SMEC + Hyder Joint Venture

OXLEY HIGHWAY TO KEMPSEY

WIDENED MEDIAN ASSESSMENT

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ROADS AND MARITIME SERVICES

PACIFIC HIGHWAY UPGRADE -OXLEY HIGHWAY TO KEMPSEY

Widened Median Assessment

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APPENDICES

1 INTRODUCTION

The upgrade of the Pacific Highway between the Oxley Highway and Kempsey (the Project) is part of the Pacific Highway Upgrade Program. This program is a joint commitment by the New South Wales (NSW) and Federal Governments to provide a continuous dual carriageway on the Pacific Highway between Hexham (near Newcastle) and the Queensland border. The Project is approximately 37 kilometres in length, from its southern extent, approximately 700 metres north of the Oxley Highway interchange, to its northern connection to the Kempsey Bypass, just south of Kempsey.

NSW Roads and Maritime Services (RMS) completed an environmental assessment of the Project (the Project EA) in 2011 (GHD 2011a). After consideration of the Project EA and Submissions Report, the Minister for Planning approved the Project under part 75J of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 8 February 2012 subject to the Minister's Conditions of Approval (CoA) being met.

In addition to the CoA, the Statement of Commitments (SoC) for the Project (RTA 2011) included a commitment to further investigate the feasibility of widening the medians. Relevant CoA and SoC are identified in Table 1 below.

The (then) NSW Department of Environment, Climate Change and Water (DECCW) (now the Environment Protection Authority (EPA)) identified retained vegetation in the median and on road verges as a priority over rope ladders and glider poles when considering mitigation measures to provide aerial connectivity.

Table 1: CoA and SoC that identify widened median requirements.

Condition / commitment	Detail
CoA B4	The Proponent shall investigate the provision of widened medians (with the aim of retaining existing vegetation in a widened median where feasible and reasonable) as an alternative to the provision of glider poles and rope bridges to facilitate the movement of gliders across the project at the following locations: (a) Cairncross 1 – between station 10000 to 11600; (b) Ballengarra 1b - between station 23200 to 24100; and (c) Maria River 1b - between station 33760 to 34380 The investigation shall be undertaken by a suitably qualified and experienced ecologist and in consultation with the EPA and DPI (Forests). The Proponent shall prepare a report on the median widening investigation, including the location and final design of the glider crossing measures and consequential impacts on other ecologically significant element potentially affected by the widening…
CoA B5	As part of the investigation into widened medians under condition B4, the Proponent shall investigate and report on the provision of widened medians at Barrys Creek (station 23967) as an alternative fauna crossing design for Koalas and Quolls.
F18	The feasibility of widening the median will be further investigated in consultation with DECCW (now EPA) during the detailed design.

Condition A7 of the project approval allows Roads and Maritime Services (RMS) to construct and/or operate the Project in stages provided a Staging Report is submitted to the Director General prior to the commencement of the first proposed stage. A staging report has been

prepared and submitted to the Director General. Due to the Project's length and funding models available, the Project will be essentially delivered in two main sections – from the Oxley Highway to Kundabung (approximately 24 kilometres) and from Kundabung to Kempsey (approximately 14 kilometres).

The Kundabung to Kempsey section of the Project will be delivered as a construct only contract and detailed design has been developed for this section. The detailed design has been able to inform the investigations into widened median locations and associated fauna crossing mitigation structures (section 2.3).

1.1 ECOLOGICAL CONTEXT

A major impact of roads is habitat fragmentation, where a division of otherwise continuous habitat reduces habitat connectivity. A reduction in habitat connectivity may impact upon the ability of an animal to move through habitat to obtain food, shelter and breeding resources or to disperse from natal areas or undertake seasonal migrations (van der Ree *et al.* 2007, QDMR 2000, Goosem 2005, van der Ree *et al*. 2010, McCall *et al.* 2010).

The movement of gliders may be affected by road widening: they may be deterred by the larger gap (i.e. a larger distance between trees) that may exceed their gliding capability; or may attempt to cross and fall short of reaching vegetation on the other side of the road, resulting in increased mortality (van der Ree *et al.* 2010, McCall *et al.* 2010). Retaining tall trees in the median that separates the carriageways may mitigate the barrier effect of roads on gliders, provided that the gap in tree cover is within their glide distance capacity. Median widening is an alternative means of providing safe crossing opportunities for gliding species in locations where mature vegetation between carriageways would allow gliding species to cross the upgraded highway in a staged manner (GHD 2011b).

Habitat adjoining the Project is known to support a diversity of gliding mammals including Sugar Glider (*Petaurus breviceps*), and Yellow-bellied Glider (*Petaurus australis*). It was assessed that the likelihood of the Squirrel Glider (*Petaurus norfolcensis*) to occur in the study area is Moderate, given that potential foraging, sheltering and breeding habitat occurs in the study area (GHD 2010, GHD 2011a).

1.2 OBJECTIVE

This report considers the parameters for widened median functionality ('glidability') based on recent Pacific Highway projects such as Devil's Pulpit, and a review of the existing literature on fauna crossings and gliding performance of the target species, taking into account previous studies undertaken for the Project. Previous relevant studies considered include:

- *Pacific Highway Upgrade – Oxley Highway to Kempsey: Flora and Fauna Working Paper* (GHD 2010)
- *Pacific Highway Upgrade-Oxley Highway to Kempsey Supplementary Flora and Fauna Assessment* (GHD 2011a)
- *Pacific Highway Upgrade – Oxley Highway to Kempsey; Median Widening Assessment – Preliminary Scoping Investigation* (GHD 2011b)
- *Oxley Highway to Kempsey – Pacific Highway Upgrade: Ecological Review of Fauna Crossings in the Ballengarra State Forest* (GHD 2011c)

Objectives of this widened median assessment are:

- Undertake a literature review of glider species ecology, including glide distances and angles.

- Determine the feasibility of providing widened medians at the locations identified in CoA B4 and CoA B5.
- For locations determined to be feasible following preliminary assessment, , undertake a field survey to identify and record attributes of potential glider launch trees in the study area.
- Determine the glidability of the proposed widened median(s) by comparing potential glide distances (related to potential glider launch tree attributes) to clearing widths.
- Conclude whether a widened median at the location investigated is feasible, and recommend any supplementary mitigation measures, if required.
- Provide the basis for consultation with EPA and Forestry Corporation of NSW (formerly part of Department of Primary Industries (DPI)), as required by CoA B4 and commitments made in SoC F18.

1.3 CONSULTATION

The proposed widened median was discussed with representatives from SHJV, RMS, EPA and DPI (Fishing and Aquaculture) at a workshop on 7 September 2012. The aspects discussed are documented in the workshop minutes provided in Appendix E. EPA have provided comments on the draft of this report. Responses to comments have been prepared and provided to EPA and this report amended where required.

Consultation with DPI (Fishing and Aquaculture) and EPA regarding fauna crossing structures has also occurred as part of the development of the *K2K Fauna Connectivity Report* (RMS 2013) and development of the refined concept design for the OH2Ku section of the Project. Further detail is provided in section 2.3 of this report.

Consultation with Forests Corporation of NSW (Forests Corporation) has included provision of the draft Widened Median Report for comment and two subsequent on-site meetings with RMS (one in early May 2013 and another in mid August 2013. Both meetings included discussion of the widened median proposal, options to ensure the functionality of the widened median and potential options to secure Forest Corporation land in Cairncross State Forest adjacent to the proposed widened median as an RMS Biodiversity Offset.

In early September 2013 Forests Corporation provided in principle agreement to the introduction of the proposed widened median (refer Appendix E).

Consultation with Forests Corporation is ongoing.

2 PRELIMINARY INVESTIGATIONS

2.1 BACKGROUND

GHD (2011b) prepared a *Median Widening Assessment - Preliminary Scoping Investigation* to consider the feasibility of widened medians at locations where glider poles were previously proposed. In addition to the need for glider poles, a commitment was made in the Environmental Assessment that consideration would be given to the potential for median widening at those locations where it is reasonable and feasible to do so.

GHD (2011b) identified seven potential widened median locations in three fauna movement corridors. The potential widened median locations were assessed through a review and workshop process that considered the level of constraint for each location according to environmental, social/community and engineering selection criteria.

The preliminary scoping investigation concluded that three locations were potentially suitable as widened median locations and required further investigation (

Table 2). These three locations are as per the Minister's Conditions of Approval (CoA B4).

Table 2: Median investigation areas identified as potentially suitable by GHD (2011b)

Median Investigation Area	Constraints identified in GHD (2011b)
Cairncross 1	Median widening would require lengthening of the proposed Bill Hill Road overbridge resulting in further ecological impacts. Adequate separation of carriageways would be required to provide a viable stand of vegetation. Two incidental fauna crossings proposed in this area may require lengthening.
Ballengarra 1b	Constrained by proposed service road to west and extent of cuts and fills. Existing trees are not likely to be high enough, given the topography; glider poles may still be required between service road and northbound carriageway in conjunction with the widened median. Median widening would require lengthening of a dedicated fauna crossing.
Maria River 1b	One combined fauna crossing in this area could require lengthening. Surrounding vegetation may not be of sufficient height relative to road level to provide required glide distances.

The CoA (CoA B5) also require that consideration be given to the feasibility of including a widened median at Barrys Creek (station 23967).

2.2 REVIEW OF POTENTIALLY SUITABLE WIDENED MEDIAN LOCATIONS

The parameters for widened median functionality ('glidability') were reviewed in May 2012 based on recent Pacific Highway projects such as Devil's Pulpit. A review of the existing literature on fauna crossings and gliding performance of the target species was also

undertaken, taking into account the previous studies carried out for the Project. The results of this review are discussed in further detail in Section 3 of this report.

An assessment of functionality of widened medians in each of the locations identified in CoA B4 and CoA B5 was undertaken. Indicative plan drawings and cross-sections were prepared for each of the identified potential widened median locations; these are provided in Appendix A of this report.

2.2.1 CAIRNCROSS 1

The cross-section for the potential widened median between stations 10300 and 11200 shows a median width of approximately 25 metres at station 10500; the width may increase to about 35 metres further north. The ground surface in this location has a fairly gentle slope and minimal cutting will be required. The cross-section shows that there will be a shallow cut into the existing ground level. Each carriageway forms an approximately 15-20 metre wide gap. The indicative plan and cross section for a widened median at Cairncross 1 is provided in Appendix A.

This section of the alignment includes an incidental fauna crossing at station 10680 and a combined fauna crossing at station 11151. The widening of the medians would increase the length of these crossings.

The preliminary investigations found that a widened median may be feasible at Cairncross 1, as the design requires minimal cut, allows for retention of trees in the median and may result in glidable gaps across carriageways. This location was subsequently the subject of further detailed investigation (Section 3 of this report).

2.2.2 BALLENGARRA 1B

The section of highway between stations 23200 and 24000 traverses an undulating ground surface. The carriageways and the potential widened median would be in the cutting of a north-facing slope. The indicative plan and cross section for a widened median at Ballengarra 1b is provided in Appendix A.

The cross-sections at stations 23460 and 23500 show that at least half of the approximately 21 to 24 metre wide median would be in cut. Salvaging existing vegetation, particularly trees, within cut areas would not be possible and all trees within the median would need to be cleared to facilitate construction.

The gap to the east of the potential widened median would consist of a 12 metre wide carriageway as well as batters to a width of 35 metres, creating a total gap between potential glide trees of at least 47 metres. The vertical offset between the top of the batter and the level of the median would be about 12 metres at this location.

These dimensions will not result in a glidable gap in both directions between the median and retained vegetation to either side of the highway, even if it were possible to retain vegetation in the median.,

In addition, the proposed service road to the west of the potential widened median at this location would create another gap of 20 to 25 metres and further fragment the crossing.

The preliminary investigations concluded that a widened median would not be feasible at Ballengarra 1b. The installation of artificial mitigation structures has been considered, including for the Ballengarra 1b area, and these have subsequently been included in the detailed design (section 2.3).

2.2.3 MARIA RIVER 1B

The section of highway between stations 33700 and 35000 is also on undulating ground and major cutting is required in some locations. The cross-sections at stations 34180 and 34300 show that the carriageways and median would all be in cut. The indicative plan and cross section for a widened median at Maria River 1b is provided in Appendix A.

Salvaging existing vegetation, particularly trees, within cut areas would not be possible and all trees within the median would need to be cleared to facilitate construction.

This section of the alignment includes a combined fauna crossing at station 34086 and a dedicated fauna crossing at station 34714. The widening of the medians would increase the length of these crossings. The preliminary investigations concluded that a widened median would not be feasible at Maria River 1b. The installation of artificial mitigation structures has been considered, including for the Maria River 1b area, and these have subsequently been included in the detailed design (section 2.3).

2.2.4 BARRYS CREEK

The location of the potential widened median at Barrys Creek (station 23967) is close to the northern extent of the potential widened median at Ballengarra 1b. The indicative plan and cross section for a widened median at Barrys Creek is provided in Appendix A. The cross-section at station 23940 shows that the median at this location is 6.65 metres wide and is built up 1-2 metres above the existing ground level.

In addition to the approximately 45 metre wide gap created by the highway carriageways and earthworks, a service road also forms part of the Project and is located immediately to the west of the highway alignment. The service road creates another 30.6 metre gap and further fragments the crossing.

