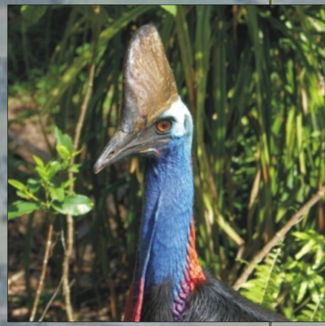
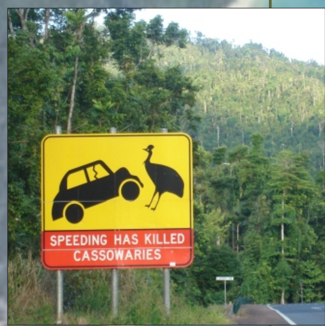
WONGALING CORRIDORS FAUNA CROSSINGS





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Acknowledgements

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EXECUTIVE SUMMARY

The number one cause of cassowary mortality at Mission Beach is vehicle strike.

The cassowary is regarded as an Endangered species at the national and State level. Mission Beach currently represents one of the highest concentrations of the species, supporting, at most, 79 independent birds.

The Wongaling Creek area of Mission Beach supports cassowaries. It is crossed by two Main Roads including El Arish – Mission Beach Road and Tully – Mission Beach Road on which there have been reported cassowary crossings and known cassowary road deaths.

Terrain NRM has commissioned this current study to prepare a concept plan for possible fauna-friendly treatments of main roads in the Wongaling Creek area of Mission Beach, particularly regarding cassowary crossings.

There has been some work in the Mission Beach area on measures to mitigate cassowary road deaths including implementation of driver awareness (through signage), psychological measures to slow traffic (e.g. the installation of line markings and rumble strips), modifying culverts with the aim of providing safe passage for cassowaries, construction of fences aimed to channel cassowaries to crossing structures and enhancing vegetation and landform under bridges. Monitoring of the efficacy of this work and other structures has been limited and is on-going. Results to date from these structures and an understanding of cassowary ecology have lead researchers to the strong view that culverts are not suitable for cassowary movement. One of the key recommendations of the comprehensive strategy for the proposed Kuranda Range Road was that elevated road platforms are likely to be the best solution to facilitate cassowary crossings under roads.

Recently Biotropica (2008) prepared "The Wongaling Creek Habitat Linkages" study which identified several linkages in the area, a number of which inevitably are intersected by roads resulting in 'Connectivity Gaps'. These 'Connectivity Gaps' do not necessarily represent the points at which cassowaries cross roads and identification of cassowary crossing points is currently the subject of a study being undertaken by James Cook University which is due to be completed in March 2009.

In the interim, the 'Connectivity Gaps' in addition to previous known cassowary crossings and other anecdotal evidence including vegetation lines can form the basis from which to develop an integrated approach to facilitating fauna crossings in the Wongaling Creek area with a focus on the safe movement of cassowaries. Through review of the best structures likely to facilitate the movement of cassowaries one possible solution was developed for the study area integrating elevated road structures plus a land bridge. It is estimated that this possible solution will cost in excess of $25 million. The suitability of this possible integrated solution will need to be reviewed against the findings of James Cook University's current investigations.

Several other options may form part of an integrated solution for the area including:

- Reducing cars on the road through the establishment of bikeways and suitable public transport;
- Reducing cars on the road through approval of low traffic-producing development;
- Reducing the speed environment from 80km/hr to 50km/hr. This will require enforcement which might be achieved through fixed speed cameras;
- Reducing the speed environment by establishing vegetation close to the edge of the road and achieving canopy connectivity (which has benefits for other fauna species);
- Reducing the speed environment through the integration of roundabouts;
- Establishment of suitable guide fencing to dedicated fauna crossing structures. Further research is needed to determine suitable fencing for cassowaries; &
- Integrate fauna underpasses through oversized culverts and rope bridges to connect canopies. Although it is unlikely that these would be suitable for cassowaries, they will be of importance to other fauna that contribute to the biodiversity values of Mission Beach.

Irrespective of the ultimate solution, it will be necessary to adequately monitor any measures implemented for their efficacy. The data collected will allow better informed decisions in future and will guide improvement and enhancement of future and existing measures.

Some measures could be partly funded through EPBC development approval offset contributions where development results in increased motor traffic through cassowary habitat or corridors. Implementation base funding should be attained from National and State government. There are many agencies that need to be involved in the planning, funding and implementation of appropriate mitigation measures including, amongst others, Queensland Department of Main Roads, Terrain, Council, Department of Environment Water, Heritage and the Arts, Queensland Transport, Environmental Protection Agency, James Cook University, community groups and the development and tourism industries.

1.0 INTRODUCTION

1.1 BACKGROUND

It is estimated that there are between 900 (C4, 2007) and 1,500[1] (Weston & Goosem, 2004) individual cassowaries remaining in the Wet Tropics, with the highest densities of the species found in the lowland plain below the 80m contour (WTMA, 2006). The Mission Beach population represents one of the highest concentrations of the species in Australia (Weston, 2006; *pers comm.,* Moore, 2008) and is estimated to include approximately 79 independent birds[2] in 2000 (adults and independent adults) (*pers comm.,* Moore, 2008).

At the National level, the Southern Cassowary is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). At the State level, the northern (Cape York) and southern (Wet Tropics) populations are listed separately under the Queensland *Nature Conservation Act 1992* as:

- Northern (Cape York) population listed as Vulnerable; and
- Southern (Wet Tropics) population listed as Endangered.

Moore (1991) noted that 68% of the home range of the adult bird population in the Mission Beach area includes habitat that abuts or crosses Tully Mission Beach Road or El Arish-Mission Beach Road. The “National Recovery Plan for the Southern Cassowary” (Latch, 2007) states that 76% of total cassowary deaths recorded at Mission Beach occur on roads and hence collisions with cars has been identified as the number one cause of cassowary mortality in Mission Beach (QDMR, 2001; Moore & Moore, 1999). The issue of road mortality is therefore an imperative for cassowary conservation and is highlighted as Recovery Plan Action 3.1 of the “National Recovery Plan for the Southern Cassowary” (Latch, 2007) to “minimise cassowary road mortality and injury”.

Mission Beach has been identified as a Priority Biodiversity Area in the ‘Sustaining the Wet Tropics’ Regional Plan (FNQ NRM Ltd & Rainforest CRC, 2004). The area between North Mission Beach and Wongaling Beach is a significant ecological area with corridors that connect rich coastal habitat to the National Park foothills. The area straddles the old Johnstone/Cardwell Shire boundary and is experiencing increasing development and motor traffic. It is anticipated that if current trends continue by the year 2025 there will be 5,789 vehicles movements per day on Tully – Mission Beach

[1] To understand how few cassowary are remaining by way of comparison, it is estimated that there are 1,600 Pandas remaining in the wild (WWF, 2008)
[2] However, following Cyclone Larry it now may be as low as 65 birds (*pers comm.,* Moore, 2008).

Road and 2,251 on the El Arish – Mission Beach Road (Williams *et al*., 2008). Most of the study area is in the Regional Landscape and Rural Production category in FNQ Draft Regional Plan 2025 (QDIP, 2008).

The Wet Tropics Management Authority's Cassowary Advisory Group 28/01/08 Minutes includes the following Action: "There is a need for members to work with MRD, Councils and other stakeholders on road design – urgently required for cassowary movement in the Mission Beach district".

Traffic management is a major theme addressed by the community in the "Mission Beach Habitat Network Action Plan: Community Workshop Outcomes" draft report (Terrain & CSIRO, 2008).

Terrain NRM commissioned Biotropica Australia to prepare a report describing and recommending Habitat Linkages in the study area. The Wongaling Creek Habitat Linkages (Biotropica, 2008) identified several linkages in the area, a number of which inevitably are intersected by roads resulting in 'Connectivity Gaps'.

Terrain NRM has commissioned this current study to prepare a concept plan for possible fauna-friendly treatments of the main road in the Wongaling Creek area of Mission Beach, particularly regarding cassowary crossings. The main focus of this study is therefore the Tully Mission Beach Road (from near the intersection with Wongaling Beach Road northwards) and the El Arish-Mission Beach Road in the vicinity of its crossing of Wongaling Creek (Figure 1). This area, incorporating Reserve 214[3], is known be active with cassowaries and there have been a number of cassowary roadkills in recent years (see Figure 2). It is understood that the ecologically diverse area associated with Reserve 214 is important for adults with chicks (*pers comm.,* Moore, 2008).

This report aims to identify a number of options to address not only roadkill of cassowaries in the study area, but also of a broad suite of fauna (see Appendix A for some of the mammal species known to occur in the Mission Beach area).

The ecology of cassowaries is complex and a failsafe method of eliminating car related cassowary mortality has not yet been determined. However due to an increasing rate of traffic in the Mission Beach area, corresponding to an increasing local and tourist population (Williams *et al*., 2008) and ongoing cassowary road mortality, there is a need to identify best probable solutions based on existing knowledge, as it is likely that the rate of road mortality will increase (NRA, 2006).

[3] R214 is a common name for Lots 109 & 634 on Plan CWL3519.

Low cost solutions (e.g. simple signage) are unlikely to yield realistic conservation outcomes and the elimination of cassowary road mortality is likely to require relatively expensive solutions. However, the expense of providing safe fauna crossings should be considered in the context of traffic accident reduction and the likelihood that the cassowary may become locally extinct in the absence of intervention. This may in turn reduce eco-tourism opportunities as well as have a significant impact on a state and nationally-listed endangered species.

Given cassowaries are long-lived, slow reproducing species with lengthy parental care it is possible that each road death will influence a population's dynamics and reproductive fitness (Latch, 2007). Therefore each individual must be regarded as essential to maintain the viability of the cassowary population at Mission Beach. To address the issue it will be necessary to adopt an integrated rather than piecemeal approach.

Biotropica (2008) noted that although their study considers habitat continuity for the southern cassowary, it did not identify individual birds and their utilisation of existing linkages in the Wongaling area and hence the density of cassowaries and their utilisation of the resources in nominated areas, was not discussed. Their report therefore assumed that cassowaries are using all of the areas identified to some degree, including the Habitat Linkages identified. Researchers including Miriam Goosem and Les Moore are currently undertaking significant studies in the broader Mission Beach area that will, overtime, improve our understanding of current cassowary activity in the area and enable more targeted planning outcomes for cassowaries.

1.2 SCOPE

This report specifically aims to consider:

- Possible solutions/concepts/options/visions for fauna-friendly treatments of main roads in the study area;
- All native fauna species in the area, yet focus particularly on cassowaries;
- Appropriateness of solutions for the fauna species (e.g. funnelling all cassowaries to one narrow crossing point might conflict with cassowaries' solitary and territorial nature);
- Impacts on future road development (e.g. an overpass might constrict future road widening options or block a pedestrian/cycleway);
- National and state road legislation and policy (e.g. requirements for site clearance along road sides, exemptions in significant environmental areas, process for lowering speed limits);

- Existing wildlife crossing management in the study area;
- The context of the broader Mission Beach area (e.g. the importance of this area for wildlife crossings relative to other areas at Mission Beach);
- The affect of a wet tropical climate, including cyclones, on proposed solutions.
- The likelihood of success of the fauna crossing proposals;
- Local aesthetics; and
- The option that safe fauna crossings may be practically impossible and/or that cassowary conservation efforts would be better invested elsewhere (e.g. purchase and revegetate areas elsewhere to create additional habitat) or that the area is ecologically critical, development impacts are significant and cannot be mitigated or offset through fauna crossings and therefore development approval will result in cassowary decline.

The report has been prepared for Terrain NRM for information purposes and places no obligation on agencies to endorse or implement the findings.

1.3 CONCURRENT STUDIES

James Cook University are currently undertaking the Mission Beach Cassowary Road Management Study. The preliminary aims of the project include:

> *Based on knowledge of cassowary road use at Mission Beach:*
>
> 1. *Devise a strategy to minimise cassowary road death;*
> 2. *Incorporate in this strategy methods to improve habitat connectivity throughout the Mission Beach area;*
> 3. *Consult with the Mission Beach Habitat Network Action Plan Committee to ensure integration of the findings of this study into an integrated road strategy, i.e. MBHNAP traffic strategy.*
> 4. *To investigate the cassowary population in the area of Smiths Gap (including the Bruce Highway and adjacent railway line) to:*
>   - *Monitor the use of the area by cassowaries and locate current crossing points;*
>   - *Establish which of the current crossing points provide the best site for a permanent safe crossing point;*
>   - *Evaluate the contribution such a connection would make to the viability of the Mission Beach cassowary population;*
>   - *Advise methods and strategies to facilitate this connectivity.*

The objectives of the study include:

1. *To locate all active cassowary road crossing areas on the El Arish-Mission Beach Road, Cassowary Drive (Wongaling Section), Tully-Mission Beach Road and South Mission Beach Road, Bingil Bay Road and compare with previous data.*
2. *To investigate crossings in the Smith's Gap area.*
3. *To identify birds that are using these crossings as far as possible.*
4. *To create a set of identikit profiles of these birds.*
5. *To examine temporal usage patterns of road crossings.*
6. *To examine seasonal changes in demographics at crossing points.*
7. *To systematically collect cassowary droppings at each active crossing point for future DNA analysis and disease load studies.*
8. *To examine risk factors associated with crossing points and any crossing points receiving multiple usage.*

It is understood that the final reports for this study will be completed by March 2009.

As a separate project the Department of Environment, Water, Heritage and the Arts (DEWHA) have engaged a consultant to identify the scale and extent of development approvals in coastal areas at Mission Beach. The findings of this project are expected late 2008 and might assist with population and traffic projections.

1.4 METHOD OF CURRENT STUDY

The report has largely been prepared as a desktop exercise with a minor field component. The study phases included:

1. Review of previous assessments of the Wongaling area to identify locations where mitigation measures may be required for the target roads;
2. Research of literature of mitigation measures for reducing cassowary road mortality. This included, where possible, consultation with Queensland Department of Main Roads and researches from James Cook University;
3. Assessment of some of the behavioural traits of cassowaries that may affect their interaction with mitigation measures;
4. A review of other mitigation measures employed for other fauna species for the purpose of identifying suitable measures for other species in the study area and to potentially identify measures that can be adapted for cassowaries;
5. A brief field trip specifically for the purpose of assessing the landform and existing landscape features at key locations in the study area; and
6. The development of preliminary options for mitigation measures and identification of implementation issues.

Significantly the draft report was subjected to a rigorous review by representatives from numerous organisations including DEWHA; Terrain NRM; CSIRO; Cassowary Coast Regional Council; Mission Beach Community Association; Wet Tropics Management Authority; Queensland Department of Main Roads; James Cook University; Department of Infrastructure and Planning; C4; and Queensland Parks and Wildlife. However it is not suggested that these organisations therefore endorse this report.

2.0 PREVIOUS ASSESSMENTS OF THE WONGALING AREA

2.1 BIOTROPICA (2008)

Based on desktop and on-ground survey, Biotropica (2008) identified six Habitat Linkages, comprising four primary linkages and two secondary linkages. Primary linkages were identified as critical to the safe movement of cassowaries between State land habitats, and secondary linkages were identified as providing movement within, as opposed to between, habitat blocks. These linkages, mapped in Figure 1, included:

- Habitat Linkage 1: Clump Mountain National Park to Marcs Park (2 sections);
- Habitat Linkage 2: Marcs Park to Reserve 214;
- Habitat Linkage 3: Marcs Park through Oasis development;
- Habitat Linkage 4: Sartori Resort to Reserve 214;
- Habitat Linkage 5: Reserve 214 to Tam O'Shanter National Park (north section); and
- Habitat Linkage 6: Reserve 214 to Tam O'Shanter National Park via Lot 802 SP110366.

Biotropica mapped a number of 'Connectivity Gaps' (CG) (see Figure 1) where the above links are crossed by roads. These are described in Table 1 below:

Table 1 – Connectivity Gaps

Connectivity Gap	Description (from Biotropica, 2008)
CG 1	The crossing of Wongaling Creek over the El Arish Mission Beach Road is the main Connectivity Gap to be considered for Habitat Linkage 1. C4 has undertaken tree planting works in this area over a number of years and this has significantly improved the safety of this cassowary crossing point through control of Guinea grass. However, birds continue to cross the road above rather than below the bridge, suggesting an aversion either to the structure or its surrounds. There is scope to improve this Connectivity Gap by continuing to re-plant the riparian zone. The assistance of Ergon Energy Corp Ltd should be sought in relation to the establishment of appropriate low growing species beneath the 22kV feeder lines on the northern side of the El Arish Mission Beach Road. Habitat on the southern side of the road at this point is also highly degraded and requires both weed control and active restoration as part of an overall plan for management of this Connectivity Gap.
CG 2	There was no CG 2 identified due to the nature of Habitat Linkage 2.

