Appendix M Survey and assessment summary

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Wetland and migratory bird species

Target species	Listed status		Status on project and additional species methods	Further report reference	
	TSC / FM Act	EPBC Act		Impact	Mitigation
Australasian Bittern *Botaurus poiciloptilus* (AB)	E1	E1	Confirmed. Section 3. This species was also targeted in spotlighting surveys around wetlands and riparian sites (16 sites)	4.3.2.	6.3
Australian Painted Snipe *Rostratula australis* (AS)	E	V, Mi	Predicted all sections	4.3.2.	6.3
Black-necked Stork *Ephippiorhynchus asiaticus* (BS)	E1	-	Confirmed: Sections 1-5. Known breeding habitat. Targeted searches for nest sites across the project particularly in Sections 3-5)	4.3.2.	5.3.2
Pale-vented Bush Hen *Amaurornis molucanna* (PH)	V	-	Predicted	3.11.2	6.3
Magpie Goose *Anseranas semipalmata* (MG)	V	-	Confirmed: Section 3. Wants Lane, Coldstream wetland	4.3.2.	6.3
Comb-crested Jacana *Irediparra gallinacea* (CJ)	V	-	Predicted	4.3.2.	6.3
Black Bittern *Ixobrychus flavicollis* (BB)	V	-	Predicted	4.3.2.	5.6 & 6.3
Brolga *Grus rubicundus* (B)	V	-	Confirmed, Clarence River floodplain	4.3.2.	6.3
Freckled Duck *Stictonetta naevosa* (FD)	V	-	Predicted	3.11.2.	6.3
Pied Oystercatcher (*Haematopus longirostris*)	E	-	Observed in adjacent coastal areas outside the project boundary	3.9.4	-
Migratory listed wetland species including but not limited to: Lathams Snipe, Cattle Egret, Great Egret, White-bellied Sea Eagle		Mi	Predicted all sections	4.3.2	5.2

Wetland birds targeted survey methods and effort

Survey (method)

- Area and time–based bird surveys were conducted in representative wetlands, wet forest, swamp forests, wet heaths and riparian habitats.
- The survey periods varied from 5-20 minutes at each site depending on the condition and size of the site, location and noise of traffic.
- Surveys were conducted across swamp forests, wet heaths, wetland habitat and modified lands covering a total of 20 sites and 130 person hours over four seasons.
- Systematic bird surveys were also conducted at the small areas of floodplain wetlands near the project boundary.
- This involved a point census from wetland edge or vantage point along nearby road during early morning and dusk census for a total of 1 person hour at each site including at Chaffin Swamp, the Coldstream wetland near Tucabia and north of Sandy Crossing (Wants Lane) in Section 3.
- The surveys covered a broad range of potential habitats for wetland birds, including wetlands, modified floodplains, swamp forests and creek and riparian habitats.
- Birds were also recorded opportunistically during all fauna survey activity with binoculars carried in the field at all times to assist in identification.
- Focus was to identify the distribution and quality of potential foraging habitat within the study area

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Diurnal census (birds)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (262 person-minutes)	11 sites (93 person-minutes)	13 sites (116 person minutes)	2 sites (4 person hours)	3 sites (6 person hours)	2 sites (4 person hours)

Wetland and migratory bird species

Survey compliance / limitations

- Survey effort is considered adequate for this assessment and no further targeted surveys are required for wetland and migratory species due to survey limitations.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species and important habitats for reuse such as woody debris

Biometric vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	PH	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	AB, AS, BS, PH, MG, CJ, BB, B, FD	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	PH	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	AB, BS, MG, BB, FD	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	AB, BS, PH, BB	1.5	5 (1.3ha), 10 (0.2ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	AB, BS, MG, BB, FD	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	AB, BS, PH, CJ, BB	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	AB, BS, BB	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	AB, BS, PH, CJ, BB	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	AB, AS, BS, PH, MG, CJ, BB, B, FD	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	PH	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	PH	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	AB, BS, PH, MG, CJ, BB, B	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	PH	8.6	10 (7.9ha), 11 (0.7ha)
	Total	455.8 hectares	

Remaining uncertainties

- Potential indirect impacts to habitat from altered hydrology regimes and poor water quality.
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Overview of impacts

- Loss of potential nesting and foraging habitat
- Potential impacts on foraging and movement life-cycle activities
- Prone to impacts from altered hydrology and water quality
- Indirect impacts may result on adjacent habitats through edge effects, mostly noise but also weeds

Wetland and migratory bird species

- Total area of potential impact to these species within the project boundary is up to 455.8 hectares (potential vegetation type / habitat area), further details below.

Avoidance measures

- Potential habitat was considered in the route selection process, particularly in avoiding the significant floodplain wetlands of the Clarence River and Richmond River, also listed SEPP14 wetlands and the catchments for wetlands of national significance.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The concept design has been located to minimise vegetation clearing where possible and minimise potential impacts to habitat used by the target species.
- The detailed design will aim to further minimise vegetation/habitat clearing where possible.

Proposed mitigation and management measures

- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29) The location of exclusion zones would be determined and established to avoid damage to any adjacent wetlands and other aquatic habitats which provide habitat for the species.
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Reuse of woody debris and bushrock (B31)
- Riparian and aquatic habitat management (B38-B52)
- Water quality (B53-B57)

Previous / known success of measures

- The procedures used for exclusion zones, riparian and aquatic habitat management, and water quality management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedures and guidelines

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 455.8 hectares of wetland, floodplain, rainforest and swamp habitat including some adjacent wet sclerophyll forest habitats on footslopes potentially used by the target species
- High to moderate indirect impacts associated with edge effects for the project

Proposed offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (ha) in 30 km radius
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7

Wetland and migratory bird species					
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Large forest owls and other nocturnal birds

Target species	Listed status		Status on project and additional species methods	Further report ref*	
	TSC / FM Act	EPBC Act		Impact	Mitigation
Barking Owl *Ninox connivens* (BO)	V		Predicted across a range of habitats	4.3.2.	6.3
Powerful Owl *Ninox strenua* (PO)	V		Confirmed at a number of locations	4.3.2.	6.3
Grass Owl *Tyto longimembris* (GO)	V		Confirmed and predicted in restricted habitats	4.3.2.	6.3
Masked Owl *Tyto novaehollandiae* (MO)	V		Confirmed	4.3.2.	6.3
Sooty Owl *Tyto tenebricosa* (SO)	V		Confirmed in restricted habitats	4.3.2.	6.3

Large forest owls and nocturnal birds survey methods and effort

- Targeted surveys were conducted at 38 individual sites over a total of 53 survey nights.
- Calls of target species were broadcast through a 15-20W loudspeaker for 5 minute periods, followed by periods of listening and spotlighting.
- Sooty Owl and Grass Owl were only played at sites with suitable habitat.
- Playback sessions were repeated at each site in all sections and varied from 2 nights per site in Sections 1-2, 4 nights per site in Section 3-5, 8 nights per site in Section 6-7. In section 9-11, 5 nights per site were repeated for Powerful Owl, Barking Owl and Grass Owl, 6 nights for Sooty Owl and 7 nights for Masked Owl.
- Surveys were conducted all year round and were widely spaced to account for different home range areas.
- Searches for owl pellets were conducted at all 129 habitat assessment sites.
- Spotlighting searches were conducted at 56 sites for a total of 138 person hours, covering all habitat strata.
- The spotlighting searches targeted nocturnal birds.

Survey Method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Call playback (nocturnal birds)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul 05; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	17 sites (36 sessions)	8 sites (6 sessions)	8 sites (6 sessions)	3 sites (3 sessions)	1 site (1 session)	1 site (1 session)
Timed nocturnal search (nocturnal birds and mammals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (61 person hours)	10 sites (24 person hours)	13 sites (40 person hours)	2 sites (6 person-hours)	6 sites (6 person hours)	1 site (1 session)

Survey compliance / limitations

- The method of listening, call-playback, stationary spotlighting, and waiting for vocal responses is an established technique for detecting the five owls species concerned (Kavanagh & Peake 1993; Kavanagh & Bamkin 1995; Kavanagh et al. 1995; Debus1995, 1997; Maciejewski 1997; Debus et al. 1998, 2001; Debus 2001).
- These surveys were conducted in accordance with the DEC survey guidelines for threatened owls by incorporating call-playback on different nights in dry, calm conditions.
- At least two surveys per site was conducted at all sites, the minimum number of surveys for each species as recommended in DEC (2004) was not meet at all sites.
- No further targeted surveys are required for large forest owls however pre-clearing surveys will be undertaken to determine the presence of nesting/roosting species as part of the nest box management strategy

Large forest owls and other nocturnal birds			
Vegetation / habitat types linked to large forest owls	**Species (Abbreviated)**	**Area in project boundary (ha)**	**Project Section (extent in hectares)**
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	BO, PO, MO, SO.	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	BO, PO, MO.	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	BO, PO, MO, SO.	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	BO,PO, GO,MO.	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	BO, PO, GO, MO, SO.	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	BO, GO.	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	PO, MO, SO.	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	BO, PO, GO, MO, SO.	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	BO, MO.	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	BO, PO, MO, SO.	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	BO, PO, GO, MO, SO.	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	BO, PO MO.	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	BO, PO, MO.	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	BO, PO, MO, SO.	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	BO, PO, MO, SO.	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	BO, PO, GO, MO.	71.9	3 (49.6ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	BO, PO, MO.	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	BO, PO, MO.	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	BO, PO, MO, SO.	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	BO, PO, MO, SO.	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	BO, PO, GO, MO, SO.	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	BO, PO, SO	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	PO, MO, SO	44.5	3 (44.5ha)

Large forest owls and other nocturnal birds

White Booyong - Fig subtropical rainforest of the North Coast	PO, MO, SO	8.6	10 (7.9ha), 11 (0.7ha)
	Total	936.4 hectares	

Remaining uncertainties

- The number of pairs potentially impacted and the presence and extent of home range territories overlapping the construction footprint is not known nor is the core breeding territory for pairs or owl nest sites known
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.
- Presence of humans or edge effects remains to be ascertained

Impacts

- Loss of potential foraging and nesting habitat from within the home range of established pairs
- Loss of habitat for important prey species
- Loss of habitat for dispersal and establishment of new territories
- Indirect impacts may result on adjacent habitats through edge effects
- Total area of potential impact to the species within the project boundary is 936.4 hectares (potential vegetation type / habitat area).

Avoidance measures

- Potential habitat was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat which might contain the home range territories of established pairs.
- The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts habitat present in the study area.
- Detailed design will further aim to minimise vegetation/habitat clearing
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats for prey species and potential nest sites.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Nest box management strategy (B36)
- Reuse of woody debris and bushrock (B31)

Large forest owls and other nocturnal birds

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure
- Nest boxes for owl species have been proven to be effective, and additionally several main prey species for owl species use nest boxes

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 936.4 hectares of potential habitat
- High to moderate indirect impacts associated with edge effects for the project

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Biometric vegetation association	**Direct loss (ha)**	**Edge effects (ha)**	**Offset ratio**	**Offset target (ha)**	**Area (hectares) in 30 km radius**
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2

Large forest owls and other nocturnal birds					
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Microchiropteran bats

Species	Status		Status on project	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Large-eared Pied Bat *Chalinolobus dwyeri (*LPB)	V	V	Predicted, foraging habitat identified.	4.3.2.	6.3
Hoary Wattled Bat *Chalinolobus nigrogriseus* (HB)	V	-	Confirmed in Sections 1-3 & 6-8	4.3.2.	6.3
Eastern False Pipistrelle *Falsistrellus tasmaniensis* (EP)	V	-	Confirmed in Sections 1-3	4.3.2.	6.3
Golden-tipped Bat *Kerivoula papuensis* (GTB)	V	-	Confirmed in Sections 9-11	4.3.2.	6.3
Little Bent-wing Bat *Miniopterus australis* (LBB)	V	-	Confirmed in Sections 1-11	4.3.2.	6.3
Eastern Bent-wing Bat *Miniopterus schreibersii oceanensis* (EBB)	V	-	Confirmed in Sections 1-2 & 6-11	4.3.2.	6.3
Beccari's Freetail-Bat *Mormopterus beccarii* (BB)	V	-	Likely and predicted to occur, potential habitat	4.3.2.	6.3
Eastern Freetail-Bat *Mormopterus norfolkensis* (EFB)	V	-	Confirmed in Sections 6-11	4.3.2.	6.3
Southern Myotis *Myotis macropus* (LM)	V		Confirmed in Sections 1-2 and 6-11	4.3.2.	6.3
Eastern Long-Eared Bat *Nyctophilus bifax* (ELB)	V	-	Confirmed in Sections 6-11	4.3.2.	6.3
Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* (YSB)	V	-	Confirmed in Sections 9-11	4.3.2.	6.3
Greater Broad-nosed Bat *Scoteanax rueppellii* (GBB)	V	-	Confirmed in Sections 9-11	4.3.2.	6.3
Eastern Cave Bat *Vespadelus troughtoni* (ECB)	V		Confirmed in Sections 6-11	4.3.2.	6.3

Survey methods

The survey methods used for bats were consistent with or exceeded the DEC survey guidelines in terms of survey effort and survey period. For example the guidelines recommend four trap nights per 100 hectares of each stratification unit. On the basis of the broad habitat stratification units this survey effort is exceeded. The limitation with the trapping and bat call detection related to optimum survey locations in order to trap bats. Ideal locations represent narrow tracks through forest where bats can be funnelled into traps. No further surveys are required for microchiropteran bats due to survey limitations.