The median in the vicinity of Barrys Creek would not provide any additional functionality for crossing by Koalas, Quolls or other mammals. The crossing point for terrestrial fauna across the potential widened median at Barrys Creek would be fenced to prevent terrestrial fauna accessing the rest of the median. Given this arrangement would theoretically provide a longer crossing length than the Barrys Creek bridge, it is not likely to provide any additional crossing functionality than that already provided by the bridge.

A combined fauna crossing was proposed at station 23967 to facilitate fauna movement beneath the highway along Barrys Creek. Based on consultation with DPI and EPA and further design development, the combined fauna crossing (culverts) have been replaced with twin bridges, a substantially improved outcome for fauna movement.

As part of the investigation into widened medians under condition B4, the Proponent shall investigate and report on the provision of widened medians at Barrys Creek (station 23967) as an alternative fauna crossing design for Koalas and Quolls.

The preliminary investigations concluded that a widened median would not be feasible at Barrys Creek. The replacement of the combined fauna crossing culvert with twin bridges at this location is considered to provide an improved outcome for Koala and Quoll movement. It is possible that some of the existing trees (regrowth eucalypts) could be retained in the gaps between the twin bridges over Barrys Creek and the gap between the main alignment and service road to the west to improve fauna crossing functionality at this location, however constructability and safety requirements may prevent this. The opportunity to retain vegetation between bridges would be investigated during detailed design.

2.2.5 PRELIMINARY ASSESSMENT – CONCLUSIONS

Based on review of the potential cross-sections, the preliminary investigations concluded that widened vegetated medians would not be feasible at the investigation areas at Ballengarra 1b, Maria River 1b and Barrys Creek. The highway design at these locations require carriageways and medians to be at lower levels than the existing landforms, therefore the medians would be in cut and all vegetation and topsoil would be cleared from these areas. Salvaging existing flora, particularly trees, within cut areas would not be possible, and all trees within the median would be cleared during construction.

The preliminary investigations concluded that a widened median may be feasible at Cairncross 1. This location was subsequently the subject of further detailed investigation (Section 3 of this report).

2.3 ALTERNATIVE MITIGATION MEASURES

Given that widened medians are not considered to be feasible at Ballengarra 1b, Maria River 1b and Barrys Creek, the introduction of glider poles and/or rope crossings have been considered at these locations. Yellow-bellied Gliders were recorded in the north of Ballengarra State Forest (GHD 2010) and an effective crossing structure for this species in this location is required.

A *K2K Fauna Connectivity Report* (RMS 2013) has been prepared that details the approach to fauna crossing structures for the K2K section of the Project. This report has been prepared in consultation with EPA and DPI (Fisheries) and addresses the requirements of the Minister's Conditions of Approval (CoA), specifically CoA B2, B3 and B6.

The locations and scope of fauna crossing structures for the Project such as glider poles and rope bridges are discussed in the *K2K Fauna Connectivity Report* and are described below.

2.3.1 GLIDER POLES

Glider poles (**Figure 1**, **Figure 2**) are vertical poles placed in the centre median or on the road verge, and enable launch and landing opportunities, thereby providing connectivity for gliding mammals. General design considerations include:

- Preferred glide pole distance of 22 metres or less.
- Maximum of 40 metres between glider poles.
- Cross bars on glider poles must point to the desired landing.
- Glider poles must include shelter pipes and predator shields to discourage attack from aerial predators.
- Habitat trees for gliders must be within gliding distance of glider poles for glides in both directions.

Figure 1: Example of glider poles at Oxley Highway (Source: Laura Worthington, Hyder Consulting)

Figure 2: Example of glider poles at Oxley Highway (Source: Laura Worthington, Hyder Consulting

Glider poles at two locations will be monitored as a requirement of the Ecological Monitoring Program (SHJV 2012) (Table 3). Potential locations were initially identified following a desktop analysis of mapped habitat types, mapped fauna corridors, vegetation communities and drainage lines. These locations were verified by a site investigation undertaken in October 2012, in order to determine adjoining vegetation communities, habitat features and take note of other important habitat variables in proximity to proposed glider pole locations. The final glide pole locations will be developed during detailed design, in consultation with EPA.

Table 3: Potential locations of glider poles

Station	Target Species	Details
25100	Squirrel Glider Yellow-bellied Glider	Two pairs of glider poles located within 100 metres of each other Located in proximity to tributary of Barrys Creek and within Ballengarra State Forest Mapped Regional fauna movement corridor Vegetation in this area includes Moist Slopes Forest and Riparian Forest
34150	Squirrel Glider Yellow-bellied Glider	One set of glider poles either just north or just south of C34.10 (combined culvert) Located in proximity to rope bridge. Located within the Maria River State Forest andwithin mapped Regional corridor. Vegetation in this area includes Moist Slopes Forest, Moist Gully Forest and Dry Ridgetop Forest.
35385	Squirrel Glider Yellow-bellied Glider	One set of glider poles either just north or just south of C35.70 (combined culvert). Located in proximity to rope bridge. Located within the Maria River State Forest and within mapped Regional corridor. Vegetation in this area includes Moist Slopes Forest, Moist Gully

Station	Target Species	Details
		Forest, Dry Ridge-top Forest. Habitat: canopy trees 20-25 metres tall to be retained between existing highway and proposed alignment. Large canopy tree to east of proposed alignment. Midstorey of regenerating eucalypts and Black She-oak (*Allocasuarina littoralis*) to 12 metres.

2.3.2 ROPE BRIDGES

Rope bridges (**Figure 3**, **Figure 4**) are rope ladders or netting suspended above the traffic, that typically provide for the crossing of arboreal species. At three locations along the K2K section of the Project, rope bridges will be suspended across the highway between poles on each side (Table 4). General design considerations include:

- The rope ladder must be constructed of marine grade silver (high UV rating) rope and stainless steel cables.
- The rope bridge must be linked to adjacent glider habitat trees by ropes or ladders tied off onto the support poles and the trees.
- Support poles used in the median must include metal guards to prevent animals descending to the ground in the median.
- The rope bridge must have a clearance of no less than 10.6 metres above the road pavement surface.
- Rope bridges will be constructed to start and end at canopy height.

Figure 3: Rope bridge, Oxley Highway (Source: Laura Worthington, Hyder Consulting)

Figure 4: Rope bridge, Oxley Highway (Source: Laura Worthington, Hyder Consulting

Rope bridges at three locations will be monitored as a requirement of the Ecological Monitoring Program (SHJV 2012) (Table 4). Potential locations were initially identified following a desktop analysis of mapped habitat types, mapped fauna corridors, vegetation communities and drainage lines. These locations were verified by a site investigation undertaken in October 2012, in order to determine adjoining vegetation communities, habitat features and take note of other important habitat variables in proximity to proposed rope bridge locations.

Table 4: Potential locations of rope bridges

Station	Target Species	Existing Environment
24100	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek and riparian zone, within Ballengarra State Forest and within a mapped Regional fauna movement corridor. Vegetation in this area includes Riparian Forest, Moist Floodplain Closed Forest with Rainforest Elements and Moist Gully Forest. . .
34000	Squirrel Glider Yellow-bellied Glider	Located in proximity to combined underpass C34.10 and in proximity to glider pole locations. Located within Maria River State Forest and within a mapped Regional fauna movement corridor Vegetation in this area includes Moist Slopes Forest, Moist Gully Forest and Dry Ridgetop Forest.
35700	Squirrel Glider Yellow-bellied Glider	Located in proximity to combined underpass C35.70 Located within Maria River State Forest, in proximity to an unnamed watercourse and within a mapped Regional fauna movement corridor. Vegetation in this area includes Moist Slopes Forest, Moist Gully Forest and Dry Ridgetop Forest.

3 DETAILED INVESTIGATIONS

Following the preliminary investigations, the feasibility of a widened median at Cairncross 1, between station 10000 and 11600, was investigated in detail.

3.1 STUDY AREA

Cairncross 1 is located between station 10000 to 11600 in Cairncross State Forest. For the purpose of this assessment, the widened median location assessed is between Bill Hill Road in the north (station 11400) and where the carriageways diverge at station 10300 in the south.

The study area comprises the northbound and southbound carriageways, separated by a wide median, between station 10300 and station 11400 (Figure 5). The proposed median is 54 metres wide, between fill batters, at its widest at station 10700.

Vegetation communities in the study area (Figure 11) include Moist Gully Forest, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest and Dry Ridgetop Forest. One Endangered Ecological Community, Swamp Sclerophyll Forest on Coastal Floodplain, occurs between station 11100 and station 11300. Vegetation within and adjoining the study area is continuous with native vegetation of the regional corridor mapped to the north (station 11600).

The clearing footprint in the study area consists of the proposed alignment of each carriageway (approximately 12 metres wide), in addition to four metres clearing width at the top of cut batters and two metres clearing width at the bottom of fill batters. Batter slopes of up to 17 metres wide are proposed where substantial fill is required to lift the vertical alignment.

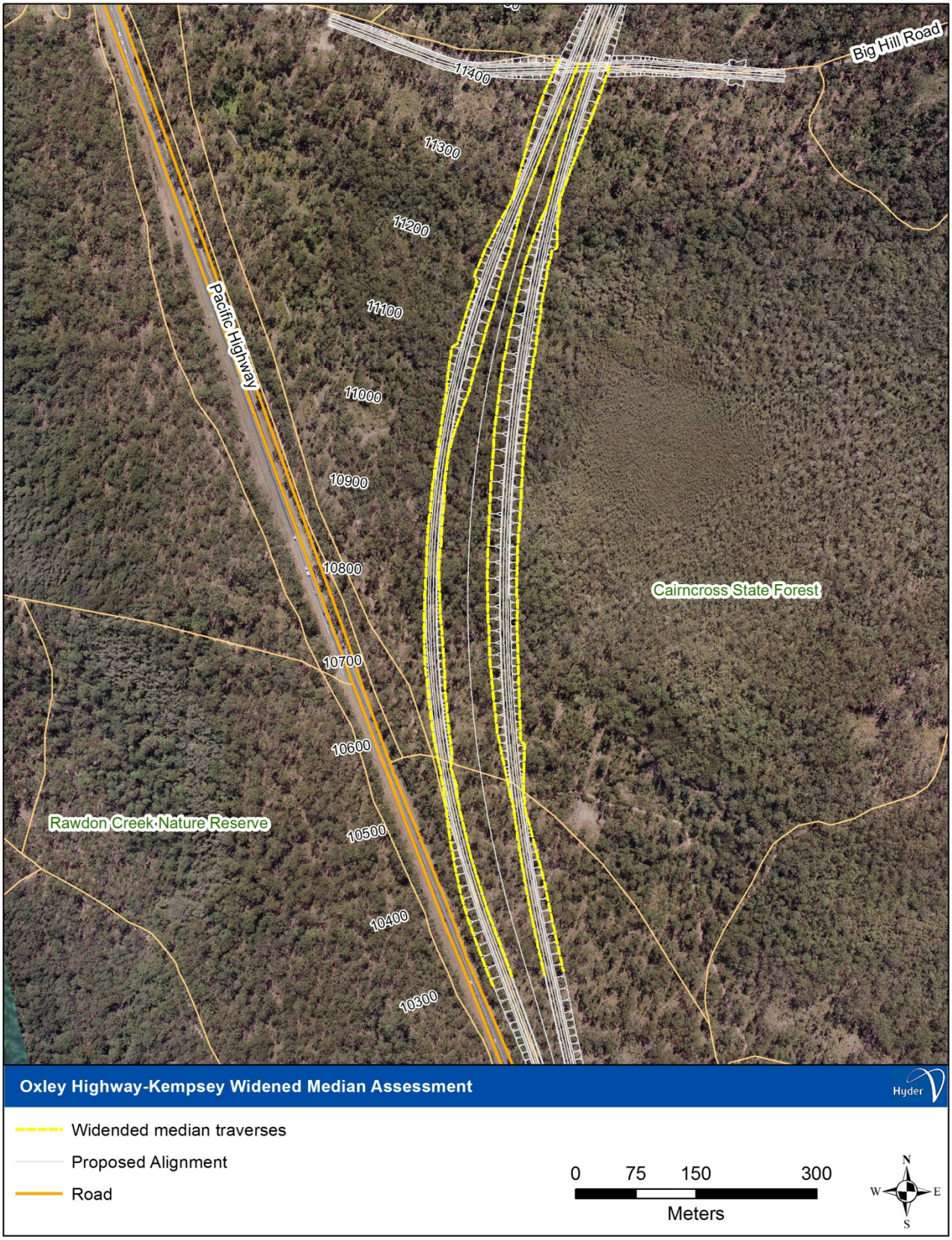

Figure 5: Cairncross 1

3.2 METHODOLOGY

3.2.1 LITERATURE REVIEW

A review of relevant information was undertaken to provide an understanding of the ecology of glider species and the effectiveness of widened medians. Reports and literature reviewed included, but were not limited to, the following:

- *Pacific Highway Upgrade-Oxley Highway to Kempsey Flora and Fauna Working Paper* (GHD 2010).
- *Pacific Highway Upgrade-Oxley Highway to Kempsey Supplementary Flora and Fauna Assessment* (GHD 2011).
- *Median Widening Assessment-Preliminary Scoping Investigation. Oxley Highway to Kempsey Environmental Assessment Submissions Report Appendix C* (RMS 2011).
- Published articles regarding impacts of linear infrastructure, highway edge effects, glider ecology and fauna crossing mitigation measures.