CG 3	The road crossing and associated disturbance between Lot 2 RP721421 and Lot 103 SP177188 is the Connectivity Gap associated with this linkage. Clear and obvious passage between the two habitat patches is severely affected by Guinea grass invasion on the eastern side of Lot 2 RP721421. This large area compromises the efficacy of the dedicated linkage traversing west from Lot 103 SP177188, by effectively isolating these two patches with 80-90 metres of Guinea grass. This restoration is urgently needed to improve linkage utility in this area. Restoration should begin as soon as possible on Lot 2 RP721421 with a strip at least as wide as the adjacent linkage emanating from Lot 103 SP177188, commencing directly opposite this linkage, and traversing to the edge of the Melaleuca dominated communities on Lot 2 RP721421. Restoration would aim to plant a mesophyll vine forest which merged into Melaleuca wetland where soil and drainage begin to alter. As noted, this strip should be at least as wide as the existing habitat to the east, but preferably much wider to produce higher value core habitat opposite the linear patch on Lot 103 SP177188. Given the inevitable traffic increases resulting from adjacent development, driver education and crossing design will need careful scrutiny at this Connectivity Gap.
CG 4	The Connectivity Gap associated with the linkage to Reserve 214 is the Conch Street crossing, and the weed colonisation associated with the riparian strips on the reserve tenure blocks (Lot 999 RP898592 and Lot 5 NR7162) at these crossings. There is permanent freshwater available close by, adding to the habitat values of this area. Replacing Guinea grass with native species would improve the utility of this linkage. The watercourses providing native cover are heavily degraded and unless effort is made to re-plant weedy areas with appropriate native species they are unlikely to provide any significant functionality.
CG 5	The Tully-Mission Beach Road is the major Connectivity Gap within this linkage. Unpublished data sourced from the Qld EPA indicates there have been at least two known cassowary deaths caused by car strike (1992-2006) in the vicinity of the Connectivity Gap, despite the presence of warning signage. Cassowary crossings occur at this point on a regular basis. Unless this Connectivity Gap can be better managed the value of this linkage is compromised. This area is the second Connectivity Gap which requires significant restoration effort to maximise its value. As noted above, the joint restoration of riparian zones on Lot 1 RP747525, Lot 3 RP732964 and Lot 4 RP747525, and parts of Lot 2 RP732964, would achieve a number of positive conservation outcomes, including management of the Connectivity Gap. A fencing strategy may be required to limit negative interactions, particularly from established and proposed residential developments. Fencing of the main subdivision component on Lot 2 RP732964 should be reviewed. The fencing of road-side sections may also be warranted and would need to be examined in the context of riparian restoration works.
CG 6	The Tully-Mission Beach Road represents the major Connectivity Gap along Linkage 6. Unpublished data sourced from the Qld EPA indicates there have been at least two known cassowary deaths caused by car strike (1992-2006) in the vicinity of the Connectivity Gap, again despite the presence of warning signage. Linkage function is also compromised by a second Connectivity Gap represented by Rockingham Close which provides the main thoroughfare for traffic emanating from residential subdivisions to the south. The low density residential development to the north of Lot 66 SP164474 (Mission Circle) retains high quality habitats, particularly along low lying areas, although interior roads are also potential car strike points. However, of these three roads, the Tully-Mission Beach Road is clearly the most dangerous for cassowaries accessing Linkage 6. Hard and soft engineering are both required. The cooperation of Ergon Energy Corp Ltd should be sought to improve the quality of habitat beneath the 22kV feeder line and to enhance the visual amenity of the power-line corridor. Fencing, signage and road surfacing are also likely to be key ongoing components of Connectivity Gap management.

Biotropica identified that significant works (i.e. both hard and soft engineering) would be required at most road crossing points where linkages intersect. They recommended that close attention is given to the design and management of known crossing points where these intersect with linkage habitats.

It was confirmed with Terrain NRM that the focus roads of this study are those controlled by the Queensland Department of Main Roads as illustrated in Figure 1. Therefore CG 3 and CG 4 are not considered for the purposes of the current study nor CG 6 for the portion affected by the local road Rockingham Close.

It is noted during the preparation of this report; the Federal Environment Minister rejected a development application in the immediate study area (i.e. located on Biotropica's Habitat Linkage 6) because of impacts on cassowary movement corridors.

2.2 MOORE & MOORE (1999)

Previous mapping (QDMR, 2001; Moore & Moore, 1999) has identified known cassowary crossings on the Tully-Mission Beach Road including two located in the current study area, reproduced in Figure 3. Moore and Moore (1999) identifies Crossing 11 as covering an area from 650-800m south from the junction with El Arish-Mission Beach Road, with the area of greatest probable crossing occurring between 700 and 750m. They identify Crossing 12 as covering the area extending 1,800 to 2,100m south from the junction with the area of greatest probable crossing occurring between 1,900 and 2,100m. Recommended measures to mitigate cassowary road mortality in the vicinity of Crossings 11 and 12 included regulatory speed signs, cassowary crossing warning signs, cassowary conservation zone signs and cognitive signs (see Figure 3). Crossing 12 corresponds with CG6 identified by Biotropica (2008) report whereas Crossing 11 does not correspond with any CG.

It is important to note that all active cassowary road crossing areas on the El Arish-Mission Beach Road, Cassowary Drive (Wongaling Section) and Tully-Mission Beach Road are currently being re-assessed by James Cook University and will be subsequently compared with Moore & Moore (1999) and other later assessments.

2.3 JOHNSTONE SHIRE COUNCIL PLANNING SCHEME

Map 7c "Johnstone Shire Council – Natural Areas Plan" of the Planning Scheme identifies a number of "Wildlife Crossing Points". Figure 3 of this study identifies their location within the study area. These areas correspond with CG 1 and CG 5 identified by Biotropica (2008). It's noted that the Johnstone Shire Planning Scheme only applies in the northern half of the study area.

The mapping triggers the Natural Area Code of the Planning Scheme. Specific Outcome 8 of the code requires "Road design and construction does not increase the risk to wildlife at identified crossing points". The Acceptable/Probable Solution to this Specific Outcome is:

> *On a section of road identified on Map 7a-e as wildlife crossing point is to implement measures to reduce the risk to wildlife caused by vehicles. Measures include the following:*
>
> - *Reduction in design speed of the road to 40km/h; or*
> - *Provision of wildlife crossing points to separate wildlife and vehicles (e.g. underpass); or*
> - *Road surface and edge treatment to encourage a reduced vehicle speed; or*
> - *Fencing along the road to reduce wildlife movement onto the road; or*
> - *Establish and maintain a cleared road shoulder to enable motorists a better opportunity to see wildlife earlier; or*
> - *Erection of signage to educate motorists on wildlife crossing areas; or*
> - *Encourage wildlife to use other corridors through establishment of new corridors; or*
> - *Any combination of the above.*

The Acceptable Solution identifies several alternative measures to address crossing mitigation, some of which would be more effective than others (e.g. a speed reduction to 40km/h would be more effective than educational signage). The decision as to the suitability of a proposed solution would initially be at the discretion of the assessing officer at Council in consultation with the Queensland Department of Main Roads.

3.0 ROADS & FAUNA MANAGEMENT

3.1 CASSOWARIES & ROADS

3.1.1 Constructed infrastructure that has been designed to consider cassowaries

3.1.1.1 Planning

The most detailed planning for cassowary management for the entire Tully-Mission Beach Road was undertaken by the Department of Main Roads (QDMR, 2001). The plan considered a number of crossing points previously identified by Les Moore (QDMR, 2001; Moore & Moore, 1999).

The investigation identified six management strategies for the entire length of Tully-Mission Beach Road as tabulated below:

Table 2 – Cassowary Management Strategy - Tully-Mission Beach Road Management Strategies

Management Strategy Group	Details
1	a. Cassowary crossing warning signs b. Relative size signs c. Cassowary conservation zone signs d. Conservation zone (reminder) signs
2	a. Cognitive signs (i.e. with a variable message to be rotated initially on a 2month timeline) b. Decreasing the Clear Zone Width (reducing the clear zone from 10m to 8m)
3	a. For 500m either side of a critical crossing b. Transverse Line markings c. Reduction in thickness and an increase the spacing and frequency of separation lines d. Reduction in lane width e. Chevron marking of road shoulders f. Reduction in the spacing of guide posts (The measures identified above are illustrated in Figure 4)
4	a. Landscaping and fencing of the North Hull Bridge b. Rumble strips
5	a. Landscaping and fencing of dedicated large culvert b. Pull over area (for a specific crossing point for the purpose of speed limit enforcement)
6	a. Cassowary awareness centre (located at the eastern side of the intersection between East Feluga Road and Tully-Mission Beach Road) b. Cassowary awareness centre sign c. Life size cassowary sign

The estimated costs to implement the above measures at the time of the report are identified in Appendix B.

Other approaches considered in the report included the possible use of wildlife reflectors, dependent on their success in a trial for other fauna in Barcaldine. Subsequent research has shown that the reflectors are not effective for other species of Australian wildlife (Ramp & Croft, 2006).

3.1.1.2 Outcomes

Implementation of measures to reduce cassowary road mortality and facilitate cassowary crossings of roads has been limited. Following the Cassowary Management Strategy – Tully-Mission Beach Road (QDMR, 2001) a number of the recommended measures (see Table 2) were implemented including signage in the current study area. Of particular interest was the enhancement of the bridge crossing at the North Hull River and the modification of a culvert at Stoney Creek (in accordance with Management Strategies 4 and 5 respectively). The following sites were established and monitored:

- Stoney Creek - modified culvert underpass. An existing 3m x 3m culvert was fitted with a concrete bench incorporating alternating rubber matting and sandtraps set into the bench. Fencing was installed to direct fauna towards the culvert (see Plate 1);
- North Hull Bridge - an existing bridge where approaching slopes were profiled and revegetation with cassowary food species was undertaken on approaches and under the bridge (Plate 2); and
- Limbo Creek - an unmodified large culvert representing the control site (Yates, 2008).

PLATE 1 – QDMR's large culvert trial. Note the raised platform allowing dry passage

PLATE 2 – The North Hull River bridge

Although the QDMR are yet to receive a report from the Queensland Parks and Wildlife Service, initial evidence suggests that the North Hull River bridge has been utilised by Cassowaries in addition to a diversity of other fauna including snakes, bandicoots, lace monitors, pademelons, melomys, water rats, curlews, echidna and orange footed scrubfowl. Cassowary scats had been recorded in the Stoney Creek modified culvert underpass (see Plate 3), but there has been insufficient evidence to conclude they actually move through the culvert (*pers comm.*, Moore, 2008). There has however been other fauna using the culvert demonstrating that it is effective for some mammal species (*pers comm.*, Goosem, 2008). To date, there has been no evidence to suggest that the underpasses are consistently effective for cassowaries and recent tracking suggests otherwise (*pers comm.*, Goosem, 2008).

Line marking identified in Group 3 and in 4b of the measures identified in QDMR (2001) are illustrated in Plate 4.

PLATE 3 – Cassowary scats in the Stoney Creek culvert (photo courtesy of the Department of Main Roads). Note the Wetpour safety surface material used to line the culvert floor.

PLATE 4 – Line markings preceding the North Hull River bridge

Another project in the Atherton Tablelands associated with the upgrade of the East Evelyn Road, incorporated 3 underpasses to facilitate the movement of a broad group of rainforest fauna including cassowaries (Goosem, Weston & Bushnell, 2005). The road upgrade design incorporated four underpasses 3.4m high and 3.7m wide, constructed as galvanized steel arches with a concrete base (see Plate 5). Contributing factors to the design of the underpass was the height of the cassowary (1.5-2m) and the requirement to allow animals a direct line of sight to rainforest habitat at either end of the underpasses. Underpass design and siting were established in collaboration with QDMR, researchers from the Rainforest CRC, the Centre for Tropical Restoration in the Queensland Environmental Protection Agency, and community groups including the Tree Kangaroo and Mammal Group, Trees for the Evelyn and Atherton Tablelands and Wildlife Rescue.

PLATE 5 – East Evelyn Road fauna underpass (photographed late 2007).

The underpasses were subsequently monitored using sand track beds complemented by infrared-triggered digital photography.

Although used by a diversity of fauna (including Lumholtz's tree-kangaroo), the Southern Cassowary has yet to use an underpass, having become exceedingly rare in the area. On one occasion a bird was observed attempting to climb through fencing erected at an underpass entrance aimed at deterring cattle from resting in the tunnel (Goosem, Weston & Bushnell, 2005), but it is not known whether the individual was or was not interested in using the underpass (*pers comm.*, Goosem, 2008). Moore (*pers comm.,* 2008), who undertook fauna assessments for the Evelyn Road upgrades, noted that cassowaries had no real reason to utilise these culverts and the length of the culvert under the road would discourage cassowary usage.

As part of QDMR's recent upgrade to the El-Arish Mission Beach Road a series of culverts were upgraded at Lacey Creek (see Plate 6) to larger cells. Preliminary work has been undertaken to see whether cassowaries are utilising the cells. Thus far, crossings have been across the road on either side of the Lacey Creek Bridge (*pers comm.,* Moore, 2008 & *pers comm.,* Goosem, 2008). Future management strategies may include trying to encourage usage of the culvert at Lacey Creek but the likely success or otherwise of that approach is unknown (*pers comm.*, Moore, 2008 & *pers comm.,* Goosem, 2008). Moore also suggested that cassowaries may shy away from underpass structures because of the bulkiness they convey.

It is apparent that work on culverts has not yielded definitive results. Moore (*pers comm.,* 2008) notes cassowaries do not like culverts and are unlikely to use them willingly. In some situations they may be regarded as the last resort, but this is entirely dependant on topography, vegetation, the frequency and reason for crossing, and a situation of no other choice.

PLATE 6 – El-Arish Mission Beach Road culvert at Lacey Creek.

PLATE 7 – Guide fencing at Stoney Creek. Also note diagonal bars at road edge.

Moore & Moore (1999) have suggested that rumble strips located on the approach to cassowary crossings is a useful way to alert not only drivers to changed conditions, but to cassowaries as well, as they have excellent hearing.

Fencing can reduce the number of crossing points by preventing crossing at certain points and channelling fauna to designated crossings. However, fences have to be covered with shade cloth (otherwise cassowaries will try to push through them) and have a space underneath that is small enough to allow other small mammals through whilst preventing young cassowaries passing. Existing fences installed at Mission Beach have a gap that is tall enough to allow young chicks through and hence are inappropriate (see Plate 7). The fences also have vertical gaps in them that are intended to allow cassowaries 'trapped' in the carriageway to run along the fence and be directed through the gap to the rainforest side (*pers comm.*, Burgoyne, 2008). Given there has been no monitoring of the fencing it is unclear whether the vertical gaps are effective.

It may be possible to use fencing to encourage cassowaries to occasionally cross roads via culverts (similar in dimensions to the Stoney Creek Culvert) or other crossing structures, but they are also likely to walk along a fence until they come to a break in it, rather than venture into an "underpass", although this needs to be tested (*pers comm.,* Goosem, 2008). An appropriate cassowary fence is yet to be designed and properly assessed for efficacy.

3.1.2 Planned infrastructure that has been designed to consider cassowaries

Bridges raising the traffic above surrounding land is the most likely option to be effective. We know they will pass under the Hull River bridge (but equally they still appear to cross the road surface nearby). This was the one of the options chosen in consideration of the Kuranda Range road upgrade which was approved by the Queensland Government in 2001 WTMA (2004).

The project involved the upgrade of the Macalister Range section of the Kennedy Highway, from Smithfield through the World Heritage Area to Kuranda to a four lane highway. The proposal roughly followed the existing route, but uses elevated roadways and bridges.

Research carried out to assess ‘no net adverse impact’ for the proposed upgrade included the direct impact of road kill resulting from the wider road corridor and higher traffic speeds.

One of the measures employed to offset impacts was through the design of improved habitat connectivity through the use of additional bridges, culverts and elevated sections of road as well as the rehabilitation of creek channels and unused sections of the old road. In relation to the movement of cassowaries the Impact Assessment Study (Environment North, 2004) noted “*the extensive bridges proposed should ensure effective connectivity throughout the study corridor*”.

3.1.3 Cassowary behaviour

Other factors that should be considered in the design of cassowary crossings relate to other behavioural traits. For instance, it should be understood that Habitat Linkages, such as those illustrated by Biotropica (2008), are illustrated as narrow linear paths, whereas cassowaries will use the full extent of vegetation or even cross large clearings. Indeed they may even avoid some vegetation lines due to the likelihood of interactions with competitors or because there is no attraction in the form of seasonal food resources (*pers comm.*, Goosem, 2008). Studies by Moore (*pers comm.*, 2008) suggest that as well as social structures, there is preferential use of habitat by cassowaries that influences which vegetation lines in the landscape are used as movement corridors.

Due to increased light, road edges favour the growth of weed species or ‘gap loving’ native plants such as raspberries. Cassowaries are sometimes attracted to road edges by not only these fruiting weeds, but native species also.

3.2 OTHER MEASURES UTILISED FOR FAUNA MANAGEMENT

3.2.1 Crossing structures

DEWHA recently commissioned a study titled "Review of mitigation measures used to deal with the issue of habitat fragmentation" (Van der Ree *et al.*, 2007). The report represents a thorough literature review of the:

- Effectiveness of mitigation measures employed to ameliorate the habitat fragmentation impacts of major infrastructure;
- Past and present monitoring programs of the mitigation effects of major infrastructure including their scientific merit; and
- Cost-benefits of mitigation, in relation to overall infrastructure project costs.