- Three methods were used including harp trapping, call surveys and roost surveys.
- Standard two-bank 4.2 m2 harp traps were used to sample for microchiropteran bats at 50 sites stratified by dry (28), moist (10) and swamp forest (12) for a total of 108 trap nights, comprising a total of one site per 15 hectares in dry forest, 1 site per 33 hectares in moist forest and one site per 12 hectares in swamp forest.
- Trapping sessions were conducted over a minimum of two consecutive nights resulting in 11 traps nights per 100 hectares in dry forest, eight trap nights per 100 hectares in moist forests, and 21 trap nights per 100 hectares in swamp forest.
- The surveys aimed to sample representative vegetation associations.
- Ultrasonic call recording was conducted at 72 sites for a total of 552 recording hours.
- Roost surveys were conducted for the Duck Creek and Emigrant Creek bridges (project sections 10 and 11) during the summer season.
- Identification of the distribution and quality of potential foraging habitat within the study area

Microchiropteran bats

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Harp-trapping (microchiropteran bats)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul 05;Oct 07; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	28 sites (50 trap nights)	10 sites (26 trap nights)	12 site (32 trap nights)			
Ultrasonic call recording (microchiropteran bats)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul 05; Oct 07; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	29 sites (236 hours)	18 sites (163 hours)	12 sites (140 hours)	5 sites (60 hours)		8 sites (60 hours)

Survey compliance / limitations

- The survey methods used for bats were consistent with or exceeded the DEC survey guidelines in terms of survey effort and survey period. For example the guidelines recommend four trap nights per 100 hectares of each stratification unit. On the basis of the broad habitat stratification units this survey effort is exceeded.
- The limitation with the trapping and bat call detection related to optimum survey locations in order to trap bats. Ideal locations represent narrow tracks through forest where bats can be funnelled into traps.
- No further targeted surveys are required for microchiropteran bats due to survey limitations.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement (ie nest boxes) such as woody debris, bushrock and hollow-bearing trees

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	LPB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB, GBB ECB	1.4	3 (1.4 ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	LPB, HB, EP, GTB, LBB, EBB, EFB, LM, ELB, YSB GBB	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	HB, EP, EBB, BB, EFB, LM, YSB	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	LPB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	0.5	10 (0.5 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	LPB, LBB, EBB, EFB, LM, YSB GBB	1.5	5 (1.3 ha), 10 (0.2 ha)

Microchiropteran bats			
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB, GBB	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, YSB GBB ECB	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB	2.1	2 (2.11 ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	LPB, HB, EP, LBB, EBB, BB, EFB, LM, YSB GBB ECB	144.8	1(17.9ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	28.5	1 (23.3 ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	LPB, HB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB	44.5	3 (44.5 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	LPB, EP, LBB, EBB, EFB, LM, YSB GBB	10	6 (10 ha)
White Booyong - Fig subtropical rainforest of the North Coast	LPB, EP, GTB, LBB, EBB, BB, EFB, LM, ELB, YSB GBB ECB	8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	947.90 hectares	

Remaining uncertainties

- The presence and extent of breeding and shelter habitat in the construction footprint including hollow roosts, and artificial structures such as culverts that may be removed as part of the project
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.

Impacts

- Loss of potential foraging, roosting and shelter habitat
- Indirect impacts may result on adjacent habitats through edge effects including habitat for prey species
- Total area of potential impact to the species within the project boundary is 947.90 hectares (potential vegetation type / habitat area).
- Impacts on habitat for prey species is expected to be minimal and these bat species are adapted to moving through cleared and disturbed habitat for foraging
- Low expected impacts on movements of bats

Microchiropteran bats

Avoidance

- Potential habitat was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat which might contain the home range territories of established pairs.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats for roosting and habitat for prey species.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Nest box management strategy (B36)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure
- Nest boxes for microbat species have been proven to be effective

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 947.9 hectares of potential habitat
- High to moderate indirect impacts associated with edge effects for the project

Proposed offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3

Microchiropteran bats					
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Woodland birds

Target Species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Brown Treecreeper *Climacteris picumnus* (BT)	V		Confirmed. Section 2	4.3.2.	6.3
Diamond Firetail *Stagonopleura guttata* (DF)	V		Not detected, habitat not characteristic for this species.	-	-
Speckled Warbler *Pyrrholaemus sagittatus* (SW)	V		Not detected, low likelihood	4.3.2.	-
Black-chinned Honeyeater (eastern subsp.) *Melithreptus gularis gularis* (BH)	V		Confirmed. Section 2	4.3.2.	6.3
Hooded Robin *Melanodryas cucullata* (HR)	V		Not detected, habitat not characteristic for this species.	-	-
Painted Honeyeater *Grantiella picta* (PH)	V		Not detected, habitat not characteristic for this species.	-	-
Bush Stone-curlew *Burhinus grallarius* (BC)	E1		Confirmed. Section 2. This species was also targeted in the call playback program for surveys conducted in Sections 1-9 where this coincided with suitable dry sclerophyll forest habitats.	4.3.2.	6.3

Survey methods

- Suitable habitat includes a range of dry sclerophyll forest types, predominantly with open or grassy understorey.
- Systematic bird surveys targeting these habitats were conducted at a total of 24 sites.
- These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.
- A total of 226 person hours were spent surveying woodland birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Diurnal census (birds)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (262 person-minutes)	11 sites (93 person-minutes)	13 sites (116 person minutes)	2 sites (4 person hours)	3 sites (6 person hours)	2 sites (4 person hours)

Survey compliance / limitations

- Survey effort per stratification unit was not resolved in the DEC guidelines.
- These surveys were conducted based on a species time curve approach whereby the searches at each site were ceased when no additional species were detected over the given time period.
- No further targeted surveys are required for woodland birds.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement (ie nest boxes) such as woody debris, bushrock and hollow-bearing trees

Vegetation / habitat types linked to woodland birds	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	BT, DF, SW, HR, PH.	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	BT, SW, BH, HR, PH, BC.	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3 ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	BT, DF, SW.	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)

Woodland birds			
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	BT, SW, BH, HR, PH, BC.	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	BT, BC.	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	BC	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	BT, DF, SW, BH, HR, PH, BC.	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	BT, DF, SW, BH, HR, PH, BC.	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	BT, DF, SW, HR, PH.	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	BT, DF, SW, BH, HR, PH, BC.	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	BT, SW, BH, HR, PH, BC.	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	BT, DF, SW, BH, HR, PH, BC.	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	BT. BC.	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	BT, DF, BC.	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	BT, BH, HR, PH, BC.	71.9	3 (49.6ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	BT, DF, SW, BH, HR, PH, BC.	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	BT, DF, SW, BH, HR, PH, BC.	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	BT, BC.	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	BT, BC.	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	BT, BC.	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	BT, DF, BC.	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	BC	44.5	3 (44.5ha)
	Total	936.4 hectares	

Remaining uncertainties

- The presence and extent of breeding habitat in the construction footprint
- Whether all suitable woodland (biometric vegetation types) are actually occupied by the target species, which would be affected by patch size and habitat condition
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.
- The extent to which edge effects impact on the quality of the habitat for these species.

Woodland birds

Impacts

- Loss of potential foraging and nesting habitat, including a reduction in habitat for prey species
- Potential impact on the dispersal and establishment of new territories
- Indirect impacts may result on adjacent habitats through edge effects
- Fragmentation of woodlands known to create a barrier to dispersal in some of these species and create smaller fragments of habitat that cannot sustain viable populations
- Total area of potential impact to the species within the project boundary is 936.4 hectares (potential vegetation type / habitat area).

Avoidance

- Potential habitat was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Through the detailed design further minimise vegetation/habitat clearing where possible to minimise impacts.
- Barriers to fauna movement have been considered in the route selection and concept design phase.
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Weed and pathogen management (B32-35)
- Nest box management strategy (B36)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure
- Nest boxes for bird species have been proven to be effective

Woodland birds

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 936.4 hectares of habitat
- Increased fragmentation in the region
- High to moderate indirect impacts associated with edge effects for the project

Proposed offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2

Rainforest birds

Target Species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Double-Eyed Fig-Parrot *Cyclopsitta diophthalma coxeni* (DP)	CE	E1	Potential foraging, although outside range of breeding populations.	4.3.2.	6.3
Alberts Lyrebird *Menura albertii* (AL)	V		Not detected and low likelihood in the project boundary	2.4.4.	-
Wompoo Fruit-dove *Ptilinopus magnificus* (WD)	V		Potential foraging range	4.3.2.	6.3
Rose-crowned Fruit Dove *Ptilinopus regina* (RD)	V		Recorded in Section 10 with potential foraging range in other sections.	4.3.2.	6.3
Superb Fruit-dove *Ptilinopus superbus* (SD)	V		Potential foraging range	4.3.2.	6.3
Rufous Scrub-Bird *Atrichornis rufescens* (RB)	V		Not detected and low likelihood in the project boundary.	-	-
White-eared Monarch *Monarcha leucotis* (WM)	V		Not detected and low likelihood in the project boundary	-	-
Black-breasted Button-quail *Turnip melano aster* (BQ)	CE	V	Not detected and low likelihood in the project boundary	-	-

Survey methods

- Systematic bird surveys for rainforest species were conducted at 24 sites stratified by broad habitat types where this intersects with the project boundary.
- These include wet forest/floodplain rainforests (11 sites), swamp forest (13 sites).
- These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.
- A total of 485 person hours were spent surveying all birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Diurnal census (birds)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (262 person-minutes)	11 sites (93 person-minutes)	13 sites (116 person minutes)	2 sites (4 person hours)	3 sites (6 person hours)	2 sites (4 person hours)

Survey compliance / limitations

- In spite of intensive survey effort and range of techniques applied within all habitat types during multiple seasons, it is likely that some species that would be expected to occur may not have been detected.
- Nomadic species such as the threatened Wompoo Fruit-dove, Superb Fruit-dove, and Rose-crowned Fruit dove may only visit the study area on a sporadic basis depending on the availability of food resources which varies between years, and thus may not have been detected.
- No further surveys are required for rainforest birds.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement such as important rainforest feed trees for rainforest birds to be used in landscaping activities

Vegetation / habitat types linked to rainforest birds	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	DP, AL, WD, RD, SD, BQ	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	DP, AL, WD, RD, SD, RB	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	SD	27.4	3 (0.9ha), 4 (0.1ha), 8 (1.1ha), 9 (0.9ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	DP, AL, WD, RD, SD, RB	2.0	4 (2.0ha)

Rainforest birds			
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	SD	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	DP, AL, WD, RD, SD, BQ	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	SD	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	SD	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	DP, AL, WD, RD, SD, RB	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	SD	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	SD	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	SD	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	DP, AL, WD, RD, RB, SD	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	DP, AL, WD, RD, SD, RB	44.5	3 (44.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	DP, AL, WD, RD, SD, RB, BQ	8.6	10 (7.9ha), 11 (0.7ha)
	Total	516.8 hectares	

Remaining uncertainties

- The presence of breeding habitat or established breeding territories is unknown
- Whether there are significant home range trees present, being large fruiting resources that are regularly visited when in fruit.
- Negative effects of traffic noise could cause road avoidance or avoidance to use habitats near the road in the future.

Impacts

- Loss of potential foraging and nesting habitat for some species. There is limited evidence of nesting in the study area, and the known nesting locations for Double-eyed Fig Parrot and not within the study area.
- Indirect impacts may result on adjacent habitats through edge effects
- Total area of potential impact to the species within the project boundary is 936.4 hectares (potential vegetation type / habitat area).

