridor to improve connectivity for squirrel gliders in the locality. In addition to the LMCC Assessment of Significance report, consideration of the draft Lake Macquarie Squirrel Glider Planning and Management Guidelines (LMCC, 2015e) was presented. A general discussion including suitable mitigation measures to improve corridor function for the Squirrel Glider is presented LMCC (2015d). The measures include supplementary tree planting and installation of glider poles. The Fernleigh Corridor adjacent to the subject site is very narrow and requires widening in tree canopy to improve the corridor quality and viability for the Squirrel Glider. Installation of glider poles at specific locations is designed to reduce the gap between existing canopy cover. Gaps of greater than 35 metres are considered to prevent the Squirrel Glider gliding between forested patches of habitat (Smith, 2002).

This peer review undertook additional analysis of the metahabitat identified by Clulow (2014, 2015). A total of 428.5 hectares of habitat suitable for the Squirrel Glider occurs within the Glenrock patch, north of Dudley Road. The subject site off Dudley Road and Kopa Street Whitebridge belongs to this vegetation / habitat patch. The Awabakal / Jewells habitat patch is more extensive in area, with 668.1 hectares of habitat potentially suitable for the Squirrel Glider. However, this patch appears to be more fragmented due to combination of past clearing and areas of non-suitable Squirrel Glider habitat, for instance, wet heath. In total, the extent of suitable habitat assessed for this peer review is 1,096.6 hectares. Based on current knowledge of habitat requirements, both the Glenrock and Awabakal / Jewells patches are of sufficient size to sustain a local population of the Squirrel Glider in the short term (<60 years).

The assessment of corridor function, based on measurement of gap widths and condition of vegetation, indicate 6 of the 14 gaps within the Glenrock patch, function poorly as movement corridors for the Squirrel Glider. Several inter-patch gaps provide good dispersal points for safe glider crossings, including the Dudley Bluff Corridor. However, Clulow (2014, 2015) noted that the height of the tree canopy reduces to 2-3 metres at the cliff edge, which restricts the corridor width to approximately 30 metres.

Corridor gap analysis was also conducted on trees within the subject site off Dudley Road and Kopa Street, Whitebridge. Under the current DA, the development would result in the Fernleigh Corridor linkage narrowing to 1 tree width for a distance of 80 metres. At this location, only 3 trees (#13, 14 and 15)(refer to **Figure A.2** in **Appendix 1**) would remain south of the unconstructed Kopa Street remnant, to trees along the Fernleigh Track corridor (# 2 – 12 + additional trees not mapped). Gap distances between each tree in this residual corridor indicate safe glide movements by the Squirrel Glider would be compromised. Movement through this area would require a combination of gliding and travelling along the ground.

An additional large gap unsuited to safe Squirrel Glider movements occurs at the Dudley Road crossing point. In addition to this large cleared gap, a number of additional obstacles are present, including Dudley Road with high traffic volumes (particularly at dusk in winter), overhead powerlines and barrier fencing.

Based on the review of both submissions, and site assessments and habitat analysis conducted for this peer review, I consider that subject to implementation of the recommendations by LMCC (2015d), which outline the above mentioned

ameliorative actions, the proposed development would not likely have an adverse effect on the lifecycle of the local Squirrel Glider population.

However, if no habitat enhancement measures are incorporated into the Consent Conditions for the proposed development, then the action would likely have an adverse effect on the lifecycle of the local Squirrel Glider population, particularly the northern Glenrock sub-population. Viability analysis models for Squirrel Glider populations (Smith, 2002; Goldingay and Sharpe, 2004; Goldingay *et. al,* 2006), suggest that the northern Glenrock sub-population would not be considered viable in the longer term (>100 years). This conclusion is based on the increased fragmentation of habitat, resulting from reduced corridor connectivity, and mortality risks associated with proximity to urban settlement

It is recommended that the construction of dwellings Lots 21-24 be delayed until later stages in the proposed development. Development of proposed Lots 21-24 will result in removal of 3 mature trees in the north-eastern corner of the subject site (Tree# 18-20). These trees are situated approximately 16 metres to the west (upslope) from Tree# 15, which will be the only retained mature tree on site under the current proposed staging of works. Retention of trees 18 – 20 is recommended to retain the current Fernleigh Corridor linkage until habitat enhancement works have been completed, such as installation of glider poles and in-fill plantings.