The report categorised and summarised a number of engineering options to mitigate the fragmentation effects of linear infrastructure tabulated in Table 3 below. These options might be suitable for other fauna species in the study area, but several would not be suitable for cassowaries:

Table 3 – Engineering options to mitigate the fragmentation effects of linear infrastructure

Title	Description (after Van der Ree *et al.*, 2007)	Native fauna recorded utilising existing examples (after Van der Ree *et al.*, 2007)	Additional discussion where relevant	Image (where available)
Overpass (Allows passage of animals above the road)				
Land bridge	Also known as eco-duct or wildlife bridge. This is a (typically) wide (30 - 70 metres) bridge that extends over the road. The bridge has soil on it, is planted with vegetation and enhanced with other habitat features (e.g. logs, rocks, water-body etc).	Frogs, birds, bandicoots, macropods (Eastern grey kangaroo, wallabies), rats, possums, spotted tailed-quoll, lizards, snakes.	Land bridges have the potential to facilitate the movement of terrestrial or arboreal fauna depending on their design and location. However some North Queensland rainforest ringtail possums will not cross over the road surface and may be completely prevented from moving by the canopy gap caused by a road (*pers comm.,* Goosem, 2008). Land bridges may be effective for cassowaries (*pers comm.,* Moore & Goosem, 2008), provided the bridges are large enough, but this has not been tested anywhere to date (*pers comm.,* Goosem, 2008). It is noted that topography is unlikely to allow such a structure in the study area (*pers comm.,* Moore, 2008) Land bridges have traditionally been utilised in the northern hemisphere for many years to facilitate the movement of large mammals (CEPLA, 2003) and have only recently been employed in Australia. Two specific examples include fauna overpasses constructed as part of the Yelgun to Chinderah project in New South Wales and more recently as part of the Compton Road upgrade in Brisbane. These overpass structures are vegetated and incorporate furniture (i.e. rocks, logs, 'glider poles') to mimic natural environments and thereby facilitate fauna movement. The use of guide	 **PLATE 8 - Fauna Overpass – Yelgun to Chinderah Freeway (NSW)**

			fencing is vital to their functionality. Veage & Jones (2007) recorded swift use of the Compton Road land bridge by three species of macropod following construction. Interestingly, the authors attribute this rapid use to the presence of favourable grazing opportunities on the bridge thereby resulting in acclimatization.	
Overpass (small roads)	This bridge above the major linear infrastructure is typically to allow human access across the road. This overpass is typically narrow and not hourglass shaped. The road on the overpass is typically a minor road - it may be unsealed, single lane etc.	-	-	-
Canopy bridge	This is a rope or pole suspended above the traffic, either from vertical poles or from trees. Typically installed for arboreal and scansorial species.	Squirrel glider, Fawn footed melomys, possums (Common brushtail, Common ringtail, Coppery brushtail, Eastern pygmy, Green ringtail, Herbert River Ringtail, Lemuroid ringtail, Long-tailed pygmy and striped)	-	 **PLATE 9 - Canopy bridge installed over the Palmerston Highway (Queensland)**

				 **PLATE 10 - Canopy bridge installed over the Summerland Way (NSW)**
Glider pole	These are vertical poles placed in the centre median or on the road verge, and provide species that glide intermediate landing and launch opportunities.	-	Work being undertaken on the Compton Road structures (Veage & Jones) is at this stage inconclusive. However, gliders have been recorded on the poles through hair tube analysis.	 **PLATE 11 - Glider pole installed on the Summerland Way (NSW)**

Local traffic management	Devices to reduce the speed or volume of traffic - e.g. road closures, chicanes, crosswalks, lighting, signage.	-	See further discussion in Section 3.2.2.	 **PLATE 12 – Signage installed as a result of the Cassowary Management Strategy - Tully Mission Beach Road.**
Underpass (Allows the passage of animals below the major linear infrastructure)				
Culvert	Culverts are typically square, rectangular or half-circle in shape and may be purpose built for fauna passage or water drainage, or a combination of both. They are typically pre-cast concrete cells or arches made of steel (Figs 4 - 6). By definition, culverts were originally used to carry water. However, engineers and road designers are familiar with the size and shape of culverts, and hence we suggest the continued use of the term 'culvert' to describe this type of underpass.	Frogs, birds (at least 4 species including brush turkey), antechinus, bandicoots (Long nosed, Northern brown), Rufus bettong, Dunnart, Echidna, Sugar glider, Koala, macropods (Eastern grey kangaroo, wallabies), rats, possums (Common ringtail, Coppery brushtail and Eastern pygmy), Long nosed potoroo, Spotted-tailed quoll, Lumholtz's tree-kangaroo, wombat, several lizard and snake species.	For some time culverts have been utilised in North America to facilitate the movement of large game species such as elk, deer and mountain goats under highways (DMR, 2000). Similarly, in Australia fauna have been recorded utilising culverts for movement. In recognition of their value, research has been undertaken into identifying the attributes of culverts that make them favourable to faunal movement and 'furniture' has been installed in standard culverts to enhance their function as faunal passages. The exact dimensions of underpass structures is complicated and dictated by many variables. As a general 'rule of thumb' bridges offer the best passage for fauna, however if culverts or dedicated fauna tunnels have to be used due to other considerations, then wide short passages are preferred to cater for the greatest diversity of species (CEPLA, 2003). The use of 'furniture'	

			such as rocks, ropes and ledges and appropriate planting at entrances have been shown to facilitate the movement of some species (CEPLA, 2003). It is vital that dry passage is provided for terrestrial species.	 **PLATE 13 - Dedicated fauna culvert with furniture, Compton Road, Brisbane.**
Tunnel	Tunnels are typically round pipes of relatively small diameter (e.g. < 1.5 metres diameter). May also be termed "eco-pipe".	Birds, southern bandicoot, lizards.	-	-
Bridge	A bridge is a structure that maintains the grade of the road or elevates the traffic above the surrounding land, allowing animals the opportunity to pass under the road. When used to mitigate the barrier effect of linear infrastructure, the primary function is often to facilitate water drainage or the movement of local human traffic, and secondarily to facilitate the passage of wildlife.	Numerous frog species, numerous bird species, numerous bat species, echidna, gliders, macropods (Eastern grey kangaroo, wallabies), Koala, possums, Platypus, rats, numerous reptile species	Raised bridges are guaranteed to enable the cassowaries past the road safely (*pers comm.,* Moore, 2008). They are known to be used by cassowaries (*pers comm.,* Moore, 2008) and have been recommended by WTMA for the Wet Tropics (see Section 3.1.2).	 **PLATE 14 - Bridge designed to cater for fauna movement, Springfield, Ipswich.**
Non-structural mitigation (This type of mitigation allows for sensitive road designs that facilitate "natural" permeability)				
Canopy connectivity	The width of the linear clearing is kept sufficiently small to allow the tree canopy to remain continuous above the clearing, or where not continuous, sufficiently small to allow gliders (and other volant	Squirrel glider, striped possum, fawn-footed melomys, Lumholt'z tree kangaroo	-	-

	species) to safely traverse the clearing.			
Elevating the linear infrastructure	The road or powerline is elevated above the vegetation to minimise clearing (clearing only required for bridge piers or pylons) and allow natural vegetation to grow under the infrastructure.	-	An alternative to limiting the impact of powerlines is through the use of aerial bundle cabling or through the undergrounding of cables.	-
Corridor plantings	Strips of vegetation, similar to that on either side of the linear clearing that traverse the clearing and provide corridors for animal movement.	-	-	-

Van der Ree *et al.* (2007) noted a number of common themes that positively affect the rate of use of crossing structures including:

- Abundant and high quality habitat near to the entrance of structures;
- Dirt or "natural" floors;
- Large "openness" ratios (length x width x height of underpass);
- Absence or low rate of use by humans; and
- Presence of "furniture" such as logs, rocks and vegetation on or in the structure.

However, they also note that the magnitude of the effect of these and other variables are likely to be species or species-group specific and vary from one location to another.

3.2.2 Guide fencing

The efficacy of both underpasses and overpasses can be improved through the use of exclusion or guide fencing to channel fauna to a desired crossing point (DMR, 2000).

Fencing must be designed and placed such that it cannot be breached by fauna (e.g. some fauna can climb fencing if covered by vine) or damaged by falling timber (CEPLA, 2003). This is a particular concern in a climate subject to periodic cyclones when fencing can be damaged by falling branches.

The value of fencing needs to be considered in the context of associated problems. For instance, fencing can potentially be problematic in that it may inhibit displaced cassowaries and other fauna species from re-entering core habitat, can potentially 'trap' fauna in the carriageway or can cause stress to cassowaries in cyclones or when chased by dogs. Entrapment in the carriageway can, in part, be dealt with by integrating returns in the fencing, although the effectiveness of these for cassowaries is unknown.

The use of earthen mounds might be an appropriate mechanism to channel fauna movement given slopes $\geq 30^{o}$ represent a barrier to most animals (Moore & Moore, 1999). However, cassowaries can negotiate reasonably steep slopes when necessary and crossing a mound is unlikely to deter them if they decide to cross a road (*pers comm.*, Goosem, 2008). Furthermore, in a landscape subject to frequent flooding, earthen mounds are likely to impede the flow of water.

To date there has been insufficient work on suitable fencing designs for cassowaries (*pers comm.*, Goosem & Moore, 2008). That is, an appropriate design for a cassowary fence is not known and field experiments need to be undertaken on a range of possible options.

3.2.3 Driver behaviour

Both the DMR (2000) and Dique *et al.*, (2000) report that there is a reduction (up to 5%) in koala mortalities on roads with a maximum speed of 60km/h as opposed to those that are 80km/h. This clearly indicates that driver behaviour can reduce road mortalities of fauna. Engaging and/or educating the public therefore has the potential to reduce road kill and as a result enhance the functionality of corridors.

Simple signage alerting drivers to the presence of fauna in Australia has been shown to be ineffective (Coulson, 1982 & Gardyne, 1995). The use of educative signage may be one solution as opposed to standard icon signs that are largely ignored by motorists. Signage has already been widely utilised at Mission Beach.

The effectiveness of the psychological traffic calming measures installed on Mission Beach roads is currently being evaluated (*pers comm.*, Goosem, 2008). Measures installed on the El-Arish Mission Beach Road include:

- Road has been widened but a red colouring on the bitumen at the edges gives the impression of a dirt shoulder, so drivers think the road is narrower than it is and theoretically slow down; and
- Paler bitumen marks cassowary crossings, and rumble strips across the road are aimed at encouraging drivers to slow down.

On the Tully-Mission Beach Road:

- Diagonal bars at each side of the road give the impression that it is narrower than it is (see Plate 7); and
- White lines across the road near cassowary crossings are designed to slow drivers down (see Plate 4).

Vegetation can also be utilised to slow vehicles as a psychological measure - whereby the closer the vegetation to a roads' edge the slower a vehicle tends to travel. However, the QDMR has defined clear zones at the edge of the road pavement to allow space for a driver to manage a vehicle should it leave the pavement. After a clear zone as narrow as 6m was suggested for the Tully-Mission Beach Road, the QDMR only reduced the clear zone to 8m from 10m due to these constraints (QDMR, 2001). The paradox with clear zones is that an enhanced view of the road verge allows a driver to see in advance if an animal is about to cross a road (Moore & Moore, 1999).

It has been suggested that psychological measures are generally more effective on visitors to an area than locals, because the latter get familiarised with the measures employed.

Reductions in speed require enforcement to be effective but speed reduction should reduce cassowary road deaths. Although the efficacy of psychological measures is yet to be determined at Mission Beach, it is likely that legal speed reductions with police enforcement is the best option to guarantee slower speeds (*pers comm.,* Goosem, 2008). Physical measures on the road, such as speed bumps and roundabouts, can be used to force slower speeds.

Another method that might be considered to manage driver behaviour is the Wildlife Protection System (WPS) (Newhouse, 2003). This system has been used in Canada to alert drivers to the presence of fauna in the carriageway. The WPS uses infrared cameras to detect wildlife on or near highways. When wildlife is detected, flashing lights are triggered, warning drivers to reduce speed and anticipate wildlife on the roadway. There may be limitations for its use in an environment where pedestrian access (via pathways/cycleways) is provided.

3.3 QDMR's APPROACH TO FAUNA/FLORA MANAGEMENT IN THE WET TROPICS

3.3.1 QDMR Roads in the Wet Tropics Manual

The QDMR (1998) "Roads in the Wet Tropics: Planning, Design, Construction, Maintenance and Operation" aims to improve the performance and management of road corridors within the wet tropics region by using current information and the latest technology in such a way that takes into account the costs and benefits to the environment, community and economy.

The document is presented in several parts. Part B discusses the "Context of the Roads" and identifies a number of Environmental Commitments of the QDMR contained within a number of key plans, policies and strategies. These include:

- 1997 – 2001 Strategic Plan:
  - The planning, delivery and operation of a road system will, amongst other things, promote "environmentally sustainable solutions";
- Transport Coordination Plan
  - "Environmental Sustainability" is included as one of four main outcomes;
- QDMR's environmental policy:
  - Includes four key outcomes in achieving sustainable transport:
    - Biodiversity and Ecological Systems;
    - Amenity and Quality of life;
    - Resource conservation; and
    - Global environment.
- Queensland Road Network Strategy
  - "Environmental sustainability" is included as one of six outcomes.

The manual recognises the following phases of road management:

- Concept;
- Planning and Preliminary design;

- Detailed design;
- Construction; and
- Operation and maintenance.

The parts of the manual are generally structured according to the above.

The manual notes in relation to integrated design that "the desired outcome is for road design to recognise and consider fauna management requirements". The manual also notes "of critical significance in the wet tropics region is the effect roads have on an endangered species, for example the Cassowary. Roadkills are one of the key threatening processes resulting in declining populations in their remaining habitat." In response, the document tabulates a number of options for fauna crossings (reproduced below as Table 4) and illustrates a number of conceptual fauna crossings (included herein as Appendix C).

Table 4 – Fauna Crossing Techniques from QDMR (1998)

Drainage Control Technique	Application/ Function	Limitations	Advantages	Disadvantages
Pipe Angled Inlet	For fauna crossing in steep terrain at cut/fill transition zones	Does not work for all fauna species.	Ease of construction. Economical. Dual function. Works in steep terrain.	Does not work for all fauna species.
Specific Fauna Culvert	Fauna crossing when culvert has constant and frequent high flows fauna crossing numbers or when fauna crossing is required for specific species but a drainage culvert is not required.	Does not work for all fauna species.	Ease of construction. Economical. Place anywhere.	Does not work for all fauna species. Needs funnel design.
Combination Culvert Fauna Crossing	Fauna crossing combined with culvert use with constant/frequent flow of water.	Does not work for all fauna species. Used only in creek beds.	Can provide protection for smaller fauna species. Economical. Dual function.	Does not work for all fauna species. Needs special design ledge and funnel.
Drop Invert Structure which allows Fauna movement	Fauna crossing in very steep terrain usually cuttings.	Does not work for all fauna species. Use only if no other options are available.	Can use in very steep terrain. Dual function.	Works for only a few species. Not particularly safe for motorists and pedestrians.
Rumble Strips	Warning motorists to slow down and be alert for native fauna crossing the road.	Only a warning device.	Ease of construction. Economical. Motorists know when to pass over them.	Only a warning device can be ignored. Can't place the corners as motor cyclists may lose control.
Mid Block Deflector	Speed reducing device to physically reduce the motorists speed.	Cannot be used on major highways were higher speeds are used.	Actually physically reduces speed.	Need lighting. Only reduces speed at a single location. Permanent. Not mobile.
Traffic Slow Point Fauna Crossing	Speed reducing device to physically reduce the motorists speed.	Cannot be used on major highways were higher speeds are used.	Actually physically reduces speed.	Need lighting. Only reduces speed at a single location. Permanent. Not mobile. Only on low speed roads.

The Integrated Design part of the manual also includes a number of figures (Figures 27, 30 & 33) that identify maintenance of canopy closure along a corridor as a positive outcome.

The Operational and Maintenance part of the manual notes that environmental considerations in this phase focus on maintenance requirements of the road and its shoulders (e.g. mowing grass, resurfacing and cleaning out table drains). The manual refers to the desired outcome for vegetation management is “to maintain and manage roadside vegetation in adjoining areas in such a way to provide for driver safety whilst maintaining the conservation and presentation values of the vegetation”. The manual recommends vegetation should be maintained and managed so that sight lines and visibility ensures driver’s safety, but notes that this results in a conflict between safety and flora conservation issues and that a balanced approach should be adopted to these issues. With regard to best practice guidelines for vegetation management it notes, amongst other points:

- Undertake vegetation clearing practices which retains as much existing native vegetation and regrowth as possible. Areas of importance should be identified prior to field operations;
- Areas of wildlife connectivity should be identified in maintenance procedures and work orders; and
- Clearing of existing vegetation for hazard management and clearance for sight distance should be selective and take into account the nature of the hazard, sight, distance, roadside values, traffic and road characteristics, accident record and the conservation values of the site.

3.3.2 QDMR Road Maintenance Code of Practice for the Wet Tropics World Heritage Area

Although the QDMR (2002) “Road Maintenance Code of Practice for the Wet Tropics World Heritage Area” has been specifically prepared for work in World Heritage Areas, it includes a number of principles that are applicable throughout the Wet Tropics Bioregion. Some of the principles that relate to roadworks include:

- Maintenance of canopy connectivity (see Plate 15 below);
- Avoidance of mowing if possible. The document notes that mowing encourages grasses, spreads weeds and can kill native herbs and shrubs that do not regrow as quickly;
- Encourage low growing native plants on roadsides on the basis that this can reduce maintenance work; and
- Clear only roadside vegetation that obstructs visibility or is a safety threat.