Avoidance

- Potential habitat was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- A part of the detailed design further minimise vegetation/habitat clearing particularly large mature trees which provide potential fruit resources where possible.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale was a priority in the route selection process.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Weed and pathogen management (B32-35)

Rainforest birds

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure

Residual impacts

- Loss of about 516.8 hectares of habitat
- High to moderate indirect impacts associated with edge effects for the project

Proposed offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

General forest birds

Target Species	Listed status		Status on project and additional methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Little Eagle *Hieraaetus morphnoides* (LE)	V		Predicted. General searches for nest sites within the project boundary	4.3.2.	6.3
Square-tailed Kite *Lophoictinia isura* (SK)	V		Predicted. General searches for nest sites within the project boundary	4.3.2.	6.3
Eastern Osprey *Pandion haliaetus* (EO)	V	Mi	Present. General searches for nest sites within the project boundary	4.3.2.	6.3
Red Goshawk *Erythrotriorchis radiatus* (RG)	CE	V	Predicted, no known breeding populations but habitat suitable.	4.3.2.	6.3
Glossy Black-cockatoo *Calyptorhynchus lathami* (GC)	V		Confirmed: Section 1, 3, 7 and 10. Survey of Allocasuarina species (feeding resources) and density at 129 sites as part of the habitat assessment survey.	4.3.2.	6.3
Little Lorikeet *Glossopsitta pusilla* (LL)	V		Predicted	4.3.2.	6.3
Mangrove Honeyeater *Lichenostomus fasciogulari* (MH)	V		Confirmed and predicted restricted to small localised habitats crossed by the project.	4.3.2.	6.3
Turquoise Parrot *Neophema pulchella* (TP)	V		No known populations, low likelihood of occurring in the actual project boundary	-	-
Olive Whistler *Pachycephala olivacea* (OW)	V		Low likelihood of occurring in the actual project boundary	-	-
Ground Parrot (eastern subsp.) *Pezoporus wallicus wallicus* (GP)	V		Not detected with suitable habitat in section 8-10, known populations in conservation reserves.	4.3.2.	6.3
Barred Cuckoo-shrike *Coracina lineata* (BCS)	V		Predicted, foraging habitat identified.	4.3.2.	6.3
Grey-crowned Babbler (eastern subsp.) *Pomatostomus temporalis temporalis* (GB)	V		Confirmed. General searches for dormitories near bird and mammal survey sites	4.3.2.	6.3
Collared Kingfisher *Todiramphus chloris* (CK)	V		Absent and unlikely	-	-
Coastal Emu *Dromaius novaehollandiae* (CE)	E2		Confirmed. Sections 3-4. Population surveys, landowner interviews, scat and feather collections, genetic study and road kill investigation	4.3.2. - 4.3.5.	5.5 & 6.3
Migratory listed wetland species including but not limited to: Satin Flycatcher, Rainbow Bee Eater, Black-faced Monarch, Rufous Fantail, Spectacled Monarch and White-throated Needletail		Mi	Predicted all sections	3.9.5	-

Diurnal birds survey methods

- Systematic bird surveys were conducted at a total of 55 sites stratified by broad habitat types where this intersects with the project boundary.
- Dry forest (24 sites), wet forest/floodplain rainforests (11 sites), swamp forest (13 sites), and heath (2 sites), cleared lands (5 sites).
- These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.
- A total of 485 person hours were spent surveying birds. In general, these surveys covered an average two hectares search area at each site.
- Birds were also recorded opportunistically during all fauna survey activities.

General forest birds

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Diurnal census (birds)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (262 person-minutes)	11 sites (93 person-minutes)	13 sites (116 person minutes)	2 sites (4 person hours)	3 sites (6 person hours)	2 sites (4 person hours)

Survey compliance / limitations

- Survey effort per stratification unit was not resolved in the released DEC guidelines.
- These surveys were conducted based on a area and time based approach
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement such as hollow-bearing trees and woody debris

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	BCS, LE, SK, GB.	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE.	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	LE, EO, RG, GC, LL, TP, GB, CE.	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	BCS, LE, SK, EO, RG, GC, LL, MH, GP, CK, GB, CE.	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	LE, SK, EO, GC, OW	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	BCS, LE, SK, EO RG, GC, LL, OW	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE.	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	BCS, LE, SK, RG, GC, LL, TP, GB, CE.	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	BCS, LE, SK, GB	0.5	10 (0.5 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	LE, SK, EO, MH, CK	1.5	5 (1.3 ha), 10 (0.2 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE.	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, GB, CE.	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	BCS, LE, SK, RG, GC, LL, TP, GB, CE.	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, CK, GB, CE.	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11. 2ha), 10 (0.3 ha)

General forest birds			
Red Mahogany open forest of the coastal lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	BCS, LE, SK, EO RG, GC, LL, TP, GB, CE.	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	BCS, LE, SK, RG, GC, LL, TP, GB, CE.	2.1	2 (2.11 ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	BCS, LE, SK, RG, GC, LL, TP, GB, CE.	144.8	1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, CK, CE.	28.5	1 (23.3 ha), 2(5.2 ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, CK, CE.	44.2	1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	BCS, LE, SK, EO, RG, GC, LL, MH, GP, CK, CE.	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	BCS, LE, SK, EO, RG, GC, LL, TP, OW, GB	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	BCS, LE, SK, EO, RG, GC, LL, OW, GB	44.5	3 (44.5 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	LE, SK, EO, RG, MH, GP, CE.	10	6 (10 ha)
White Booyong - Fig subtropical rainforest of the North Coast	BCS, LE, SK, EO, OW	8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	947.9 hectares	

Remaining uncertainties

- The potential presence of nest sites for species such as raptors and Glossy Black cockatoo was not determined however these may change prior to construction.
- Some threatened bird species may nest in the corridor prior to clearing
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements, particularly for emus.
- Emus are not known to move under bridges and the effectiveness of using bridges and arch structures for movements across the alignment are not known.

Impacts

- Loss of potential foraging and nesting habitat
- Potential impact on the movement life-cycle activities and access to important habitat through fragmentation and barrier effect
- Indirect impacts may result on adjacent habitats through edge effects
- Total area of potential impact to these species within the project boundary is 947.9 hectares (potential vegetation type / habitat area).

General forest birds

Avoidance

- Potential habitat was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- Barriers to fauna movement have been considered in the route selection and concept design phase.
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Nest boxes (B36)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure
- Nest boxes for bird species have been proven to be effective

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 947.9 hectares of habitat
- High to moderate indirect impacts associated with edge effects for the project
- Potential loss of access to important habitat for emus in the Pillar Valley and Tucabia area

General forest birds

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Megachiropteran bats

Species	Status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Grey-headed Flying-fox *Pteropus poliocephalus* (GF)	V	V	Confirmed in Sections 1-2, 4-6, & 8-11	4.3.2.	6.3
Common Blossom-bat *Syconycteris australis* (CB)	V	-	Confirmed in Section 10	4.3.2.	6.3

Survey methods

- The primary focus of this study was to identify the distribution and quality of potential foraging habitat for these species within the study area and in the case of the Grey-headed Flying-fox identify the location of known roost camps for the species from the EPA Grey-headed flying-fox database.
- The assessment used vegetation mapping for the project and region to identify the distribution and extent of critical foraging habitat for the species with reference to DECCW (2009).
- Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types.
- Spotlighting was generally foot-based and comprised of a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights
- Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.
- Concentrated searches were conducted for these species where flowering trees were noted.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Timed nocturnal search (nocturnal birds and mammals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (61 person hours)	10 sites (24 person hours)	13 sites (40 person hours)	2 sites (6 person-hours)	6 sites (6 person hours)	1 site (1 session)

Survey compliance / limitations

- Survey comply with DEC (2004) in terms of technique and effort.
- The species presence is dependent on seasonal nectar productivity of the dominant tree species in the habitat and this varies from year to year.
- No further surveys are required.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement such as favoured feed trees for these species to be utilised in landscaping

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	GF	1.4	3 (1.4 ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	GF	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	GF, CB	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	GF	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	GF, CB	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	GF, CB	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	GF, CB	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	GF	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	GF, CB	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)

Megachiropteran bats			
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	GF	0.5	10 (0.5 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	GF	1.5	5 (1.3 ha), 10 (0.2 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	GF	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	GF	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	GF, CB	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	GF, CB	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	GF, CB	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	GF	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	GF, CB	2.1	2 (2.11 ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	GF, CB	144.8	1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	GF, CB	28.5	1 (23.3 ha), 2(5.2 ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	GF, CB	44.2	1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	GF, CB	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	GF, CB	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	GF, CB	44.5	3 (44.5 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	GF, CB	10	6 (10 ha)
White Booyong - Fig subtropical rainforest of the North Coast	GF, CB	8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	947.90 hectares	

Remaining uncertainties

- Presence of temporary Grey-headed Flying-fox camps in the construction footprint
- Potential for roost camp to become established in the corridor between project approval and the commencement of construction
- Presence and extent of breeding/roosting habitat for Common Blossom-bat

Impacts

- Loss of potential foraging and nesting habitat
- Potential impact on the foraging and movement life-cycle
- Indirect impacts may result on adjacent habitats through edge effects
- Total area of potential impact to the species within the project boundary is 947.90 hectares (potential vegetation type / habitat area).

Megachiropteran bats

Avoidance

- Potential habitat for both species was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- The location of Grey-headed Flying-fox roost camps was considered in the route selection phase.
- The detailed design phase will allow further avoidance of vegetation/habitat clearing where possible
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats that would constitute critical and important foraging habitat for these species.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Weed and pathogen management (B32-35)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 947.9 hectares of potential habitat containing important seasonal food resources (blossom and fruit)
- High to moderate indirect impacts associated with edge effects for the project

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5

Megachiropteran bats					
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Reptiles

Species	Status		Status on project	Further reference*	
	TSC / FM Act	EPBC Act		A	B
White-crowned Snake *Cacophis harriettae* (WS)	V		Not recorded. Possible habitat in the project boundary	-	-
Three-toed Snake-tooth Skink *Coeranoscincus reticulatus* (TS)	V	V	Not recorded. Low likelihood	-	-
Pale-headed Snake *Hoplocephalus bitorquatus* (PS)	V	-	Not recorded. Potential habitat in Sections 1, 2, 3 and between 6-8.	4.3.2.	6.3
Stephens' banded snake *Hoplocephalus stephensii* (SS)	V	-	Confirmed in Section 3. Potential habitat in Sections 1, 2 and between 6-8.	4.3.2.	6.3

Survey methods

- Targeted surveys consisted of dry pitfall traps, spotlighting diurnal and nocturnal searches during the same periods of frog surveys.
- The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered.
- The surveys were both time-based and area-based and varied in duration according to the size of the habitat, wetland.
- Systematic reptiles searches were conducted at a total of 122 sites stratified by habitat types (56 dry sclerophyll habitats; 27 wet/moist sclerophyll habitats; 28 swamp forest; 7 heathland and 8 in modified landscapes.
- The total survey effort equated to 44 person hours. In addition to this, a total of 14 pitfall trap sites (each containing between 4-6 pits) were employed and nocturnal reptiles were also targeted during the spotlighting surveys.
- Systematic reptile searches were also conducted at the habitat assessment sites. This involved an active area search across the habitat plot (20 x 50 metres). A total of 129 habitat plots were sampled of these reptile searches were conducted at 83 plots.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Modified
Timed diurnal active searches (reptiles)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07; Dec 11; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	56 sites (approx 22 person hours)	23 sites (approx 7.5 person hours)	28 sites (approx 9.5 person hours)	7 sites (approx 2.5 person hours)	8 sites (approx 2.5 person hours)

Survey compliance / limitations

- Survey methods and effort were conducted in accordance with the guidance of DEC (2004).
- In particular a range of seasons were targeted and additional supplementary summer surveys were conducted in 2011 and 2012 to target locations where inappropriate seasons were missed in the previous surveys such as sections 3 and 4.
- No further surveys are required for reptiles.
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement such as hollow-bearing trees.

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	TS, PS, SS	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	WS, PS	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	WS, TS, PS, SS	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	WS, PS	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	WS, PS, SS	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	WS, PS	0.2	9 (0.2 ha)

Reptiles			
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	WS, TS, PS, SS	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	WS, PS, SS	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	WS, PS	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	TS, PS, SS	0.5	10 (0.5 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	WS, PS, SS	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	WS, PS	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	WS, PS	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	WS, PS, SS	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha),7 (20.6 ha),8 (11.2 ha),10 (0.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	WS, TS, PS, SS	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	WS, PS	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	WS, PS	2.1	2 (2.11 ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	WS, PS	144.8	1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	WS, PS, SS	28.5	1 (23.3 ha), 2(5.2 ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	WS, PS, SS	44.2	1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	WS, PS, SS	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	WS, TS, PS, SS	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	WS, TS, PS, SS	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	WS	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	TS, PS, SS	8.6	10 (7.9ha), 11 (0.7ha)
	Total	946.40 hectares	

Remaining uncertainties

- Despite intensive targeted surveys, the presence the distribution and abundance of these species is poorly known, assumptions have been made about potential habitat
- The presence and extent of actual sheltering habitat in the construction footprint such as hollow-bearing trees and rocky outcrops
- Negative effects of barrier effects on reptiles is poorly known.

Impacts

- Loss of potential habitat including dispersal and establishment in new habitats, in particular the loss of shelter and breeding sites in the form of tree hollows and hollow logs
- Potential impact on the movement life-cycle
- Indirect impacts may result on adjacent habitats through edge effects
- Total area of potential impact to these species within the project boundary is 946.40 hectares (potential vegetation type / habitat area).