3.2.2 FIELD SURVEY

Potential Glider Trees

Field surveys of the proposed widened median in Cairncross State Forest were undertaken on June 26th and July 3rd and 4th 2012 by Hyder Consulting.

The proposed alignment of the Pacific Highway upgrade between station 10300 and station 11400 was uploaded into a Getac PS236 rugged handheld GPS. The outer boundary of the proposed alignment was traversed on the western and eastern side of both carriageways (Figure 5). Potential glide trees were identified approximately every 10 metres as close to the boundary as possible and tagged with fluorescent flagging tape and located with a handheld Garmin Etrex GPS. Potential glide trees were classified as trees taller than 12 metres with a Diameter at Breast Height (DBH) greater than 0.2 metres and within five metres of the proposed road edge.

For each tree tagged and located with the GPS, the following attributes were recorded:

- Species.
- Diameter at Breast Height (DBH).
- Distance from road edge.
- Canopy diameter.
- Presence of any suitable launch branches (>100mm diameter) in upper canopy.
- Distance of suitable launch branches from top of tree.

The coordinates for each tagged glide tree were given to RMS and tree height surveys were undertaken on 16th and 17th of July 2012 by RMS. A Trimble GPS unit, connected to Corsnet was used to locate required trees and a Contour xlr Class 1 Laser (Serial No. LC2099) was used to survey tree heights. The Slope Measurement mode was used to determine tree heights and measurements were checked using both two Shot Height and three Shot Height modes.

Targeted Glider Surveys

Targeted surveys for glider species was undertaken Lewis Ecological Surveys over three days in late October 2012 (Appendix B). Seventeen sites were selected in a grid like formation

across the broad area associated with the proposed widened median. Call broadcast and spotlighting surveys were undertaken at each site.

Reference Tree Survey

Reference tree surveys were undertaken by Lewis Ecological Surveys in late October 2012 (Appendix B). The purpose of the reference tree surveys was to investigate the potential growing height and crown coverage of retained trees in the vicinity of the proposed widened median.

The survey sites were located west of the existing Pacific Highway, in Rawdon Creek Nature Reserve and the adjoining road reserve, in areas that had not been recently logged. The location, species, height, Diameter at Breast Height (DBH) and the canopy width of the ten largest trees in each study area were recorded.

Limitations

Ideal conditions for GPS surveying are a clear view of the sky with no obstructions; any obstructions in the area of the GPS antenna can cause a significant reduction in accuracy. Examples of interfering obstructions include buildings, trees, fences and cables. Obstructions may have the following effects, thereby reducing accuracy:

- Reduced number of satellites seen by the receiver.
- Reduced strength of satellite geometry (Dilution of Precision (DOP) values).
- Satellite signal multipath.
- Corruption of GPS measurements.

GPS positional accuracy is also reduced by atmospheric errors, satellite errors and receiver noise. Atmospheric errors are one of the main causes of GPS errors and occur because charged particles and moisture in the atmosphere can slow satellite signals down.

Poor weather (heavy rain and thick cloud cover) during survey on June 26th may have resulted in errors in positional accuracy while traversing the outer boundaries of the proposed alignment and locating trees with GPS. It is possible that dense canopy cover in parts of the study area may have also contributed to errors in positional accuracy.

Any positional accuracy errors in tree locations (i.e. tagged trees) were verified and corrected by the RMS survey. Any differences in coordinates of tagged trees were attributed to positional accuracy errors in the Garmin Etrex GPS during the survey undertaken by Hyder Consulting. In this case, the coordinates recorded by RMS for tagged tree locations superseded the Hyder coordinates and were used in all subsequent calculations. As a result, tree locations are considered likely to be accurate.

3.3 RESULTS

3.3.1 EFFECTIVENESS OF WIDENED MEDIANS

Road widening may deter gliders from attempting to cross the larger gap (i.e. a larger distance between trees) as it may exceed their gliding capability, or gliders may attempt to cross and fall short of reaching vegetation on the other side of the road, resulting in increased mortality (van der Ree *et al.* 2010, McCall *et al.* 2010). Retaining tall trees in the median that separates the carriageways may mitigate the barrier effect of roads on gliders, provided that the gap in tree cover is within their glide distance capacity.

There has been little research into the effectiveness of vegetated medians in comparison to other mitigation measures, or the factors that make them effective. Vegetated medians may be more effective than other crossing structures for the following reasons (Kylie Soanes, Australian Research Centre for Urban Ecology, pers. comm. 9 May 2012):

- Trees are retained during construction of the road, meaning connectivity is not disrupted and there is lower disturbance to normal movement patterns of the population.
- Trees are part of the gliders' natural environment, so they don't have to adapt to them in any way. They also provide additional habitat and feeding resources.
- Recent evidence from monitoring of canopy bridges suggests that a small group of gliders could include a structure as part of their territory and exclude other gliders from also accessing the structure, meaning it is less likely to be effective for a large number of individuals. A vegetated median has multiple crossing options and would be more difficult for a few opportunistic animals to monopolise.

There is very little information available regarding the effectiveness of vegetated medians to provide safer crossing for ground-dwelling fauna such as Koalas and Quolls.

The key factor that limits glider crossing is gap width. The distance that a glider can cross, or the "glidability" of a gap, is directly related to the height of trees the gliders use to launch from that are adjacent to the gap.

3.3.2 SQUIRREL GLIDER ECOLOGY

Radio-tracking of squirrel gliders in fragmented woodland adjoining the Hume Highway in north-east Victoria found that gliders were likely to cross one or both carriageways of a highway where there were tall trees in the median, but that there was an almost complete lack of glider crossing at sites where trees were absent from the median (van der Ree *et al.*. 2010). The difference in frequency of crossings was attributed to the wider gap in canopy (50 to 64 metres at sites with no trees in the median compared with five metres to 13 metres at sites with trees in the median).

Several studies have attempted to determine the gliding ability of the squirrel glider (Table 5). Typical glide distances range from 30-40 metres. The maximum glide distances recorded for Squirrel Gliders of 70 - 80 metres are considered to be extreme performances and should not be considered as typical when designing mitigation options (van der Ree *et al.* 2010, Goldingay and Taylor 2009).

Table 5: Review of gliding ability of squirrel gliders in available literature

Literature review of gliding ability of squirrel gliders
▪ Average glide length of approximately 30-35 metres (van der Ree and Bennet 2003, van der Ree *et al.* 2003 cited in van der Ree *et al.* 2010).
▪ Average glide length of approximately 20 metres (Goldingay and Taylor 2009).
▪ Glide lengths of 50-64 metres recorded in van der Ree *et al.* (2010) are considered atypical (van der Ree *et al.* 2010).
▪ The Squirrel glider is similar to the sugar glider in gliding ability. The sugar glider can volplane for at least 50 metres (Strahan *et al.* 1995).
▪ Glide length of 80 metres recorded with a launch height of 45 metres (GHD 2011a).
▪ Maximum glide length recorded is approximately 70 metres (van der Ree *et al.* 2003 cited in van der Ree *et al.* 2010).
▪ Maximum glide was 80 metres with an average of 30-40 metres (van der Ree 2006).

Goldingay and Taylor (2009) undertook a study of gliding performance by the Squirrel Glider to determine gap-crossing ability. Observations of 85 glides by 73 individuals resulted in the following average values (Table 6):

Table 6: Results of study of gliding performance by the Squirrel Glider (Goldingay and Taylor 2009)

Parameter	Mean value
Launch height	17.4 ± 0.5 metres
Landing height	5.7 ± 0.3 metres
Launch position – distance below tree top	1.7 ±0.5 metres
Launch position – distance from main trunk	2.3 ± 0.3 metres
Horizontal glide distance	21.5 ± 0.9 metres
Glide angle	28.5° ± 0.8°

Based on these results, Goldingay and Taylor (2009) concluded that trees would need to be at least 13 metres tall adjacent to a gap of 20 metres (two-lane road), to enable gliders to safely glide across. Trees would need to be at least 25 metres tall adjacent to a gap of 43 metres (four-lane road), to enable gliders to safely glide across.

The results of Goldingay and Taylor (2009) were the basis for a formula for calculating potential glide distance for Squirrel Gliders across gaps as used by Geolink (2012) when assessing potential locations for vegetated medians at the Pacific Highway Upgrade at Devils Pulpit. The formula is as follows:

Potential Glide Distance	=	average glide vertical to horizontal plane ratio	x	(tree height – average glider launch height from tree top – preferred minimum landing height)	+	(average launch distance from launch tree trunk – average launch tree trunk distance from clearing edge – average landing tree distance from clearing edge)

3.3.3 YELLOW-BELLIED GLIDER ECOLOGY

The gliding ability of Yellow-bellied Gliders has not been investigated in detail in the available literature. Goldingay (1989) recorded an average glide distance of 39 metres from measurements of 100 glides by Yellow-bellied Gliders, however this was in 40 to 45 metre high forest (Goldingay and Taylor 2009).

In a review of glider pole locations along the Oxley Highway Deviation, Goldingay (2010) refers to preliminary unpublished data collected for the Yellow-bellied Glider which suggest that its glide performance is equivalent to that of the Squirrel Glider (approximately 43 metres) for trees in the canopy height range of 20-30 metres. GHD (2011) specified a maximum 30 metre glide for this species.

Table 7: Review of gliding ability of yellow-bellied gliders in available literature

Literature review of glide lengths a yellow-bellied gliders
▪ Maximum 30 metre glide (GHD 2011b).
▪ Glide characteristic (e.g. glide angle/ration) likely to be similar to Squirrel glider (R. Goldingay pers. comm. cited in Geolink 2012, Goldingay 2010).

3.3.4 PRESENCE OF GLIDERS

The targeted survey of gliding species identified the presence of three species:

- Sugar Glider (*Petaurus breviceps*).
- Feather-tail Glider (*Acrobates pygmaeus*).
- Yellow-bellied Glider (*Petaurus australis*).

Yellow-bellied Glider was recorded at two locations in late October (Appendix B). One individual was recorded approximately 460 metres to the east of the proposed widened median in Cairncross State Forest, and another approximately 430 metres west of the proposed widened median. There were also tentative records of Yellow-bellied Glider at two additional locations west of the proposed widened medians.

The vegetation on the lower slopes and associated drainage lines was considered to be of higher habitat quality for the Yellow-bellied Glider as it contains on average more hollow bearing trees and a greater diversity of plant species in the canopy and midlayer, including key autumn and winter flowering plants such as *Eucalyptus robusta* (Swamp Mahogany). These areas of vegetation are likely to provide movement corridors through the broader area (Lewis Ecological Surveys 2012).

Habitat adjoining the Swamp Sclerophyll Forest to the east also appears suitable for the threatened Squirrel Glider. This area is mapped as patches of Coastal Complex and Dry Grassy Tallowwood-Grey Gum (OEH 2012).

3.3.5 GLIDER TREE ATTRIBUTES

There were 181 potential glide trees identified, tagged and located with a GPS within the study area during the June/July survey (Appendix C).

The average tree height throughout the study area was 21.53 metres while the most frequently occurring tree height was 23 metres. The shortest tree tagged was 12 metres while the tallest was 29 metres. 127 trees were 20 metres or taller in height.

Potential glide tree species included *Corymbia gummifera* (Red Bloodwood), *Eucalyptus acmenoides* (White Mahogany), *E. globoidea* (White Stringybark), *E. grandis* (Flooded Gum), *E. microcorys* (Tallowwood), *E. pilularis* (Blackbutt), *E. piperita* (Sydney Peppermint), *E. resinifera* (Red Mahogany), *E. robusta* (Swamp Mahogany), *Eucalyptus sp.* (Ironbark) and *Syncarpia glomulifera* (Turpentine).

There were no distinct trends in trees heights throughout the study area. Tall trees (>25 metres) were scattered throughout the study area (Figure 6, Figure 7), except between station 10600 and station 10900 of the southbound carriageway where most tree heights were 20 metres or less. Shorter trees (12 to 20 metres) were also scattered throughout the study area.

Figure 6: Tall trees of moist gully forest in the study area

Figure 7: Tall trees of Paperbark Swamp Forest in the study area

There were frequent gaps between potential glide trees in the south of the study area, particularly between station 10300 and station 10800, most likely due to previous clearing activities (Figure 8). Patches of dense regrowth of *Allocasuarina littoralis* (Black She-oak) and *Syncarpia glomulifera* (Turpentine) were also scattered throughout this section (Figure 9). Trees in these patches were typically less that 12 metres in height or did not support preferred branch attributes to be considered as launch trees for gliders.

Figure 8: Previous clearing resulting in gaps

Figure 9: Dense regrowth

3.3.6 REFERENCE TREE ATTRIBUTES

The reference tree survey (Lewis Ecological Surveys 2012, Appendix B) found that trees at reference sites reached a mean maximum height of 37.7 metres and ranged from a minimum height of 29.7 metres to a maximum height of 48.2 metres. Trees on lower slopes and gullies had a greater mean maximum canopy height than trees on upper slopes and ridgelines. Tree species recorded were *Corymbia intermedia* (Pink Bloodwood), *Eucalyptus microcorys* (Tallowwood), *E. pilularis* (Blackbutt) and *E. siderophloia* (Grey Ironbark).

