PACIFIC HIGHWAY UPGRADE:

WARRELL CREEK TO URUNGA

MICROCHIROPTERAN BAT MANAGEMENT STRATEGY

OCTOBER 2014



PREPARED FOR ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

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Author
Ben Lewis
(B. App Science – Hons)

…2nd October 2014……
Date

mobile – 0413019279
email – ben@lewisecological.com.au

ACKNOWLEDGEMENTS

Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author.

Greg Ford (Balance Environmental) – Bat call analysis.

Kristy Harvey (Roads and Maritime Services) – Project management, background data and review tables.

Belinda Bock (Roads and Maritime Services) – Project management, background data.

Brett Hoffman (Roads and Maritime Services) – Project manager and logistics.

Josie Stokes (Roads and Maritime Services) – Document review.

Shayne Walker (Roads and Maritime Services) – Document review.

Andrew Mula (Roads and Maritime Services) – Document review.

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Top – The vulnerable Southern Myotis (*Myotis macropus*) from Culvert Structure 599306
Left to Right – Pacific Highway Bridge over Deep Creek; Southern Myotis using Culvert C – 599271 (Cow Creek) and Culvert 599205 (Deadman's Gully) also utilised by Southern Myotis.

Report to be cited as: Lewis, B.D (2014). Warrell Creek to Urunga: Microchiropteran Bat Management Strategy. Report prepared for Roads and Maritime Services by Lewis Ecological Surveys. ©

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ABBREVIATIONS

Abbreviation	Description
RCBC	Reinforced Concrete Box Culvert
RCPC	Reinforced Concrete Pipe Culvert
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade
WC2NH	Warrell Creek to Nambucca Heads staged Construction of the WC2U Approval
NH2U	Nambucca Heads to Urunga (northern section of WC2U Pacific Highway Upgrade)
MCoA	Ministers Condition of Approval
EPA	Environmental Protection Authority
RMS	Roads and Maritime Services
LES	Lewis Ecological Surveys
AFJV	Acconia Ferrovial Joint Venture
Vulnerable	Species listed as vulnerable under schedule two of the NSW *Threatened Species Conservation* Act (1995)

1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by Roads and Maritime Services (RMS) to prepare a management strategy following the discovery of microchiropteran bats (hereafter micro bat) utilising bridge and culvert structures associated with the Warrell Creek to Urunga Pacific Highway Upgrade project (Figure 1-1). The preparation of this strategy addresses one component of MCoA **(B30)** Construction Environment Management Plan for the project and specifically part **(b)** *a Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed*. A component of this plan specifically relates to the management of micro bats **(iv)** *a micro-bat management strategy, in the case that micro bats or evidence of roosting are identified during pre-construction surveys. The strategy shall detail measures to avoid, minimise and mitigate impacts to these species and identified roost sites, including short and long term management measures*.

Sixty-nine (69) structures were surveyed for micro bats or evidence of roosting between December 2011 and October 2012 summarised here as:

- 13 Reinforced Concrete Box Culverts (RCBC);
- 50 Reinforced Concrete Pipe Culvert (RCPC); and
- 6 concrete bridges.

Nine (13%) of the surveyed structures showed evidence of use by three species summarised in Table 1-1.

Table 1-1. Summary of pre-construction field surveys for micro bats and evidence of roosting.
Note: Bold type denotes potential maternity sites

Bat Species	Culvert	Bridge
Southern Myotis (*Myotis macropus*)	• **599205 (Deadman's Gully);** • Culvert 599222; • **Culvert 599271 (Cow Creek);** • Culvert 599293; and • **Culvert 599306 (Dalhousie Creek).**	• **Crouches Creek (7881 at Donnellyville).**
Little Bent-wing Bat (*Miniopterus australis*)	-	• **Pacific Highway Bridge (1871) over Warrell Creek.**
Gould's Wattled Bat (*Chalinolobus gouldi*)	-	• Pacific Highway Bridge (6696) over North Coast Railway at Nambucca Heads; and • **Possibly Crouches Creek (7881 at Donnellyville)**
Unknown Species (Scats only)	• Culvert 599292.	-

Although there was no observations of bats breeding (i.e. maternity) in any of the surveyed structures, those highlighted in bold type in Table 1-1 are considered likely to be used as maternity sites and require due consideration as part of this management strategy.

Both the Southern Myotis and Little Bent-wing Bat are currently listed as vulnerable species pursuant to the NSW *Threatened Species Conservation* Act (1995). None of the recorded species are currently listed under the Commonwealth *Environmental Protection and Biodiversity Conservation* Act (1999). Consideration has been given to the potential occurrence of the Large-eared Pied Bat (*Chalinolobus dwyeri*) which is currently listed as vulnerable pursuant to the *EPBC* Act (1999).

The main limitation of the summer field surveys were that they did not account for temporal variation whereby some micro bats may actually select sites for over wintering or may simply utilise one or more of the structures in response to other seasonal gradients or environmental cues. For example, the flooding of a low lying bridge may force bats to utilise an alternative roost. To address this, an assessment on the roost sites suitability of each structure was undertaken with this resulting in the identification of 15 potential micro bat roost sites [1] (Appendix 1).

[1] A potential roost site provides the necessary attributes considered favourable or conducive to bats selecting the site as a roost (i.e. sufficiently high enough above the ground, overhanging water, at least 20 mm gaps but not overly large <100 mm).

Five of these occur south of the Nambucca Heads Interchange (ch. 61265) near the intersection of Old Coast Road (599237 and 599238) and Bald Hill Road (599228 and 599229) with the remainder occurring in the northern section of the upgrade works (i.e. 599265, Boggy Creek Bridge - 6697, 599272, 599274, 599276, 599282, 599291, 599302, 599323 and 599325). All of the above structures are depicted in Appendix 1 with highlighted 'white boxes'.

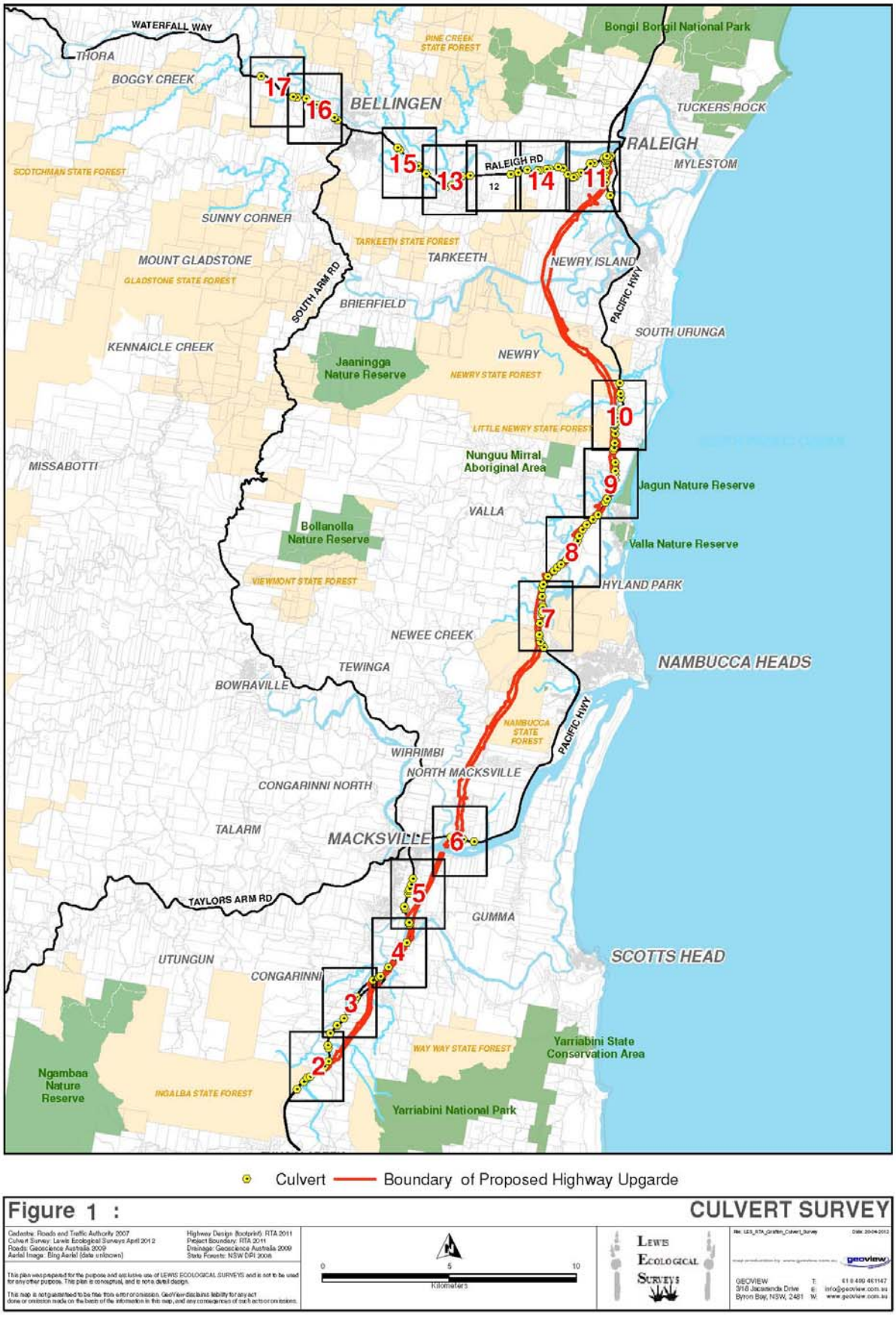


Figure 1-1. Location of culvert structures (inserts 1-11) relevant to this management strategy.