Reptiles

Avoidance

- Potential habitat for threatened species was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- The detailed design present further opportunities to minimise vegetation/habitat clearing where possible
- Barriers to fauna movement have been considered in the route selection and concept design phase.
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Nest boxes (B36)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure
- Nest boxes for snake species have been proven to be effective

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 946.40 hectares of habitat including a large number of hollow-bearing trees and hollow logs providing potential shelter sites
- Loss of habitat for prey species
- High to moderate indirect impacts associated with edge effects for the project

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5

Reptiles					
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Wetland and swamp dwelling frogs

Species	Status		Status on project	Further reference	
	TSC Act	EPBC Act		Impacts	Mitigation
Wallum Froglet *Crinia tinnula* (WF)	V	-	Confirmed records in Sections 1, 2 and between 6-11.	4.3.2.	6.3
Green and Golden Bell Frog *Litoria aurea*(GBF)	E1	V	Not recorded in the project boundary. Low likelihood.	-	-
Booroolong Frog *Litoria booroolongensis* (BF)	E1	E1	Not recorded in the project boundary. Low likelihood of occurring in the actual project corridor.	-	-
Green-thighed Frog *Litoria brevipalmata* (GF)	V		Recorded in Sections 2, 6 and 7.	4.3.2.	6.3
Olongburra Frog *Litoria olongburensis* (OF)	V	V	Not recorded in the project corridor, but known from the locality in Sections 9-11 in particular	4.3.2.	6.3

Survey methods

- Potential habitats were identified from stratification and during the initial field survey design.
- Numerous targeted frog surveys were conducted between 2006-2012 included spotlighting in suitable habitats, pitfall trapping, diurnal and nocturnal searches and call playback for each of these target species.
- Spotlighting targeted timed based wetland surveys depending on the size of the area and were conducted across spring and summer seasons.
- Survey timing varied between 20-60 minutes and involved a minimum of two people using head torches and spotlights searching for adult frogs and tadpoles in the water column. A total of 80 sites were surveyed using this technique for 69 person hours.
- Call playback involved an initial five-minute listening period, after which calls of the species were broadcast for a period of around five minutes, followed by a five minute listening period for a response. After completion of the call playback surveys, the immediate area was searched by spotlight for any species that approached the broadcast site without eliciting calls. Frog were searched under rocks, by the edge of the water, on floating vegetation, in fringing grass or other vegetation, under logs and other debris. Call playback was used at 16 sites.
- Pit traps were deployed to target a range of fauna including frogs and were used at 14 sites in total, seven of which were within suitable habitat for the target species
- On three occasions during the summer survey programs, high rainfall periods where experienced in 2006, 2007 and 2011. This prompted additional targeted frog surveys for Green-thighed Frog in particular to coincide with the breeding biology of the species which breeds during heavy rainfall and associated flood events. These rainfall events were also viewed as an optimal survey period for other target species including the Giant Barred Frog, Wallum Froglet, Olongburra Frog and Boorolong Frog.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Dry pitfall traps (small ground active & fossorial reptiles, frogs and mammals	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Jan 12) **Section 6-8** (May-Jul 05; Jan 12) **Section 9-11** (Mar 06, Jan 07)	6 sites (80 trap nights)	1 site (4 pits) 20 trap nights	2 sites (32 trap nights)	5 sites (20 traps nights		
Call playback (frogs)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Dec 11; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	4 sites (8 person hours)	4 sites (8 person hours)			8 sites	
Timed and area based nocturnal searches (frogs)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul 05; Oct 07; Dec 11) **Section 6-8** (May-Jul 05;Jan 12) **Section 9-11** (Mar 06, Jan 07)	25 sites (approx 21 person hours)	22 sites (approx 20 person hours)	14 sites (approx 12 person hours)	3 sites (3 person-hour)	6 sites (6 person hours)	10 sites (approx 7 person hours)

Wetland and swamp dwelling frogs

Survey compliance / limitations

- Survey methods and effort were conducted in accordance with the guidance of DEC (2004).
- Surveys were conducted in a range of wet habitats to sample the habitat requirements of the expected frog assemblage this including swamps, creeks, dams and riparian areas.
- The presence or absence of threatened frog species could not be confirmed during surveys done in autumn-winter or dry conditions during spring-summer. Where this occurred, additional targeted surveys were conducted in spring-summer (eg February 2006 Lewis Ecological Surveys) and additional surveys in January-February 2011 to cover this gap.
- These surveys were designed to coincide with the breeding biology of these species, particularly the Green-thighed Frog which breeds during heavy rainfall and associated flood events (typically in ephemeral habitats).
- Further surveys are required during detailed design to assist the design and development of management actions and these would be detailed in the threatened frog management plan.

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	GBF, GF	1.4	3 (1.4 ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	GBF, GF	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	BF, GF	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	GF	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	WF, GBF, GF, OF	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	GF	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	GBF, GF	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	GBF, GF	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	GF	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	GBF, GF	0.5	10 (0.5 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	GBF	1.5	5 (1.3 ha), 10 (0.2 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	GBF, GF	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	GBF, GF	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	GF	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	WF, GBF, GF, OF	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	BF, GF	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	GF	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	GF	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	GF	144.8	1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	WF, GBF, GF, OF	28.5	1 (23.3 ha), 2(5.2 ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	WF, GBF, GF, OF	44.2	1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha)

Wetland and swamp dwelling frogs			
Swamp Oak swamp forest of the coastal lowlands of the North Coast	WF, GBF, GF, OF	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	BF, GF	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	GBF, GF	44.5	3 (44.5 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	WF, GBF, BF, GF, OF	10	6 (10 ha)
White Booyong - Fig subtropical rainforest of the North Coast	GF	8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	947.90 hectares	

Remaining uncertainties

- The size of frog populations within the construction footprint.
- A complete picture of the locations and important habitat for threatened frogs is not known and also this may change in the time lag since construction, such that new populations establish
- The dispersal and movement pathways for frog species in the study area is poorly known
- Negative effects from the operation of the proposed upgrades including impacts to dispersal and genetic exchange
- Fauna crossing structures are known to have limited success for frogs (Goldingay and Taylor 2010)
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Impacts

- Loss of potential foraging and breeding habitat
- Potential impact on movements
- Prone to impacts from altered hydrology and water quality
- Indirect impacts may result on adjacent habitats through edge effects, in particular noise has potential to alter behaviour and the dependence on breeding calls

Avoidance

- Potential habitat for threatened species was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Detailed design phase presents further opportunities to minimise vegetation/habitat clearing where possible
- Barriers to fauna movement have been considered in the route selection and concept design phase.
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Wetland and swamp dwelling frogs

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Reuse of woody debris and bushrock (B31)
- Waterway management, sedimentation and erosion

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 947.90 hectares of wetland, floodplain and swamp habitat
- High to moderate indirect impacts associated with edge effects for the project
- Fauna crossing structures are known to have limited success for frogs (Goldingay and Taylor 2010)

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	1.50	0.4	4:1	7.60	865.6

Wetland and swamp dwelling frogs					
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Stream dwelling frogs

Species	Status		Status on project	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Stuttering Frog *Mixophyes balbus* (SF)	E1	V	Not recorded, low likelihood	-	-
Fleay's Barred Frog *Mixophyes fleayi* (FF)	E1	E1	Not recorded, low likelihood.	-	-
Giant Barred Frog *Mixophyes iterates*(GF)	E1	E1	Recorded in Section 1 and 7. Also recorded outside of Sections 2 and 9.	4.3.2.	6.3
Pouched Frog *Assa darlingtoni* (PF)	V	-	Not recorded, low likelihood.	-	-

Survey methods

- Survey methods and effort were conducted in accordance with the guidance of DEC (2004).
- Targeted field surveys for stream-dwelling frogs were typically the same as wetland and swamp-dwelling frogs with the use of spotlighting, diurnal and nocturnal searches and call playback in different but suitable habitat. However in addition streams were also surveyed using a combination of the time interval search or alternatively traversing a 500 metre transect along the targeted creek depending on the length of waterway and ease of traversing. A total of 22 sites and over 20 person hours were spent searching in suitable habitat using this technique.
- Creeks targeted using this methods included Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek , Black Snake Hole (Pillar Valley Creek); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek). In addition to this, numerous wetlands, drains and unnamed watercourses were sampled.
- The high rainfall events in January and February 2006, January 2007 and January 2011 resulted in optimal survey conditions for the Giant Barred Frog and Stuttering Frog which breeding occurs in summer usually after flood events.

Survey method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Dry pitfall traps (small ground active & fossorial reptiles, frogs and mammals	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Jan 12) **Section 6-8** (May-Jul 05; Jan 12) **Section 9-11** (Mar 06, Jan 07)	6 sites (80 trap nights)	1 site (4 pits) 20 trap nights	2 sites (32 trap nights)	5 sites (20 traps nights		
Call playback (frogs)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Dec 11; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	4 sites (8 person hours)	4 sites (8 person hours)			8 sites	
Timed and area based nocturnal searches (frogs)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul 05; Oct 07; Dec 11) **Section 6-8** (May-Jul 05;Jan 12) **Section 9-11** (Mar 06, Jan 07)	25 sites (approx 21 person hours)	22 sites (approx 20 person hours)	14 sites (approx 12 person hours)	3 sites (3 person-hour)	6 sites (6 person hours)	10 sites (approx 7 person hours)

Survey compliance / limitations

- Variable weather (temperature and rainfall) conditions and seasonal survey periods, especially flood events in summer allowed for the greatest opportunity to observe frogs.
- With a wide range of survey techniques undertaken, lack of threatened frog observations is possibly due to limited suitable habitat and behaviour/life cycle of targeted frogs..
- Pre-clearing surveys will be undertaken in all habitats to determine the presence of nesting/roosting fauna species to be avoided and important habitats for reuse and/or for replacement such as woody debris

Stream dwelling frogs

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	SF, FF, GF	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	SF, FF, GF, PF	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	GF	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	SF, FF, GF	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	GF	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	SF, FF, GF	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	GF	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	GF	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	SF, FF, GF, PF	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	GF	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	GF	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	GF	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	SF, FF, GF, PF	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	SF, FF, GF	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	SF	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	SF, FF, GF, PF	8.6	10 (7.9ha), 11 (0.7ha)
	Total	502.40	

Remaining uncertainties

- The size of frog populations within the construction footprint.
- A complete picture of the locations and important habitat for threatened frogs is not known and also this may change in the time lag since construction, such that new populations establish
- The dispersal and movement pathways for frog species in the study area is poorly known
- Negative effects from the operation of the proposed upgrades including impacts to dispersal and genetic exchange
- Fauna crossing structures are known to have limited success for frogs (Goldingay and Taylor 2010)
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Impacts

- Loss of potential foraging and breeding habitat
- Potential impact on movements
- Prone to impacts from altered hydrology and water quality
- Indirect impacts may result on adjacent habitats through edge effects, in particular noise has potential to alter behaviour and the dependence on breeding calls

Stream dwelling frogs

Avoidance

- Potential habitat for threatened species was considered in the route selection process, particularly in avoiding significantly large areas of continuous habitat.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Detailed design phase presents further opportunities to minimise vegetation/habitat clearing where possible
- Barriers to fauna movement have been considered in the route selection and concept design phase.
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any adjacent habitats.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Staged removal process (B30)
- Weed and pathogen management (B32-35)
- Reuse of woody debris and bushrock (B31)
- Waterway management including sediments and erosion control during construction

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and provide habitat for threatened flora and fauna species
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes for reuse following construction or to be retained and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining hollow-bearing trees within the construction footprint and avoiding threatened flora populations where possible
- The procedures used for exclusion zones, staged habitat removal, weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 502.40 hectares of wetland, floodplain and swamp habitat
- High to moderate indirect impacts associated with edge effects for the project
- Fauna crossing structures are known to have limited success for frogs (Goldingay and Taylor 2010)

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3

Stream dwelling frogs					
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Koala *Phascolarctos cinereus*

Target species	Listed status		Status on project and additional species methods	Further report ref*	
	TSC Act	EPBC Act		Impacts	Mitigation
Koala Phascolarctos cinereus	V	V	Recorded in Section 3 from scats, potential to occur in all sections	4.3.2. - 4.3.5	5.5 & 6.3

Survey methods and effort

- A search and background review of the following to establish that Koala populations occur within the study area:
  - Atlas of NSW wildlife
  - The Richmond Valley Koala Habitat Atlas. Report prepared for the Richmond Valley Council. Clarence Valley Council (2010)
  - Comprehensive Koala Plan of management for the Ashby, Woombah and Iluka localities of the Clarence Valley LGA. Coffs Harbour City Council (1999)
  - Coffs Harbour City Council Koala Plan of Management. Reported prepared by the NSW National Parks and Wildlife Service and Coffs Harbour City Council
- Gather adequate information on the characteristics of the Koala populations and the quality of potential habitat within the study area. This involved a review of the documents listed above, followed by Koala surveys and comparison of the habitat of the species as listed in the Koala Recovery Plan (DECC 2008c) against the habitats identified in the project boundary
- There are over 11,000 recorded koala sightings in the NSW Atlas for the NSW North Coast Bioregion, spread over all local government areas in a wide range of topographies and habitats. This suggests that koalas could occur in all project sections in a range of habitats that would be impacted by the project
- The two main centres of high density of koala records occur around Coffs Harbour, south of Woolgoolga (outside of the project), and in Richmond Valley LGA between Woodburn and Ballina (sections 9, 10 and 11)
- Koalas were confirmed at two sites during surveys in Section 3.