The trees recorded in the reference sites were on average 35% taller than trees recorded in the study area, suggesting there is scope for increases in height of the retained trees adjoining the proposed widened median. The forest appeared to have previously undergone stand improvement and it was recommended by Lewis Ecological Surveys (2012) that standard forestry practices associated with stand improvement would be required to attain the characteristics of trees found in reference plots.

3.4 WIDENED MEDIAN FEASIBILITY ASSESSMENT

3.4.1 CALCULATING GLIDABILITY

The results of Goldingay and Taylor (2009) were used to calculate average glide distances* of Squirrel gliders in the study area:

Potential Glide Distance	=	average glide vertical to horizontal plane ratio	x	(tree height** – average glider launch height from tree top – preferred minimum landing height)	+	(average launch distance from launch tree trunk – average launch tree trunk distance from clearing edge*** – average landing tree distance from clearing edge)

This calculation was used to determine potential glide distances of gliders in the study area was therefore:

Potential Glide Distance	=	1.84 x (average tree height-1.7m-1m)	+	(2.3-1-1)

* Glide characteristics (e.g. glide angle/ration) of Yellow-bellied glider is likely to be similar to Squirrel glider (R. Goldingay pers. comm. cited in Geolink 2012)

**To overcome GPS errors resulting in trees located within the proposed alignment being tagged, average tree heights were calculated for each 100 metre section for both the northbound and southbound carriage way. This includes trees both west and east of each carriageway

***This calculation assumes that trees are located within 1 metre of the clearing edge.

Table 8: Potential glide distances and likely clearing distances for threatened gliders

Carriageway	100 metre section	Average tree height (metres)	Potential glide distance (metres)	Average tree height (metres), accounting for embankment heights*	Potential glide distance (metres), accounting for embankment heights **	Average clearing width (alignment +4m at top of cut, +2m at bottom of fill) (metres)	Clearing distance less than potential glide distance
Northbound	10300-10400	21.33	34.59	17.83	28.15	30.77	N
	10400-10500	18.53	29.43	16.03	24.83	26.35	N
	10500-10600	21.33	34.59	21.33	34.59	19.86	Y
	10600-10700	20.04	32.21	18.54	29.45	25.20	Y
	10700-10800	21.75	35.35	20.25	32.59	24.35	Y
	10800-10900	21.4	34.71	20.40	32.87	20.63	Y
	10900-11000	20.17	32.44	20.17	32.44	17.40	Y
	11000-11100	20.8	33.60	17.80	28.08	34.62	N
	11100-11200	20	32.13	17.00	26.61	34.15	N
	11200-11300	25.38	42.02	23.88	39.26	26.72	Y
	11300-11400	22.61	36.93	16.61	25.89	25.18	Y
Southbound	10300-10400	22.75	37.19	19.75	31.67	28.13	Y
	10400-10500	22.75	37.19	20.75	33.51	24.35	Y
	10500-10600	21.79	35.42	20.79	33.58	24.53	Y
	10600-10700	21.5	34.89	17.50	27.53	34.34	N
	10700-10800	18.79	29.91	15.29	23.47	41.73	N
	10800-10900	20.79	33.59	16.79	26.23	42.60	N

Carriageway	100 metre section	Average tree height (metres)	Potential glide distance (metres)	Average tree height (metres), accounting for embankment heights*	Potential glide distance (metres), accounting for embankment heights **	Average clearing width (alignment +4m at top of cut, +2m at bottom of fill) (metres)	Clearing distance less than potential glide distance
	10900-11000	22.75	37.19	18.75	29.83	41.73	N
	11000-11100	23	37.65	19.00	30.29	40.05	N
	11100-11200	19	30.29	15.50	23.85	36.45	N
	11200-11300	24.13	39.72	22.13	36.04	29.18	Y
	11300-11400	23.3	38.20	21.80	35.44	27.03	Y

*The average embankment height for each 100m section was subtracted from actual tree heights in the same section, to determine the height of trees available to gliders for launching and landing

**The potential glide distance for gliders was also calculated using tree heights that account for embankment heights in each 100m section

Potential glide distances are greater than clearing widths throughout the proposed widened median with the exception of three discrete locations (Figure 10):

- Between station 11000 and station 11100 of the northbound carriageway, the average tree height is approximately 20 metres. These trees are not tall enough to allow gliders to glide across the entire clearing width of approximately 34 metres in this section.
- Between 10300 and 10500 of the northbound carriageway, the average tree height is approximately 17 metres. These trees are not tall enough to allow gliders to glide across the entire clearing width of approximately 26-30 metres in this section.
- Average tree heights between 10600 and 11200 of the southbound carriageway vary from approximately 18 metres to 23 metres and these trees are not tall enough to allow gliders to glide across the entire clearing width of approximately 40 metres in this section. The southbound carriageway in this section requires substantial amount of fill, resulting in batter slopes of up to 17 metres wide. Goldingay and Taylor (2009) determined that where there are gaps of 43 metres between trees (four-lane road), trees adjacent to the road would need to be at least 25 metres tall to enable gliders to safely glide across.

Over time there is potential for the currently non-glidable sections to become glidable, as trees adjoining the alignment grow and increase in height.

Lewis Ecological Surveys (2012, Appendix B) advised that species most likely to attain sufficient increases in height are *Eucalyptus pilularis* (Blackbutt) and *E. siderophloia* (Grey Ironbark), as well as *E. microcorys* (Tallowwood) *Corymbia intermedia* (Pink Bloodwood) and *E. acmenoides* (White Mahogany) in lower slope or gully situations. These species should be prioritised for retention adjoining the proposed widened median sections that are currently not glidable. Increased launch height may enable gliders to span the clearing width in the future.

As identified above, much of the northbound carriageway is glidable, however a section of the southbound carriageway is not likely to be immediately glidable (until trees adjoining these sections increase in height). The installation of a rope bridge(s) or glider pole(s) within the unglidable sections of the southbound carriageway will be considered during the detailed design phase in consultation with EPA. Conditions to maximise effectiveness of the structures will be taken into consideration when designing and locating these structures.

To maximise effectiveness, fauna crossing structures should be placed in locations where animals naturally approach and cross the highway. The characteristics of the surrounding landscape influence which sections of a highway are crossed, and how often. Barnum (2003) found that the presence of suitable habitat on both sides of the road was the baseline condition required for animals to cross the road on a regular basis and the better the habitat, the higher the frequency of crossings.

Intersections of linear guideways such as drainage lines, ridgelines and fencing with highways may support well-defined intensely used crossing zones. Crossing structures are unlikely to be used if they are located where the surrounding landscape does not encourage fauna to approach the road (Barnum 2003).

Based on the detailed investigations, I the introduction of a widened median at this location is considered feasible.

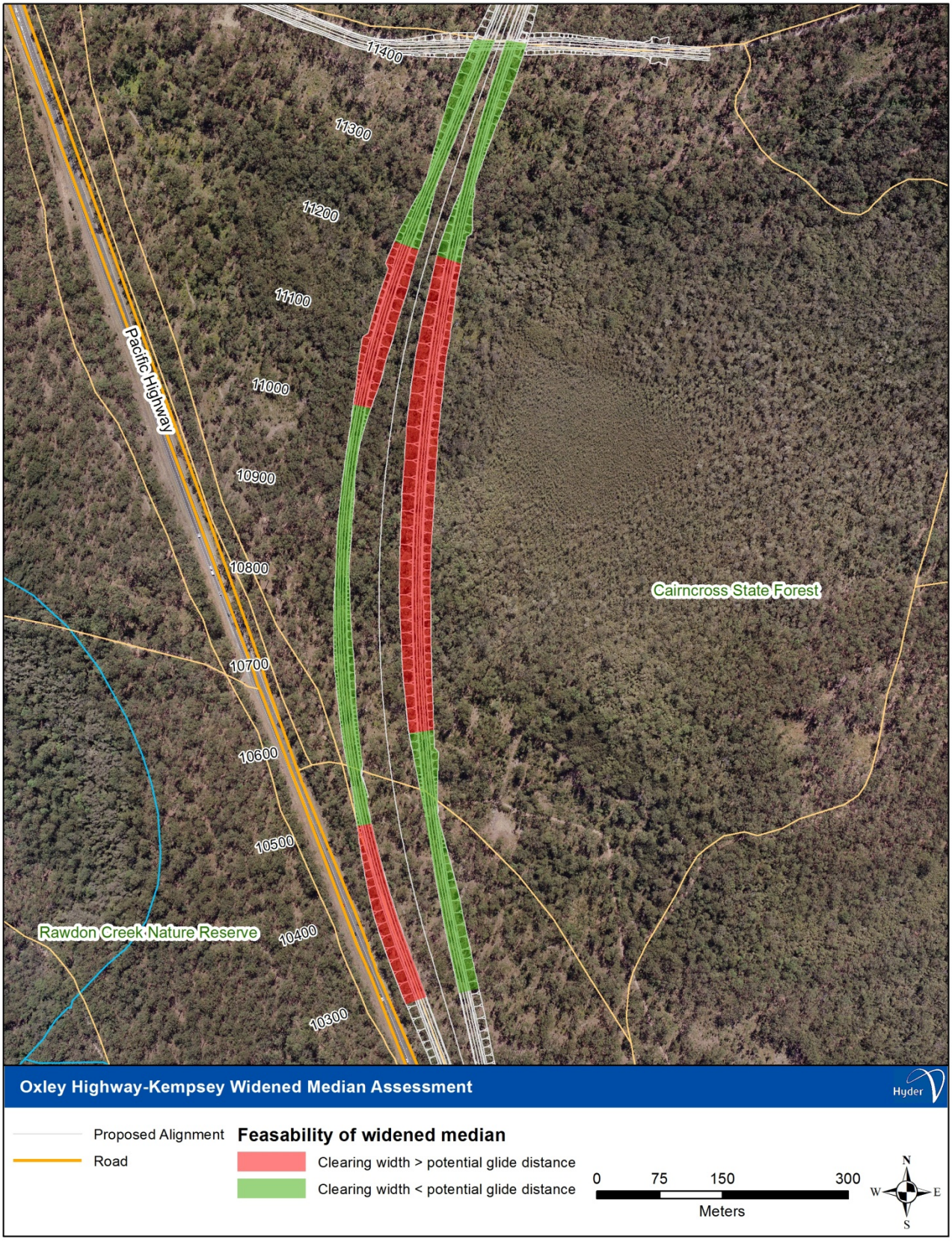

Figure 10: Areas where clearing widths are less than and greater than gliding ability

3.5 IMPACTS FROM PROPOSED WIDENED MEDIAN

The proposed widened median will have some additional impacts on threatened species habitat and threatened ecological communities as a result of additional vegetation clearing and fragmentation.

3.5.1 VEGETATION CLEARANCE AND FRAGMENTATION

The proposed widened median would result in an additional 0.89 hectares of vegetation clearance. The areas of vegetation communities to be cleared for the proposed widened median (revised design) between station 10000 and station 11600 are compared with those to be cleared for the same section in the Approved Project design in Table 9.

Table 9: Comparison of vegetation communities cleared for concept design and revised design

Vegetation community	Area impacted under Approved Project	Area impacted under revised design
Dry Ridgetop Forest	6.2551	6.7562
Moist Floodplain Forest	0.1789	0.1478
Moist Gully Forest	3.1364	3.1895
Paperbark Swamp Forest	0.4411	1.0062
Swamp Mahogany/Forest Red Gum Swamp Forest	1.2125	0.9927
Totally Cleared Open Pasture/WeedyFallow	0.0007	0.0210
Total	**11.2247**	**12.1134**

Two of the vegetation communities mapped in this area, Paperbark Swamp Forest and Swamp Mahogany/Forest Red Gum Swamp Forest, are equivalent to the Endangered Ecological Communities (EEC) Swamp Sclerophyll Forest on Coastal Floodplains listed under the TSC Act. Under the approved project footprint, a total of 1.65 hectares of this community was to be removed in this section of the Project.

The proposed widened median will result in removal of 1.99 hectares of Swamp Sclerophyll Forest, an additional 0.34 hectares compared with the Approved Project design. The vegetation to be cleared is unlikely to comprise a significant area of the extent of these communities in the locality and as such, the impacts of additional native vegetation loss for the proposed widened median are expected to be minor.

The proposed widened median will further fragment vegetation in this section of the Project. The length of road edge will increase from approximately 4.14 kilometres in the Approved Project design to 5.68 kilometres for the revised design. This is likely to result in an increase of edge effects. Given that fauna fencing will be installed along the road edges adjoining Cairncross State Forest, the additional fragmentation resulting from the proposed widened median is not considered to represent a further barrier to fauna connectivity.

3.5.2 FAUNA CROSSING STRUCTURES

The proposed widened median intersects three fauna underpasses, as listed in Table 10 and shown on Figure 11.