2.0 IMPORTANCE OF THE BAT ROOST

The field surveys identified that 22 of the 69 (32%) culvert and bridge structures provide either known or potential roost habitat for micro bats. Roost habitat and its overall importance is likely to vary between each of the structures and may even vary within the structure itself (i.e. multiple culverts), depending on the species using it, the season (i.e. summer versus winter) or the prevailing environmental conditions (i.e. flood or drought). The challenge for this management strategy is to adjust for varying needs of different species of micro bats that would utilise a particular structure for breeding, during migration, winter hibernation or simply as a temporary site within a broader area of roost site fidelity (i.e. bats may utilise a number of roost sites within close proximity to one another). The field surveys noted extensive areas of alternative potential roost sites at culvert and bridges on local road networks and the North Coast Railway. Many of these structures occurred on the same drainage line and were often within 1 kilometre of the existing Pacific Highway.

This section of the Strategy qualifies the relative importance of each structure (i.e. roost) and how this might be used over a seasonal gradient. They have been classified at three scales of Conservation Value:

- High Conservation Value
- Moderate Conservation Value
- Low Conservation Value.

2.1 High Conservation Value

A roost assigned to this category would require careful planning during the planned roost exclusion and may require additional monitoring if bats are found to be present throughout the year. For example, the Crouches Creek Bridge (7881) may require additional monitoring to evaluate the overall importance of this roost throughout the year. Sites assessed as being high conservation value roosts would also require at least some bat boxes to be installed more than 100 m away from the construction works. Bat boxes would be installed at least 6-12 months prior to construction.

Examples of high conservation value roost sites include:

- Breeding colonies of micro bats regardless of species legislative status (i.e. Southern Myotis at Cow Creek - 599271)
- Colonies of micro bats exceeding 50 individuals (Crouches Creek Bridge 7881)
- Over wintering colonies exceeding 20 individuals (reliance of Strategy B in this plan to provide more detail)
- One individual or more of the nationally vulnerable Large-eared Pied Bat (*Chalinolobus dwyeri*).

2.2 Moderate Conservation Value

A roost assigned to moderate conservation value is used by micro bats but its overall importance does not qualify it as high conservation value. In this instance, the roost is not being utilised for breeding, the roost is made up of relatively few individuals (<50 during warmer times of the year or <20 individuals in the case of an overwintering site) and could be considered a temporal roost. Whilst these may perform a relatively important function for bats during post breeding dispersal or as part of some other seasonal migration the Warrell Creek to Urunga study area supports numerous other roosting opportunities with numerous bridges over waterways, culverts on other roadways, North Coast Railway with bridges and culverts, historic mining works in Newry State Forest and potential sea caves at some of the coastal headlands. In this context, there appears to be an adequate number of 'moderate' conservation roosts in the WC2U study area.

2.3 Low Conservation Value

A low conservation value roost shows no sign of past or current use by micro bats and the roost habitat attributes are such that they could only contain a few individuals of any one species. For example, the 'vertical drainage holes' or 'lift points' in a culvert could theoretically provide habitat for only a few individuals (<5). Other considerations could include the overall configuration of the structure such as its height combined with only shallow or partial inundation of surface water would suggest that roost points would be susceptible to increased predatory pressure. Such roosts may only be used for short periods of time or in response to other roosts that may be disturbed or removed.

3.0 MANAGEMENT STRATEGIES

Seven management strategies have been proposed as a means to avoid, minimise and mitigate impacts to micro bats and identified roost sites, including short and long term management measures. They include:

A. Installation of additional roosts

B. Implementing additional field surveys

C. Planned roost exclusion

D. Seasonal limitation of construction works

E. Protection of existing habitat

F. Previously unconsidered structures and unexpected finds

G. Monitoring Requirements

A summary of these actions and the associated technique is shown in Table 3-1.

Cumulative impacts/concerns are being managed by installing alternative roost sites at all of the other locations that represent known or potential roost sites. Moreover, numerous other roost sites exists in the immediate area and include the numerous rail bridges and culverts with the north coast railway running more or less parallel to many of the affected RMS structures. Notwithstanding this, local arterial roads managed by LGA's along with rural residual landscape provide numerous bat friendly structures in the form of shedding and housing, this can be seen in the maps provided within Appendix 1.

A. Installation of Additional Roosts (Bat Boxes)

The use of artificial bat roosts has proved a useful tool in bat management and mitigation in Australia and overseas. In Europe, retro-fitting of bat boxes on bridges and culverts is among standard environmental management for the construction and maintenance of road infrastructure (Halcrow 2006). It is increasingly used here in Australia with several recent examples on the Pacific Highway and use by local government and private developers. For example, bat roost boxes have been used as a management tool in the upgrading of several timber bridges in the Tweed Shire with success and there has been long term use of the slot design style box used at Koala Beach residential development (D. Hannah Tweed Shire Council Environmental Scientist pers. comm. February 2012).

The use of artificial bat roosts is considered a suitable means to encourage passive dispersal of the roost within a particular structure. The designs proposed have been limited to three designs:

1. Small slotted-style bat boxes
2. Wedge style
3. Tree mounted with removable slots.

Example of suppliers include but are not limited to hollow log homes (www.hollowloghomes.com.au) and NHBS (www.nhbs.com) with boxes constructed from a range of materials including hardwood, marine grade plywood and woodcrete.

Two mounting options are considered viable:

Option 1
For tree mounted roosts, the following considerations must be satisfied:

1. >2 m above ground and ideally 3-4 m;
2. Overhanging >100 mm of surface water;

3. Beneath tree canopy to reduce solar radiation;
4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots);
5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side).

Option 2
Site considerations for bridge/culvert mounted roosts:

1. >1.5 m above ground;
2. Overhanging >100 mm of surface water; and
3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event.
4. Land tenure

Bat boxes should be installed by an ecologist at least 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes would continue until Year 6 (refer to Table 4-4).

B. Implementing Additional Field Surveys

Additional field surveys would be implemented for the following scenarios:

1. Qualified ecologist engaged by the Contractor to identify the conservation value of all 22 structures as over wintering habitat;
2. Qualified ecologist engaged by the Contractor to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and
3. Surveys as part of planned roost exclusion procedures (see below).

C. Planned Roost Exclusion

Roost exclusion would be necessary at those structures requiring removal or substantial modification and only at those locations specified in Table 4.2 or as deemed necessary by the Project Ecologist. Planned roost exclusion would be used:

- Outside of the breeding season for Southern Myotis and any other species detected breeding by the Project Ecologist in the structure; and
- Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis.

Where required, roost boxes would be installed in adjacent habitat by an ecologist at least 6-12 months prior to the planned roost exclusion of micro bats. For example, the removal/upgrading of 599271 (Cow Creek) would require the installation of bat boxes at least 6-12 months before any such planned exclusion could occur.

The contractor would perform a pre clearing survey in accordance with strategy B in Table 3-1. The occupied roost(s) would be left *in situ* at this point in time whilst most (**not all**) of the remaining unoccupied potential roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) would be filled with an expandable foam filler or equivalent. It is important to leave some other alternative roost points (i.e. two) because these would be used as alternative or temporary roost sites whilst the main roost is decommissioned and thus provides a 'weaning' process of excluding micro bats from the structure. Moreover, the culvert egresses would not be blocked at any stage during the roost exclusion process.

On the evening the pre clearing survey is performed (i.e. strategy B), the main roost(s) would be inspected by an ecologist using a variable beam torch and/or an endoscope about 90 minutes after nightfall. Once all the bats have vacated the roost, the ecologist would then fill the roost with expandable foam or an equivalent. Where this cannot be achieved (i.e. due to an obscure cavity), one-way plastic flaps would need to be installed (*see* Mitchell-Jones 2004). Bats returning to the culvert would be left with two options; either seek refuge within one of the sub optimal roost points or seek an alternative site adjacent to the culvert. It is expected that some bats may:

- continue to roost within the alternative roost points (i.e. sub adults), or
- quickly abandon the structure and seek an alternative roost.

Alternate roosts may be the four bat roost boxes installed in the adjacent habitat, or alternatively the numerous other suitable roost habitat in the form of dwellings, culverts and bridges associated with the North Coast Railway and adjacent shire roads.

To improve the effectiveness of this as a management tool, planned roost exclusion would not be undertaken during forecast periods of heavy rainfall (i.e. >20 mm in 24 hours forecast on the Bureau of Meteorology Website www.bom.gov.au) when potential roost sites may be limited. i.e. bats unlikely to be roosting in scuppers during rainfall. The intended timing for planned roost exclusion is in autumn (mid April-May) and the start of spring (September). This would avoid both the breeding season and overwintering period for micro bats.