Koala surveys

- Koala surveys involved a combination of the Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011) to provide an indication of how much or frequently the area of habitat is being used by Koalas and identify the relative importance of the habitat
- Call playback was used for Koala during the forest owl playback sessions. Taped calls of the Koala were broadcast through a loudspeaker for 5 minute periods, followed by periods of listening and spotlighting. Done on 1-2 consecutive nights
- Area searches for koala scats involved a traverse across the entire habitat plot (50 x 20 metres) and searching the base of all larger trees (>20 centimetres DBH) with particular focus paid to any known koala feed trees species for the north coast region as identified in the Recovery Plan for the Koala (DECC 2008c). This included primary, secondary and supplementary trees species. The locations of any scats found were recorded with a Global Positioning System.
- A total of 120 plots were searched using this method across the entire project corridor.
- An additional 12 plots were sampled using with same plot size and method in 2008 between Wells Crossing and Iluka Road (SKM 2009) and 27 plots of 20 x 20 metres in area were searched over the remainder of the project (Geolyse 2007; Ecotone 2007, Connell Wagner 2008).
- The total number of koala scat search plots surveyed over the entire project boundary was 159.
- Spotlighting and dusk census for koala was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally footbased and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.
- Vehicle-based spotlighting was routinely conducted in all sections, although time and area searched was not recorded.

Koala *Phascolarctos cinereus*

Survey Method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Area searches (Spot Assessment Technique for koala)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug 05;Oct 05; Dec 11) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	76 sites	34 sites	42 sites	7 sites		
Call playback (nocturnal animals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug 05; Oct 05; Jan 12) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	8 sites (34 sessions)	9 sites (7 sessions)	7 sites (6 sessions)	2 sites (2 sessions)		
Timed nocturnal search (nocturnal birds and mammals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (61 person hours)	10 sites (24 person hours)	13 sites (40 person hours)	2 sites (6 person-hours)	6 sites (6 person hours)	1 site (1 session)

Survey compliance / limitations

This approach is reflective of the DSEWPaC advice but follows the NSW assessment methodology rather than the QLD approach suggested in the advice. The QLD approach is not as relevant to the study area as the NSW methodology in relation to the extent of information known about the koala population in the study region. Application of the NSW methodology does not undermine or alter the outcome with regard to the interim referral advice. The survey methods comply with the DEC (2004) guidelines and exceed the recommended survey effort.

Vegetation / habitat types linked to the koala	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5	2 (11.5ha)

Koala *Phascolarctos cinereus*		
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	71.9	3 (49.6ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5ha)
	Total 927.60 hectares	

Remaining uncertainties

- Size and home range areas for local populations
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Impacts

- Loss of potential foraging habitat
- The area of habitat to be removed comprising primary koala food tree species is around 548.4 hectares. An additional 297.4 hectares containing secondary and supplementary koala food tree species would also be removed
- The species could also be negatively affected by fragmentation and the barrier effect of the highway and is regularly struck by cars where high-density populations occur in fragmented urban habitats
- The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales.
- The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

Avoidance

- The route selection process aimed to avoid and minimise impacts on vegetation and habitat and the presence of species and ecological communities of conservation significance
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection

Koala *Phascolarctos cinereus*

Proposed mitigation and management measures

- Connectivity strategy
- Monitoring of fauna connectivity structures (Monitoring Strategy) (B1)
- Pre-clearing surveys (B28)
- Staged removal process (B30)
- Fauna handling (B37)

Previous / known success of measures

- In Australia there are several published studies providing measurable evidence for the effectiveness of purpose built fauna crossing structures. This includes arboreal mammals (Goldingay et al 2011 and Goldingay et al 2012), small to medium sized terrestrial mammals, amphibians and reptiles (SMEC, 2007). Among these are several threatened fauna such as Koala, Spotted-tailed Quoll, Squirrel Glider and possibly the Long-nosed Potoroo and Black Bittern.
- In NSW, the RMS has commissioned several long-term studies involving radio-tracking of koalas pre-, during and post-construction to investigate the effectiveness of underpasses, overpasses and exclusion fencing incorporated into the Pacific Highway Upgrade, including at Lindsays Cutting (Moon 1998) and Pine Creek State Forest, near Coffs Harbour, at Raymond Terrace and Bulahdelah, north of Newcastle, and along the Yelgun to Chindera realignment in north-eastern NSW and Bonville upgrade (Lassau et al 2012). These studies have demonstrated the effectiveness of overpasses and underpasses (minimum 2.4 x 2.4 metres) for koalas crossing the highway. The knowledge gained from these studies has led to the inclusion of fauna furniture such as raised vertical and horizontal logs to encourage use and ensure the safety of Koalas from predators.
- Fauna crossing structures are particularly effective when used with fauna exclusion fencing that direct fauna away from the road and towards the structure. Various researchers have found that as a result of absent, broken or ineffective fences around crossing structures, that increased accounts of road kill were likely for species such as koala, macropods, possums, native rats and frogs (Taylor and Goldingay 2003; SMEC, 2007; Goldingay et al 2011).
- Koalas have been detected using land bridges, under bridges and larger culverts (eg minimum 2.4 x 1.2 metres and 3.0 x 3.0 metres), but may be less inclined to use tunnel/pipe underpasses

Residual impacts

- Impacts on biodiversity are expected to remain significant
- The total area impacting on koala food tree species is around 845.8 hectares.
- Road deaths for Koalas have occurred in Section 1 and 2, and as such they are considered likely to occur throughout suitable habitat
- New edge areas would also be created by clearing of a corridor through currently contiguous habitats immediately north of the Richmond River. A number of threatened fauna species have been confirmed in this locality including Koalas

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2

Koala *Phascolarctos cinereus*					
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2

Invertebrates

Target species	Listed status		Status on project and additional species methods	Further report ref*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Atlas Rainforest Ground Beetle *Nurus atlas* (AB)	E	-	Confirmed in Section 10	Appendix F and M	5.5 & 6.3
Pink Underwing Moth (PUM)	E	E	Conformed in Section 10	Appendix F and M	Chapter 5 and 6

Survey methods and effort

- Both species were recorded at the northern end of project in section 10 with rainforest remnants located within and adjacent to the project boundary. The potential habitat for this species includes lowland rainforest in the northern end of the project (Section 10 and 11).
- The records in the study area represent the first records for the region around Ballina.
- A wide representation of potential habitat was surveyed using a variety of techniques including random meander searches, active ground searches and opportunistic observations.
- A random meander search was carried out to find host plants in a 30 minute meander through each hectare of suitable habitat.
- An active ground search was also used to intensely observe the ground layer at each site for 30 minutes per hectare depending on the complexity of ground debris.
- Opportunistic observations were undertaken in 20 minute searches at suitable habitats in wetlands and swamps to find invertebrates in transit.

Survey Method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Invertebrate surveys	**Section 9-11** (Mar 06; Feb 12)		17 sites				

Survey compliance / limitations

The extent of survey locations was limited to where property access was available. Each area was surveyed using the method described in the threatened species survey and assessment guidelines (DEC, 2004).

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast		0.5	10 (0.5 ha)
White Booyong - Fig subtropical rainforest of the North Coast		8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	9.1 hectares	

Remaining uncertainties

- There is little known of the life-cycle requirements of associated habitat characteristics. The survival of these species is threatened by an extremely restricted distribution, clearing of rainforest remnants, removal of fallen timber and ground cover
- Negative effects of roads on movements and dispersal of these species
- Presence of edge effects remains to be ascertained
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Invertebrates

Impacts

- The project would clear up to 10 hectares of lowland rainforest
- This would have a significant impact on the burrowing / sheltering and breeding, and foraging life-cycle activities for these species.
- This is potentially a significant loss of habitat for this highly restricted species.

Avoidance

- The route selection process aimed to avoid and minimise impacts on vegetation and habitat and the presence of species and ecological communities of conservation significance
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection

Proposed mitigation and management measures

- Threatened Invertebrates Management Plan and targeted surveys (B9- B10)
- Pre-clearing surveys (B28)
- Staged removal process (B30)
- Re-use of woody debris and bushrock (B31)
- Fauna handling (B37)
- Habitat revegetation

Previous / known success of measures

- None identified.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- High to moderate indirect impacts associated with edge effects for the project

Proposed Offset measures

Biometric vegetation association	Direct loss	Edge effects	Offset ratio	Offset target	Area (hectares) in 30 km radius
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Ground-dwelling mammals

Species	Status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		impacts	Mitigation
Rufous Bettong *Aepyprymnus rufescens* (RB)	V	-	Confirmed in Section 1-3	4.3.2.	6.3
Common Planigale *Planigale maculata* (CP)	V	-	Confirmed in Section 1-2	4.3.2.	6.3
Long-nosed Potoroo *Potorous tridactylus tridactylis* (LP)	V	V	Not confirmed in project corridor	4.3.2.	6.3
Eastern Chestnut Mouse *Pseudomys gracilicaudatus* (EM)	V	-	Not recorded, low likelihood	4.3.5.	-
Hastings River Mouse *Pseudomys oralis* (HM)	E1	E1	Not detected , low likelihood	-	-
Spotted-tailed Quoll *Dasyurus maculatus maculatus (SE population)* (SQ)	V	E1	Not detected, but suitable habitat occurs in all sections	4.3.2. - 4.3.5.	5.5 & 6.3

Survey methods

Ground-based trapping was used to target small and medium sized ground-dwelling mammals. The technique used a combination of aluminium folding traps (Elliott type A, 33 x 10 x 9 cm, and Elliott type B, 15 x 16 x 45 cm), and cage traps (30 x 30 x 60 cm) and hair-tubes using different trap densities and transect configurations. The numbers of traps at each site varied between 10 and 25, for a period of between three to four consecutive nights.

Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7.

Searches for scats and signs of mammals were conducted over 129 habitat assessment sites.

Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.

Survey Method	Project section and survey dates	Dry forest	Wet forest / floodplain / rainforest	Swamp forest	Wet / dry Heath	Wetlands	Modified
Ground-based Elliott traps (small terrestrial mammals)	**Section 1-2** (October 06; Feb 07) **Section 3-5** (July-Aug & Oct 05; Oct 07) **Section 6-8** (May-July 05; Jan 12) **Section 9-11** (Mar 06, Jan 07; Jan 12)	11 sites (784 trap nights)	6 sites (300 trap nights)	5 sites (392 trap nights)	4 sites (40 trap nights)		
Ground-based cage traps (quolls and bandicoots)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	11 sites (4 cages) 20 trap nights	6 sites (14 cages) 80 trap nights	7 sites (28 cages) 120 trap nights	2 sites (20 trap nights)		
Ground and tree based hair-tubes (arboreal and terrestrial mammals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	12 sites (1440 trap nights)	6 sites (840 trap nights)	6 sites (1180 trap nights)	1 site (200 trap nights)	1 site (400 trap nights)	

Ground-dwelling mammals

Timed nocturnal search (nocturnal birds and mammals)	**Section 1-2** (Oct 06; Feb 07) **Section 3-5** (Jul-Aug, Oct 05; Oct 07) **Section 6-8** (May-Jul 05) **Section 9-11** (Mar 06, Jan 07)	24 sites (61 person hours)	10 sites (24 person hours)	13 sites (40 person hours)	2 sites (6 person-hours)	6 sites (6 person hours)	1 site (1 session)

Survey compliance / limitations

No further surveys are required for ground-dwelling mammals due to survey limitations.

The survey methods used in this study are consistent with the DEC (2004) suggested techniques for non-flying mammals. Survey effort per stratification unit is shown in Table 2-9 and exceeded the suggested survey effort outlined in the guidelines.