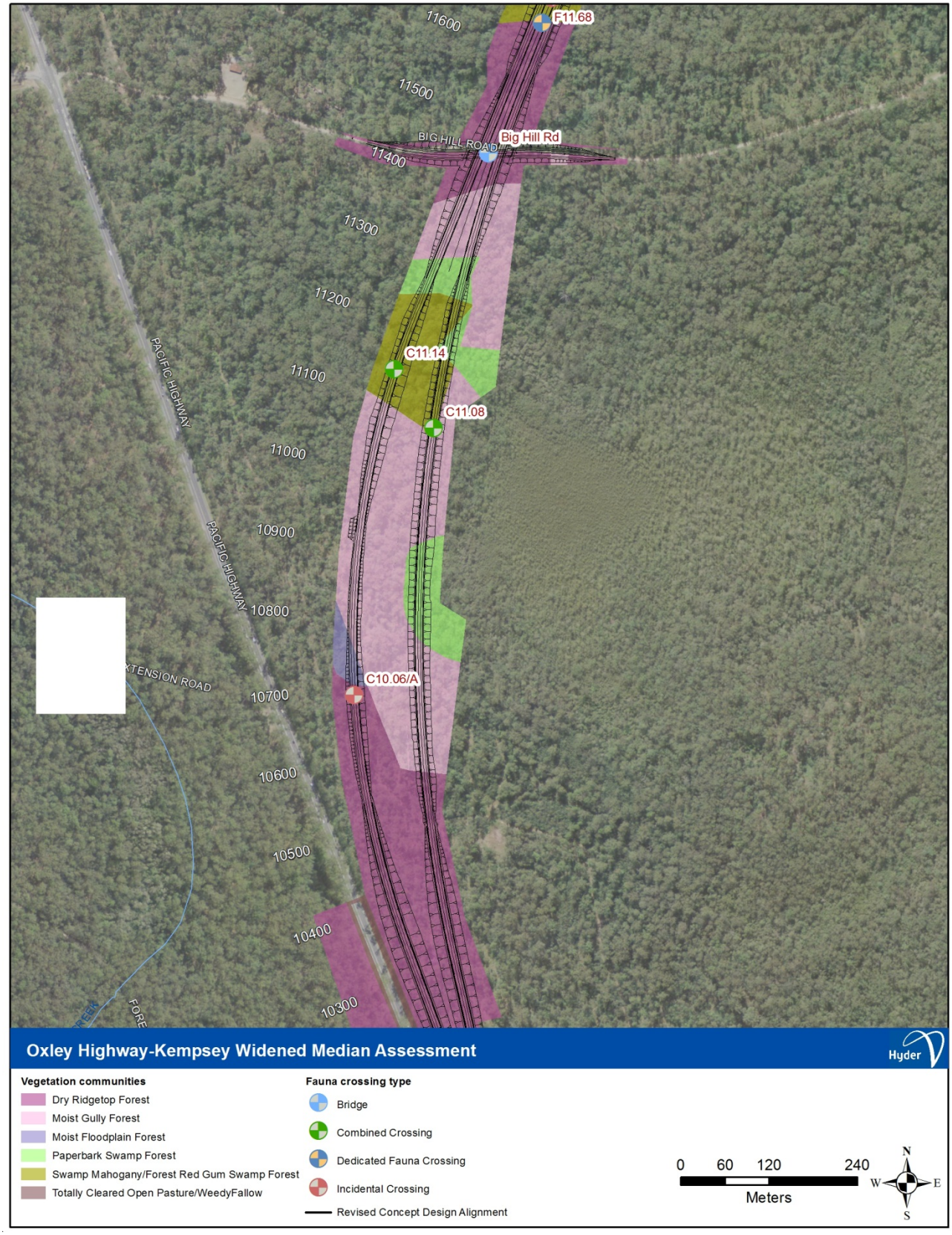

Figure 11: Vegetation communities and fauna crossings in the proposed widened median area

Table 10: Proposed fauna crossings between station 10000 and station 11600

Culvert ID and location	Crossing type	Dimensions	Length	Target species	Fauna furniture	Fish passage
C10.60 Stn 10600	Incidental	1.05 m diameter	34 m	(Frogs, some reptiles, small mammals if dry)	No	No
C11.08 Stn 11080	Combined	3 m wide x 2.4 m high	22 m	(Frogs, possibly Green-thighed frogs, reptiles, koala, spotted-tailed quoll, small mammals if dry)	Rails and refuge poles (koalas)	No
C11.14 Stn 11400	Combined	3 m wide x 2.4 m high	34 m			No

Culverts C11.08 and C11.14 are located in the northern section of the proposed widened median. The culvert (C11.08) crosses the eastern (southbound) carriageway and C10.60 and C11.14 cross the western (northbound) carriageway of the Project. The design and location of these crossings will be reviewed during detailed design in consultation with EPA and DPI (Fisheries) and will consider how fauna crossings of the widened median area can be facilitated.

3.5.3 LITTLE EAGLE

Lewis Ecological Surveys identified a Little Eagle nest in Tree 31 during fauna surveys in October 2012. . Little Eagle (*Hieraaetus morphnoides*) is listed as a Vulnerable species under the TSC Act. This tree is close to the edge of the proposed highway at approximately station 10870 and may be impacted or removed as a result of the Project. This tree was within the footprint of the Approved Project, therefore the proposed widened median is not considered to have additional impacts on nesting habitat for this species. An assessment of significance concluded that a significant impact on this species from the Project was not likely, and associated potential impact and mitigation measures have been proposed to manage any impacts.

3.5.4 IMPACTS SUMMARY

The additional ecological impacts that would result from the proposed widened median are considered to be minor in nature when compared with the identified impacts for the Approved Project. Further, there are greater benefits for fauna connectivity as a result of introduction of the proposed widened median compared with the Approved Project design.

4 CONCLUSION

Preliminary investigations concluded that widened medians were not feasible at Ballengarra 1b and Maria River 1b, largely due to changes to horizontal and vertical alignment of the Project. A widened median at Barrys Creek (station 23967) was not considered feasible for the same reasons. Other fauna mitigation measures have been recommended at these locations.

Preliminary investigations concluded that a widened median was potentially feasible at Cairncross 1 and further investigation of this location was undertaken.

Detailed investigations found that a widened median at Cairncross 1 is feasible and reasonable. Yellow-bellied Gliders have been recorded to the east and west of the proposed widened median location, and there is suitable habitat for both Yellow-bellied Gliders and Squirrel Gliders in adjoining areas.

Much of the northbound carriageway is glidable, with the exception of sections between station 10300 and station 10500 and station 11000 and station 11200. A section of the southbound carriageway is not likely to be immediately glidable, due to a combination of the width of clearing (approximately 41 metres) and lower tree heights (16-19 metres). Over time there is potential for the currently non-glidable sections to become glidable, as trees adjoining the alignment grow and increase in height.

4.1 RECOMMENDATIONS

A widened vegetated median is recommended at Cairncross 1. It is recommended that potential glide trees be retained adjoining the edge of the median, as close to the road as is practicable. Options to allow gliders to cross the alignment until such time as trees increase in height, possibly enabling gliders to span the clearing, include installation of a rope bridge(s) or glider pole(s) within the unglidable sections of the southbound carriageway, to be considered during the detailed design phase in consultation with EPA. Conditions to maximise effectiveness of the structures will be taken into consideration when designing and locating these structures.

The possibility of narrowing the proposed formation of the northbound and southbound carriageways between station 10000 and 11600 will be reviewed during detailed design This will include a review of the potential to steepen batter slopes, thereby decreasing overall clearing widths.

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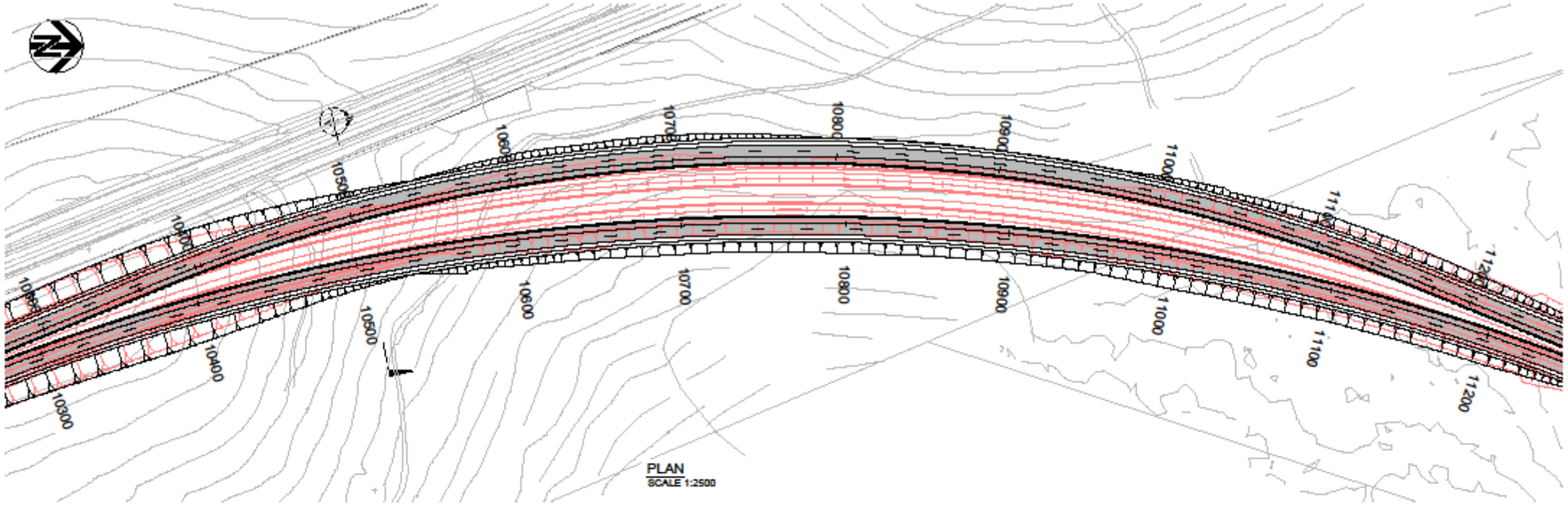
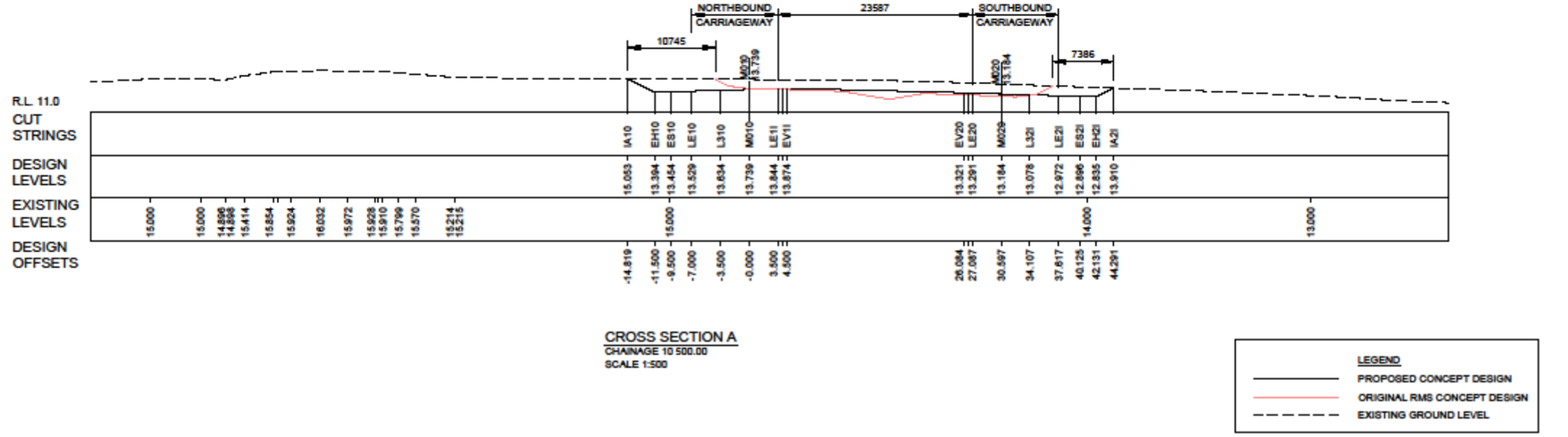
APPENDIX A