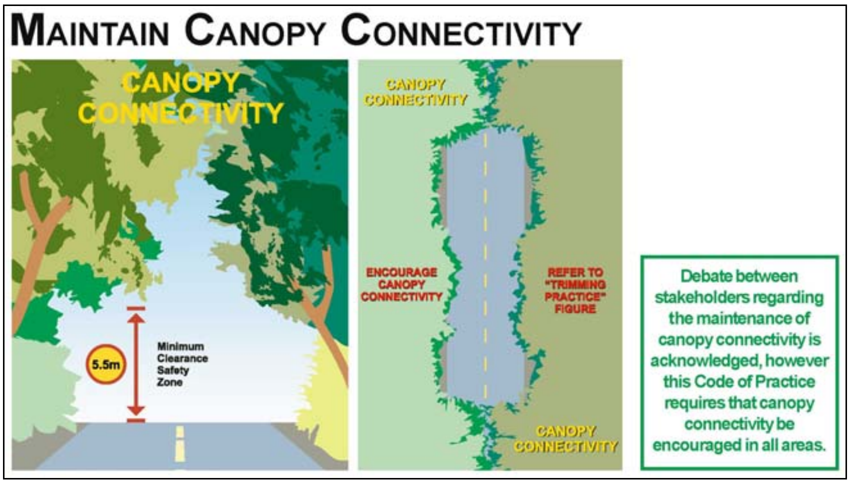


PLATE 15 – Extract from the Road Maintenance Code of Practice for the Wet Tropics World Heritage Area.

3.4 DESIGN OF FAUNA INFRASTRUCTURE IN A TROPICAL ENVIRONMENT

A tropical climate represents many design challenges for fauna crossing infrastructure. High rainfall, high humidity and regular cyclones can affect the longevity and hence efficacy of some design features.

One local example where design features may need to be reconsidered for future crossings is the use of Wetpour safety surface for flooring, previously employed in the Stoney Creek underpass on the Tully-Mission Beach Road. In a culvert that would be subject to regular major flows that would erode a natural surface, Wetpour was presumably utilised to mimic natural ground. When observed in late 2007 by the author it was noted that this surface had, in part, been stripped from the floor and deposited downstream under silt (see Plate 16).

A second example is the use of timber as 'furniture' in the East Evelyn Road fauna underpass. Much of the timber was decomposing (see Plate 17) as a consequence of insect and fungal attack. For future work, it maybe appropriate to consider more resilient furniture, or that the periodic replacement of furniture has to be factored into a maintenance schedule.

PLATE 16 – Wetpour safety surface having lifted from the culvert floor washed away and covered with silt (photographed late 2007).

PLATE 17 – Decomposing 'furniture' in the East Evelyn fauna underpass (photograph late 2007).

Fencing utilised to funnel fauna can be damaged by wind, airborne objects or falling branches thereby negating its efficacy.

4.0 ANALYSIS OF THE ROAD ENVIRONMENT IN THE STUDY AREA

Biotropica (2008) noted that although their study considers habitat continuity for the southern cassowary, it did not identify individual birds and their utilisation of existing linkages in the Wongaling area and consequently, the density of cassowaries and their utilisation of the resources in nominated areas, was not discussed. Their report therefore assumed that cassowaries are using all of the areas identified to some degree, including the Habitat Linkages identified. Similarly, the current study assumes that Connectivity Gaps identified by Biotropica are being crossed by cassowaries to some degree (this assumption is partly supported by sighting data as illustrated in Figure 2). Biotropica (2008) identify a number of management tools that will be required to achieve security and functionality across all linkages, including hard and soft engineering at Connectivity Gaps and also make the general recommendation that appropriate wildlife crossing points should be developed where Habitat Linkages are affected by roads.

Assuming that each Connectivity Gap is potentially important to cassowaries and that hard and soft engineering is required at each, it was necessary to conduct a field trip specifically to assess the landform and existing landscape features at each. A field trip was conducted on 10 June 2008 during which the study area was traversed largely on foot.

Each Connectivity Gap described by Biotropica (2008) was examined, in addition to other areas where there have been known cassowary crossings (Moore & Moore, 1999), where a fauna crossing could be potentially established and those locations where a change in road management may benefit cassowary/road interactions. Each location/feature was recorded on a hand held GPS (see Figure 5), photographed where relevant and described. Table 5 below summarises the findings.

Table 5 – Analysis of features associated with roads in the study area

Location	Associated Connectivity Gap	Description	Image	Discussion regarding feature
A	To the south of CG6	80cm diameter pipe	 PLATE 18  PLATE 19 – Vegetation upstream of pipe	There is some forest connectivity either side of the road. It is not identified by Biotropica (2008) as a CG within a Habitat Linkage. It is likely the current pipe provides little opportunity for fauna movement. No need for immediate action, however if road upgrades in the future present an opportunity to upgrade, it would be desirable to install a taller (up to 3x3m) culvert with a dry cell passage plus appropriate guide fencing / rehabilitation.
B	To the south of CG6	80km/h speed limit sign indicating change in speed limit from 60km/h. The balance of the road through to El-Arish Mission Beach Road remains at 80km/h.		If signage was moved to the north of CG6 (approximately 350m north of its current location) then speeds in a critical crossing, also identified by Moore and Moore (1999), would be reduced thereby enhancing breaking distances. Speed limits would require enforcement.

C	CG6	Culvert entirely under water, near a bikeway and underneath power line.	 **PLATE 20 – Culvert immersed in water**	 **PLATE 21 – The low grade of the road in this location. View southwards along the 'bicycle path'. Note the powerlines on the western side of the road.**	Culvert unlikely to support the passage of any terrestrial species. Very little scope to increase culvert diameter without significant raising of the road. Vegetation to the immediate east is comprised of a narrow strip between the road and urban allotments.
D	CG6	A four cell culvert approximately 80cm tall. There is a major drop off to the eastern side. The surrounding downstream area is currently being rehabilitated.	 **PLATE 22 – Four cell culverts**	 **PLATE 23 – Looking northward along the 'bicycle path'. Note the drop to the east of the culvert's concrete apron.**	The cells might provide some movement opportunities for small terrestrial species. Given the lower creek profile on the eastern side of the crossing, it would be possible to increase the height of the culvert cells by dropping the upstream creek profile whilst not compromising the current road profile. It appears possible that large (≥3x3m) box culverts could be installed in this location that may facilitate the movement of some fauna, not necessarily cassowaries. Tenure and land planning on either side of the culvert secures the long term protection of vegetation in this location.

E	In vegetation associated with CG6	80cm diameter pipe	 **PLATE 24**	The pipe drains from the front of vegetated rural residential lots on Mission Circle. Given its dry nature, it is possible that it might provide some passage for small terrestrial fauna. Its value would be enhanced if its diameter were increased; however given the existing profile of the road it is unlikely that a wide culvert could be accommodated without significant rising of the road profile.
F	At the immediate northern edge of vegetation associated with CG6	A road cutting	 **PLATE 25 – Looking westward over the cutting toward the proposed urban subdivision. The vegetation on the left of the photo is at the rear of rural residential properties.**	Given the profile of the road, this location would represent a suitable location for a land bridge. However, areas to the west of the road are subject to a proposed urban subdivision and therefore a land bridge is unlikely to be viable in this location.
G	To the south of CG5	Pipe with a small diameter	 **PLATE 26**	It is unlikely the culvert would provide reasonable passage for any terrestrial fauna. The proposed urban subdivision at the western edge of the pipe precludes it's viability in future upgrades.

H	CG5	Four cell of pipes 1.2m diameter. There is a major drop off downstream.	 **PLATE 27 – Eastern outlet of pipes**  **PLATE 28 – Western intake**	The existing cells might provide some movement opportunities for small terrestrial species. Given the lower creek profile on the eastern side of the crossing, it would be possible to increase the height of the culvert cells by dropping the upstream creek profile whilst not compromising the current road profile. It appears possible that large (≥3x3m) box culverts could be installed in this location that may facilitate the movement of some fauna, not necessarily cassowaries.
I	To the north of CG5	Nearby pipe approximately 30cm in diameter. The terrain is flat.	 **PLATE 29**	Although not identified by Biotropica (2008) as a Habitat Linkage or CG, it was identified by Moore and Moore as a crossing point. The pipe is inconsequential to any fauna as most crossings would be made at grade. Some signage as recommended by Moore and Moore (1999) in this location has been installed, however other measures have not. An underpass in this location would require substantial modification of the road grade and a land bridge could potentially affect adjacent existing buildings.
J	To the south of CG5	Inaccessible pipe of small (approximately less than 1m diameter). Wet at the time of investigation.	 **PLATE 30**	As above.

K	CG1	Advisory speed limit sign (60km/h in an 80km/h zone) to the immediate west of the Wongaling Creek crossing. Overhead powerlines.	 **PLATE 31**	It would be favourable if this area were 50km/h. There are overhead wires/cables at the Wongaling Creek crossing (CG1). Consequently a wide swathe below the wires is cleared of native vegetation and overrun by Guinea grass. If the wires/cables were undergrounded or bundled, the area could be revegetated to enhance habitat connectivity.
L	CG1	Crossing of Wongaling Creek.	 **PLATE 32 – West bank.**  **PLATE 33 – East bank of Wongaling Creek.**	The rank exotic grass plus the steep unvegetated grades of the Wongaling Creek crossing severely limits its value to cassowaries. Enhancement similar to those at the Tully Mission Beach Road crossing of the North Hull River would be achievable in this location.
M	To the east of CG1	Crossing at grade.	 **PLATE 34 – Level crossing. Note the broad well maintained clear zone on the northern edge of El-Arish Mission Beach Road.**	Although not identified by Biotropica (2008) or Moore and Moore (1999) as a Habitat Linkage/ Connectivity Gap or Crossing Point respectively, there has been cassowary activity/crossings in this area (See Figure 2). Little opportunity exists for underpass or land bridges in this location, however there are opportunities for traffic management.
N	To the east of CG1	60km/h speed limit sign, restricting speed on traffic entering Mission Beach.		Locating the 50km/h sign to the west of Wongaling Creek (approximately 900m to the west of its current location) would significantly reduce travelling speed and hence breaking distance.

5.0 POTENTIAL MITIGATIVE MEASURES

5.1 PHYSICAL MEASURES

The current investigation aims to identify several different measures to mitigate cassowary and other fauna road mortality. Table 6 below identifies several measures that could be adopted. Most measures prescribed for cassowaries will work equally well for other fauna species, conversely there are some measures that would not be suitable for cassowaries.

There is no single preferred solution to address cassowary road mortality amongst the measures presented. However, given ongoing cassowary road mortality in Mission Beach, it is preferential that an integrated solution is adopted. This is discussed in Section 6.0.

Table 6 – Physical measures to mitigate cassowary and other fauna road mortality

Measure	**Description / Potential Locations (refer to Figure 5)**	**Discussion**
Reduce speed limit from 80 to 50km/h	Preferentially, the entire study area would be 50km/h. Alternatively, the 80km/h zones should be reduced by increasing the area subject to a 50km/h speed limit associated with Locations N & B (corresponding with CG1 and CG6 respectively).	It is understood that the speed limit with the study area is set by QDMR guidelines and changing the speed limit for the entire area on a QDMR road may be unlikely. However, changing the speed environment through utilisation of roundabouts at key intersections may achieve this outcome. It is understood that to create a speed environment of 60km/hr, roundabouts are needed approximately every 1.5km. Increasing the length of road in the 50km/h zone has the potential to significantly reduce driver speed and hence improve breaking distances in two CGs. The shifting of the speed zones by 350m to the north for CG6 and 900m to the west for CG1 will only increase current travelling times by 9.28 and 23.8 seconds respectively. As it is likely that drivers might ignore a speed limit of 50km/h, the use of fixed speed cameras associated with CG1 and CG6 might encourage compliance. The use of roundabouts in key locations may also slow drivers in these areas.
Integrate psychological traffic calming measures	Integrate psychological traffic calming measures as illustrated in Figure 4. These could potentially be applied at the following Locations: ▪ Between Locations C and F (covering CG6); ▪ Location H (covering CG5); ▪ Location I; ▪ Location M; and ▪ Location L (covering CG1).	Psychological traffic calming measures are a relatively cheap way to manage driver behaviour. However, QDMR (2001) also note that its effectiveness can wear over time because regular drivers can become familiar with the modified pavement. It has been noted that recent research is not indicating a great deal of effect for some of these psychological measures (*pers comm.,* Goosem, 2008). See section 5.2.1 below regarding the utilisation of vegetation for psychological traffic calming.

Increase culvert diameter to accommodate larger fauna - but not necessarily cassowaries.	Upgrade existing narrow culverts to accommodate movement opportunities for fauna at Locations A & E. Given the value of these points (i.e. not mapped at CGs) the aim would be to accommodate movement opportunities for fauna other than cassowaries and larger macropods. Australian Museum Business Services (2001) had reported that wallabies had traversed box culverts 2.4 x 1.2 is size. This might be the minimal size that is effective and hence taller culverts are preferred.	Without major lifting of the road profile it is unlikely that a culvert of the proportions potentially suitable to allow passage by a cassowary is possible in these locations. It is likely that raising the road profile might have flow on affects to safety associated with the intersection with Mission Circle. The diameter of culverts to their maximum dimensions to enable crossing by terrestrial fauna should be undertaken as future road works permit. Minimum culvert height should be 1.2m and there need to be provision for dry cell passage. The underpass would need to be associated with appropriate guide fencing and landscaping. The culvert would need to provide for dry passage.
Recontour banks and revegetate to facilitate cassowary movement along Wongaling Creek	This is specific to Location L (covering CG1) at the crossing of Wongaling Creek by El Arish - Mission Beach Road. Rank exotic grass will need to be removed and replaced with appropriate vegetation that would not interfere with QDMR frangibility concerns. One or both banks should be recontoured and landscaped to allow for graded passage under the bridge.	This can be undertaken with relatively little expense. This has been undertaken at the crossing of the North Hull River by the Tully-Mission Beach Road for approximately $3,500 (see Appendix B). It would be necessary to ensure that recontouring and landscaping will not affect the hydrology of the creek and that downstream areas were unaffected. Preferably this would need to be associated with appropriate guide fencing to maximise utilisation by cassowaries. Considering the importance of this crossing, consideration should be given to removing fill on the approaches to the bridge and significantly lengthening the span of the bridge so that cassowaries have more than just a narrow dry ledge, but also vegetated areas that provide continuity of habitat. The application of aerial bundle cabling or undergrounding of powerlines in this area will allow for the establishment of more effective revegetation which would otherwise be constrained by the existing lines.
Fencing to prevent crossing and guide to crossing structures	As these would be employed to guide fauna to crossing infrastructure the ultimate placement will be infrastructure dependant.	Fencing might be similar to that illustrated in Plate 7, although the area of clear space at the bottom would need to be reduced (or eliminated if other fauna species are to be guided). These fences are however not aesthetic and may detract from in a key tourism area. Conversely, fencing could be designed that has improved aesthetic qualities and be highlighted as an ecotourism feature. There is a need to test and monitor fence designs for effectiveness.

Dedicated fauna underpass	Both Location H and D (CGs 5 and 6 respectively) can be upgraded to accommodate wider and taller box culverts. It appears that the existing topography would allow the installation of large ($\geq$3x3m) culverts in these locations.	The introduction of large ($\geq$3x3m) box culverts would require substantial earthworks within the stream and would therefore require subsequent revegetation. Clear vision of rainforest habitat should be provided through the underpass. There needs to be the provision of dry cell passage. Ideally this would be achieved through the use of an elevated culvert. The alternative would be to raise the floor through concreting the entire culvert width or providing an elevated platform (see Plate 1 for an example). The crossing would require the use of guide fencing for a considerable distance either side of the crossing. Given the likely peak flows in the culvert it is unlikely that an earthen floor can be employed. The previous use of Wetpour safety surface at Stoney Creek has had mixed success in terms of its longevity. Alternative flooring solutions may need to be considered. It has been estimated that the costs of these in addition to directional fencing would be approximately $250,000 at each location. Van der Ree *et al.* (2007) provided two examples of the costs of 3x3m culverts in NSW at $225,000 and $334,900. Although culverts have been shown to be effective for some species (Van der Ree *et al.*, 2007), potential effectiveness of culverts for cassowaries has not been determined. Moore (*pers comm.*,, 2008) notes that cassowaries are sometime deterred by the 'bulkiness' of overhead structures and Goosem (*pers comm.,* 2008) notes that there is insufficient evidence to suggest that 3x3m culverts are likely to be effective as underpasses for cassowaries - as it is known that where such structures are present, the road surface is still being used as a crossing route. The culverts are nonetheless likely to provide passage for other fauna.
Rope bridges / canopy connectivity – not a measure for cassowaries	For the benefit of arboreal mammals canopy connectivity or rope bridges for the following Locations: ▪ Location D (covering CG6); ▪ Location H (covering CG5); and ▪ Location L (covering CG1).	Relatively narrow rope bridges in these locations may facilitate the movement of arboreal fauna such as the Striped Possum. Care would need to taken not to interfere with the existing 22kV feeder line along the Tully Mission Beach Road. Van der Ree *et al.* (2007) reports that the cost of retrofitting a rope bridge of 100m in Victoria was $70,000 - $80,000. Three rope bridges installed on Compton Road in Brisbane costed $130,000 (Selles, 2008). Given the lengths required on the Tully Mission Beach road are substantially less than these examples, it is assumed that the cost would also be less.