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	RB, CP, LP, SQ	1.4	3 (1.4 ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	RB, CP, LP, EM, HM, SQ	79.7	1 (33.6 ha), 2 (7.2 ha), 3 (11.8 ha), 6 (4.3 ha), 7 (22.8 ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	RB, CP, LP, EM, HM, SQ	46.2	1 (22.2 ha), 9 (1.3 ha), 10 (22.7 ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	RB, CP, LP, EM, HM, SQ	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	RB, CP, LP, EM, SQ	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	CP, LP, EM, SQ	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	RB, CP, LP, EM, HM, SQ	2.0	4 (2.0 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	RB, CP, LP, EM, HM, SQ	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	RB, CP, LP, EM, SQ	48.2	3 (9.7 ha), 4 (17.7 ha), 6 (7.9 ha), 7 (1.4 ha), 8 (11.1 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	RB, CP, LP, SQ	0.5	10 (0.5 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	SQ	1.5	5 (1.3 ha), 10 (0.2 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	RB, CP, LP, EM, HM, SQ	34.7	6 (9.6 ha), 7 (14.7 ha), 8 (10.4 ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	RB, CP, LP, EM, HM, SQ	58.2	1 (16.6 ha), 2 (26.1 ha), 3 (14.6 ha), 7 (0.9 ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	RB, CP, LP, EM, SQ	11.5	2 (11.5 ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	CP, LP, EM, SQ	49.5	1 (10.5 ha), 2 (3.5 ha), 3 (1.2 ha), 4 (0.3 ha), 6 (1.9 ha), 7 (20.6 ha), 8 (11.2 ha), 10 (0.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	RB, CP, LP, EM, HM, SQ	46.2	6 (8.9 ha), 7 (35.7 ha), 8 (1.6 ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	RB, CP, LP, EM, HM, SQ	71.9	3 (49.6 ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	RB, CP, LP, EM, SQ	2.1	2 (2.11 ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	RB, CP, LP, EM, SQ	144.8	1(17.9 ha), 2 (37.9 ha), 3 (68 ha), 4 (6.8 ha), 6 (1.9 ha), 7 (12.3 ha)

Ground-dwelling mammals			
Swamp Box swamp forest of the coastal lowlands of the North Coast	CP, LP, EM, SQ	28.5	1 (23.3 ha), 2(5.2 ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	CP, LP, EM, SQ	44.2	1 (9.9 ha), 2 (7.8 ha), 3 (16.6 ha), 5 (1.3 ha), 8 (0.5 ha), 9 (7.8 ha), 10, (0.3 ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	RB, CP, LP, EM, SQ	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	RB, CP, LP, EM, HM, SQ	53	3 (36.8 ha), 4 (3.5 ha), 5(11.2 ha), 6 (1.5 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	RB, CP, LP, EM, HM, SQ	44.5	3 (44.5 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	CP, LP, EM, SQ	10	6 (10 ha)
White Booyong - Fig subtropical rainforest of the North Coast	CP, LP, SQ	8.6	10 (7.9 ha), 11 (0.7 ha)
	Total	947.90 hectares	

Remaining uncertainties

- Lack of data on the size and home range areas for local populations
- Unknown impacts on barrier effect of populations
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Impacts

- Loss of potential foraging, breeding and shelter habitat
- These species could also be negatively affected by fragmentation and the barrier effect of the highway
- The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales.
- The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals both at patch and landscape scale.

Avoidance

- The route selection process aimed to avoid and minimise impacts on vegetation and habitat and the presence of species and ecological communities of conservation significance
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection

Proposed mitigation and management measures

- Connectivity strategy
- Monitoring of fauna connectivity structures (Monitoring Strategy) (B1)
- Pre-clearing surveys (B28)
- Staged removal process (B30)
- Fauna handling (B37)

Ground-dwelling mammals

Previous / known success of measures

- In Australia there are several published studies providing measurable evidence for the effectiveness of purpose built fauna crossing structures. This includes arboreal mammals (Goldingay et al 2011 and Goldingay et al 2012), small to medium sized terrestrial mammals, amphibians and reptiles (SMEC, 2007). Among these are several threatened fauna such as Koala, Spotted-tailed Quoll, Squirrel Glider and possibly the Long-nosed Potoroo and Black Bittern.
- In NSW, the RMS has commissioned several long-term studies involving radio-tracking of koalas pre-, during and post-construction to investigate the effectiveness of underpasses, overpasses and exclusion fencing incorporated into the Pacific Highway Upgrade, including at Lindsays Cutting (Moon 1998) and Pine Creek State Forest, near Coffs Harbour, at Raymond Terrace and Bulahdelah, north of Newcastle, and along the Yelgun to Chindera realignment in north-eastern NSW and Bonville upgrade (Lassau et al 2012). Fauna crossing structures are particularly effective when used with fauna exclusion fencing that direct fauna away from the road and towards the structure. Various researchers have found that as a result of absent, broken or ineffective fences around crossing structures, that increased accounts of road kill were likely for species such as koala, macropods, possums, native rats and frogs (Taylor and Goldingay 2003; SMEC, 2007; Goldingay et al 2011).

Residual impacts

- Impacts on biodiversity are expected to remain significant
- The total area impacting on around 940 hectares.

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5

Ground-dwelling mammals					
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2

Arboreal mammals

Species	Status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Eastern Pygmy-possum *Cercartetus nanus* (EP)	V	-	Predicted. This species also was targeted using small terrestrial mammal survey methods (pitfalls and ground traps). Refer below.	4.3.2.	6.3
Yellow-bellied Glider *Petaurus australis* (TG)	V	-	Confirmed. Call playback was used in suitable habitat during the forest owl playback sessions	4.3.2.	6.3
Squirrel Glider *Petaurus norfolcensis* (SG)	V	-	Confirmed. Call playback was used in suitable habitat during the forest owl playback sessions.	4.3.2.	6.3
Brush-tailed Phascogale *Phascogale tapoatafa* (BP)	V	-	Confirmed.	4.3.2.	6.3

Survey methods

Trapping for arboreal mammals used Elliott type B traps attached to tree trunks 3 - 3.5 metres above ground and also used a combination of trap numbers and transect configurations. Trapping was conducted at 34 sites stratified by dry forests (19 sites), wet forests (6 sites), swamp forests (6 sites) and heath (3 sites), resulting in a total of one site per 23 hectares in dry forest, one site per 55 hectares for wet forests, one site per 24 hectares for swamp forest, and one site per 3 hectares in heath. Trapping sessions were conducted over 3-4 consecutive nights and the resulting in a total of 1182 trap nights in dry forest or 135 trap nights per 50 hectares. Wet forests equate to 68 traps nights or 10 trap nights per 50 hectares and swamp forest was 234 trap nights or 78 trap nights per 50 hectares and heath was 240 trap nights over 10 hectares.

Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7.

Spotlighting and dusk census for arboreal mammals was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.
Call playback was used for Yellow-bellied Glider, Squirrel Glider and Koala during the forest owl playback sessions.

Survey compliance / limitations

No further surveys are required for arboreal mammals due to survey limitations.

The DEC guidelines specify a survey effort per 50 hectares of a stratification unit of 24 trap nights over 3-4 consecutive nights, this was exceeded in most habitat types

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	EP	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	EP, TG, SG, BP	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	EP, TG, SG BP	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	EP, TG, SG BP	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	EP, TG, SG BP	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	EP, SG	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	EP, TG, SG BP	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	EP, TG, SG BP	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	EP, TG, SG BP	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)

Arboreal mammals			
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	EP	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	EP, TG, SG BP	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Vegetation / habitat types linked to target species	**Species (Abbreviated)**	**Area in project boundary (ha)**	**Project Section (extent in hectares)**
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	EP, TG, SG BP	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	EP, TG, SG BP	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	EP, TG, SG BP	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	EP, TG, SG BP	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	EP, TG, SG BP	71.9	3 (49.6ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	EP, TG, SG BP	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	EP, TG, SG BP	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	EP, TG, SG BP	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	EP, TG, SG BP	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	EP, TG, SG BP	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	EP, TG, SG BP	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	EP, TG, SG BP	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	EP BP	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	EP	8.6	10 (7.9ha), 11 (0.7ha)
	Total	946.40 hectares	

Remaining uncertainties

- Lack of data on the size and home range areas for local populations and family groups
- Impacts on movements, genetic isolation and dispersal largely unknown
- Negative effects of traffic noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements.
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Arboreal mammals

Impacts

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Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the	2.00	1.6	2:1	7.20	4095.5

Arboreal mammals					
North Coast					
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
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Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2

Oxleyan Pygmy Perch

Species	Status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Oxleyan Pygmy Perch (*Nannoperca oxleyana*)	E	E	Confirmed in Section 7-9	4.3.2. & 4.3.7.	5.5 & 6.3

Survey methods

- Investigations were done at 67 different sites covering 36 different waterways (named and unnamed), this includes 43 sites surveyed for the preferred route studies and an additional 24 sites surveyed to address gaps in the data particularly to target the Oxleyan Pygmy Perch and Purple spotted Gudgeon.
- The named creeks surveys were: Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek , Black Snake Hole (Pillar Valley Creek), Coldstream River, Pheasants Creek); Section 4 (Edwards Creek, Shark Creek); Section 5 (Clarence River - at two locations); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek, Richmond River at two locations); Section 9 (Richmond River at two locations), Section 9 (Evan's River, Rocky Mouth River, Tuckean Broadwater, Bingil Creek); Section 10 (Garretts Creek); Section 11 (Duck Creek and Emigrant Creek).
- In addition to this, numerous wetlands, drains and unnamed watercourses were sampled.
- The additional targeted surveys were aimed at addressing gaps from the preferred route studies and were undertaken in September 2011 in consultation with the Department of Fisheries, and in accordance with the Survey Guidelines for Australia's Threatened Fish (DSEWPaC 2011). This ensured the optimum survey period for the Oxleyan Pygmy Perch. Targeted surveys were undertaken, before the onset of the Oxleyan Pygmy Perch breeding season, to prevent disturbance to breeding populations and breeding habitats. Fish sampling methods involved the use of electrofishing, bait traps and dip netting. Where habitat and site access allowed, backpack electrofishing was undertaken with an electrical output of 500b, 60Hs pulsed DC to allow capture but without causing muscle rigidity. Unbaited bait traps were set for a period of 30-60 minutes (as baiting does not improve the probability of attracting fish (Knight et al. 2007). Up to 40 nets were deployed at each site, set around 1.5-2 metres apart. Dip-netting was undertaken in areas where it was too shallow to trap.

Survey method	Project section and survey dates
Targeted Survey (10-15 March 2007) where potential habitat Electro fishing, seine nets, fyke nets and bait traps Electro fishing: 100m transects Seine nets used to sample stands of emergent and submerged veg, areas adjacent to snags, woody debris and structure, areas underneath overhanging veg and open water. Fyke net set overnight for 12 hours in open water, amongst or against vegetation and woody material. Bait traps – 15 baited traps set overnight close to emergent vegetation, submerged macrophytes and woody debris.	Section 1-2 • Corindi River, (upstream one location) and downstream (two locations) of route preferred route corridor (Woolgoolga to Wells) – No fish recorded but potential habitat • Arrawarra Gully, Blackadder Gully (downstream of preferred route only) – Not recorded, unsuitable habitat • Cassons Creek and Redbank Creek (downstream of preferred route only) – No fish recorded but potential habitat identified • Halfway Creek – desktop assessment no potential habitat no survey.

Oxleyan Pygmy Perch	
Targeted Survey 25-29 June 2007 Electro fishing (4 of 8 sites) Bait Trapping (6 baited traps in shallow water habitat near macrophytes and submerged snags) deployed for 1 hr Gill Netting (two gill nets deployed for 30 minutes)	**Section 3-5** • Serpentine Channel 6747104E/523559N • Edwards Creek (Clarence Rive side) 6739443E/519858N • Shark Creek 6735475E/518504N • South Arm (Clarence River at Tyndale) 6730240E/514515 • Champion Creek 6719525E/513121N • Black Snake Hole (Pillar Valley Creek) 6709701E/510647N • Coldstream River 6708557E/507905N • Pheasant Creek (off Eight Mile Road) 6704940E/ 503122N NO OPP FOUND, but low lying swamps and wallum creeks along Coldstream River (south of Tucabia) contain potential habitat
March/May 2006 – Habitat assessment only and desktop assessment 2011 – Electrofishing, dip net	**Section 6-7** • Garretts Creek 523840E/6753186 • Mororo Creek 523282E/ 6753283N • Mororo SF 522435E/6756100 • Tabbimoble Creek 521249E/6758196N – Potential Habitat • Tabbimoble Floodway 520485E/6759112 • Unknown Watercourse at chainage 114000 525630E/6768986 – OPP RECORDED • Unknown Watercourse at chainage 117800 527105E/6772471 • Unknown Watercourse at chainage 118500 527342E/6773023 • Unknown Watercourse at Minumai rd 527293E/6773010N • Unknown Watercourse at chainage 120600 528789E/6774697 • Unknown Watercourse at chainage 122100 529871E/6775638 • Oakey Creek 530053E/6775670 • Unknown Watercourse at chainage 122500 530236E/6775814 • Unknown Watercourse at chainage 123700 530976E/6776621 • Unknown Watercourse at chainage 124500 531247E/6777356 • Unknown Watercourse at chainage 128700 533124E/6780934 • Intermittent Watercourse 200m South of New Italy Rest Area 528771E/6774693N

Oxleyan Pygmy Perch	
March and May 2006 – OPP recorded near Broadwater National Park and in the McDonalds Creek area – Bait trapping, dip netting, electrofishing, seine nets and fyke nets	• Section 8-11 • Macdonalds Creek Chainage 136600- OPP RECORDED • Richmond River • Duck Creek Chainage 164400– OPP Recorded • Saltwater Creek • Bingle Creek • Eversons Creek • Monits Creek • BNP Dams and Swamp • Tucken Channel (Evans River) • Macdonalds Creek Dams
2010/ 2011 – Bait traps, Seine nets, Fyke Nets, Dip net in Duck Creek, Lang Hill (unnamed tributary of Richmond River – **OPP recorded**	• Shark Creek 518948E/6734792 • South Arm 519889E/6739524 • James Creek 53686E/6743231 • Clarence River 523455E/6744648 • Serpentine Channel 532604E/6747094 • Tuckombil Canal 532976E/6782595 • Duck Creek 548085E/6806959 • Lang Hill – OPP recorded • Evan's River at Weir 532880E/6782350N • Evans River along Tuckmobil Canal 533560E/6781850N • Rocky Mouth River at weir 532800E/6782400N • Broadwater National Park drainages, road to Evans Head 539800E/6780500N • Cane Farm drainage along Pacific Highway 536050E/6784750N • McDonald's Creek FloodGate 537070E/6785500N • McDonald's Creek Tributaries 538000E/6785750N • Wallum Heath Wetlands near McDonald's Creek 537870E/6784750N • Riley's Hill Drainage 539830E/6790050N • Riley's Hill Ben Richmond River 539500E/6791500N • Pelican Island Junction, Richmond River 540250E/6790250N • Tuckean Broadwater near Barrage 539880E/6793330N • Tuckean Broadwater at overhead cables 540750E/6793130N • Richmond River north of Junction with Tuckean Broadwater 542880E/6792180N • Bingil Creek 544500E/6797130N • Richmond River north of Wardell, south of Pimlico Island 546250E/6797500N • Wallum Heath Wetlands adjacent to Indigenous Settlement, Lumley Road 544400E/6798630N