CURRENT DESIGN AND POTENTIAL PLAN CROSS-SECTIONS

CAIRNCROSS 1





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SCALE 1:500

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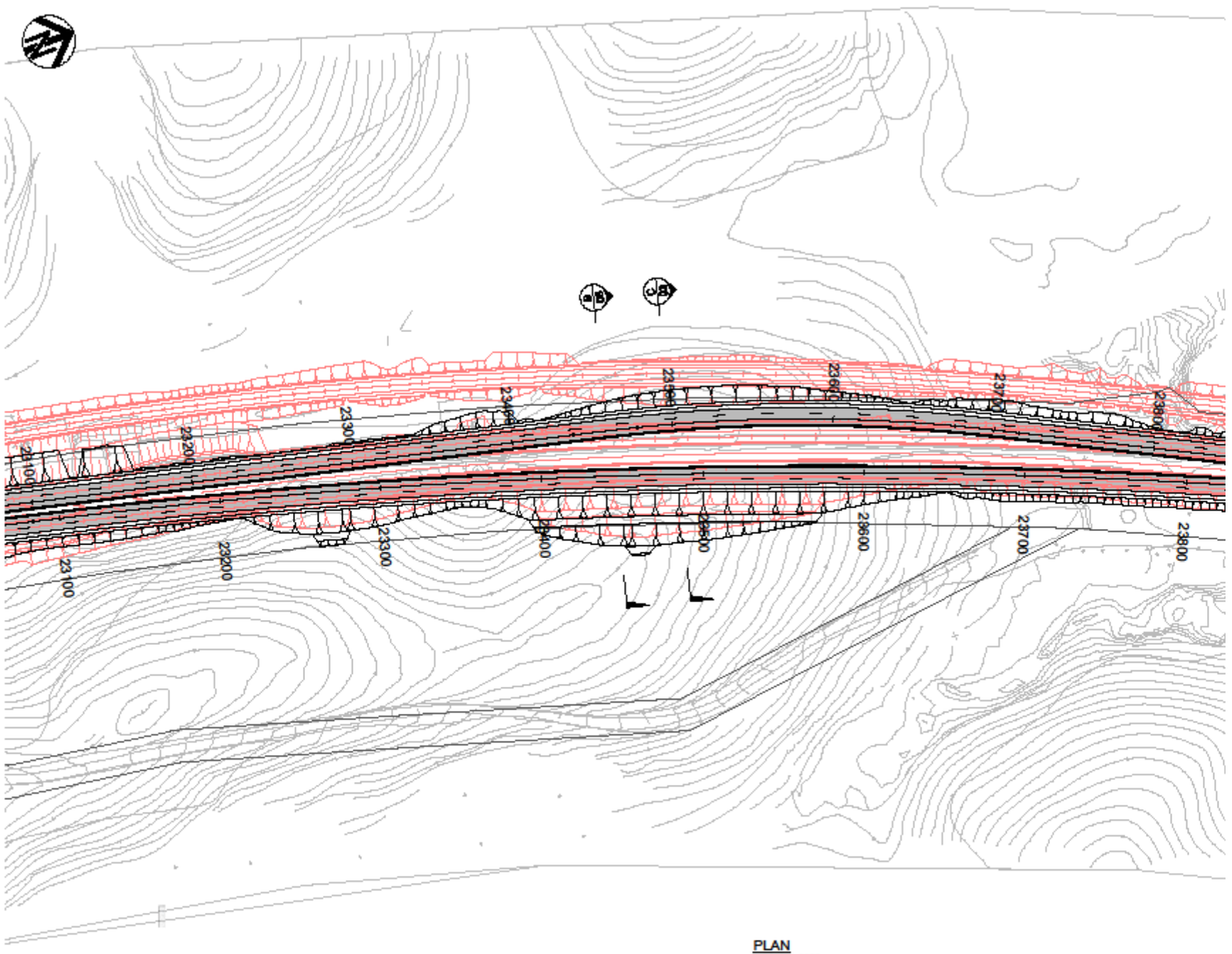
BALLENGARRA 1B



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HW10 PACIFIC HIGHWAY
ROAD WIDENING - SHEET 2

INFORMATION DOCUI
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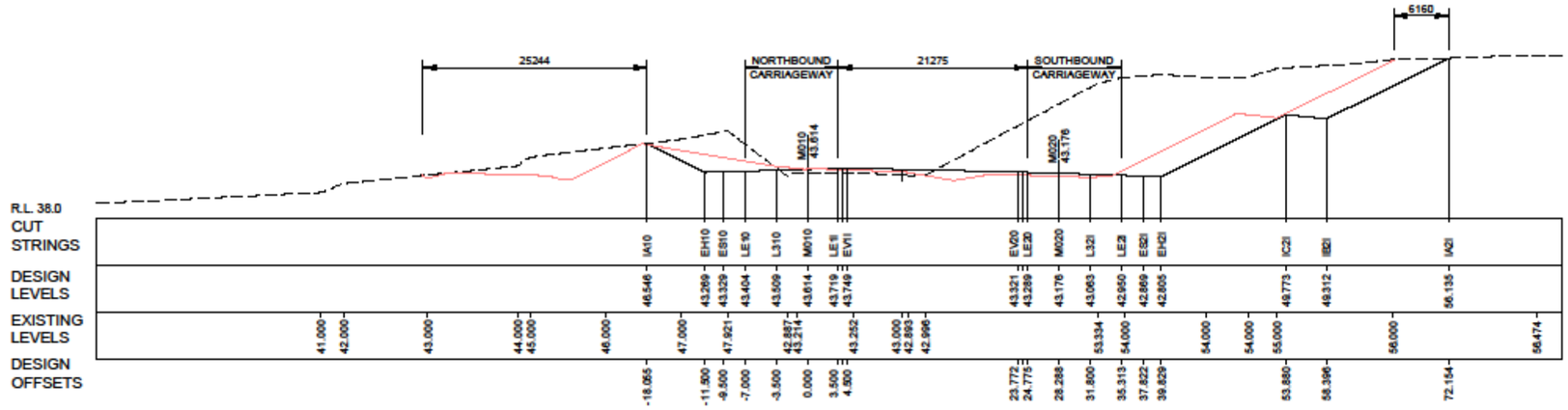

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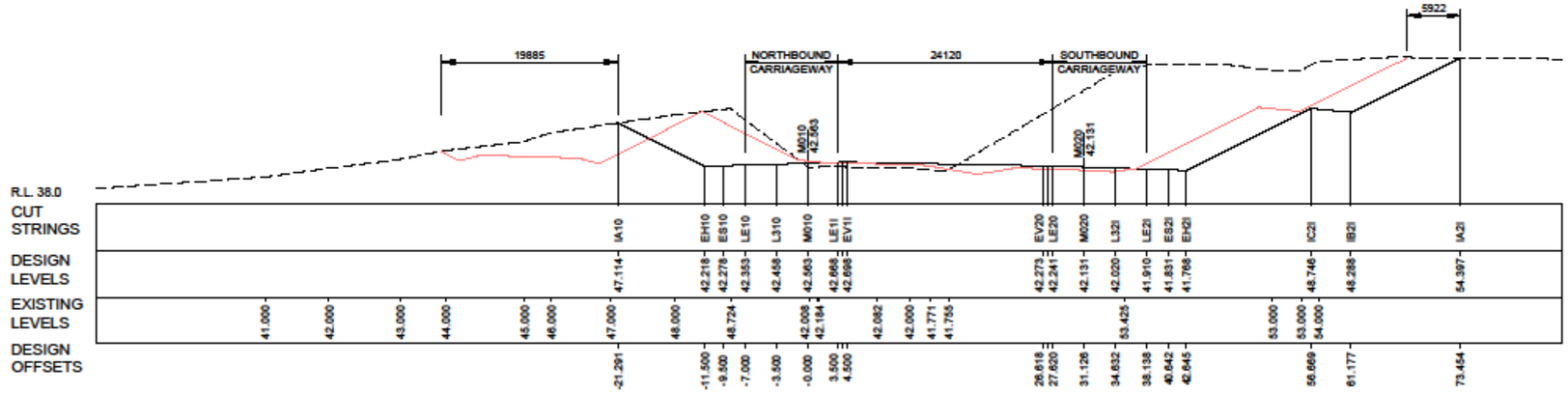

CROSS SECTION
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LEGEND
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- ORIGINAL RMS CONCEPT DESIGN
- EXISTING GROUND LEVEL

NOT FOR CONSTRUCTION

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AT A3 SIZE DRAWING

HW10 PACIFIC HIGHWAY
ROAD WIDENING - SHEET 3

INFORMATION DOCUMENT
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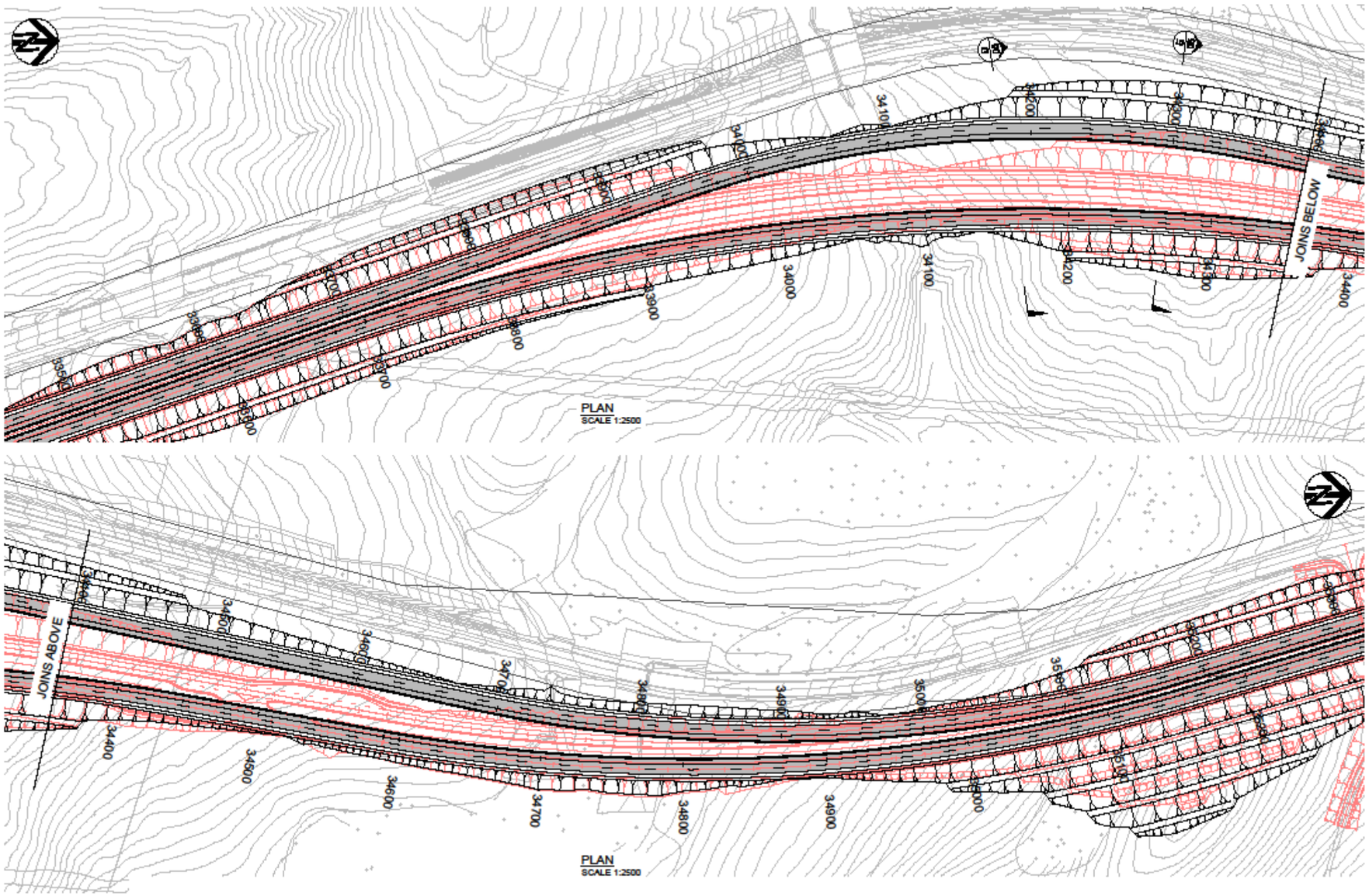
MARIA RIVER 1B



NOT FOR CONSTRUCTION

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HW10 PACIFIC HIGHWAY
ROAD WIDENING - SHEET 4

INFORMATION DOCUMENT

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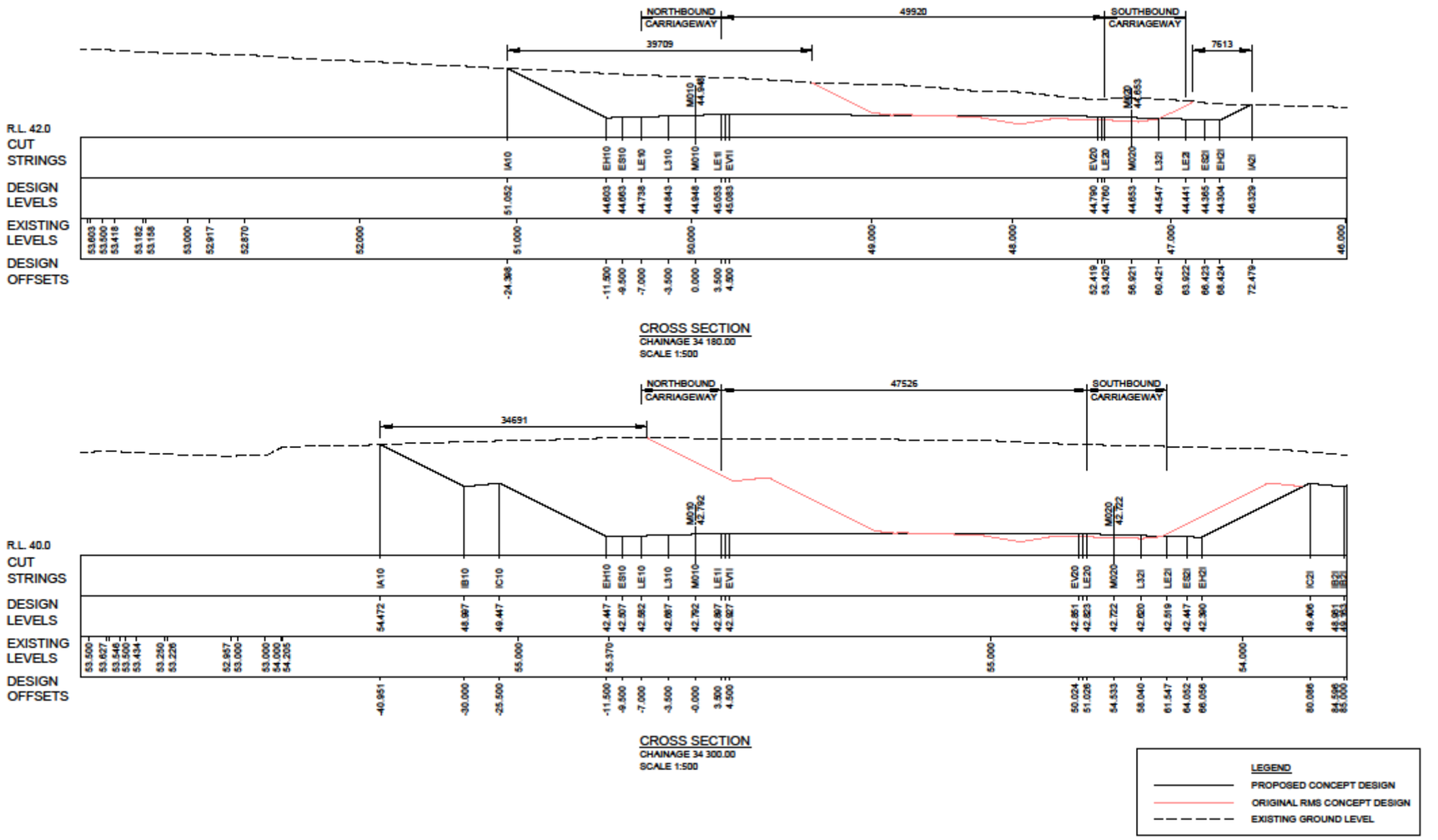