D. Seasonal Limitation of Construction Works

Seasonal limitation of construction works would be required at high conservation value sites (i.e. breeding or important overwintering habitat) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. For example, a structure that supports a breeding colony of Southern Myotis, seasonal limitation of construction works would be required between November and February for the above construction activities whilst an overwintering colony of Little Bent-wing Bat would require seasonal limitation of between mid June and mid August. During seasonal limitation of construction works, the construction activities listed above must develop an attended noise and vibration monitoring program in consultation with the Project Ecologist. Provisions must also be made for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period as part of this program. The details of this monitoring must be recorded and submitted with the 6 monthly tracking compliance report.

Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.

E. Protection of Existing Habitat

The contractor would manage the integrity of drainage lines and associated riparian vegetation so as to not constrict micro bat flyways. This would include an:

- Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[2].
- Ecologist would monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section H2 of this strategy.

The contractor would manage water quality and velocity of the adjoining waterways including creeks, rivers and dams would be maintained in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the WC2U Upgrade.

F. Previously Unconsidered Structures and Unexpected Finds

This strategy 'previously unconsidered structures and unexpected finds' would address:

- Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or
- Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys).

[2] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

If micro bats are found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 3-1; Table 4-1 and 4-2.

G. Monitoring Requirements

Monitoring associated with this management strategy is divided into short term and long term commitments. Short term monitoring is required for roost exclusion activities which are expected to last for a number of nights at each structure and is dependent on the timing of the construction program. In contrast, long term monitoring is required up to Year 6 and provides an opportunity to rationally evaluate the management strategies outlined in this plan.

G1. Bat Roost Boxes

Monitoring of bat boxes would commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of the boxes would continue up until Year 6 (i.e. 4 surveys per year for 5 years) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of micro bats and breeding activity. Information would also be collected as to the roost identification number, date and time of the inspection. The value of data loggers would be investigated following the outcomes of analogous monitoring works on the Tintenbar to Ewingsdale Pacific Highway Upgrade project (*see* EcoLogical 2011).

G2. Habitat Monitoring

Habitat monitoring would focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point would be installed and a visual assessment be undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management).

Monitoring of water quality would also be undertaken on both the upstream and downstream sides of the construction works. This monitoring would be undertaken on a monthly cycle in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters: turbidity; total suspended solids; conductivity and pH at both upstream and downstream points.

G3. Monitoring of Bat Persistence and Behaviour

Monitoring of bat persistence and behaviour would be undertaken at the Crouches Creek Bridge (7881). This site has been selected because it contained the largest micro bat roost during the summer field survey and provides the greatest opportunity to examine the disturbance thresholds of micro bats. The monitoring program would be developed by the construction contractor and their Project Ecologist or another ecologist with sufficient experience and expertise. The monitoring must consider the differences in roost use between summer and winter along with the species that are likely to use it as a roost. For example, Southern Myotis during the summer months and Bent-wing Bats during the winter months.

Table 3-1. Micro bat management strategies for the Warrell Creek to Urunga Pacific Highway Upgrade.

Strategy	Definition	Techniques	Timing	Responsibility
A	Installation of additional roosts (bat boxes)	• The use of artificial bat roosts (3-4) to promote passive dispersal of the roost. Designs to be one or more of the following and that thermoregulatory considerations focus on aspect and paint/finish (i.e. bat friendly chemicals) of the box itself (i.e. black coloured box with absorb more heat than a neutral colour): **A** - small slotted-style bat boxes; **B** - wedge style; and **C** – tree mounted with removable slots. Two options are available: **Option 1** For tree mounted roosts, the following considerations must be satisfied: 1. >2 m above ground and ideally 3-4 m; 2. Overhanging >100 mm of surface water; 3. Beneath tree canopy to reduce solar radiation; 4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots); 5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side). **Option 2** Site considerations for bridge/culvert mounted roosts: 1. >1.5 m above ground; 2. Overhanging >100 mm of surface water; and 3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event. Land tenure	Bat boxes should be installed by an ecologist at least 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes would continue until Year 6 (refer to Table 4-4). Pre construction and construction.	Roads and Maritime Services
B	Implementing Additional Field Surveys	Additional field surveys would be implemented for the following scenarios: • Qualified ecologist engaged by the Contractor to identify the conservation value of all 22 structures as over wintering habitat; • Qualified ecologist engaged by the Contractor to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and • Surveys as part of planned roost exclusion procedures.	Prior to construction disturbance (i.e. works occurring within 200 m of the structure).	The Contractor
C	Planned Roost Exclusion	Roost exclusion would be necessary at those structures requiring removal or substantial modification (requirement for exclusion due to substantial modification is to be determined case by case via consultation between Roads & Maritime, Contractor / project ecologist and EPA) and only at those locations specified in Table 4.2 or as deemed necessary by the Project Ecologist. Planned roost exclusion would be used: • Outside of the breeding season for Southern Myotis and any other species detected breeding by the Project Ecologist in the structure; and • Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis. Once the conditions above have been satisfied the following 10 step process would occur: 1. Pre-clearing survey to identify presence/absence of the roost; 2. Once the roost(s) has been identified, record species and approximate number of individuals and assess importance of the roost; 3. Select two suitable alternative roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) with gaps of >25 mm and depths exceeding 50 mm; 4. For the remaining potential roost points the Project Ecologist/Bat Ecologist must be confident in ensuring the cavity is devoid of micro bats and other native vertebrate fauna. Once absence has been confirmed, the void/roost point is closed up (i.e. filled with expandable foam or some other equivalent material). 5. At no stage shall the culvert inlets/outlets be constricted or closed off in any way. 6. Where all of the roost point cannot be confidently inspected for signs of native vertebrate fauna then one-way plastic flaps must be installed at that point in time or a minimum of 1 hour before dusk. 7. The active roost points identified during the pre-clearing survey are re inspected around 90 minutes after dark. If all individuals have vacated the roost then at this point in time the roost is filled with expandable foam or similar material. Again, where this cannot be ascertained (i.e. obscure cavity) one-way plastic flaps would need to be installed and left in place for 48-72 hrs (*see* Mitchell-Jones 2004). The above procedure leaves micro bats with two options: **Option A** – Individuals seek refuge within one of the sub optimal roost points; **Option B** – Individuals abandon the site and seek an alternative roost. 8. Inspect the culvert on the following day for signs of use in the sub optimal roost points. If they are not being utilised then decommission by filling with expandable foam or equivalent. 9. If they are being utilised repeat point 7. 10. Once the one-way plastic flaps have been installed for at least 72 hrs re inspect with torch and endoscope and decommission with expandable foam or equivalent. Seasonal considerations associated with cool temperatures must be considered.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA Opportunities to review on a site by site basis Optimum timing for roost exclusion is considered April and May or September.	The Contractor

Strategy	Definition	Techniques	Timing	Responsibility
D	Seasonal limitation of construction works	• Applied to sites/structure defined as high conservation value (i.e. breeding and important overwintering sites) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. • During seasonal limitation of construction works, the construction activities listed above must develop an attended noise and vibration monitoring program in consultation with the Project Ecologist. Provisions must also be made for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period as part of this program. The details of this monitoring must be recorded and submitted with the 6 monthly tracking compliance report. • Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA	The Contractor
E1	Protection of existing habitat	The contractor would manage the integrity of drainage lines and associated riparian vegetation so as to not constrict micro bat flyways. This would include an: • Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[3]. • Ecologist would monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section H2 of this strategy.	Construction.	The Contractor
E2		The contractor would manage water quality and velocity of the adjoining waterways including creeks, rivers and dams would be maintained in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the WC2U Upgrade.	Construction and post construction.	The Contractor
F	Previously unconsidered structures and unexpected finds	This strategy 'previously unconsidered structures and unexpected finds' would address: • Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or • Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys). Microbats found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 3-1; Table 4-1 and 4-2.	Pre-construction, during construction for both construction stages of the WC2U project (2012-2016)	The Contractor
G1	Monitoring Requirements (Habitat)	Habitat monitoring will focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point will be installed and a visual assessment be undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management). Monitoring of water quality will also be undertaken on both the upstream and downstream sides of the construction works. This monitoring will be undertaken on a monthly cycle in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters: turbidity; total suspended solids; conductivity and pH at both upstream and downstream points.	Once prior to construction and monthly during construction. Pre-construction sampling for baseline data and monthly during construction.	The Contractor
G2	Monitoring Requirements (Bat Roost Monitoring)	Short term monitoring associated with planned roost exclusion outlined as strategy C. The data collected in this strategy reflects a short term monitoring commitment to the project and should be tabled within a post clearing report compiled by the project ecologist or sub consultant bat ecologist. Monitoring of bat boxes would commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of the boxes would continue up until Year 6 (i.e. 4 surveys per year for 5 years) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of micro bats and breeding activity.	Within 7-14 days of planned construction activities impacting Commence monitoring 6 months after bat box installation followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of roosts up until Year 6 of this management strategy.	The Contractor
G3	Monitoring Requirements (Bat roost monitoring during construction to examine bat behaviour and roost persistence)	Microbat roost monitoring will focus on Crouches Creek Bridge (7881) during construction to evaluate the response of micro bats to a range of construction activities. The monitoring program should be developed by the Project Ecologist and ensure that a range of construction activities are monitored and there are provisions for this to occur during both the summer breeding period and also a winter period to capture different species which may use the bridge as a roost site.	Monitoring would commence once construction activities start within 100 m of the Crouches Creek Bridge Structure (7881). The timing and duration would be developed by the construction contractor's Project Ecologist or another ecologist. The timing is to take into account summer and winter seasons.	The Contractor

[3] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

4.0 IMPLEMENTATION OF THE MANAGEMENT STRATEGIES

Using the management strategies summarised in Table 3-1 this section identifies what strategies are required at each of the 22 identified structures (Appendix 1). One limitation with identifying management strategies is that the design for the carriageway has not progressed from the concept design for either the Warrell Creek to Nambucca Heads or the Nambucca Heads to Urunga sections of the project. To overcome this, a matrix has been developed to address the potential nature of impacts at three scales:

- 100-200 m from the structure;
- <100 m of the structure; and
- Works on the structure itself.