Oxleyan Pygmy Perch

	• Wallum Heath Wetlands adjacent to Wardell Sports fields and cement works 544630E/6798000N • Wallum Heath Wetlands behind Wardell Golfclub 544880E/6797650N • Carlisle Street Wetlands 545000E/6797500N • Wallum Heath open wetland adjacent to airstrip, Wardell 545500E/6798630N • Wallum Heath roadside wetland adjacent to airstrip 545520E/6798780N • Wallum Heath black pond adjacent to airstrip 545750E/6798000N • Waterbody 1 adjacent to sewage works 545700E/6799400N • Water Body 2 adjacent to sewage works 545900E/6799420N Wardell Heathlands – Potential Habitat

Survey compliance / limitations

- Surveys in Sections 1 and 2 were completed in a dry period which would have affected the results of the survey. The presence of Oxleyan Pygmy Perch and Purple-spotted Gudgeon has been assumed in these sections where suitable habitat was identified.
- No further surveys are necessary for these fish species considering their presence has been assumed and additional surveys are unlikely to result in an expansion of this assumed area of occupancy in Section 1 and 2.

Vegetation / habitat types linked to target species	Species (Abbreviated)
• Prefers slow-moving or still waters with dense aquatic vegetation (eg sedges) or undercut, root-filled banks. • The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 4.5-6.5) with low conductivity (90 to 830µS/cm). Potential habitat observed in a number of Class 1 waterways throughout the project boundary.	OPP

Impacts

Direct impacts –

- Removal of riparian vegetation and associated habitats
- Disturbance to the bed and bank of the waterway.
- Removal of large woody debris (snags)
- Installation of structures (bridges and culverts (that alter natural flow regimes)
- Degradation of native vegetation

Indirect (potential) –

- Creation of long term barriers to fish movement
- Bed and bank erosion
- Continuing pollution from erosion and sedimentation
- Predation by the Mosquito Fish (Gambusia holbrooki)
- Long-term water quality impacts

Oxleyan Pygmy Perch

Avoidance

- The concept design has included bridge structures across all class 1 waterways with the exception of two locations. During detailed design, the crossing structures would be reviewed
- Unnamed ephemeral drainage lines with potential Oxleyan Pygmy Perch habitat, were conservatively classified as Class 2. The crossing methods of these watercourses will be further addressed during the detailed design
- Detailed design of bridges and culverts would ensure that barriers to fish are not created, including the design of bridges to avoid where feasible placement of piers within the waterways.

Proposed mitigation and management measures

- Construction of fish-friendly bridge and culverts\
- Maintain natural flow rates
- Design

Consider fish passage-

- crossing structures appropriate for the size and type of watercourse
- -maintenance of fish passage through constructions
- -preservation of spawning grounds
- -minimisation of disturbance to and removal of snags
- -preferred crossing design
- -habitat rehabilitation

Rehabilitation and compensatory issues:

- -the area of crossing should be rehabilitated following the OPP habitat description and in keeping with local flora communities
- -drains and water control dams constructed following the OPP habitat preferences
- -areas should be rehabilitated and reserved indefinitely through some sort of conservation agreement
- -construction of water quality control dams should be provided to protect the creeks

Lowland Rainforest

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion (State) Lowland Rainforest of Subtropical Australia (Cwth)	E	CE	Recorded in Section 10. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.4

Survey methods

The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 march 2012. Surveys were undertaken in section 8-11 at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:

- One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
- Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
- Several sites at south Coolgardie (ch:154500-155000) Section 10
- One site along Wardell Road (Wardell) (ch:152800) Section 10
- One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
- Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
- Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
- Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
- One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
- Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
- Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
- Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

The recommend EPBC Act survey approach *Commonwealth Listing Advice* (DSEWPC, 2011), was used to determine the condition thresholds for Lowland Rainforest of subtropical Australia.

Vegetation / habitat types	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	10.5	

Habitat

- Occurs on fertile soils in lowland river valleys (only occurring as small remnants on the NSW North Coast, with less than 1000 hectares in total thought to remain
- A total of 95 hectares of Lowland Rainforest has been identified within and surrounding the study area mainly in Section 10 near Coolgardie Road.
- In an undisturbed state, it exhibits a closed canopy of rainforest tree species with high species richness and structural complexity. In disturbed stands (as are represented in the study area) the canopy continuity may be broken, or the canopy may have introduced tree species, such as Camphor Laurel, or sometimes smothered by exotic vines
- Common representative rainforest tree species include: Rough-leaved Elm (*Aphananthe philippinensis*), Bangalow Palm (*Archontophoenix cunninghamiana*), Cabbage Tree Palm (*Livistona australis*), Figs (*Ficus spp.*), Pepperberry (*Cryptocarya obovata*), Lilly Pilly (*Syzygium spp.)* and Weeping Lilly Pilly (*Waterhousea floribunda*)

Lowland Rainforest

Remaining uncertainties

The full extent of Lowland Rainforest (EPBC Act) outside the project corridor and in adjoining areas, particularly between section 8-9. This would be determined dy conducted further surveys during the detailed design phase.

Impacts

- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for remaining individuals.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project.
- Diseases which may impact the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.
- Loss of 10.3 hectares to Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion. Six patches (52.4 hectares) occur (ch: 155500-159000) of Lowland Rainforest of Subtropical Australia, of this, 5.8 hectares would be impacted with four patches reduced in extent by 2-16% and two patches reduced in extent by 40-45%.
- There is potential for indirect impacts such as altered hydrology and sedimentation levels.
- Habitat connectivity for Lowland Rainforest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation and edge effects of the community adjacent to the existing highway.
- Loss of threatened species habitat for several flora and fauna.

Avoidance

- The location of endangered ecological communities was considered in the route selection process..
- Detailed design presents further opportunities to minimise vegetation/habitat clearing where possible
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pathogen management (B34)
- Stockpile and ancillary facilities management (61)

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this community and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this community would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained community as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for this community that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Lowland Rainforest

Residual impacts

- Loss of 10.3 hectares to Lowland Rainforest.
- Further indirect impacts expected

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Sandstone Rough Barked Apple (*Angophora robur*)

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Sandstone Rough Barked Apple (*Angophora robur*)	V	V	Confirmed. Section 3-4, Targeted surveys were undertaken to quantify accurate numbers within the project boundary.	4.3.1.	5.5 & 6.3

Angophora robur survey methods

The species was first identified in 2009 and reported in SKM (2009) in the area between Pillar Valley and Tyndale as part of the route selection and preferred route surveys. Targeted surveys were conducted in summer of 2010 and spring-summer 2011 to identify the size and extent of the local population in addition to a wider survey of the regional population.

Mapping occupied habitat

General observations of the distribution of *Angophora robur* in the study area indicated that the species most commonly occurred on the Summervale Range and Richmond Range landscape units (Mitchell 2003). The distribution of the species was initially mapped at a fine scale following extensive ground truthing along the footslopes of the Summervale Range between Pillar Valley and Tyndale within proximity to the project corridor. The extent of each of the populations was mapped using a handheld GPS identifying the approximate edge of the distribution of the species, as well as recording point data for individual plants and groups of trees.

Predictive mapping of the extent of species was undertaken in areas to the west of the study area in the Copmanhurst and Coaldale regions and also to the east in Newfoundland State Forest. Predictive mapping used several GIS layers as well as field observations including Mitchell Landscapes, elevation data, broad-scale vegetation mapping, aerial photography and field observations where access was available.

Rapid habitat assessment

Rapid habitat assessments were undertaken within habitats where Angophora robur occurred. A range of environmental variables were recorded including dominant flora species and broad structural vegetation community type, the extent of disturbance including clearing, grazing and fire, the presence of rocky outcrops basic soil attributes, the reproductive health of the population including the population structure and subjective assessments of the health of trees, and potential hybridisation in the population.

Population estimates

The size of the local and regional population was estimated utilising a combination of several methods including ground-truthed mapping of the distribution of the species and direct counts within these populations, and predictive mapping based on soil landscape data, rapid field observations and government-maintained databases coupled with data obtained from direct counts.

Direct counts were undertaken in each of the populations using belt transects of various lengths in which every tree was counted in a 20 m wide area (10 m either side). A total of 32 transects were undertaken in each of the larger populations and the average number of plants per hectare was extrapolated across the entire extent of the population. Two different estimates have been calculated based on the known extent of Angophora robur and the predicted extent.

Survey compliance / limitations

On more exposed ridges and upper slopes with skeletal soils *Angophora woodsiana* is dominant, with a low abundance of *Angophora robur* (c. 1/hectares), and hybrids between the two species were observed in these areas. *Angophora woodsiana* was also observed co-occurring with *Angophora robur* on lower slopes in some areas, but in a very low abundance. This species is not listed and the presence of both species at a site at times made identification difficult. In this instance the species was assumed to be the listed *A,robur*

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Total	137.90 hectares	

Sandstone Rough Barked Apple (*Angophora robur*)

Habitat

- There is limited published information regarding habitat for *Angophora robur* apart from general descriptions in identification texts (Harden 2002; Brooker *et. al*. 2002) which describe the species as occurring in dry open forest in sandy or skeletal soils on sandstone, or occasionally granite, with frequent outcrops of rock. From the field surveys, it is evident that *Angophora robur* occurs on sandy soils on slopes and ridges, but was absent from the dryer ridges and upper slopes with highly skeletal soils and the more fertile lower slopes where Turpentine (*Syncarpia glomulifera*) is dominant and some gullies where swamp forest and other riparian vegetation is present. It was recorded on the fringes and within swamp forest habitats in several locations.
- Estimated to be around 9,000 individuals over 105 hectares based on detail surveys comprising direct counts of individuals within the boundary and detailed mapping of the distribution. Based on calculations from the detailed surveys the average number of individuals per hectare is 84.
- The known regional distribution is estimated to comprise 152,712 individuals over around 1818 hectares and the predicted distribution is estimated to consist of 618,912 individuals over around 7368 hectares.
- The population within and surrounding the project boundary represents the known eastern distribution of the species in Section 3-4. Eleven subpopulations within the larger eastern subpopulation have been mapped within and surrounding the project boundary occurring over 1471 hectares with individual clusters ranging from 1.3 to 684 hectares in area. All clusters within 500 metres of each other have been regarded as being part of the same subpopulation based on the likely dispersal distance of pollinators between subpopulations.
- The age structure and density of the populations varied substantially depending on the disturbance history of the area, with densities varying from 16 to 920 individuals per hectare based on transect and plot data. Some areas supported a very high density of juveniles and medium trees whilst other areas supported a low density of larger mature trees. The edges of the population clusters generally supported a lower abundance of the species with numerous outliers from the main population recorded.

There may be larger populations in surrounding state forests and national parks (ie Yuraygir, Woodford Island, Newfoundland state forests) as these areas have not been extensively surveyed and are relatively remote. During the field surveys the species was recorded in Corymbia, Yuraygir and Wombat Creek state conservation areas and Fortis Creek National Park. It is also reserved in Banyabba and Sherwood nature reserves and Waihou Flora Reserve (Johnson & Hill, 1990; Sheringham & Westaway, 1995).

Remaining uncertainties

- *Angophora robur* was also absent from some areas which appeared to support suitable habitat which makes it difficult to predict the distribution and abundance of the species. Further, there has not been any detailed soil landscape mapping undertaken for the Grafton and Bare Point 1:100 000 map sheets which cover Sections 3 to 5 of the study area, making it problematic to accurately predict and map the distribution of the species.
- Due to property access constraints several areas could not be assessed, therefore the average density was extrapolated across these areas where habitat appeared suitable.