		A preferential alternative to rope bridges is to facilitate the reconnection of tree canopies through replanting and ceasing to mow in some locations. The proximity of trees to the road may also assist in slowing travelling speeds. However, it is likely that this would significantly interfere with QDMR's clear zone requirements. Furthermore, areas under canopy will be darker and hence less visible and there is the possibility that these areas would become damp and slippery. If canopy connectivity was desired, it is likely that rope bridges will need to be installed as an interim measure whilst vegetation establishes. There is a need to establish which arboreal species are common in the vicinity prior to embarking on the establishment of rope bridges. This may include collection of roadkill data as part of the assessment process.
Land bridge	The assessment of an existing cutting at Location E indicates that a land bridge is not suitable in the location. Alternative locations for the land bridge might be considered at Locations I, H (CG5) and D (CG6) given these are the areas with best connectivity to adjacent vegetation.	Land bridges in these locations would require considerable earthworks and result in impacts on adjacent vegetation. It would also be necessary to locate the bridges outside of waterways. The land bridges could potentially limit future road duplications, if at some stage they are deemed necessary. Similarly pedestrian paths and cycleways could be potentially blocked unless channelled under the bridge. Despite the negative attributes, land bridges have been shown to cater for the movement of a broad suite of native fauna and it is anticipated that with appropriate fence channelling and rehabilitation that they would cater for cassowaries. The land bridge at Compton Road, Brisbane covering a dual lane road cost $1,385,000 (Selles, 2008). This cost excludes guide fencing.
Elevated road	Elevating the road to the point that would allow cassowaries to pass freely beneath it might be considered at locations H (CG 5) and D (CG 6).	This approach, recommended by both Moore and Goosem (*pers comm.,* 2008) and adopted as a strategy for the Kuranda Range Road (Environment North, 2004), would allow unencumbered movement by cassowaries and other fauna. Fauna may need to be funnelled to these locations through the use of guide fencing. Although exact design specifications must be considered in consultation with cassowary ecologists, initial indications are that the elevated road should be at least 3m from the existing ground surface (to bottom of road) for a minimum length of 20 metres (shorter distances are too enclosed). The undercarriage of the elevated road structure is likely to require insulation against traffic noise. Bridge costs are approximately $3,000/m^2 (*pers comm*., Breen, 2008).

Scientists monitoring the movement of fauna across the land bridge constructed on Compton Road in Southeast Queensland were surprised to observe the rapid utilisation of the structure by macropods. They attributed this behaviour to the abundant green pick present on the land bridge after construction compared to surrounding forests (Jones & Veage, 2007). It might be possible that the tendency of cassowaries to become habituated to human sources of food (NRA, 2006) could be exploited to encourage their rapid utilisation of constructed crossing infrastructure. That is, it might be possible to initially ‘bait’ paths through infrastructure to encourage movement, but this could only be used with carefully designed fencing and by provision of food when birds are not within sight to avoid habituation (or further habituation) to humans. However, Latch (2007) notes that hand feeding at roadsides can result in subsequent road strikes. The possibility of ‘baiting’ paths would therefore need to be subject to further debate regarding its suitability.

All of the measures identified in Table 6 will require considerable monitoring effort prior to and post construction. “Before” studies are necessary to confirm the proposed measure is located in the correct position and is appropriately designed for the fauna species utilising the area. Post construction monitoring is vital to determine the efficacy of measures. An “adaptive management” approach will not only result in the improved design of future measures, but also provide scientific feedback to inform the refinement of existing constructed measures. Therefore, monitoring programs must be detailed and long term (Van der Ree *et al.*, 2007). Monitoring is likely to require a range of techniques (e.g. photo traps, sand traps etc) to target cassowaries and assess the efficacy of measures for other fauna. It might be possible that community organisations can participate with some monitoring activities (e.g. monitoring roadkill, cassowary scat collection).

5.2 ADDRESSING DRIVER BEHAVIOUR

5.2.1 Roadside management

Currently QDMR contracts Council or others to slash roadsides. QDMR serves a work order on Council to slash when grass gets as high as guide posts (approx 500mm). If the intervention level was changed to serve a work order when grass is 300mm high, visibility of wildlife on the side of road would be improved and roadkill might be reduced. This would probably result in slashing 6 times/year rather than the current 4 times/year and is therefore likely to be a relatively low cost method of increasing visibility for drivers.

Although slashed road verges increase visibility of cassowaries it also reduces habitat connectivity across the road for other species that are part of the biodiversity significance of Mission Beach and may possibly create an environment where people are more likely to drive faster. An intermediate response for the road verge environment may be to encourage canopy closure over the road and facilitate an open understorey using shade-tolerant, low natives and removing seedlings, saplings and lianas. This would be in keeping with QDMR's best practice guidelines as outlined in Section 3.3.1. However, it has been noted that roads under canopies do not dry out which can cause structural problems. Furthermore, less light under the canopy may make it harder to see cassowaries and there is concern regarding limb drop onto roads. Given this, more work is needed on roadside vegetation management and any on ground work needs evaluation and monitoring.

5.2.2 Discouraging driving

Another approach to reduce cassowary road mortality at is to encourage people to walk and cycle rather than drive, thereby reducing the number of cars on the road.

Planning for bikeway routes in Mission Beach includes two key documents:

- Map 16 'FNQ Cycle Network' of the FNQ2025 Draft Regional Plan (QDIP) identifies the Study area as a cycle route; and
- Map PN-20 'Preliminary Principal Cycle Network' of the Draft Principal Cycle Network Plan for Far North Queensland (Carndno Eppell Olsen, 2007) identifies the Tully-Mission Beach Road as a Future Principal Route. Principal routes are those described as catering for cycling trips within and between urban centres.

Implementation of the plans outlined above would reduce traffic levels on the Tully-Mission Beach Road. Less traffic is also likely to be appealing to tourists and bikeways also protect village atmosphere.

It is noted during field work that the current 'bikeway' is in state of disrepair and is hazardous in some locations (see Plate 23). Rectification of the path would also need to consider how it interfaces with potential cassowary crossing measures. Integrating cassowary and pedestrian crossings would not be an appropriate outcome based on the Recovery Plan objectives (Latch, 2007) and best practice fauna crossing design (Van der Ree *et al.*, 2007). Where cycling paths cross over underpass structures it would be desirable to construct the path out of a material that allows the permeation of light.

Improved public transport in the Mission Beach area could be employed as another measure to decrease car trips. The mechanisms behind this including funding, public education etc require further investigations.

6.0 POTENTIAL INTEGRATED SOLUTION

6.1 ASSESSING APPROPRIATE LOCATIONS FOR CROSSING MEASURES

Moore & Moore (1999) noted that in order to design a management solution which allows both cars and cassowaries to co-exist with minimal conflict, it is necessary to understand:

1. Where are the crossing points and how wide are they?;
2. What are the cassowary home ranges as they relate to the road?;
3. Why are cassowaries crossing (feeding, breeding or water access)?; and
4. How frequently do individual cassowaries use the crossing point and what is its importance within the context of local cassowary population dynamics.

Considering the above, it is known that cassowaries have been sighted in many locations within the study area (see Figure 2) and that crossings points have previously been identified (Moore & Moore, 1999) (Figures 3). However, the Moore & Moore data (and subsequent studies) is likely to be outdated and may have changed as a consequence of Cyclone Larry. Currently James Cook University is revisiting this information through Les Moore and Dr Miriam Goosem (as outlined in Section 1.3). This work is partly funded by an EPBC offset condition of development approval in the study area and QDMR. Once this data is attained, a definitive assessment of potential crossing infrastructure can be made.

6.2 SELECTION OF APPROPRIATE MEASURES

Although a number of options have been outlined in Section 5.0, combining these as an integrated solution is difficult at this stage. In the absence of current information regarding cassowary crossings in the study area, the selection of measures can only be based on previous known cassowary crossings, plus the Connectivity Gaps identified by Biotropica (2008) to act as surrogates. As such, any measures proposed herein must be revisited once studies regarding current cassowary crossings are completed. Furthermore, the measures considered are based on current knowledge and understanding of local fauna and other preferred options may come to light in future.

The selection of measures must meet two fundamental ecological objectives:

1. Cassowary road strike is mitigated; and
2. Habitat in Reserve 214 is accessible by cassowaries and other fauna utilising the broader habitat network.

These objectives must be achieved within the context of an existing road and reasonable cost parameters. Therefore, closing the road or tunnelling the road is unlikely to be a viable solution, although they would meet the objectives. Conversely, signage may be cost effective but will not achieve Objective 1.

There is no research that demonstrates culverts are a viable measure for facilitating the safe passage of cassowaries across roads. However it is recognised that bridge structures allow the safe passage of cassowaries (Environment North, 2004).

There is evidence that indicates road collisions with fauna are reduced when vehicles travel at slower speeds. It understood that without either physical measures in place to slow vehicles or without ongoing speed limit enforcement in place drivers will continue to speed. A change in the speed environment is therefore likely to require a physical change to the road such as integration of roundabouts. Conversely, the speed environment might not be affected if vehicles were separated from crossing points by elevating the road structure.

The road through the study area is on relatively flat terrain. The road also provides access to a number of side streets (Mission Circle, Stephens Street and Kent Close), direct access to a number of existing properties and a proposed subdivision. The combination of terrain and property accessibility issues makes it difficult to integrate elevated road structures along the full length of the road.

One approach that is likely to achieve the objectives, plus consider accessibility issues is illustrated in Figure 6. The elevated road platform is further detailed conceptually in Figure 7. This approach is based on the following considerations:

- Current research indicates that cassowaries do not like moving through culverts;
- Elevated road structures are regarded by researchers as the best approach to facilitate the movement of cassowaries;
- Vehicular accessibility to properties within the study area should not be compromised;
- An elevated road structure in the vicinity of Stephens Street would compromise vehicular accessibility to the area. This area has previously been identified as a cassowary crossing and requires suitable mitigation measures although Biotropica (2008) consider this linkage is of lesser value to fauna than some others. Although signage has been installed in this area, cassowary road strikes have continued – it therefore seems psychological measures may not be appropriate for this location. A land bridge has therefore been recommended for this area;

- Ropeways may benefit arboreal species if they are found to be active in the area. The establishment of a closed canopy over the roadway may be difficult to achieve where the roadway is elevated and/or take considerable time; and
- Relatively minor additional work is required at the crossing of Wongaling Creek and El Arish – Mission Beach Road, similar to that undertaken at the North Hull River.

The major measures incorporated in this approach include the elevated road structure, the land bridge, ropeways and an enhanced crossing at Wongaling Creek. These major measures are listed in Table 7 below along with a broad estimate of costs.

Table 7 – Broad estimates of costs associated with major elements of one approach to integration of mitigative measures in the study area

Measure	Basis for broad estimate	Estimate
Elevated Road Structure	Based on construction costs of $3,000/m^2 and the approximate surface area of the two lane bridge is 7,896m^2 (based on 8.4m pavement width plus 0.5m for rails = 9.4m overall width and length of approximately 840m).	$23,688,000
Land Bridge	The land bridge at Compton Road, Brisbane covering a dual lane road cost $1,385,000. Given this is a large land bridge spanning 4 lanes of traffic and was recently constructed, it may serve as a good example to estimate costs.	$1,385,000
Ropeways	Three potential rope bridges have been identified. Three rope bridges installed on Compton Road in Brisbane costed $130,000	$130,000
Enhanced Crossing at Wongaling Creek	Previous work North Hull River by the Tully Mission Beach Road costed approximately $3,500. This work was undertaken some time ago and work required for Wongaling Creek may be more extensive than the North Hull River. Given this, an estimated amount of $10,000 might be considered.	$10,000
TOTAL		**$25,213,000**

This figure clearly does not cover all costs associated with the potential measures identified in Figure 6. Amongst other things the overall costs must consider, the relocation of the local road to the west, the integration of traffic calming to the relocated road, potential resumptions, the construction of a roundabout, the establishment of new access to adjoining lots and streets, the establishment of guide fencing and the cost of revegetation. It also does not consider integration of ancillary works such as bikeways.

This approach of course represents only one option that might be considered following completion of current investigations of cassowary crossings in the Wongaling area. However, it is costly and is likely to cause disruption to traffic, adjacent land holders, pedestrians and fauna during construction. There may be alternative solutions utilising untested measures, such as the extensive use of guide fencing to dedicated crossing structures, which might be considered following completion of current investigations of cassowary crossings. Furthermore, the integration of bikeways may also partly reduce traffic levels – the location of these can only be determined once the location of fauna mitigation structures measures has been established.

As previously discussed, any constructed work will also require considerable monitoring and application of an adaptive management approach. This will not only result in the improved design of future measures, but also provide scientific feedback to inform the refinement of existing constructed measures. Monitoring will also provide an opportunity to consider the cost - benefit of measures. Cost - benefit analysis calculations are complicated and require an understanding of the cost of mitigation measures and their benefits to target species. Van der Ree *et al*. (2007) listed some of the critical variables that should be considered as part of a cost-benefit analysis.

7.0 IMPLEMENTATION

Although cassowary mortality continues to occur as a result of road strike, current levels of planning indicate that large habitat areas will remain intact. The FNQ2025 Draft Regional Plan (QDIP, 2008) identifies most habitat and corridors at Mission Beach as high ecological significance (Map 5: FNQ areas of ecological significance) and excludes most habitat and corridors (along with rural land) from the Urban Footprint (Map 3g: Tully/Cardwell regional land use categories). The plan also notes the following:

- p34 “These areas (Mission Beach) are not considered appropriate for high density urban development”;
- p63 “Growth in Mission Beach will be contained to ensure the natural values of the area will be protected”; and
- p112 Regarding transport development, “the significant biodiversity and scenic values of Mission Beach are recognised”.

It is noted during the preparation of this report; the Federal Environment Minister rejected a development application in the immediate study area (i.e. located on Biotropica’s Habitat Linkage 6) because of impacts on cassowary movement corridors.

Given the commitment to protect habitat, measures to facilitate safe passage of fauna over roads appears justified.

To successfully mitigate cassowary road mortality in the study area it will be necessary to implement a combination of measures identified in Section 5.0, possibly through an integrated approach such as that identified in Section 6.0. These options however are based on current knowledge and understanding, other options may come to light in future that are preferred. Some of these measures may also have flow on benefits for the community and tourism as well as for fauna. For example, if implemented in an integrated manner, there is the potential to improve aesthetics in a highly visible part of Mission Beach, unify Mission Beach where it was previously divided by the old Cardwell/Johnstone Shire boundary and focus on the geographic centre of Mission Beach. That is, it could be implemented as a project to showcase the new united Mission Beach. An approach that integrates crossing structures, cycling and pedestrian paths, public transport, landscaping as well as a reduced speed environment could be managed through a master planning approach.

Implementation would potentially be costly and may result in some traffic disruptions during construction. Given the potential expense of implementation, a number of points should be considered:

- Would funding be better applied to protecting and restoring habitat away from roads (e.g. through a Trust for a strategic regional cassowary conservation initiative)?
- Would reducing the overall speed of the road to 50km/h significantly reduce mortality?
- Who pays?

As noted earlier in this report, 67% of the known cassowary population at Mission Beach crosses the major access roads of El Arish to Mission Beach, Tully to Mission Beach, Wongaling, and South Mission Beach Roads. Thus two-thirds of the cassowary population are at constant risk of road death (*pers comm.,* Moore, 2008). The Wongaling area is known to be utilised by cassowaries and has been an important component of their home range. There is a need to establish how much Reserve 214 is currently being used by cassowaries and could be used if conflicts were resolved. Once this is established, the need to maintain and restore connectivity to Reserve 214 and provide safe cassowary crossings in the study area can be categorically acknowledged. In any case, protecting connectivity between the Wet Tropics World Heritage Area, R214 and the Great Barrier Reef World Heritage Area will help protect a range of significant values including World Heritage values.

Reducing the speed of vehicles travelling in the study area could significantly reduce road kill. There are certain requirements for reducing speed limits on a Main Road. Gazetting the road as a Local Road might allow greater control with regard to traffic calming. To be effective, speed limit reduction needs to be undertaken in conjunction with education, policing and changes to the road environment including traffic calming (e.g. roundabouts). Appropriate roadside plantings providing canopy closure could help calm traffic as well as protect the unique aesthetic and lifestyle values of Mission Beach.

Some of the major infrastructure measures proposed, such as an elevated road structure, could be funded partly through EPBC development approval offset contributions[4]. As implementation of such measures may not be QDMR core business, it may be appropriate that 'smart partnerships' are established through an MOU. For example, the DEWHA may play a lead role and facilitate implementation

[4] It may be reasonable and relevant, given the recognition of the impact of traffic on cassowaries at Mission Beach and the fact that all traffic at Mission Beach will pass through cassowary habitat that any development proposal that generates additional traffic should contribute to offsets under the EPBC Act.

of specific measures through a developer or an offset contribution fund. There are many agencies that need to be involved in the planning, funding and implementation of appropriate mitigation measures including, amongst others QMRD, Terrain, Council, DEWHA, Queensland Transport, EPA, James Cook University, community groups, development and tourism industries. The role of each agency will of course differ, for example QDMR may play a role in design, construction and potentially funding, James Cook University may assist with planning and monitoring and community groups may be involved with programs such as 'Adopt a Road' to play a valuable role in ecological restoration and some aspects of monitoring.

The required work is likely to require considerable funds. This is unlikely to be fully sourced through EPBC development approval offset contributions nor should it be because traffic and road kill are also caused by historic approvals. Implementation base funding should be attained from National and State government, considering the National and State significance of Mission Beach biodiversity including cassowaries.

REFERENCES

Australian Museum Business Services. (2001). Fauna underpass monitoring stage one – final report – Brunswick Heads. Prepared for the RTA.

Biotropica. (2008). “Wongaling Creek Habitat Linkages”. Prepared for Terrain NRM.

Breen, J. (2008). Pers comm., Discussion with Mr John Breen of Queensland Department of Main Roads.