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ROAD WIDENING - SHEET 5

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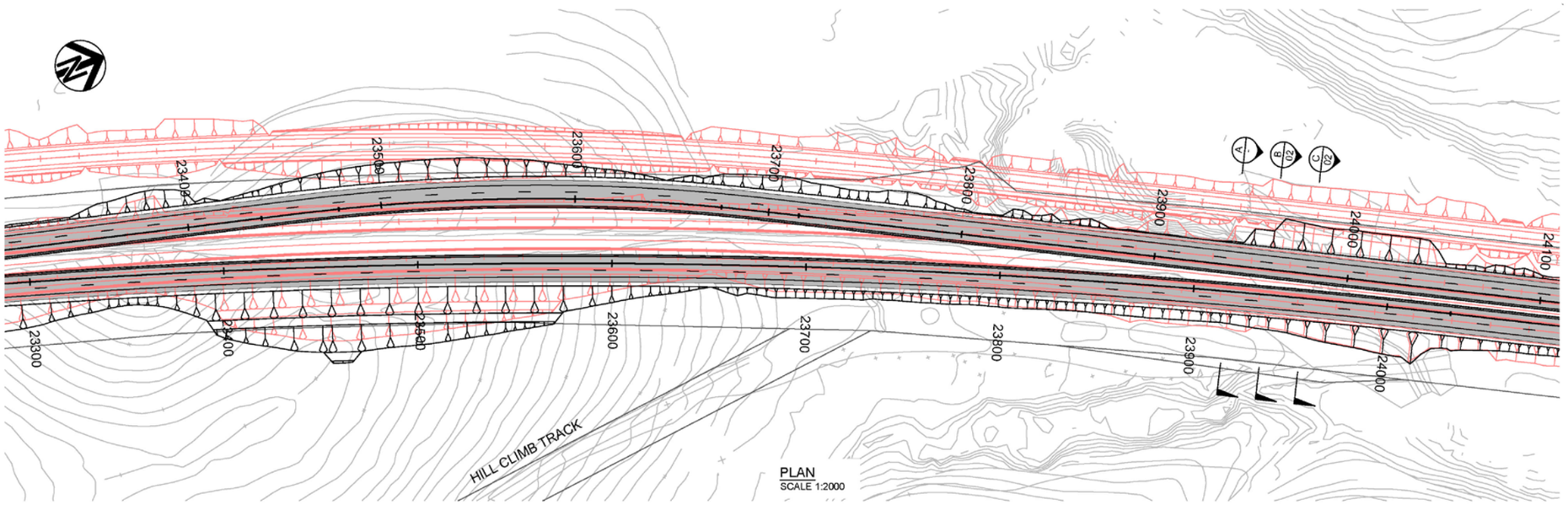

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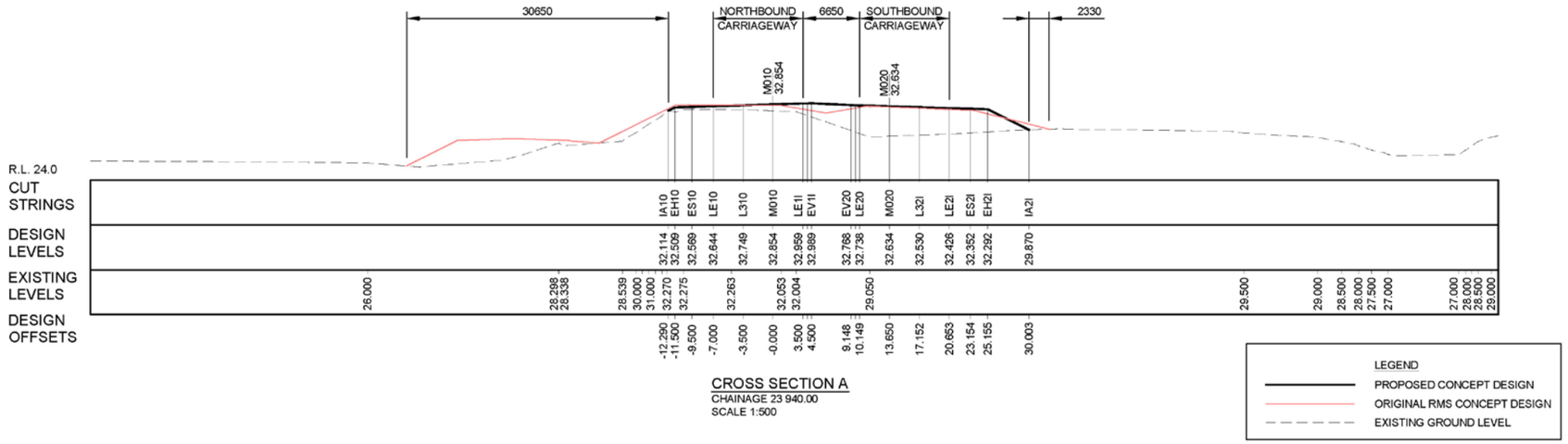

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OH2K PROJECT
ROAD WIDENING - BARRYS CREEK - SHEET 1

INFORMATION DOCUMENT
120525-OH2K-CON-RD_WIDENING-01

SMEC + Hyder Joint Venture

APPENDIX B

GLIDER AND REFERENCE TREE SURVEYS (LEWIS ECOLOGICAL SURVEYS 2012)

APPENDIX C
POTENTIAL GLIDER TREES

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
1	*E. piperita*	0.4	8	N	N/A	03-JULY-12	14
2	*E. piperita*	0.4	4	N	N/A	03-JULY-12	13
3	*E. microcorys*	0.8	8	Y	2-4	03-JULY-12	16
4	*Angophora*	0.3	4	N	N/A	03-JULY-12	14
5	*E. globoidea*	0.6	6	Y	4-6	03-JULY-12	17
6	*E. globoidea*	0.4	6	N	N/A	03-JULY-12	15
7	*Angophora*	0.5	6	N	N/A	03-JULY-12	16
8	*Corymbia gummifera*	0.8	6	Y	2	03-JULY-12	18
9	*E. globoidea*	0.4	4	Y	2	03-JULY-12	17
10	*E. globoidea*	0.3	4	Y	2-4	03-JULY-12	17
11	*Corymbia gummifera*	0.2	4	N	N/A	03-JULY-12	13
12	*Corymbia gummifera*	0.2	4	N	N/A	03-JULY-12	13
13	*E. globoidea*	0.8	6	Y	2-4	03-JULY-12	25
14	*E. microcorys*	0.8	8	Y	4-6	03-JULY-12	24
15	*Corymbia gummifera*	0.2	3	N	N/A	03-JULY-12	10
16	*E. resinifera*	1	10	Y	2-4	03-JULY-12	21
17	*E. pilularis*	1	6	Y	4-6	03-JULY-12	14

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
18	*E. pilularis*	1.1	10	Y	2-4	03-JULY-12	28
19	*E. pilularis*	0.6	4	N	N/A	03-JULY-12	16
25	*E. pilularis*	1.1	8	Y	2-4	03-JULY-12	28
26	*E. pilularis*	0.9	6	N	N/A	03-JULY-12	25
27	*E. globoidea*	0.5	4	N	N/A	03-JULY-12	23
28	*E. microcorys*	0.7	8	Y	4-6	03-JULY-12	16
29	*E. globoidea*	0.3	4	N	N/A	03-JULY-12	15
31	*E. pilularis*	1.3	12	Y	4-6	03-JULY-12	29
32	*Corymbia gummifera*	0.7	6	Y	4-6	03-JULY-12	21
33	*Syncarpia glomulifera*	0.8	8	Y	4-6	03-JULY-12	10
34	*E. globoidea*	1	8	Y	2-4	03-JULY-12	23
35	*E. pilularis*	1.1	12	Y	4-6	03-JULY-12	
36	*E. pilularis*	1.4	16	Y	4-6	03-JULY-12	26
49	*E. globoidea*	0.8	12	Y	2-4	03-JULY-12	29
50	*E. pilularis*	1.2	20	Y	4-6	03-JULY-12	24
51	*Syncarpia glomulifera*	0.2	2	N	N/A	03-JULY-12	13
52	*Syncarpia glomulifera*	0.1	8	Y	4-6	03-JULY-12	15

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
53	*E. globoidea*	1	8	Y	4-6	03-JULY-12	28
54	*E. robusta*	0.9	10	Y	4-6	03-JULY-12	18
55	*E. resinifera*	1.9	12	Y	4-6	03-JULY-12	22
56	*E. globoidea*	0.7	12	Y	4-6	03-JULY-12	23
57	*E. pilularis*	0.4	6	N	N/A	03-JULY-12	23
58	*Corymbia gummifera*	0.5	6	Y	4-6	03-JULY-12	15
59	*E. globoidea*	0.2	2	N	N/A	03-JULY-12	16
60	*E. globoidea*	0.8	6	Y	4-6	03-JULY-12	26
61	*E. pilularis*	0.9	12	Y	4-6	03-JULY-12	26
62	*E. microcorys*	0.7	8	Y	4-6	03-JULY-12	24
63	*E. microcorys*	1	12	Y	2-4	03-JULY-12	29
64	*E. globoidea*	0.7	6	N	N/A	03-JULY-12	23
65	*E. globoidea*	0.9	10	Y	4-6	03-JULY-12	24
66	*E. microcorys*	1.1	12	Y	2-4	03-JULY-12	27
67	*E. microcorys*	1.2	16	Y	4-6	03-JULY-12	23
68	*E. pilularis*	1.4	20	Y	2-4	03-JULY-12	27
69	*E. microcorys*	0.5	4	N	N/A	03-JULY-12	20

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
70	*E. robusta*	0.7	6	Y	4-6	03-JULY-12	14
71	*E. pilularis*	1	16	Y	4-6	03-JULY-12	26
72	*Syncarpia glomulifera*	0.4	4	N	N/A	03-JULY-12	13
73	*Corymbia gummifera*	0.8	6	Y	2-4	03-JULY-12	23
74	Ironbark	0.8	8	Y	2-4	03-JULY-12	23
75	*E. globoidea*	0.7	8	Y	4-6	03-JULY-12	23
76	*E. globoidea*	0.4	4	N	N/A	03-JULY-12	22
77	*E. globoidea*	0.8	12	Y	4-6	03-JULY-12	15
78	*E. globoidea*	0.2	12	Y	4-6	03-JULY-12	18
79	*E. resinifera*	1.1	10	Y	4-6	03-JULY-12	22
80	*E. globoidea*	0.6	8	Y	4-6	03-JULY-12	22
81	*E. pilularis*	0.7	12	Y	2-4	03-JULY-12	22
82	*Syncarpia glomulifera*	0.8	4	N	N/A	03-JULY-12	15
83	*Syncarpia glomulifera*	0.8	8	Y	4-6	03-JULY-12	19
84	Ironbark	0.2	4	N	N/A	03-JULY-12	15
85	*E. pilularis*	0.7	12	Y	4-6	03-JULY-12	23
86	*E. pilularis*	1	10	Y	2-4	03-JULY-12	27