In each instance, all construction works relating to the project that fall within 200 m of the structure would be subject to this management strategy.

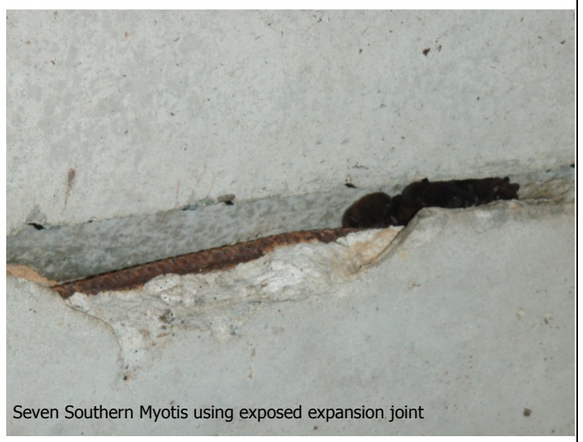
A subjective scale has been developed to qualify the likelihood of a particular bat species using each of the culvert structures (Table 4-1). In this context, biological traits (i.e. breeding/overwintering) that have been assigned as 'moderate' or 'high' have a real possibility of occurring in the particular structure. The 'low' category translates to a key habitat attribute missing from the structure but it could still theoretically provide roost habitat, albeit of lower importance or conservation value. The 'very low' category indicates the roost/structure does not align with a particular species biological traits or the structure could not physically support the required microhabitat elements. For example, a roost that could not physically support thousands of bats associated with a maternity colony of bent-wing bats.

A summary of the required strategies for known and potential structures for micro bats is provided in Table 4-2 and Table 4-3 and the respective timing of key actions, responsibilities and documentation requirements is outlined in Table 4-4.

Table 4-1. Definitions of the subjective scale used to derive the likelihood of a species utilising the structure for a particular biological trait of breeding and over wintering.

Likelihood of species performing a particular biological trait	Description
Very Low	The structure provides unsuitable habitat attributes or does not align with the species' particular biological habits. For example, Bent-wing bats use regional maternity sites often found in caves where the structure can accommodate thousands of individuals. In contrast, the roost habitat within the identified structure could not physically support this requirement.
Low	There is normally a key habitat attribute missing but the structure could still physically provide roost points for this species. For example, a relatively small culvert (i.e. <1.5 m) that doesn't hold water and is relatively low but it contains suitable roost points for Southern Myotis. Another example is the structure lets too much light in to be considered suitable for Eastern Horseshoe Bat which generally prefers to roost in complete darkness.
Moderate	The structure provides the required attributes for the species but it is not considered 'ideal'. For example, a culvert that is <1.5 m in height, retains water and provides roost points with unconstricted inlets and outlets has a moderate chance of providing breeding habitat for Southern Myotis. In this context, the height of the culvert structure detracts slightly from its overall suitability.
High	The structure provides all the required roost attributes for the species to perform a particular biological trait such as breeding. For example, a culvert >1.5 m in height, permanent water and suitable roost points capable of holding >10 individuals with unconstricted inlets and outlets.
Known	Species was recorded during the survey.

Table 4-2. Proposed management strategies at bridges and culverts known to contain micro bats. na = not applicable.

Warrell Creek to Nambucca Heads						See Table 3-1.	See Table 3-1.	See Table 3-1.	
Culverts									
599205 (Deadman's Gully)  Known Southern Myotis habitat using expansion joints on western end	 Seven Southern Myotis using exposed expansion joint	Southern Myotis	-	High	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	No impact from current design
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
599222 (Donnellyville)  Known Southern Myotis habitat within vertical weep/drainage holes	 Vertical drainage/weep holes with earth cavities used by Southern Myotis	Southern Myotis	-	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	May require clean out
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	

Bridges									
Crouches Creek   Southern Myotis using expansion gaps in bridge deck	 Couches Creek and southern abutment	Southern Myotis	-	High	High	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	No impact from current design
		Gould's Wattled Bat	-	Moderate	Moderate	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
Warrell Creek Bridge (1871) 	No pic	Little Bent-wing Bat	-	Low	High	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	No impact from current design
		Forest Bat (*Vespadelus spp*)	-	Low	Low	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	
			Southern Myotis	High	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, E1, E2, G1, G2	
			Gould's Wattled Bat	Moderate	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	
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Nambucca Heads to Urunga									
Culverts									
599271 (Cow Creek) No pic	 Southern Myotis using gaps in the expansion join	Southern Myotis	- Little Bent-wing Bat Eastern Horseshoe Bat	High Low Low	Moderate Moderate Moderate	E1, E2 E1, E2 E1, E2	B, E1, E2 B, E1, E2 B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2 A (option 2), B, C, D, E1, E2, G1, G2 A (option 2), B, C, D, E1, E2, G1, G2	
599293  Box culvert with seasonal water flow	 Single Southern Myotis using gaps in the expansion join	Southern Myotis	- Little Bent-wing Bat Eastern Horseshoe Bat	Moder ate Low Low	High Moderate Moderate	E1, E2 E1, E2 E1, E2	B, D, E1, E2 B, D, E1, E2 B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2 A (option 2), B, C, D, E1, E2, G1, G2 A (option 2), B, C, D, E1, E2, G1, G2	
599306 (Dalhousie Creek)  East side of culvert showing permanent water	 Likely breeding site for Southern Myotis	Southern Myotis	- Little Bent-wing Bat Eastern Horseshoe Bat	High Low Low	Moderate Moderate Moderate	A1, A2 A1, A2 A1, A2	na na na	na na na	

Bridges									
North Coast Railway Bridge (Nambucca Heads) 	No pic	Gould's Wattled Bat	-	Moderate	Moderate	E1	E1, A (option 2), B,	E1, A (option 2), B,	
			Little Bent-wing Bat	Low	High	E1	E1, A (option 2), B,	E1, A (option 2), B,	
			Eastern Horseshoe Bat	Low	Low	E1	E1, A (option 2), B,	E1, A (option 2), B,	

Table 4-3. Proposed management strategies at bridges and culverts that provide potential habitat for micro bats.

Warrell Creek to Nambucca Heads					See Table 3-1.	See Table 3-1.	See Table 3-1.	
Culverts								
599228 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Low Low (typically have water beneath – this is a dry passage culvert) Low	High Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, E1, E2, B, E1, E2, B,	E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, ,G1, G2 E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
599229 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Low Low (most likely towards the eastern end where water tends to pool in the culvert) Low	Moderate Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, E1, E2, B, E1, E2, B,	E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
599237 		Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Low Low (typically have water beneath – this is a dry passage culvert with high cattle use) Low	High Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, E1, E2, B, E1, E2, B,	E1, E2, B, A, C, , G1, G2 E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)

599238 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Low Low (typically have water beneath – this is largely a dry passage culvert) Low	High Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, E1, E2, B, E1, E2, B,	E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, G1, G2 E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
Bridges								
None identified								
Nambucca Heads to Urunga								
Culverts								
599265 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Low (most likely towards the eastern end where water tends to pool in the culvert) Very Low	Low Moderate Very Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
599272 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Low Very Low	Low Low Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	

599274 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Very Low	Low Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
599276 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Low	Moderate Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
599282 		Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Low	Moderate Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	

599291 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Low Very Low	Low Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
599302 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Very Low Very Low	Low Low Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
599323 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Very Low	Low Moderate Moderate	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	

599325 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Low Very Low	Low Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
Bridges								
Boggy Creek Bridge (6696) 		Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Very Low	Moderate Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	

Table 4-4. Timing of key actions for this micro bat management plan, responsibilities and documentation requirements.

Management Action/Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Responsibility	Documentation Requirements
Pre Construction								
Prepare Micro Bat Management Strategy	√						RMS	Construction Environmental Management Plan
Construction	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Commission Construction of Bat Boxes	√	√					Project Ecologist – Contractor responsibility	-
Install Bat Boxes	√	√					Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Survey 22 structures to assess over wintering habitat		√	√				A Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Planned Exclusion Works		√	√				Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Bat Box Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Autumn		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Winter		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Spring		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Habitat Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Autumn		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Winter		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Spring		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Roost Disturbance Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Autumn			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Winter			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Spring			√	√			Project Ecologist –	Yearly reporting

							Contractor responsibility	
Maintenance								
Maintenance of boxes			√			√	Project Ecologist – Contractor responsibility	
Pre Handover Maintenance Inspection						√	Project Ecologist – Contractor responsibility	Yearly reporting

5.0 CONCLUSION

The Warrell Creek to Urunga bat management strategy incorporates seven management measures to adequately address MCoA **(B30b iv)** including:

- Installation of additional roosts
- Implementing additional field surveys
- Planned roost exclusion
- Seasonal limitation of construction works
- Protection of existing habitat
- Previously unconsidered structures and unexpected finds
- Monitoring requirements

Together, they are provided as bat management strategies A-G in this document with their implementation staged according to the proposed distance of construction works and the overall importance of the bat roost itself. Importantly, all construction works that fall within 200 m of the identified structures would be subject to management strategies outlined in this plan.