Burgoyne, AJ. (2008). Pers comm., Comments on draft Wongaling Corridors Fauna Crossings report from Ms Alison Burgoyne of Queensland Department of Main Roads.

C4 Webpage reviewed on 13/9/07 http://www.cassowaryconservation.asn.au/

Cardno Eppell Olsen. (2007). “DRAFT - Principal Cycle Network Plan for Far North Queensland”. Prepared for Queensland Transport and the Department of Main Roads.

Chenoweth Environmental Planning and Landscape Architecture. (2003). “Ecological Corridors and Edge Effects Project”. Prepared for Brisbane City Council.

Coulson, GM. (1982). Road kills of macropods on a section of highway in Central Victoria. Australian Wildlife Research. 9:21 – 26.

Department of Main Roads. (2000). Fauna Sensitive Road Design - Volume 1: Past and Existing Practices. Department of Main Roads.

Dique, D., de Villiers, D., Thompson, J., Preece, H., Penfold, G. & Leslie, R. (2002). The impact of differential speed signs on koala mortality on roads in southeast Queensland. Queensland Parks and Wildlife Service.

Environment North. (2004). Integrated Transport Study For Kuranda Range Impact Assessment Study Impact Assessment Study Addendum (Draft).

FNQ NRM Ltd & Rainforest CRC. (2004). Sustaining the Wet Tropics: A Regional Plan for Natural Resource Management 2004–2008. FNQ NRM Ltd, Innisfail (208pp).

Gardyne, W. (1995). Cleveland-Redland Bay Road Duplication – Koala issues. Unpublished report. Queensland Department of Transport, Transport Technology

Division. In Department of Main Roads. (2000). Fauna Sensitive Road Design - Volume 1: Past and Existing Practices. Department of Main Roads.

Goosem, M., Weston, N. and Bushnell, S. (2005). Effectiveness of rope bridge arboreal overpasses and faunal underpasses in providing connectivity for rainforest fauna. In: Proceedings of the 2005 International Conference on Ecology and Transportation, Eds. Irwin CL, Garrett P, McDermott KP. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC: pp. 304-316.

Goosem, M. (2008). Pers comm., Comments on draft Wongaling Corridors Fauna Crossings report from Ms Miriam Goosem of James Cook University.

Jones, DN. & Veage, L. (2007). Breaking the Barrier: Assessing the Value of Fauna-friendly crossing structures at Compton Road. Prepared for Brisbane City Council. Centre of Innovative Conservation Strategies, Griffith University, Brisbane, Qld, Australia.

Latch, P. (2007). Recovery plan for the southern cassowary *Casuarius casuarius johnsonii* 2007 – 2011. Report to Department of the Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Moore, L. (2008). Pers comm., Discussion with Les Moore of James Cook University and comments on draft Wongaling Corridors Fauna Crossings report.

Moore, LA. (2001). The cassowaries of Mission Beach: Population number, densities, distribution, demography and implications for conservation. Report commissioned by the Department of Main Roads. *In* Wet Tropics management Authority. (2006). Wet Tropics Coastal Cassowary Corridor Network – Strategic Priorities. Prepared for the Australian Rainforest Foundation.

Moore, LA. (2007). Population ecology of the southern cassowary *Casuarius casuarius johnsonii*, Mission Beach north Queensland. Journal of Ornithology. 148:357–366.

Moore, N. & Moore, LA. (1999). Conservation Roads – Fauna Friendly Roads in Environmentally Sensitive Areas. In the Proceedings of the Transport Corridor Management Conference.

Natural Resource Assessments. (2004). The Southern Cassowary (*Casuarius casuarius johnsonii*): Review of Ecology, Values and Threats in the Wet Tropics Bioregion, Queensland. Prepared for the Department of Environment and Heritage.

Natural Resource Assessments. (2006). Clump Point, Natural Values Assessment for NQ Clump Mountain Project Co-Op Society Ltd, September 2004.

Newhouse, N. (2003). The wildlife protection system: early successes and challenges using infrared technology to detect deer, warn drivers, and monitor deer behavior. Road Ecology Center eScholarship Repository John Muir Institute of the Environment University of California, Davis.

Queensland Department of Infrastructure and Planning. (2008). Far North Queensland Draft Regional Plan 2025.

Queensland Department of Main Roads. (1998). Roads in the Wet Tropics: Planning, Design, Construction, Maintenance and Operation.

Queensland Department of Main Roads. (2001). Cassowary Management Strategy – Tully-Mission Beach Road.

Queensland Department of Main Roads. (2002). Road Maintenance Code of Practice for the Wet Tropics World Heritage Area.

Ramp, D. and Croft, DB. (2006). Do wildlife warning reflectors elicit aversion in captive macropods?. Wildlife Research 33:583-590.

Selles, A. (2008). Brisbane City Council Wildlife Movement Solutions – Compton Road Upgrade Fauna Protection Measures. A presentation.

Terrain & CSIRO. (2008). Mission Beach Habitat Network Action Plan: Community Workshop Outcomes draft.

Wet Tropics Management Authority, (2004), Wet Tropics Conservation Strategy: the conservation, rehabilitation and transmission to future generations of the Wet Tropics World Heritage Area.

Wet Tropics Management Authority. (2006). Wet Tropics Coastal Cassowary Corridor Network – Strategic Priorities for the Australian Rainforest Foundation.

Trenerry, M. (ca1996). Native Mammals of the Mission Beach District (20km radius).

Van der Ree, R., Clarkson, DT., Holland, K. Gulle, N. and Budden, M. (2007). Review of Mitigation Measures Used to Deal with the Issue of Habitat Fragmentation. Prepared for the Department of the Environment and Water Resources.

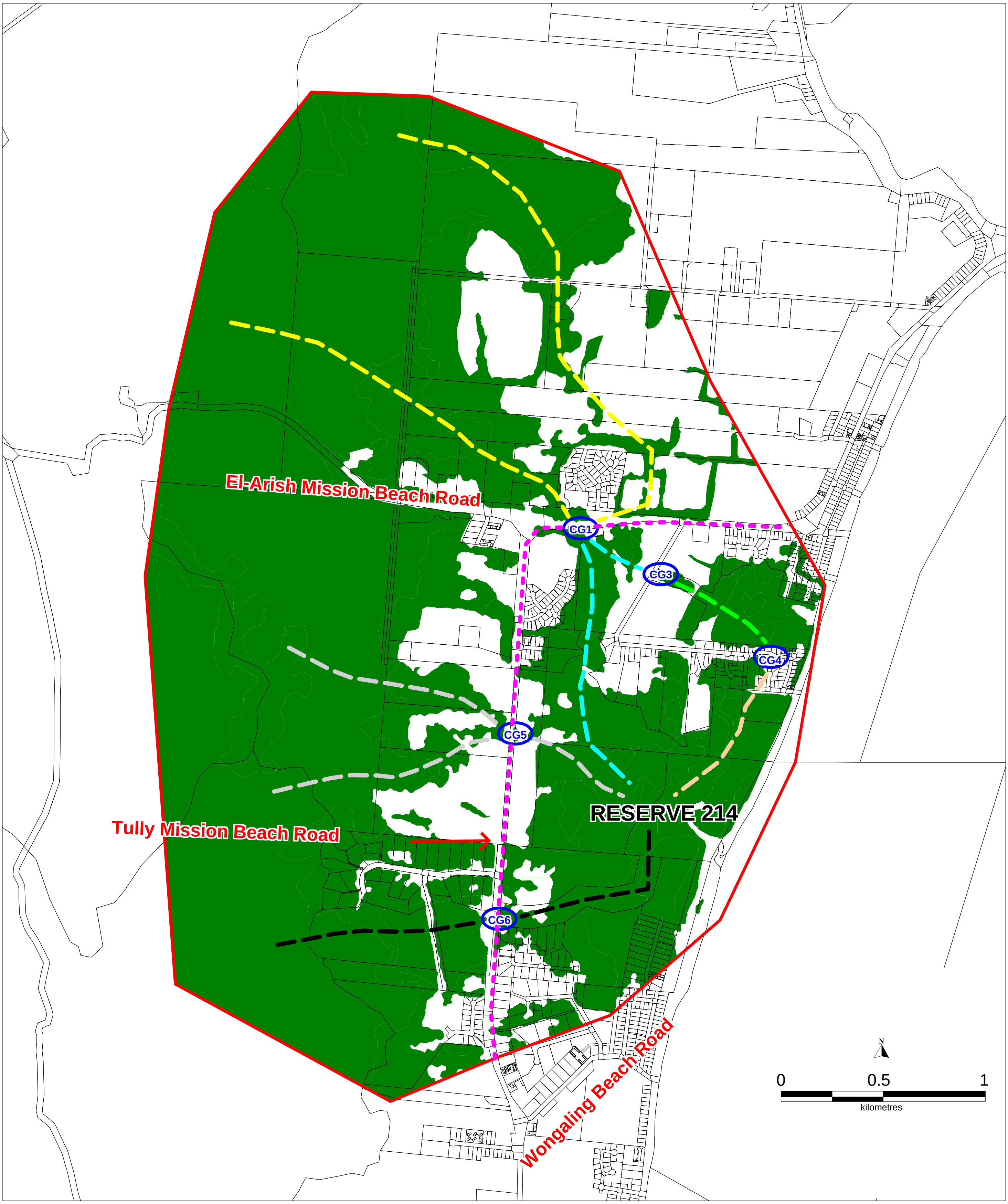
Weston, N. (2006). “Local Area Planning Approach to Mission Beach Cassowary Conservation Stage 1: Framework (DRAFT)”. CRC for Tropical Rainforest Ecology and Management, Cairns, QLD.

Weston, N. and Goosem, S. (2004). Sustaining the Wet Tropics: A Regional Plan for Natural Resource Management. Volume 2A Condition Report: Biodiversity Conservation. Rainforest CRC and FNQ NRM Ltd, Cairns (211 pp).

Williams, K., Hill, R., Pert, P. & Harding, E. (2008). Business as Usual Scenario – 2025 Land Use and Population Mission Beach and Surrounds. CSIRO

Worldwide Fund for Nature Webpage reviewed on 2/7/08 http://www.panda.org/about_wwf/what_we_do/species/about_species/species_factsheets/giant_panda/index.cfm

Yates, M. (2008). Pers comm., Discussed the Department of Main Roads monitoring of underpass structures with Mr Michael Yates of the Department of Main Roads.



LEGEND

- Study area
- CG Biotropica's Connectivity Points
- Focus Road
- Cassowary Critical Habitat (Biotropica, 2008)

Biotropica's Habitat Linkages

- Habitat Linkage 1
- Habitat Linkage 2
- Habitat Linkage 3
- Habitat Linkage 4
- Habitat Linkage 5
- Habitat Linkage 6

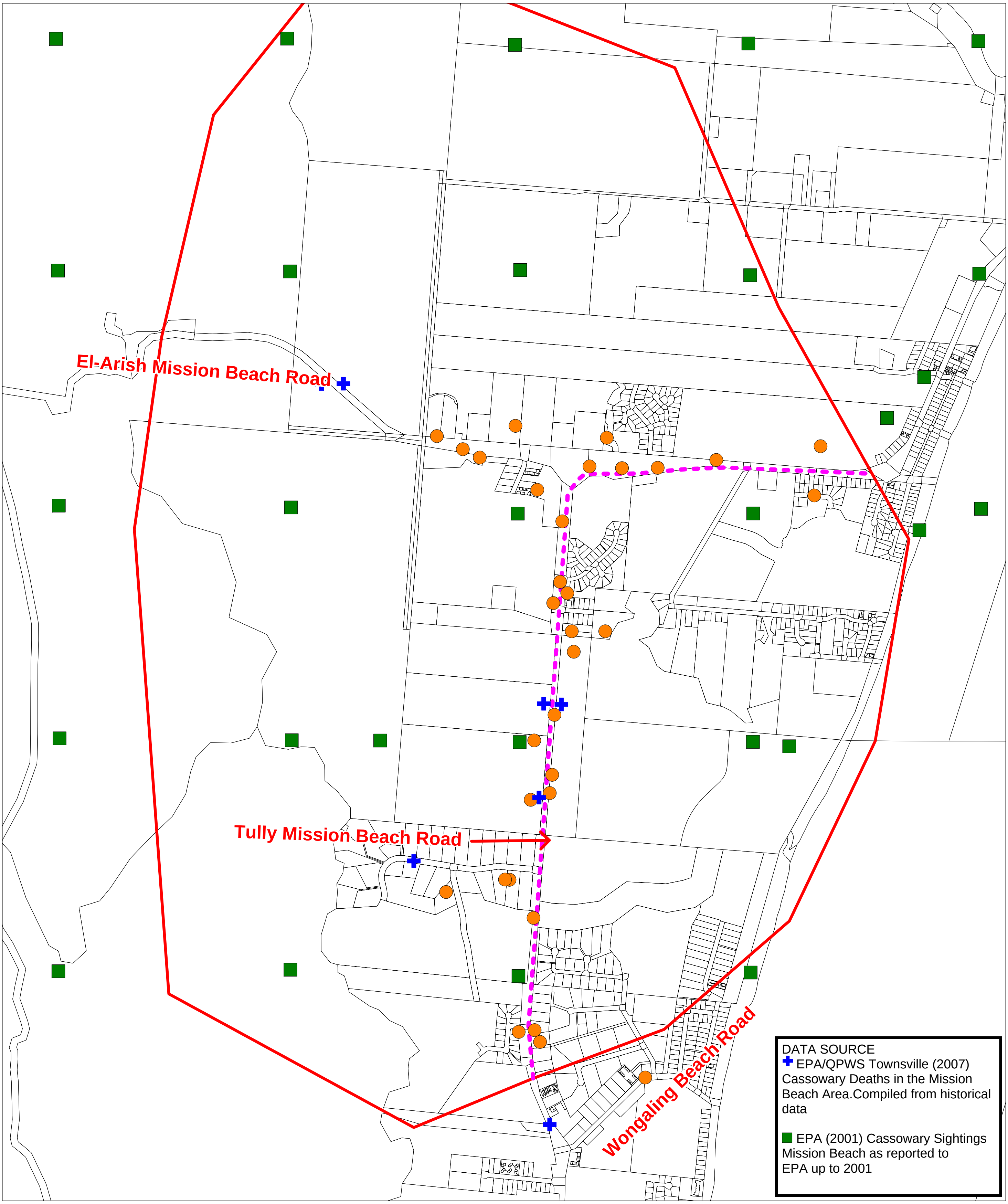
Wongaling Corridor
Fauna Crossings

Study Area

FIGURE 1

CHENOWETH
ENVIRONMENTAL PLANNING
& LANDSCAPE ARCHITECTURE

File: 088036_Figure1_Study area.WOR
Date: 4/7/2008
088036 Dwn: AP



LEGEND

- Study area
- C4 recorded cassowary sightings
- EPA recorded cassowary sightings
- EPA recorded cassowary road mortalities
- Focus roads