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
87	*E. microcorys*	0.4	8	Y	4-6	03-JULY-12	18
88	*E. pilularis*	0.2	4	N	N/A	03-JULY-12	16
89	*E. globoidea*	0.6	4	N	N/A	03-JULY-12	26
90	*E. microcorys*	1	10	Y	2-4	03-JULY-12	26
91	*E. globoidea*	0.7	6	Y	4-6	03-JULY-12	24
92	*E. microcorys*	0.5	8	Y	4-6	03-JULY-12	16
93	*E. microcorys*	0.2	6	N	N/A	03-JULY-12	14
94	*E. microcorys*	0.3	10	Y	4-6	03-JULY-12	24
95	Ironbark	0.9	12	Y	2-4	03-JULY-12	29
96	*E. microcorys*	0.8	16	Y	4-6	03-JULY-12	27
97	*E. microcorys*	0.9	10	Y	4-6	03-JULY-12	28
98	Ironbark	1	16	Y	4-6	03-JULY-12	28
105	*E. pilularis*	0.8	6	Y	4-6	04-JULY-12	22
106	*E. microcorys*	1	10	Y	2-4	04-JULY-12	27
107	*Syncarpia glomulifera*	0.2	4	N	N/A	04-JULY-12	12
108	*E. acmenoides*	1.4	16	Y	4-6	04-JULY-12	27
109	*Syncarpia glomulifera*	0.3	4	N	N/A	04-JULY-12	12
110	*E. globoidea*	0.9	14	Y	4-6	04-JULY-12	25

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
111	*E. globoidea*	0.8	12	Y	4-6	04-JULY-12	27
112	*E. globoidea*	1.1	16	Y	2-4	04-JULY-12	26
113	*E. globoidea*	1.2	16	Y	2-4	04-JULY-12	23
114	*E. globoidea*	1	8	Y	4-6	04-JULY-12	22
115	*E. pilularis*	1.4	20	Y	4-6	04-JULY-12	27
116	*Corymbia gummifera*	0.6	6	N	N/A	04-JULY-12	21
117	*Syncarpia glomulifera*	1.1	10	Y	4-6	04-JULY-12	21
118	*E. resinifera*	1.7	20	Y	4-6	04-JULY-12	21
119	*E. resinifera*	0.9	6	Y	4-6	04-JULY-12	20
120	*E. pilularis*	1.2	10	Y	4-6	04-JULY-12	23
121	*Corymbia gummifera*	0.7	6	N	N/A	04-JULY-12	22
122	*E. pilularis*	0.5	8	N	N/A	04-JULY-12	22
123	*E. microcorys*	0.2	4	N	N/A	04-JULY-12	21
124	*E. pilularis*	2.1	20	Y	4-6	04-JULY-12	27
125	*E. globoidea*	1.1	16	Y	4-6	04-JULY-12	28
126	*E. pilularis*	2	20	Y	2-4	04-JULY-12	28
127	*E. pilularis*	1.8	18	Y	4-6	04-JULY-12	28

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
128	*Syncarpia glomulifera*	0.7	4	N	N/A	04-JULY-12	14
129	*E. globoidea*	0.7	6	Y	4-6	04-JULY-12	24
130	*Corymbia gummifera*	0.8	12	Y	4-6	04-JULY-12	22
131	*E. microcorys*	9.7	10	Y	4-6	04-JULY-12	20
132	*E. microcorys*	1	12	Y	4-6	04-JULY-12	23
133	*E. globoidea*	0.5	4	N	N/A	04-JULY-12	19
134	*E. globoidea*	0.6	8	Y	4-6	04-JULY-12	22
135	*E. resinifera*	0.2	4	N	N/A	04-JULY-12	17
136	*E. microcorys*	0.9	10	Y	2-4	04-JULY-12	23
137	*E. pilularis*	1	12	Y	2-4	04-JULY-12	23
138	*E. microcorys*	0.6	8	Y	4-6	04-JULY-12	23
139	*E. microcorys*	0.4	8	Y	4-6	04-JULY-12	17
140	*E. acmenoides*	0.7	10	Y	4-6	04-JULY-12	25
141	*E. pilularis*	0.8	12	Y	4-6	04-JULY-12	25
142	*E. pilularis*	0.5	6	N	N/A	04-JULY-12	22
143	*E. pilularis*	0.8	8	Y	4-6	04-JULY-12	22
144	*E. pilularis*	0.7	6	Y	4-6	04-JULY-12	23

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
145	*E. microcorys*	0.8	12	Y	4-6	04-JULY-12	24
146	*E. globoidea*	1	12	Y	4-6	04-JULY-12	25
147	*E. globoidea*	0.7	6	Y	4-6	04-JULY-12	19
149	*E. globoidea*	0.9	8	Y	4-6	04-JULY-12	24
150	*E. pilularis*	1.4	16	Y	2-4	04-JULY-12	23
151	*E. pilularis*	1.1	6	Y	4-6	04-JULY-12	28
152	*E. microcorys*	0.9	10	Y	4-6	04-JULY-12	20
153	*E. globoidea*	0.6	6	Y	4-6	04-JULY-12	18
154	*E. globoidea*	0.5	6	Y	4-6	04-JULY-12	18
155	*E. microcorys*	0.5	8	Y	4-6	04-JULY-12	21
156	*E. acmenoides*	0.8	16	Y	2-4	04-JULY-12	25
157	*E. acmenoides*	0.6	12	Y	4-6	04-JULY-12	25
158	*E. microcorys*	0.7	8	Y	4-6	04-JULY-12	24
159	*E. pilularis*	1.1	12	N	2-4	04-JULY-12	24
161	*Corymbia gummifera*	0.5	4	Y	N/A	04-JULY-12	18
162	*E. pilularis*	0.7	8	Y	4-6	04-JULY-12	19
163	*E. pilularis*	0.7	8	Y	4-6	04-JULY-12	21

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
164	*E. pilularis*	1	10	Y	4-6	04-JULY-12	26
165	*E. pilularis*	1.3	16	Y	2-4	04-JULY-12	29
166	*Corymbia gummifera*	0.4	6	N	N/A	04-JULY-12	21
167	*Corymbia gummifera*	0.9	12	Y	4-6	04-JULY-12	23
168	*Syncarpia glomulifera*	0.5	8	Y	2-4	04-JULY-12	9
169	*Syncarpia glomulifera*	0.8	8	Y	2-4	04-JULY-12	18
170	*Syncarpia glomulifera*	1	10	Y	2-4	04-JULY-12	18
171	*Syncarpia glomulifera*	0.8	8	Y	2-4	04-JULY-12	18
172	*E. globoidea*	0.8	10	Y	4-6	04-JULY-12	18
173	*E. resinifera*	1.6	18	Y	2-4	04-JULY-12	19
174	*E. acmenoides*	1	10	Y	4-6	04-JULY-12	20
175	*E. globoidea*	0.8	6	Y	4-6	04-JULY-12	19
176	*E. resinifera*	0.7	12	Y	2-4	04-JULY-12	19
177	*E. globoidea*	1.1	12	Y	4-6	04-JULY-12	19
178	*Corymbia gummifera*	1.1	14	Y	2-4	04-JULY-12	24
179	*E. robusta*	1.3	14	Y	4-6	04-JULY-12	20
180	*E. pilularis*	1	12	Y	4-6	04-JULY-12	24

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
181	*E. pilularis*	1.2	14	Y	4-6	04-JULY-12	25
182	*E. globoidea*	1.1	14	Y	4-6	04-JULY-12	20
183	*Corymbia gummifera*	0.9	12	Y	4-6	04-JULY-12	19
184	*Syncarpia glomulifera*	0.2	4	Y	2-4	04-JULY-12	7
186	*Corymbia gummifera*	1.2	16	Y	4-6	04-JULY-12	22
187	*E. globoidea*	0.8	8	Y	2-4	04-JULY-12	23
188	*E. globoidea*	0.8	10	Y	4-6	04-JULY-12	24
189	*E. globoidea*	0.9	10	Y	4-6	04-JULY-12	28
190	*E. globoidea*	1.2	16	Y	2-4	04-JULY-12	28
191	*E. pilularis*	1.1	14	Y	4-6	04-JULY-12	27
192	*E. pilularis*	1.1	12	Y	4-6	04-JULY-12	27
193	*E. pilularis*	1	10	Y	4-6	04-JULY-12	25
194	*E. pilularis*	1	12	Y	2-4	04-JULY-12	24
195	*E. pilularis*	0.8	8	N	N/A	04-JULY-12	20
196	*E. grandis*	0.8	5	Y	4-6	26-JUN-12	23
197	*E. pilularis*	0.8	8	Y	2-4	26-JUN-12	25
198	*E. pilularis*	0.9	9	Y	2-4	26-JUN-12	25
199	*E. pilularis*	0.8	6	Y	4-6	26-JUN-12	27

Waypoint	Tree Species	DBH (m)	Canopy diameter (m)	Suitable branches (>100mm) (Y/N)	Distance of suitable branch from top (m)	Date	Approx. Height
200	*E. globoidea*	0.7	8	Y	2-4	26-JUN-12	27
201	*E. pilularis*	0.6	8	Y	4-6	26-JUN-12	24
202	*Syncarpia glomulifera*	0.6	10	N	4-6	26-JUN-12	15
203	*E. grandis*	0.7	6	Y	4-6	26-JUN-12	26
204	*E. globoidea*	0.5	4	Y	2-4	26-JUN-12	24
205	*Syncarpia glomulifera*	0.8	8	Y	2-4	26-JUN-12	24
206	*E. globoidea*	0.6	8	Y	2-4	26-JUN-12	25
207	*E. globoidea*	0.5	6	Y	2-4	26-JUN-12	24
208	*Syncarpia glomulifera*	0.6	8	Y	4-6	26-JUN-12	23
209	*E. pilularis*	0.7	10	Y	4-6	26-JUN-12	19
210	*E. resinifera*	1.1	12	Y	2-4	26-JUN-12	23

APPENDIX D

LOCATIONS OF POTENTIAL GLIDER TREES

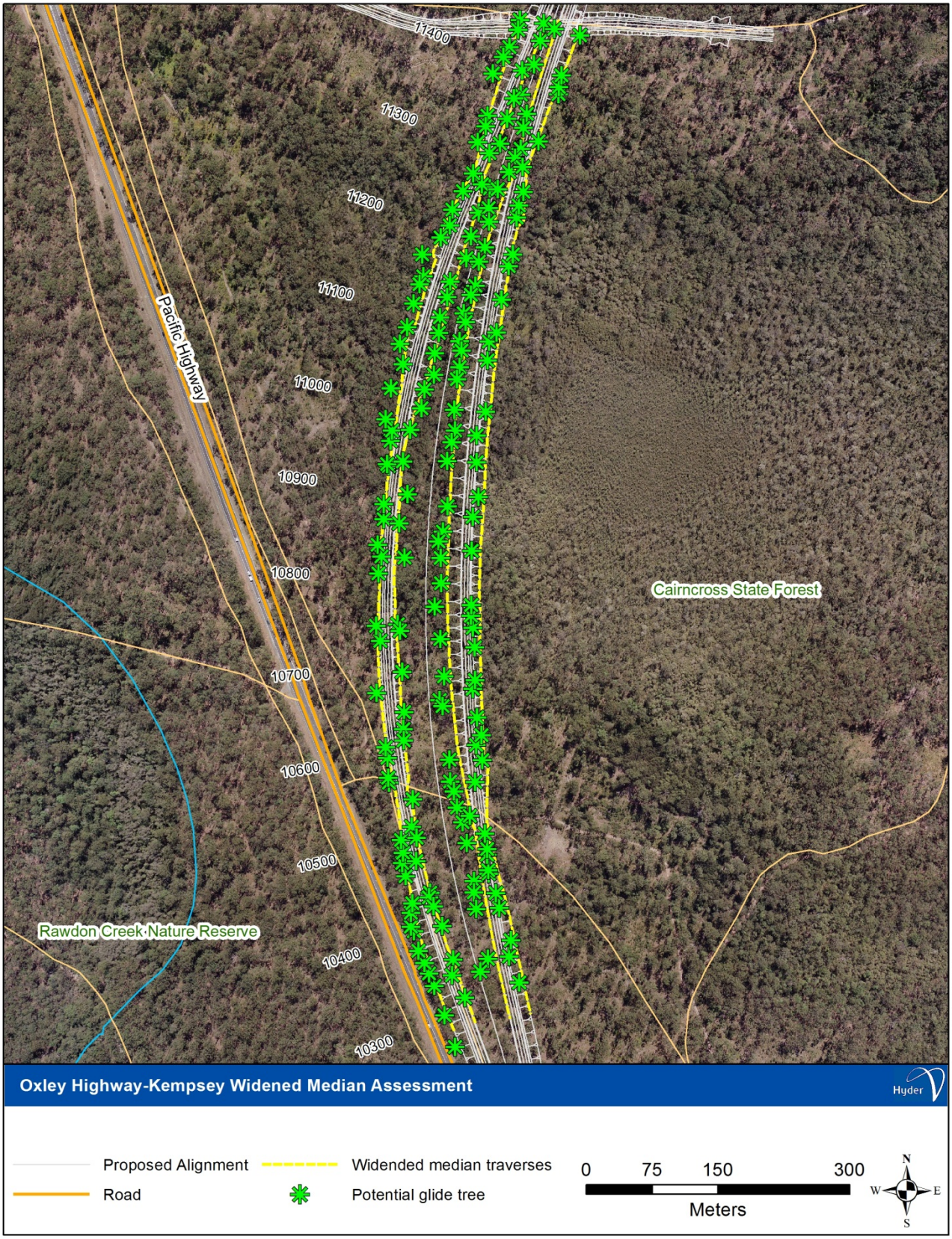

Figure 12: Locations of tagged potential glide trees

APPENDIX E
AGENCY CONSULTATION