The use of bat boxes would provide opportunities for passive relocation of bat roosts and these would need to be installed at least 6-12 months prior to any planned roost exclusion and/or construction works. The monitoring framework would assess the overall performance of these measures and provide an opportunity to evaluate potential changes in habitat quality of flyways, water ways, the uptake of bat roost boxes and form part of the planned roost exclusion. In one instance and for the largest of the recorded micro bat roosts (Crouches Creek 7881) the use of monitoring during construction will allow for the examination on how micro bats respond to construction related disturbances.

This micro bat management strategy provides guidance to RMS and highlights the importance of planning ahead and acting in advance of the construction phase of the project. The strategic installation of additional roost sites followed by planned roost exclusion and monitoring at culvert structures during September and again in April-May would provide a more equitable outcome for both construction and the local ecology as micro bats should neither be breeding nor over wintering at these times.

6.0 REFERENCES

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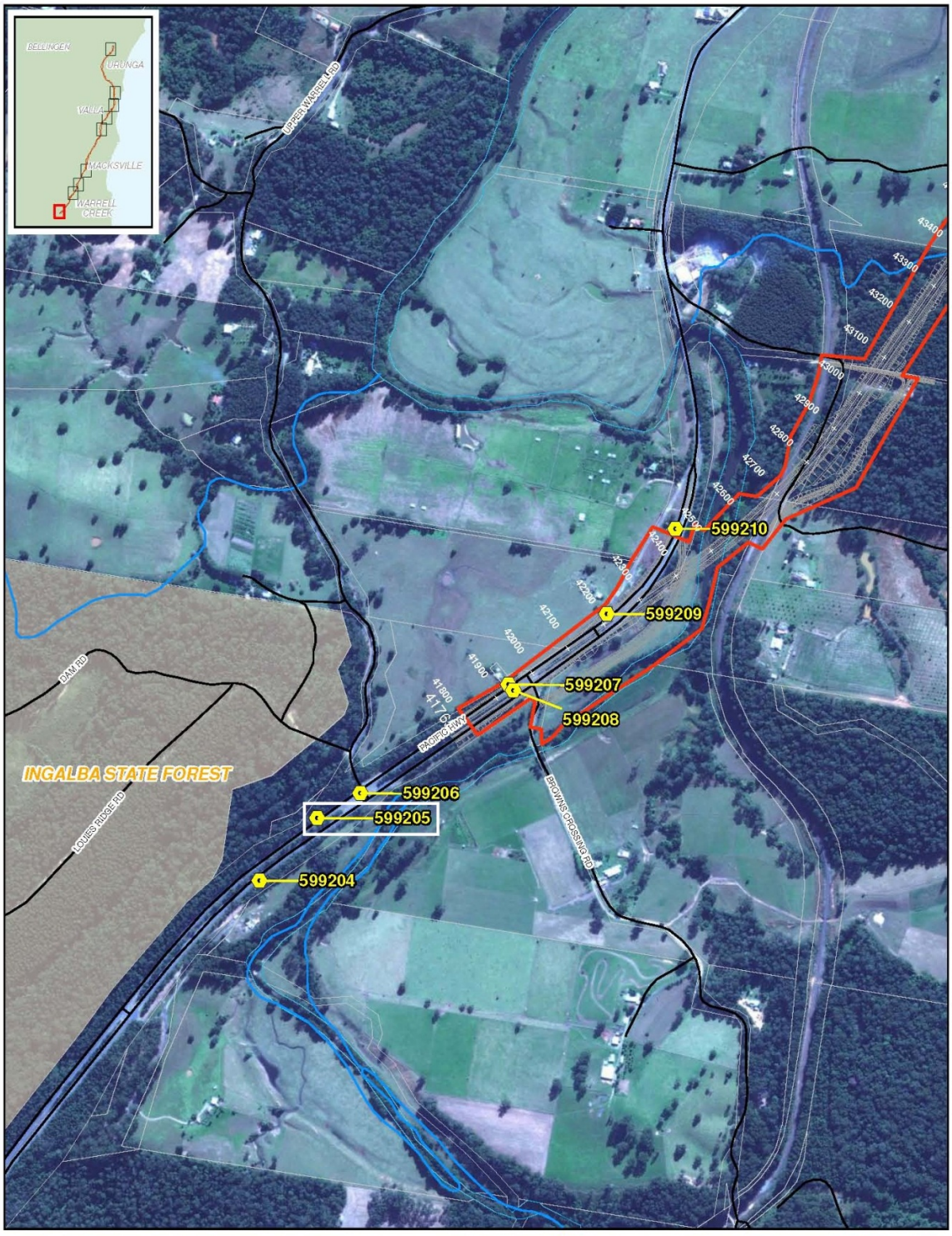
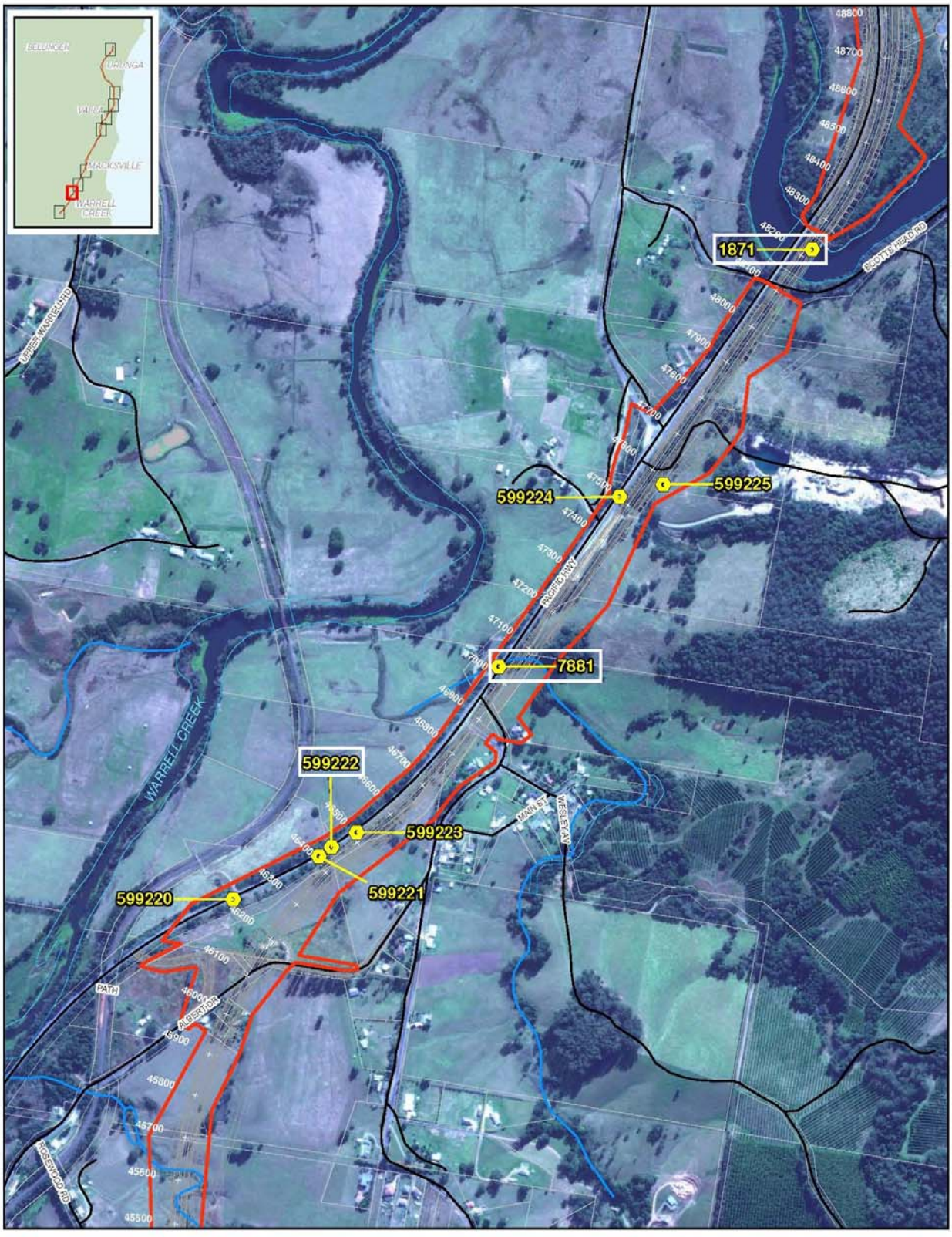
7.0 APPENDIX 1 – CULVERT AND BRIDGE LOCATIONS

Note – White boxes around culverts depicts culverts representing micro bat habitat.





Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 3 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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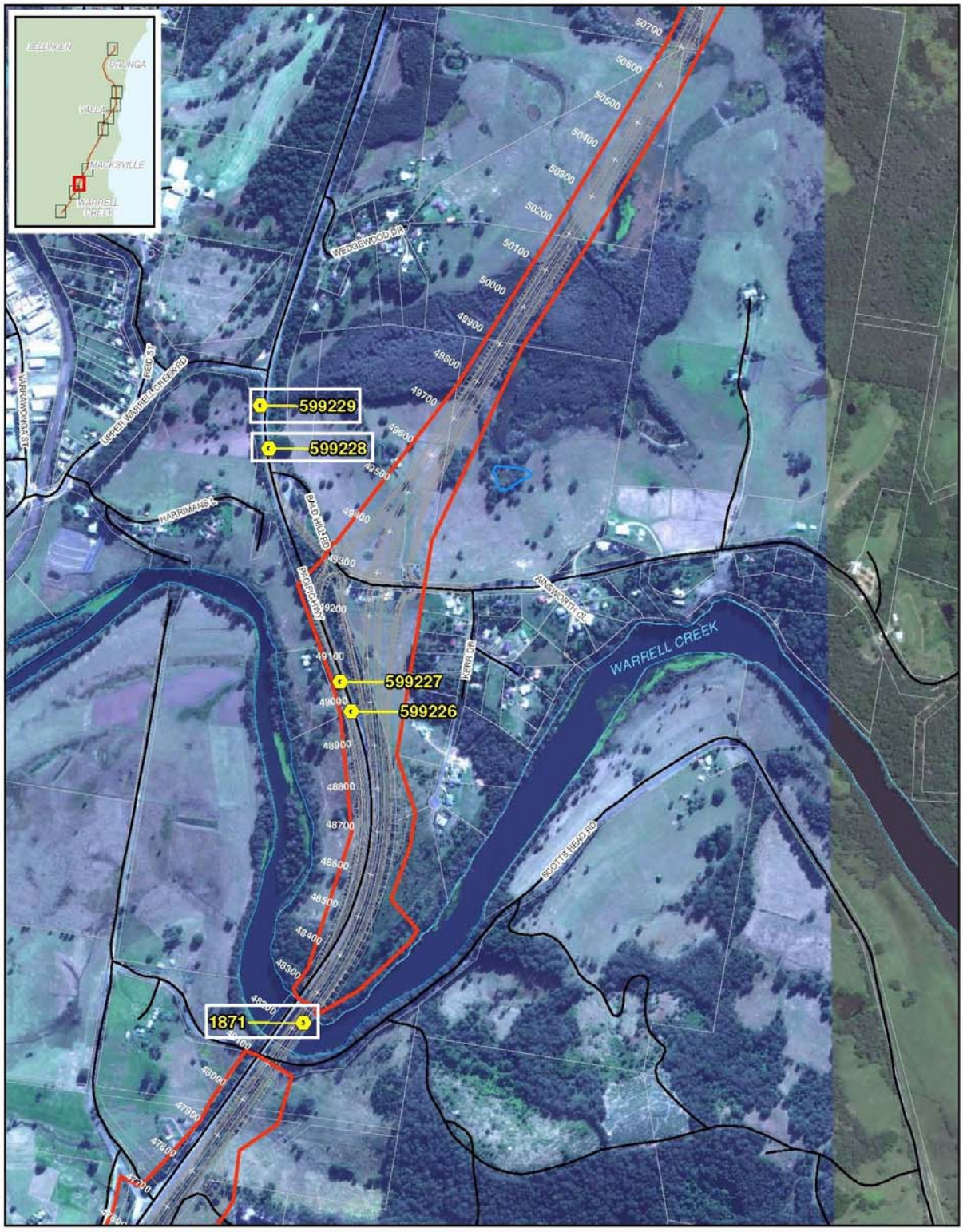

Figure 4 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)
Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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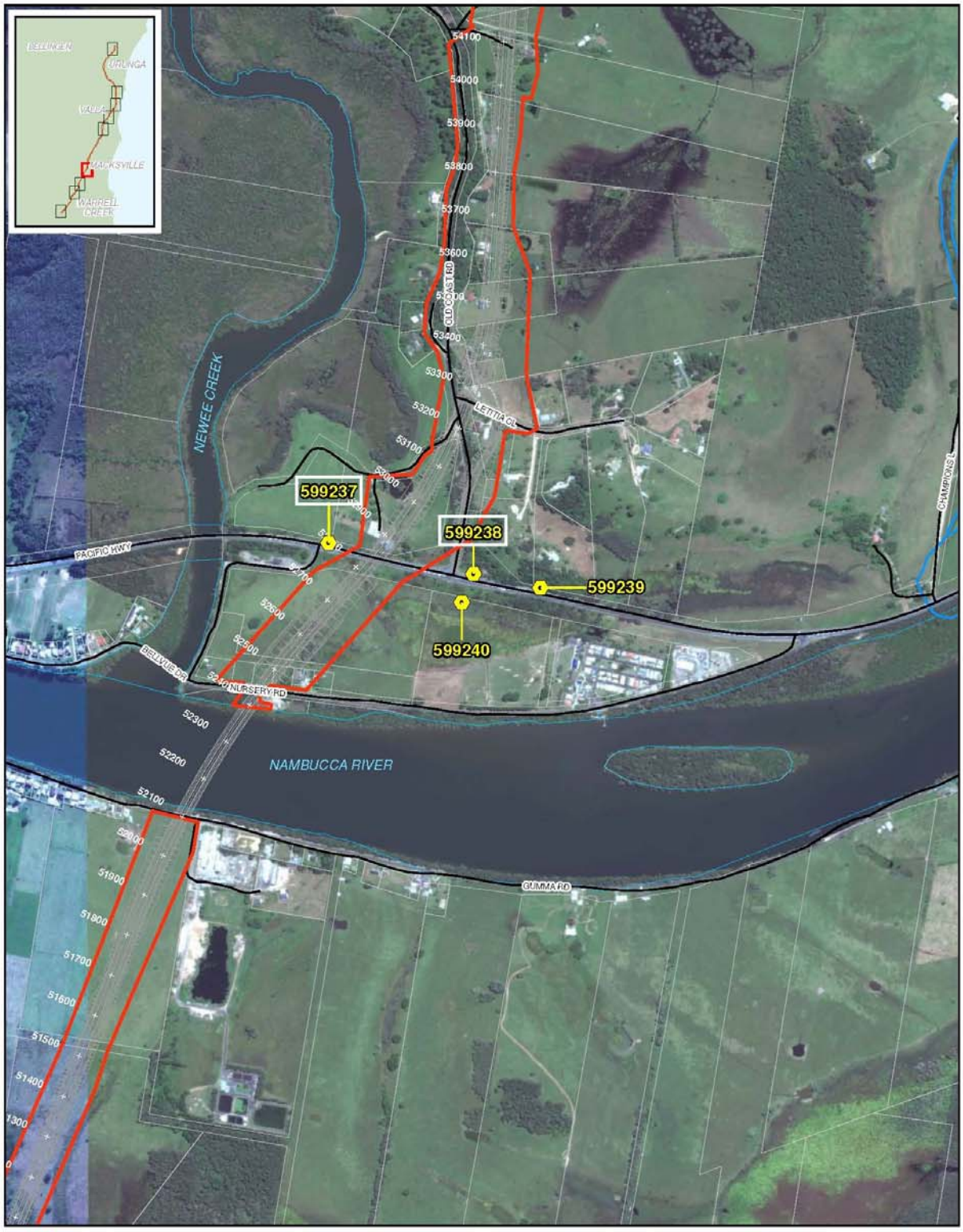
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MACKSVILLE
WARRELL CREEK
NEWEE CREEK
OLD COAST RD
LETITIA CL
CHAMPION ST
599237
599238
599239
599240
PACIFIC HWY
BELLVIEW DR
NURSERY RD
NAMBUCCA RIVER
GUMMA RD
54100
54000
53900
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52700
52600
52500
52400
52300
52200
52100
52000
51900
51900
51700
51600
51500
51400
51300
Culvert
Project Boundary
Drainage line
Cadsastral Boundary
Detail Road Design (Construction Footprint)
Figure 5 :
CULVERT SURVEY
Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)
Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006
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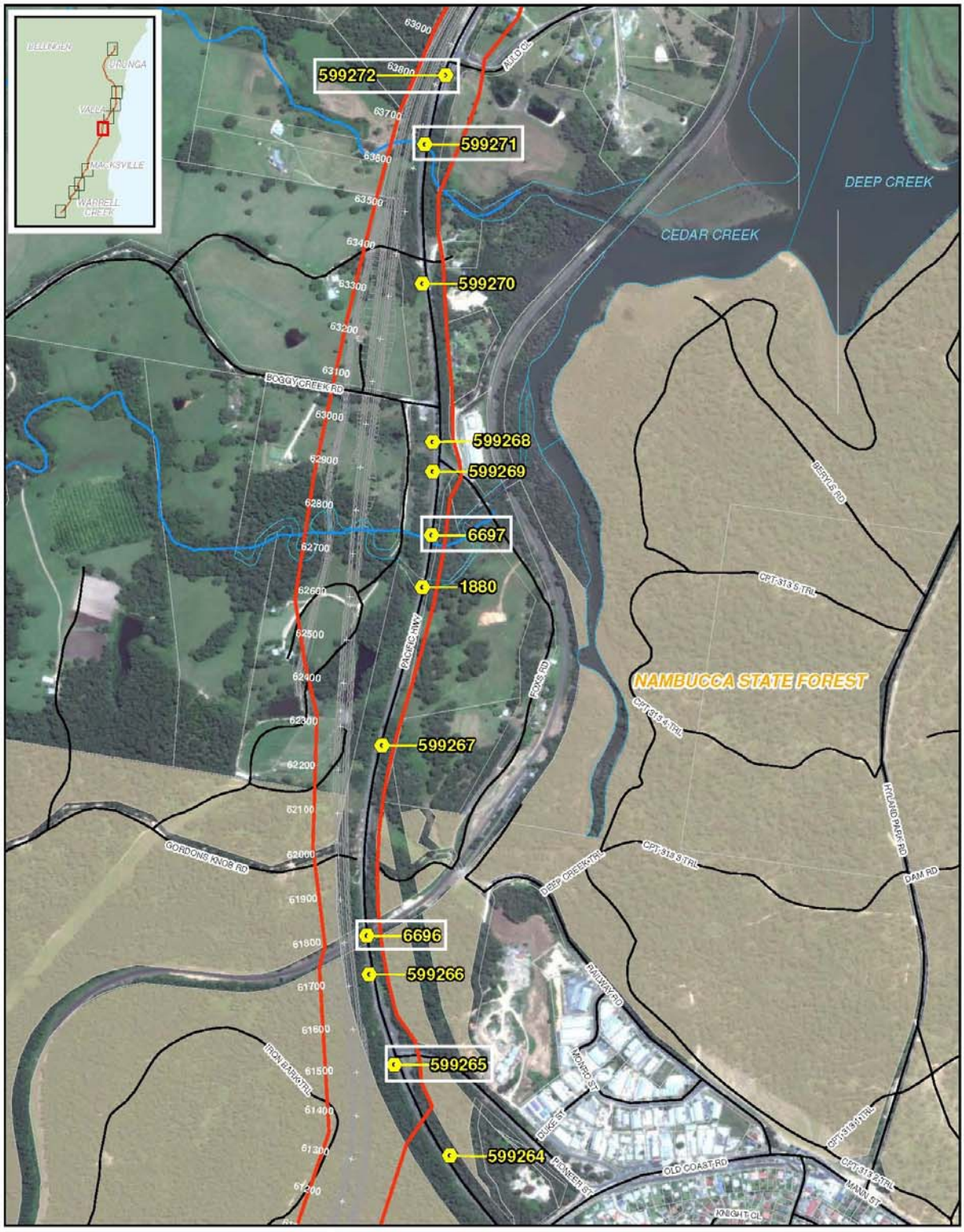