N

0 0.5 1

kilometres

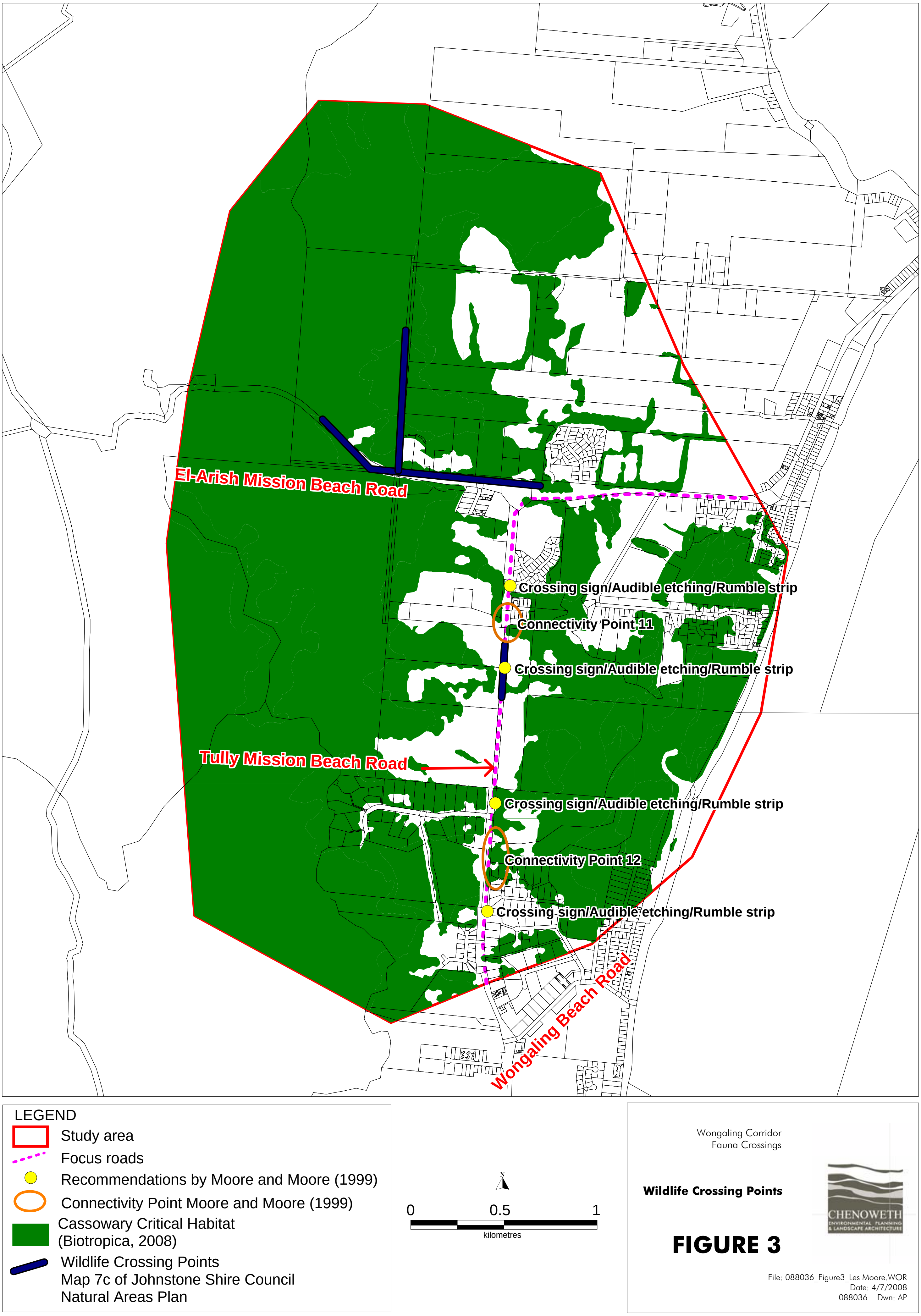
Wongaling Corridor
Fauna Crossings

Cassowary Sighting Data

FIGURE 2

CHENOWETH
ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE

File: 088036_Figure2_Sightings.WOR
Date: 4/7/2008
088036 Dwn: AP



Wongaling Corridor
Fauna Crossings

Wildlife Crossing Points

FIGURE 3

CHENOWETH ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE

File: 088036_Figure3_Les Moore.WOR
Date: 4/7/2008
088036 Dwn: AP

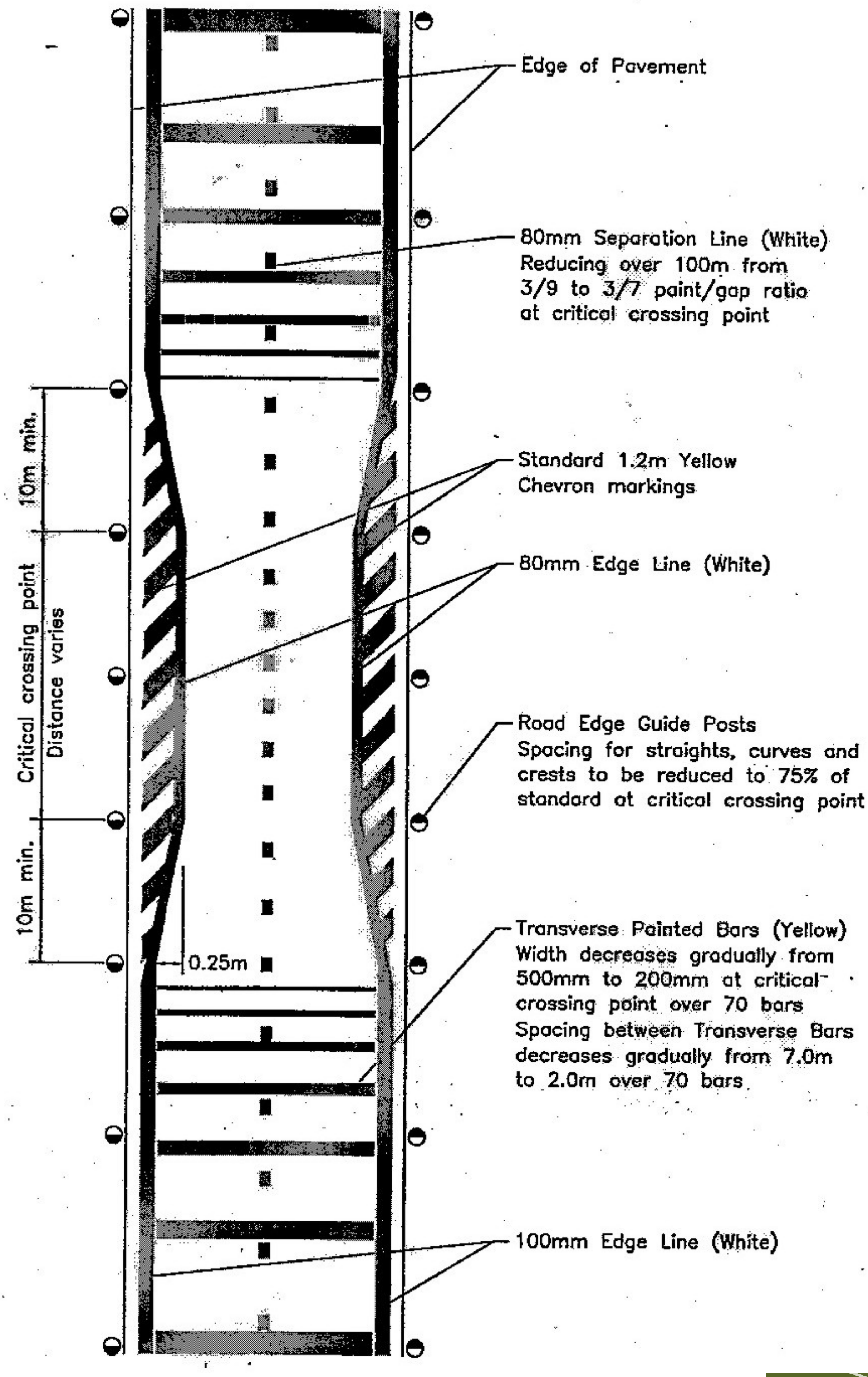


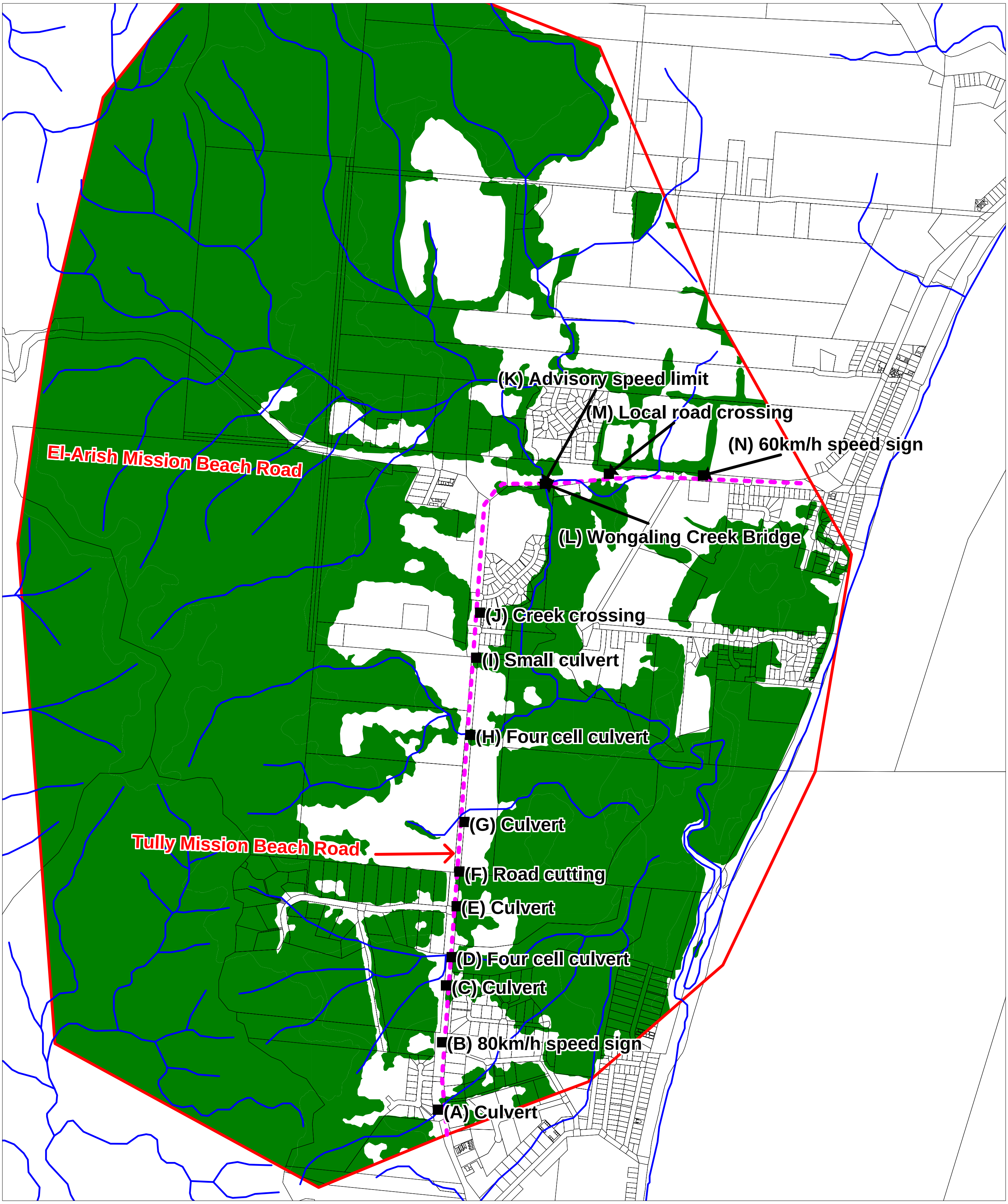
Image from Queensland Department of Main Roads. (2001). Cassowary Management Strategy – Tully-Mission Beach Road.

Wongaling Corridors
Road Marking

Figure 4

CHENOWETH
ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE
Level 20, 344 Queen Street
BRISBANE, 4000 Australia
Telephone: +61 (07) 3831 8582
Facsimile: +61 (07) 3831 8587
E-mail: mail@chenoweth.com.au

088036 Dwn. AP 4/7/2008



LEGEND

Study area

Hand-held GPS position of features

Focus roads

Waterways

Cassowary Critical Habitat (Biotropica, 2008)

N

0 0.5 1

kilometres

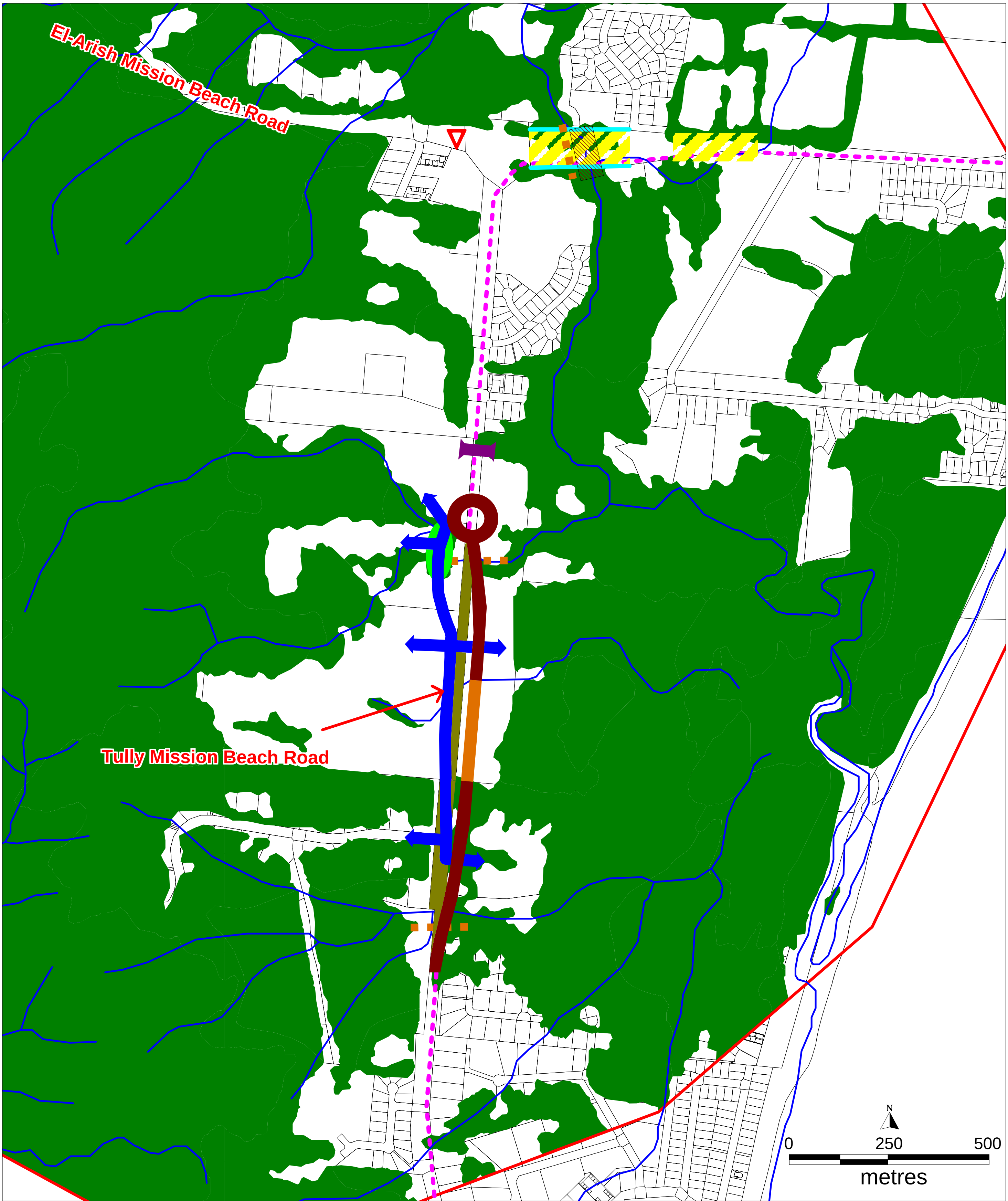
Wongaling Corridor
Fauna Crossings

Field Data

FIGURE 5

CHENOWETH
ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE

File: 088036_FigureX.WOR
Date: 4/7/2008
088036 Dwn: AP



LEGEND

- Study area
- Focus roads
- Waterways
- Cassowary Critical Habitat (Biotropica, 2008)
- 50km/h signs
- Rope Bridge
- Elevated road & roundabout at grade
- Road at grade
- Fauna overpass
- New 40km/hr road
- Traffic calming
- Revegetation
- Guide fencing/bunding
- Psychological traffic calming
- Recontour and rehabilitate creek banks

Wongaling Corridor
Fauna Crossings

Conceptual Potential Measures

FIGURE 6

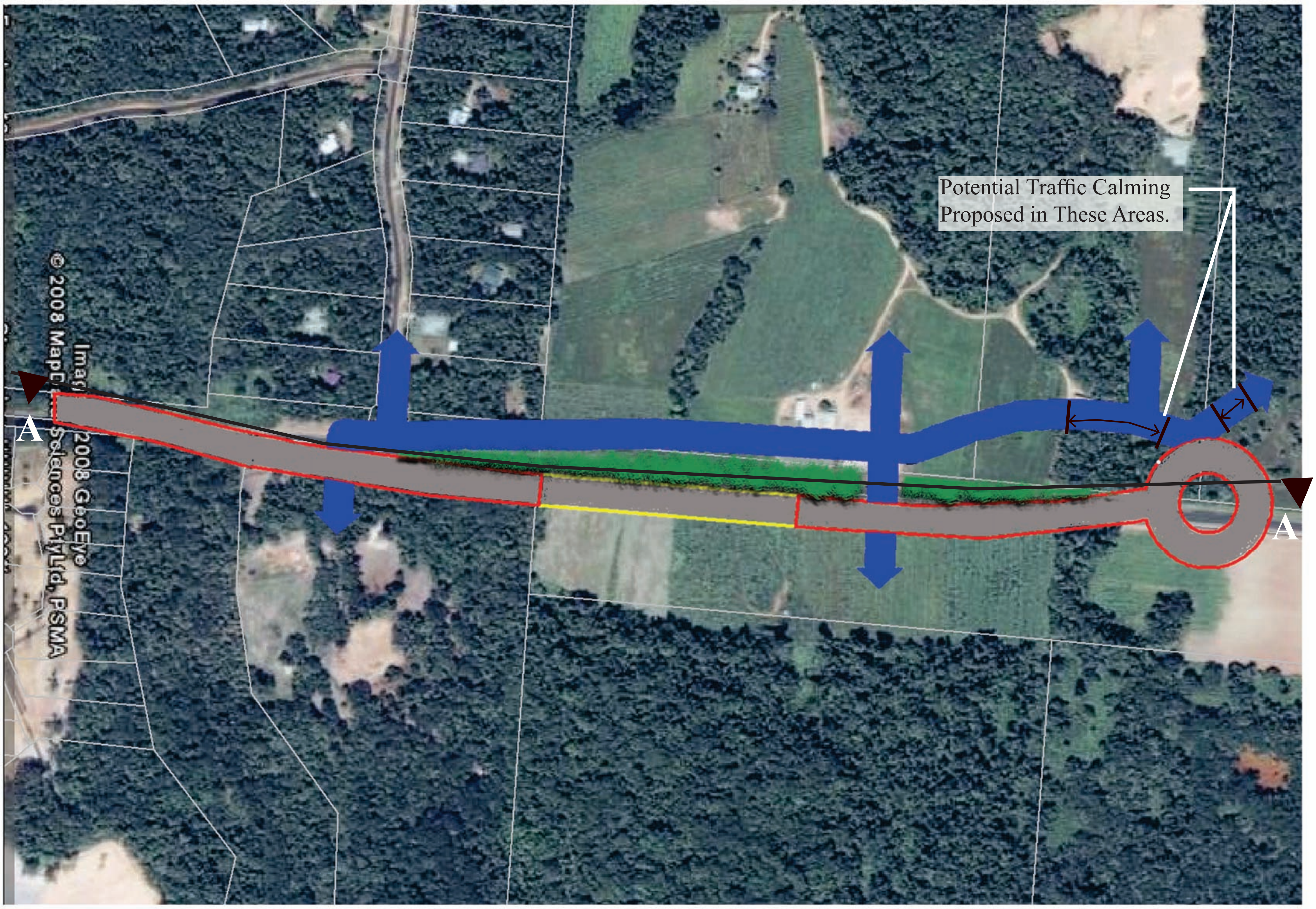
CHENOWETH
ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE

File: 088036_Figure5_potentialmeasures.WOR
Date: 7/7/2008
088036 Dwn: AP

A-A CROSS SECTION THROUGH WESTERN ROAD CORRIDOR ALONG POTENTIAL ROAD

Raised Road/ Cassowary Underpass

Existing Raised Land/ road cutting



LEGEND

Potential Revegetation

Potential Road- Resident Access 40km/hr

Existing Raised Land/ Road Cutting

Raised Road/ Cassowary Underpass

N

NOT TO SCALE

FIGURE 7
Conceptual Cross Section Through Elevated Road

CHENOWETH
ENVIRONMENTAL PLANNING & LANDSCAPE ARCHITECTURE

Appendix A

Fauna of Mission Beach

Trenerry, ca2006

Known and probable Native Species

Placental Mammals

NAME	HABITAT	PRESUMED DISTRIBUTION OR ABUNDANCE
Little Red Flying Fox	Various	Sporadic occurance
Black Flying Fox	Various	Sparse along coast
Spectacled Flying Fox	Various	Common, widespread
Tube-nosed Fruit Bat	Mostly rainforest	Common but patchy
Common Blossom Bat	Mostly rainforest	Common
Northern Blossom Bat	Various	Apparently common
Large-eared Horseshoe Bat	Various	Probably common
Eastern Horseshoe Bat	Streams and tall open forest	Probably common
Dusky leaf-nosed Bat	Rainforest mainly	Common
Diadem Leaf-nosed Bat	Various	Moderately common locally
Common Sheathtailed Bat	Various	Probably common
Bare-rumped Sheathtailed Bat	Eucalypt forest	Uncommon
Coastal Sheathtailed Bat	Coastal strip	Restricted
Beccaris Freetail Bat	Various, may roost in roofs	Probably common
Little Northern Freetail Bat	Mangroves/Rainforest	Locally common
Golden Tipped Bat	Rainforest and ecotones	Probably sparsely spread
Little Bentwing Bat	Tall forest	Probably common
Common Bentwing Bat	Well timbered valleys	Probably common
Eastern Long-eared Bat	Rainforest/Streamlines	Possibly common
Cape York Pipistrelle	Streams and open forest	Recently detected nearby
Large Footed Myotis	Mostly around streams	Common
Northern Broad-nosed Bat	Various	Common widespread
Eastern Cave Bat	Open woodlands	Probably thinly spread
Eastern Chestnut Mouse	Grassy woodland	Probably uncommon
Water Rat	Shore and streamlines	Widespread
Grassland Melomys	Grassy areas and sugarcane	Common
White-tailed Rat	Various, especially rainforest	Common
Prehensile-tailed Rat	Rainforest	Rarely seen
Cape York Rat	Rainforest	Locally common
Canfield Rat	Grassy areas and sugarcane	Common, widespread
Pale Field Rat	Sclerophyll	Rarely seen
Fawn-footed Melomys	Rainforest	Common
Dingo	Various	Sparse: Naturalised Exotic

Total number of Known and probable species is 51

Known and probable Native Species

Placental Mammals

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Pale Field Rat	Sclerophyll	Rarely seen
Fawn-footed Melomys	Rainforest	Common
Dingo	Various	Sparse: Naturalised Exotic

Total number of Known and probable species is 51

Other Possible Native Mammals

NAME	HABITAT	PRESUMED DISTRIBUTION OR ABUNDANCE
Brush-tailed Phascogale	Open forests, uplands and lowlands	Recent Wet Tropics records
Spotted-tailed Quoll	Rainforest mostly, almost gone from lowlands	Probably extinct locally but known from Palmerston Highway
Common Dunnart	Sclerophyll with fallen timber	Possibly in district
Common Ringtail	Sclerophyll forest with Eucalypts	Could be in taller Eucalypts
Long-tailed Pygmy Possum	Mostly rainforest, prefers uplands	Perhaps sparsely spread. Known from near El Arish.
Whiptail Wallaby	Various	Known from nearby
Tube-nosed Insectivorous Bat	Rainforest mainly	Distribution is poorly known
Northern Freetail Bat	Open forest	Suitable habitat is present
Ghost Bat	Open habitats	Found as close as Cardwell
Eastern Forest Bat	Moister forests	Found in adjacent uplands
Greater Broad-nosed Bat	Various	Known from adjacent uplands
Bush Rat	Rainforest, preferably elevated	Possible in some areas

Representing less than 0.1% of Queensland's total area this district contains a disproportionate number of native mammal species. With the likely occurrence of between 51 and 63 (55 is a conservative estimate) species, there are about 32% of all Queenslands' native terrestrial mammal species present. The entire state of Tasmania has only about 32 or 33 native land mammal species, of which only 6 are bats!

Mike Trenerry
Planner-NPWS/CS

Appendix B

Previous Cost Estimates for Cassowary ‘infrastructure’
from
Queensland Department of Main Roads, 2001

Table 3 - Indicative Cost for Implementation of the "Cassowary Management Strategy"

Implementation Strategy	Activity	Cost ($)
1. Regulatory speed signs	Preparation & Installation of 6 signs at $350 each	2,100
2. Under Road Crossing Structures		
a) North Hull Bridge Landscaping	Earthworks-15 m³ @ $40/m³ = $600 Fencing-100 m @ $20/m = $2000 Site Preparation - $500 Replanting-100 trees @ $4/tree= $400	3,500
b) Large Culvert Trial (3m x 3m)	Includes supply- 28,000; excavation- 2,500; base slab and boxes- 15,000; end structures - 19,000; aprons - 17,000; pavement and surfacing- 4,100; reveg and protection- 10,000; guardrail- 2,400; Fencing and landscaping - 2,000; Solar lighting - 3,000 and 20% reserve- 21,000	123,600
3. Informative and Warning Signs		
a) Crossing Warning Signs	Preparation & Installation of 6 signs at $1000 each.	6,000
b) Relative Size Signs	Preparation & Installation of 4 signs at $1,500 each.	6,000
c) Information Centre Signs	Preparation & Installation of 2 information centre signs at $700 Preparation and installation of Life Size Cassowary Sign at $2,000	1,400 2,000
d) Cassowary Zone (Reminder) Signs	Preparation & Installation of 2 signs at $700 each	1,400
e) Conservation Zone Signs	Preparation & Installation of 2 signs at $1,000	2,000
4. Cognitive Signs	Preparation & Installation of 4 signs at $1,000	4,000
5. Cassowary Awareness Centre - including car parking and accessory works	Includes rest area, access and sealed parking area & associated facilities (shelter, posters, tables, bins, signs)	*#note (a)*
6. Pull Over Areas	Construction of 2 areas at $20,000	40,000
7. Line Marking		
a) Transverse Lines	240 bars at approx 4 m² / bar @ $12.75 / bar = $51 / bar = $12,240	12,240
b) Separation Lines - reduction in thickness and increase in spatial frequency pattern	Center Line - 6 kms at $500 / linear km	3,000
c) Edge Lines - reduction in thickness	Edge Line - 6 kms at $125 / linear km (x2)	1,500
d) Chevron Markings	6 kms at $500 / km	3,000
e) Existing paint removal (2 options)	Option 1 - total reseal of 6 km - 6000 x 8 = 48,000 m² x $2.50 = $120,000 Option 2 - edge line + separation line removal - 6000 x 0.2 + 6 x 25 = 1350 m² @ $35 / m² = $47,250	120,000

8. Reduction in the spacing of guide posts for 6.5 kms	Relocating guide posts, and the installation of additional guide posts	5,000
9. Rumble strips	4 Locations at $1000 each	4,000
10. Reduction in Lane Width	Would occur with the implementation of the above strategies	
11. Revegetation of Road Verges	If community groups are utilised, support would be needed for seed collection and propagation.	5,000 *#note (b)*
12. Monitoring effects over 3 years for speeds, numbers and vehicle class.	1 x loop and 2 x tube classifiers plus installation and maintenance	27,800
	Subtotal	373,540
	Cash Management Reserve (50%)	186,770
	TOTAL	**$560,310** *#note (c)*

#Notes:

a) The cost of this item has not been estimated as it will depend on the style & extent of the awareness centre and on the interest and participation by other relevant agencies and local groups.

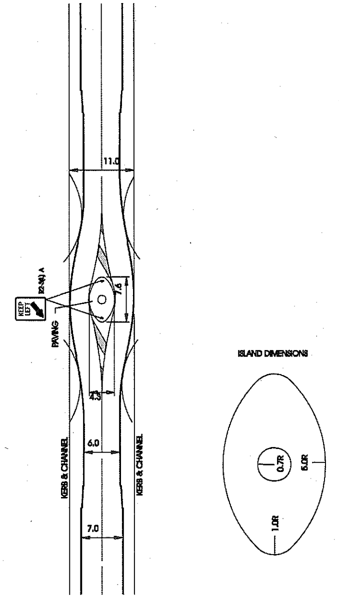
b) The clear zone width can still be decreased, rehabilitated, by reducing the mowing and slashing requirements in the Maintenance Contract. (No costs would be associated with this option).

c) This total estimated cost excludes item 5. (refer to note (a)).

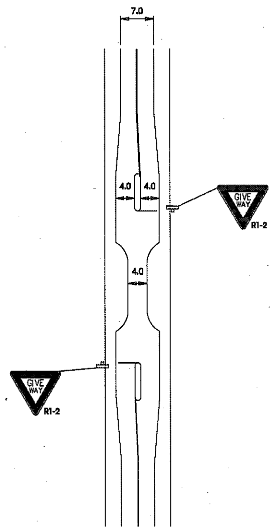
Appendix C

Fauna Crossing Concept Plans
from
Queensland Department of Main Roads, 1998

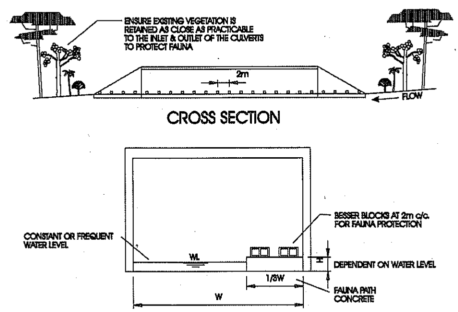
A. MIDBLOCK HORIZONTAL DEFLECTOR - 11.0m



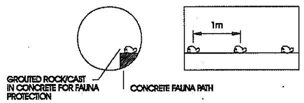
B. TRAFFIC SLOW POINT



C. COMBINED BOX CULVERT - FAUNA PATH

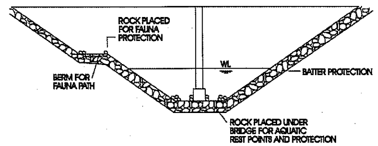


D. COMBINED PIPE CULVERT - FAUNA PATH

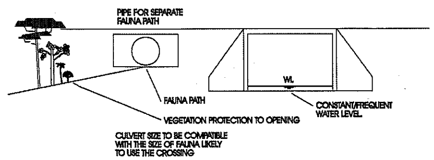


FOR PIPES D>1350mm

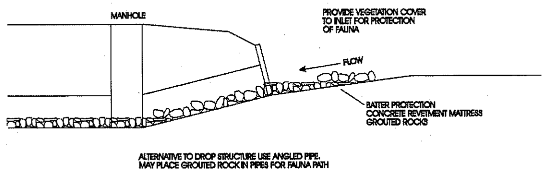
E. BRIDGE WITH FAUNA PATH



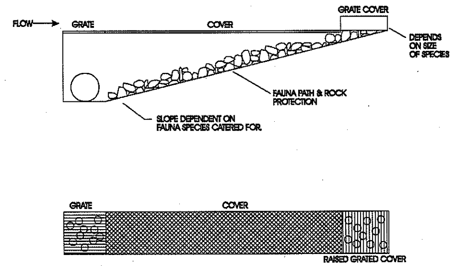
F. CULVERT AS FAUNA PATH ONLY



G. ANGLE PIPE INLET AND FAUNA PATH

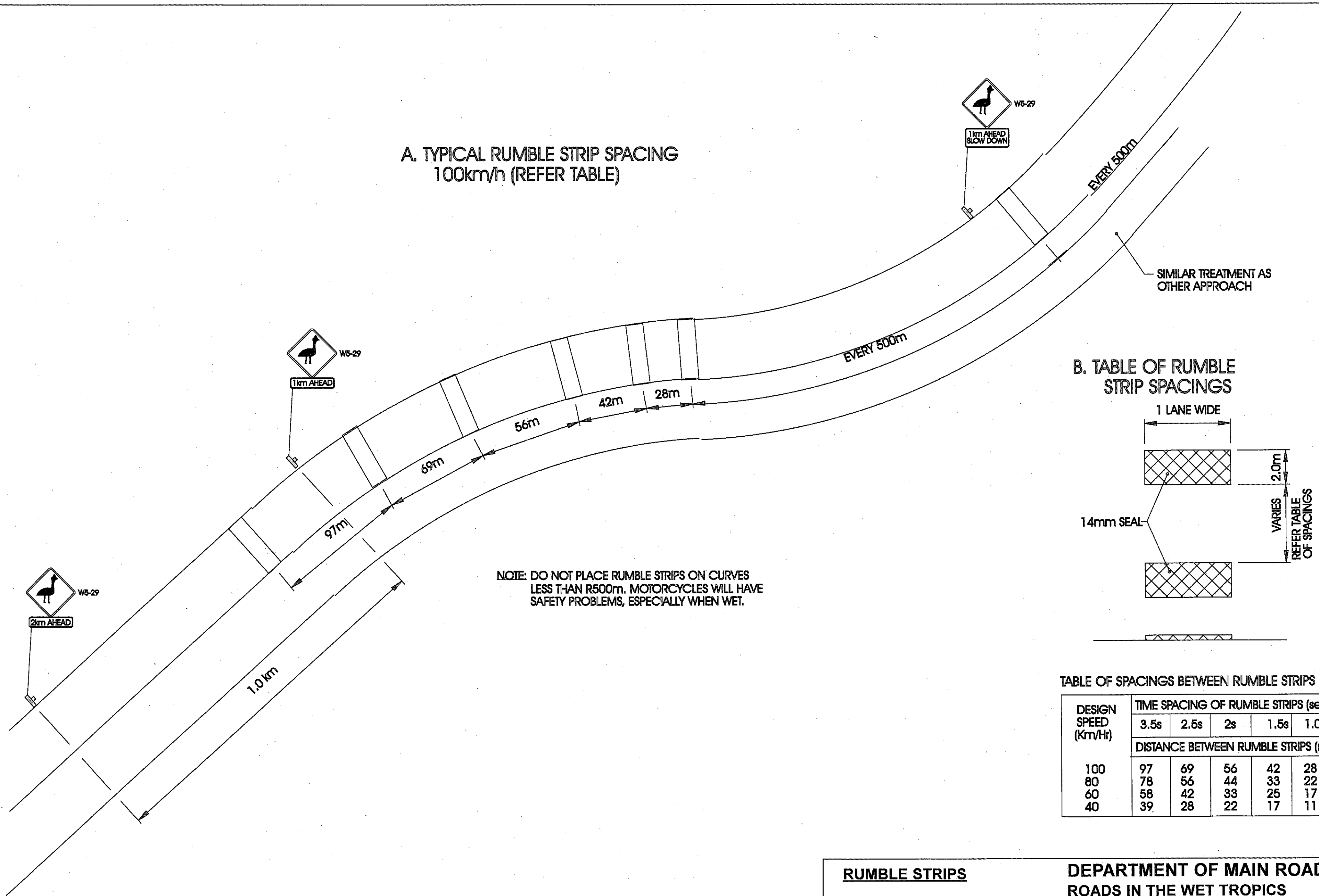


H. GRATED INLET FAUNA PATH DROP STRUCTURE



VARIOUS TYPES OF FAUNA PATHS	**DEPARTMENT OF MAIN ROADS** **ROADS IN THE WET TROPICS** **NOT TO SCALE**

A. TYPICAL RUMBLE STRIP SPACING 100km/h (REFER TABLE)



NOTE: DO NOT PLACE RUMBLE STRIPS ON CURVES LESS THAN R500m. MOTORCYCLES WILL HAVE SAFETY PROBLEMS, ESPECIALLY WHEN WET.

B. TABLE OF RUMBLE STRIP SPACINGS

1 LANE WIDE

2.0m

VARIES

REFER TABLE OF SPACINGS

14mm SEAL

TABLE OF SPACINGS BETWEEN RUMBLE STRIPS

DESIGN SPEED (Km/Hr)	TIME SPACING OF RUMBLE STRIPS (sec.)				
	3.5s	2.5s	2s	1.5s	1.0s
	DISTANCE BETWEEN RUMBLE STRIPS (m)				
100	97	69	56	42	28
80	78	56	44	33	22
60	58	42	33	25	17
40	39	28	22	17	11

RUMBLE STRIPS

DEPARTMENT OF MAIN ROADS
ROADS IN THE WET TROPICS
NOT TO SCALE