The metahabitat patch identified by Clulow (2014, 2015) has tenuous linkage between the Glenrock and Awabakal – Jewells – Belmont habitat patches, the Fernleigh Track and Dudley Bluff corridors. Analysis of the Lake Macquarie Local Environmental Plan (2014) reveal that several large parcels of land immediately south of the Dudley Road area retain old land use zonings, which will require detailed consideration for ecological conservation for any future land use rezoning. Failure to consider this future land usage without significant conservation considerations, would jeopardise any ameliorative works undertaken along the Fernleigh Track Corridor, within and immediately adjacent to the subject site. A significant E2 zoned corridor, several hundred metres in width, is required to ensure long term viability of both the Glenrock and Awabakal – Jewells – Belmont Squirrel Glider sub-populations.

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APPENDIX ONE. SITE DRAWINGS

Figure A.1 Proposed Development Layout (copyright Smith & Tzannes, 2015)

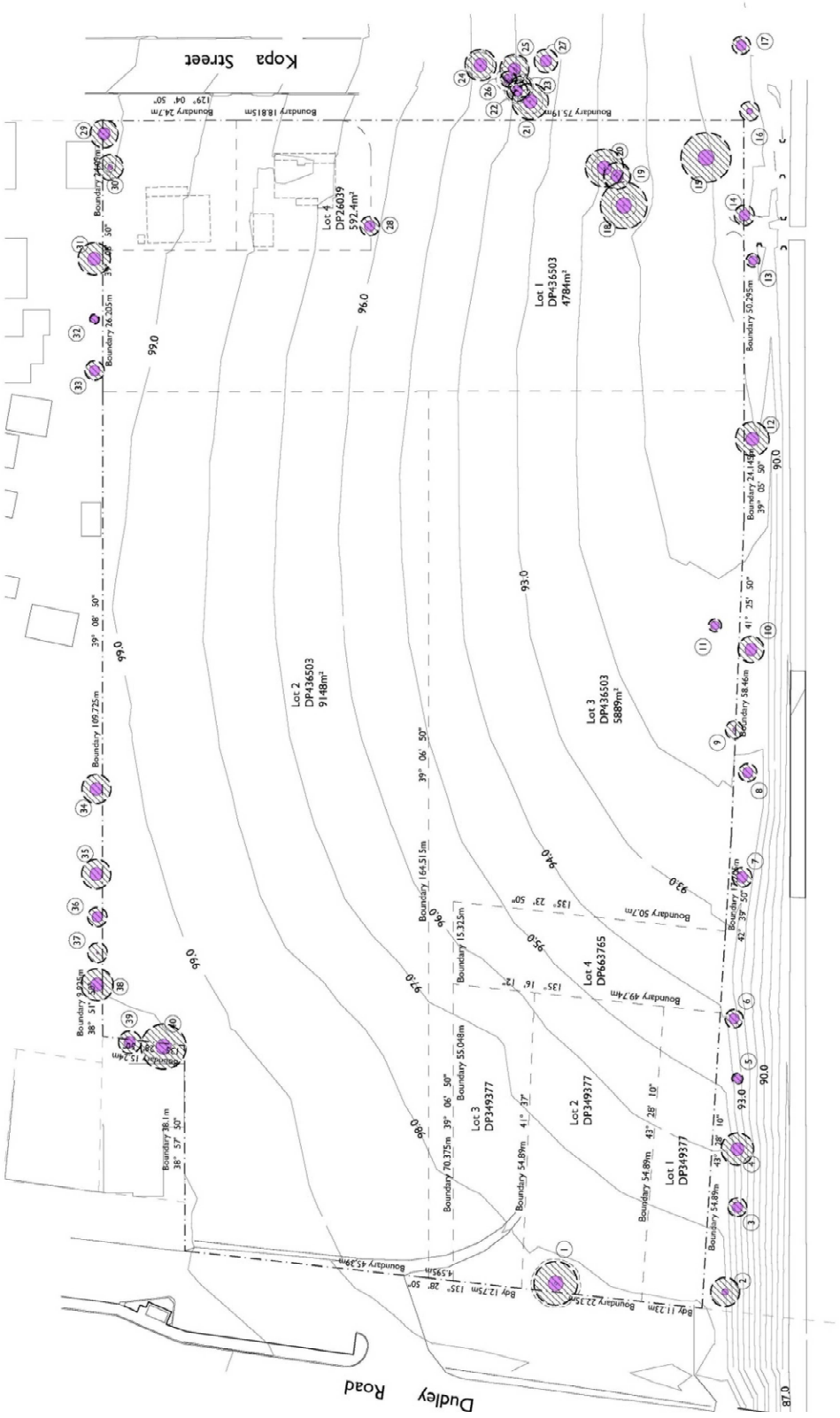

Figure A.2 Tree Protection Plan (copyright Mansfield Urban, 2015)

Note: Plan cropped to enlarge tree numbering details.