Figure 6 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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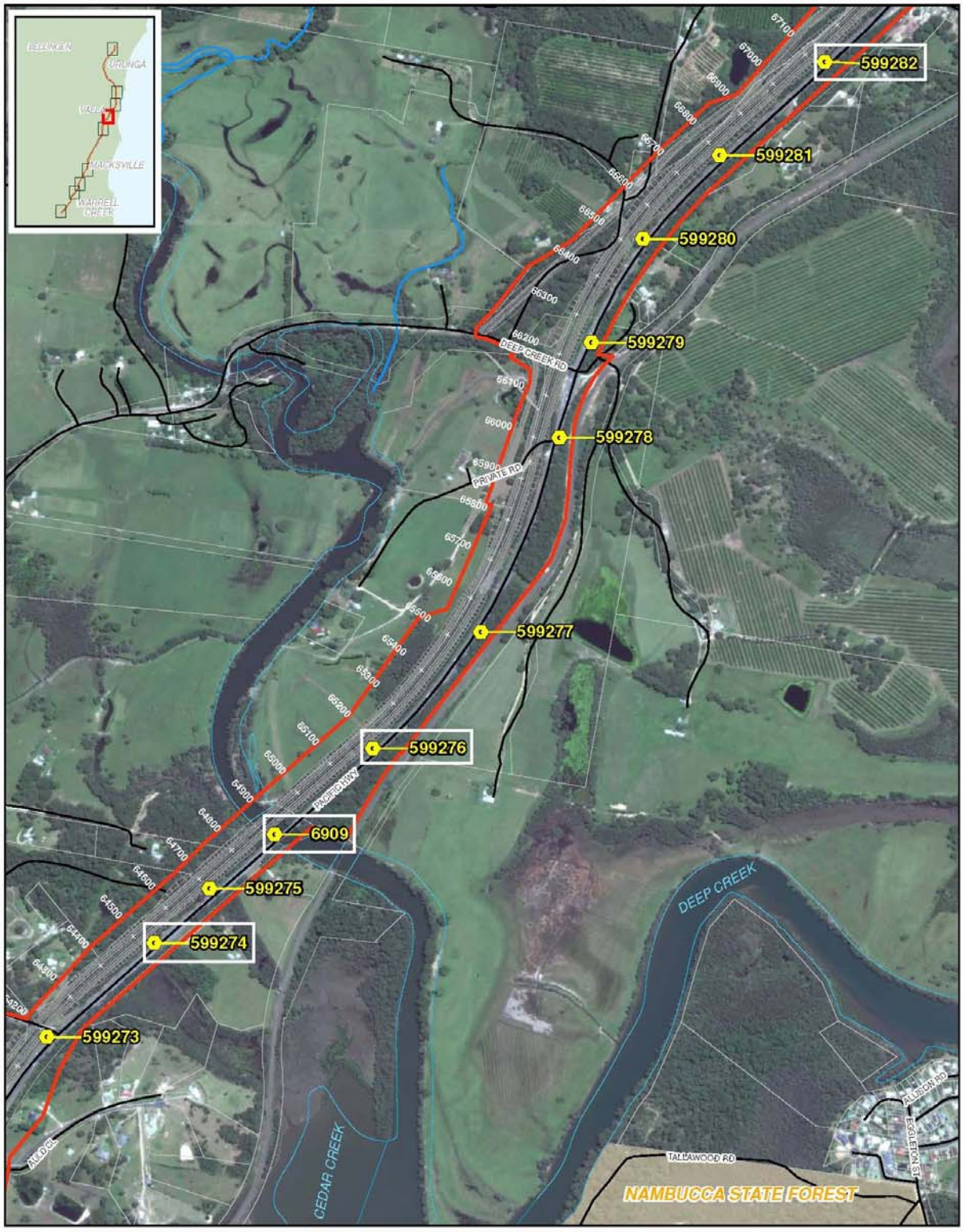
W: www.geoview.com.au



Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 7 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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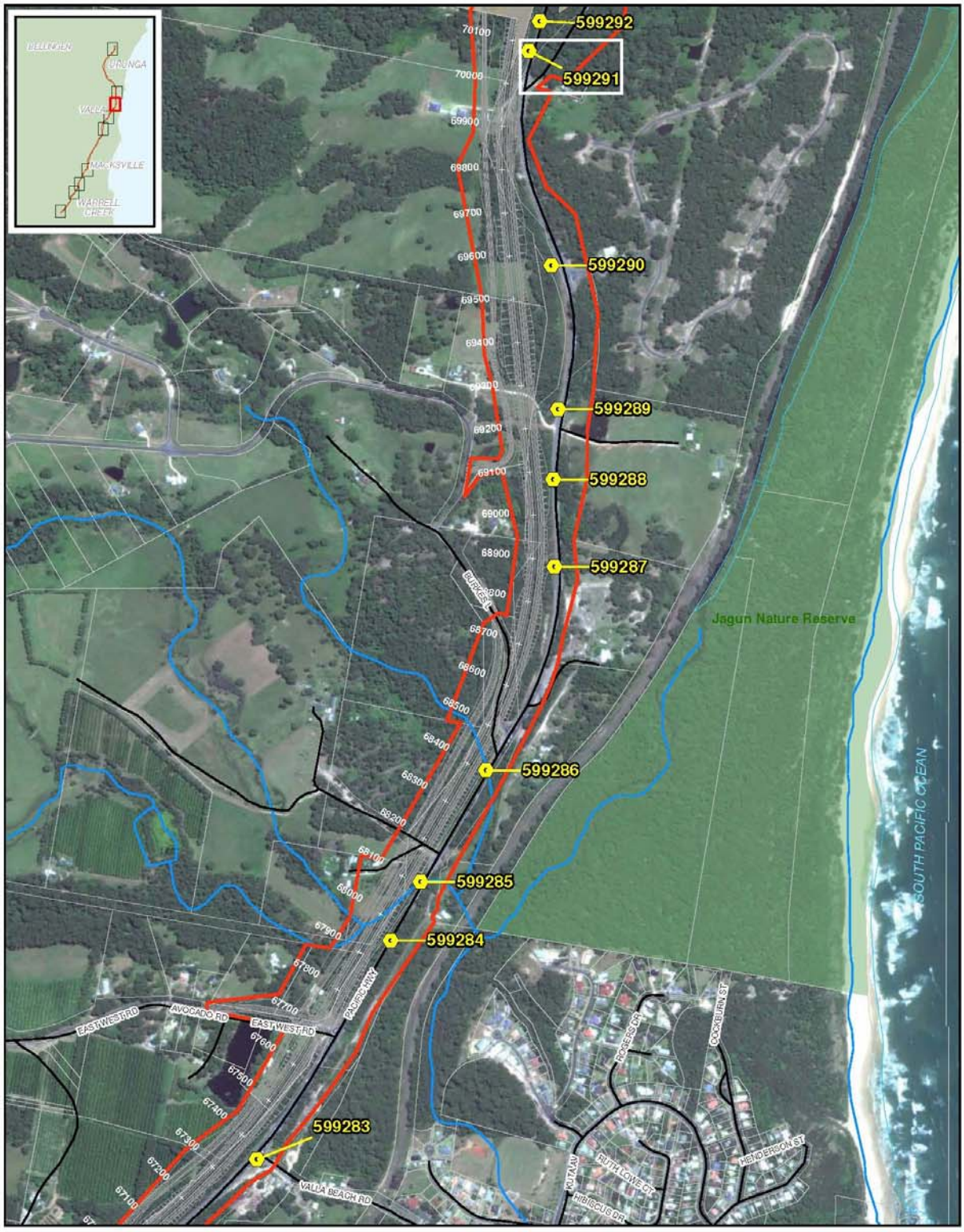

Figure 8 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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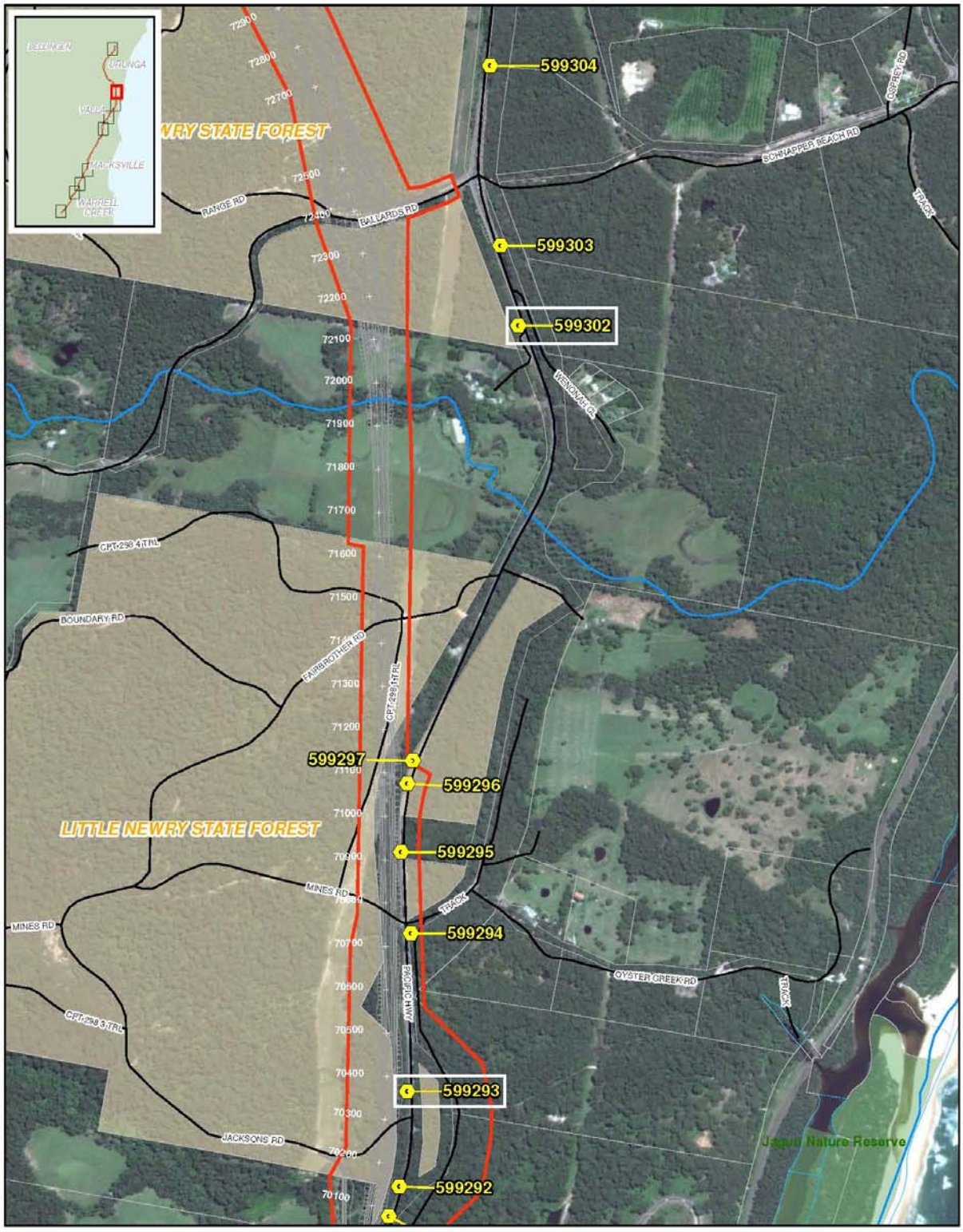

Figure 10 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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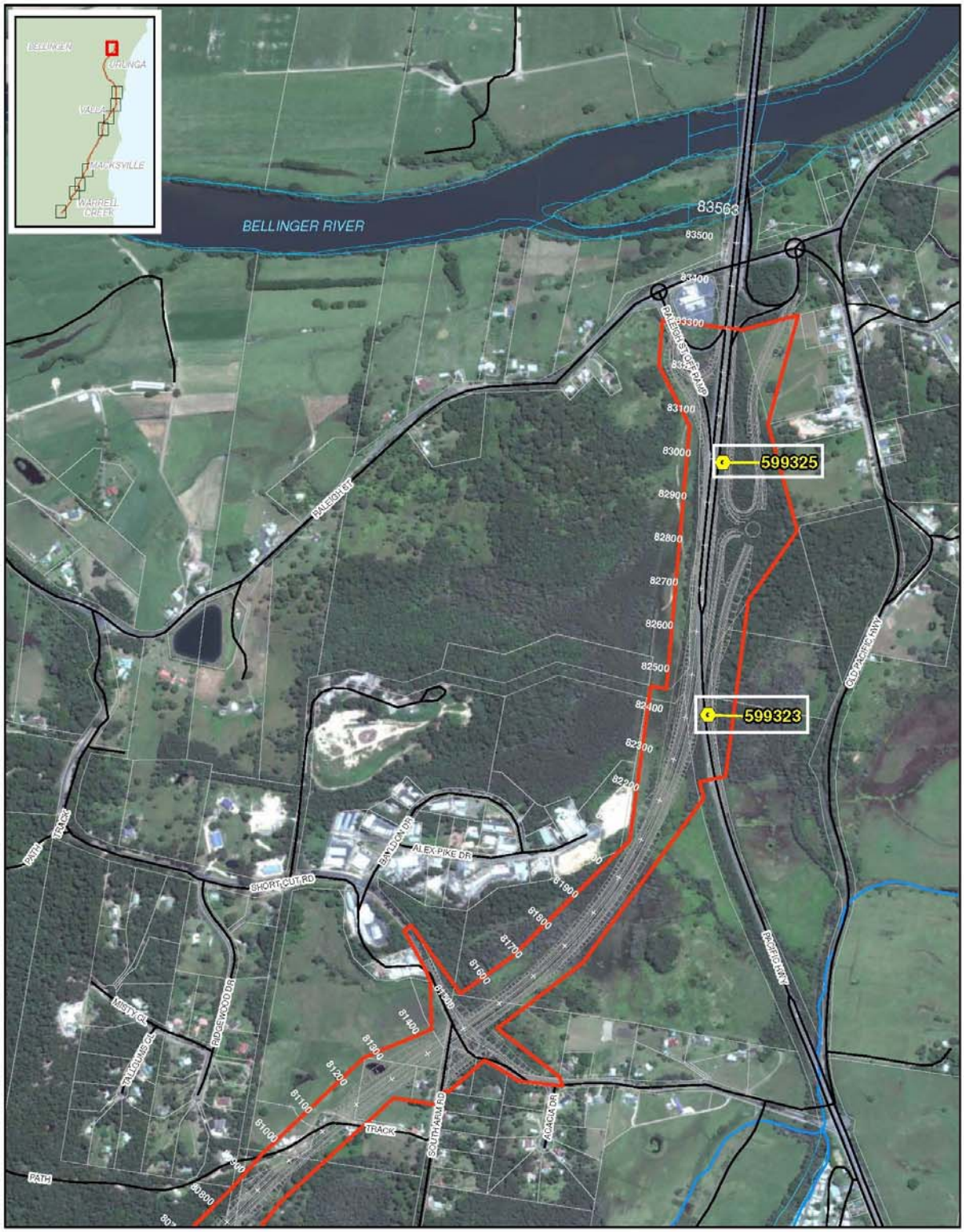

Figure 9 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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