Impacts

- The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to 5 per cent of the local population would be impacted. The local gene pool would be reduced from the project. Considering the large proportion of the population that would remain in the local area and the high mobility of pollinator species the project is unlikely to lead to inbreeding depressions due to fragmentation. Habitat for pollinator species would however be removed.
- Fragmentation of a portion of the identified Sandstone Rough-barked Apple (*Angophora robur*) population and known and potential habitat for a range of threatened and common fauna species expected in Sections 3 and 4. Much of this habitat occurs on sandy soil that is identified as having a high density of hollow-bearing trees and generally higher fauna species richness.
- The project would result in the removal of up to 105 hectares of known occupied habitat for *Angophora robur*. This are of potentially impacted habitat comprises around:
  - Seven per cent of the known occupied habitat of the eastern subpopulation.
  - 5.5 per cent of the known extant of the eastern population and northwest subpopulation
  - 1.2 per cent of the known and predicted extent of the eastern and northwest subpopulations and records from the southwest subpopulation (500 individuals).
- Impacts to the eastern subpopulation *(*7 per cent) are relatively significant considering this population represents the eastern extent of the species, there is limited known representation in conservation reserves and this area would be subject to increasing development pressure in the future. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- Edge effects would be greatest where the project deviates substantially from the existing Pacific Highway. While portions of the habitat in these sections are already fragmented and edge affected, substantial clearing and creation of a new edge would occur in Section 3 along the western foothills of the Summervale Range from Pillar Valley to Tyndale. Large sections of open forest habitat in

Sandstone Rough Barked Apple (*Angophora robur*)

moderate to high condition would be exposed to edge effects particularly on the eastern edge of the highway where *Angophora robur* habitat occurs.

- Diseases which may impact *Angophora robur* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.
- Considering that the majority of the population adjacent to the project boundary occurs upslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would not affect the remaining individuals of *Angophora robur*.

Avoidance

- Targeted survey of the species during the detailed design stage for Section 3 to physically survey and map the specific location of individuals and patches along the edges of the project boundary. The objective of the survey was to further refine the detailed design to avoid and minimise removal of the species.

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase – this occurred in vicinity of Tyndale interchanges with a reduction of about 2ha of impact to A. Robur habitat as a result of the refined concept design..
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Threatened flora management plan - Angophora robur (Targeted surveys – B8)
- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- *Angophora robur* was recorded in currently edge affected habitats in the study area including open paddocks. Therefore *Angophora robur* is likely to be somewhat tolerant of edge effects and indirect impacts are not expected to significantly impact the life cycle attributes of *Angophora robur*, particularly with appropriate mitigation to reduce these edge effects such as weed treatment, water quality controls and native landscaping.
- Seed collection and a propagation strategy will successfully improve the population gene flow.
- The project would not significantly conflict with the recovery actions proposed for Angophora robur. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.
- Sufficient habitat for large populations of potential pollinator species would remain in surrounding areas to reduce the effects of inbreeding.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 137.90 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Sandstone Rough Barked Apple (*Angophora robur*)

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Angophora robur* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Angophora robur* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss	Edge effects	Offset ratio	Offset target	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7

Square-fruited Ironbark (*Eucalyptus tetrapleura)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
Square-fruited Ironbark (*Eucalyptus tetrapleura)*	V	V	Confirmed. Section 1-2. Targeted surveys were undertaken to quantify accurate numbers within the project boundary.	4.3.1.	5.5 & 6.3

Eucalyptus tetrapleura survey methods

The species was first identified in Glenugie State Forest as part of the Glenugie Upgrade between Section 2 and 3 (SKM 2010). This data contributed to the assessment of impacts and was built on for the EIS as the southern extent of the species in the study area extends into Section 2 of the project. Within SKM (2010) previously identified populations occurring within State Forests and conservation reserves were surveyed to assess the overall distribution and abundance of the regional population. The approximate extent of each population was mapped using a hand-held GPS to mark the boundaries of the population. Within each extent the density of trees per hectare was identified.

At each locality standardised transects were traversed recording details on the number of trees 10 m either side of the centreline, with the start and finish of the transect recorded using a hand-held GPS so the exact length of the transect could be calculated. Trees were characterised into size classes based on the Diameter at Breast Height (DBH). The density of trees per hectare was calculated based on the average density from all transects undertaken within that population and extrapolated across the entire distribution of the population cluster.

Follow-up surveys were conducted in 2010 to establish an accurate depiction of the distribution and abundance of the species from Halfway Creek to the start of the Glenugie upgrade including Wells Crossing Flora Reserve and these data were added to the overall knowledge of the local Glenugie population.

Survey compliance / limitations

In some circumstances the approximate distribution of *Eucalyptus tetrapleura* was extrapolated based on the particular distribution within that population and identified environmental variables. For example in some populations *Eucalyptus tetrapleura* was restricted to ridge and upper slope areas and faded out below a certain elevation, and so the approximate area of its distribution could be mapped based on contour levels. In other circumstances it was restricted to areas below a certain contour level or was closely associated with a thick shrubby understorey which could be mapped through aerial photography interpretation. However several areas appeared to have complex soil, topography, geology and hydrological interactions making the mapping of *Eucalyptus tetrapleura* more problematic, requiring a larger degree of ground-truthing to determine the limits of the population. Where State Forests and conservation reserves adjoin areas of private property, the approximate distribution of *Eucalyptus tetrapleura* on private property was extrapolated from data collected and identified as a predicted occurrence.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5	2 (11.5ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Total	286.30 hectares	

Habitat

- Several known populations surrounding the existing Pacific Highway in Section 2. The population extends into the surrounding private properties and state forest including Wells Crossing Flora Reserve. The population is estimated to comprise 1,213 individuals in proximity to the project boundary, comprising around 14.5 hectares of known habitat in Section 3.
- *Eucalyptus tetrapleura* is endemic to coastal lowlands and foothills from near Glenreagh in the south to Casino in the north, occurring within a range of around 100 kilometres north-south and 50 kilometres east-west.
- *Eucalyptus tetrapleura* occurs in dry or moist eucalypt forest on moderately fertile soil, often in low areas with poor drainage. Observations of the distribution of *Eucalyptus tetrapleura* in the region suggest that there are complex soil, topography, geology and hydrological interactions which limit the distribution of the species.
- Habitat for *Eucalyptus tetrapleura* is not well defined and is not restricted to one particular vegetation association, landform, soil type or geology. Its occurrence was observed to be associated with a

Square-fruited Ironbark (*Eucalyptus tetrapleura)*

number of physical features influencing soil moisture and groundwater levels, including soil texture, soil depth, slope, bedrock geology and subsoil permeability. In several areas soil texture was observed to be a limiting factor to the distribution of *Eucalyptus tetrapleura*, occurring on more sandy soils overlaying clay subsoil, with *Eucalyptus fibrosa* becoming dominant in areas where the clay content of the soil is greater. In other areas, groundwater drainage appeared to be major influencing factor with *Eucalyptus tetrapleura* occurring on areas of relatively shallow soils overlying sandstone bedrock such as in Chambigne Nature Reserve and Yuraygir Crown Reserve. Overall *Eucalyptus tetrapleura* seems to occupy a niche where it is able to out-compete other Eucalypt species where soils are not too dry or wet, where drainage is not significantly impeded and in some circumstances where soils are not too shallow but shallow enough for the bedrock to influence groundwater levels.

Remaining uncertainties

- In some circumstances the approximate distribution of Eucalyptus tetrapleura was extrapolated based on the particular distribution within that population and identified environmental variables. For example in some populations Eucalyptus tetrapleura was restricted to ridge and upper slope areas and faded out below a certain elevation, and so the approximate area of its distribution could be mapped based on contour levels. In other circumstances it was restricted to areas below a certain contour level or was closely associated with a thick shrubby understorey which could be mapped through aerial photography interpretation. However several areas appeared to have complex soil, topography, geology and hydrological interactions making the mapping of Eucalyptus tetrapleura more problematic, requiring a larger degree of ground-truthing to determine the limits of the population. Where state forests and conservation reserves adjoin areas of private property, the approximate distribution of Eucalyptus tetrapleura on private property was extrapolated from data collected and identified as a predicted occurrence.
- Within its range, the current known distribution is patchy, however the species has not been extensively surveyed and the full extent of the population is unknown.
- *Eucalyptus tetrapleura* was recorded along areas of Rockview Road at Chambigne during the surveys and was observed to extend into areas of private property surrounding this road, and although no population assessments were carried out in this area, *Eucalyptus tetrapleura* is expected to be relatively abundant in this area.
- Diseases which may impact *Eucalyptus tetrapleura* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens such as Myrtle Rust (*Puccini psidii* s.l.).

Impacts

- The potential impact from the project and the Glenugie upgrade represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1,289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 16.08 hectares of known habitat for *Eucalyptus tetrapleura*.
- When considering cumulative impacts from the Glenugie upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.6 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat. The project would result in the removal of habitat for pollinator species, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas. The cumulative impacts of the project and the Glenugie upgrade, while reducing the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions or impacts from stochastic events.
- The project would result in a larger fire break to fire approaching from the west of the highway, potentially resulting in the frequency of fire to be reduced in populations to the east. However state forest areas are likely to be fire-managed with control burns implemented in areas during cooler months. Although there is potential for fire regimes to change following the project it is considered unlikely to significantly impact the life cycle of populations of *Eucalyptus tetrapleura*.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight. Other indirect impacts from vegetation clearing would include stormwater run-off potentially increasing water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species. To offset the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Eucalyptus tetrapleura* and habitat for other threatened flora and fauna.
- The population is currently fragmented by the existing highway and the project would widen the disturbance width further fragmenting habitats on the western side of the existing highway from populations to the east.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Square-fruited Ironbark (*Eucalyptus tetrapleura)*

Proposed mitigation and management measures

- Threatened flora management plan
- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Considering the high mobility of some pollinator species such as insects, birds and bats, and wind dispersal of pollen, gene flow is expected to continue across the existing highway and the width of the project. There are estimated to be about 7,100 individuals on the western side of the existing highway, and this is likely to be a large enough gene pool to continue to successfully reproduce without inbreeding depressions.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- The project would not significantly conflict with the recovery actions proposed for *Eucalyptus tetrapleura.* Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.
- *Eucalyptus tetrapleura* was recorded in currently edge affected habitats in the study area including open paddocks. Therefore *Eucalyptus tetrapleura* is likely to be somewhat tolerant of edge effects and indirect impacts are not expected to significantly impact the life cycle attributes of *Eucalyptus tetrapleura*, particularly with appropriate mitigation to reduce these edge effects such as weed treatment, water quality controls and native landscaping.
- Seed collection and a propagation strategy will successfully improve the population gene flow.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 286.30 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Eucalyptus tetrapleura* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Eucalyptus tetrapleura* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9

Water Nutgrass (Cyperus aquatilis) & Hairy-joint Grass (Arthraxon hispidus)

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Water Nutgrass (*Cyperus aquatilis)* (WN)	E	-	Recorded in Section 6 and 7. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.3
Hairy-joint Grass (*Arthraxon hispidus) (*HG)	V	V	Targeted surveys recorded several large populations in Section 10.	4.3.1.	6.3

Survey methods

Cyperus aquatilis is an annual species which grows in ephemerally wet situations, and is dependent upon summer rainfall for germination and some level of soil disturbance, with populations being found in roadside drainage swales, deep tyre ruts on disturbed trails and depressions in grazed paddocks. Targeted surveys were conducted in summer (2011-12) by two botanists over period of 20 days. Considering the large area of potential habitat for this species across the project as a whole, representative survey sites were selected focusing on at least one site per 50 hectare in suitable habitat. In addition known locations as determined by the initial preferred route studies and review of the atlas of NSW wildlife were targeted using direct counts of individuals and a general meandering technique.

Arthraxon hispidus

- Given the widespread and numerous number of plant counts of abundance used replicated plots of known size to sample the number of plants in a known area and the extent of occupied habitat was recorded to create a polygon. Population estimates were then derived by multiplying the mean number of plants in a known area (plot) by the total area of occupied habitat. The plot size for counts were 50 m x 2 m along fence lines or 5x5 m in other areas. These data were then extrapolated across the entire identified group of polygons to estimate the population size within and adjacent to the project boundary.
- The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. The survey aimed to record the distribution of the populations during the flowering period of the species within and adjacent to the project boundary by mapping the outer perimeters of the population to develop a series of polygons.
- Surveys were undertaken in section 8-11 at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
  - One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
  - Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
  - Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8

Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

Identified populations *C. aquatilis* occurred in low numbers and individual clusters could not always be adequately delineated. Population density estimates and area polygons were used to identify abundance.

A. hispidus is a slender inconspicuous tufted annual, it flowers during summer-autumn which represents the optimum time to conduct surveys. The species was in flower during the targeted survey.

Water Nutgrass (Cyperus aquatilis) & Hairy-joint Grass (Arthraxon hispidus)

Vegetation / habitat types linked to *C. aquatilis* and *A. hispidus*	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	HG	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	WN	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	HG	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	HG, WN	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	WN	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	HG, WN	2.0	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	HG	0.5	10 (0.5ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	WN	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	WN	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	WN	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	HG, WN	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	HG	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	HG, WN	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	HG, WN	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	HG, WN	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	HG	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	HG, WN	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	WN	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	HG	8.6	10 (7.9ha), 11 (0.7ha)
	Total	640.50	

Habitat

Arthraxon hispidus

- This species is a cosmopolitan species which is relatively widespread but uncommon throughout southeast Queensland and the NSW North Coast and Northern Tablelands, as well as occurring from Japan to central Eurasia.
- *Arthraxon hispidus* occurs in moist, shady positions and is usually found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.
- Four large subpopulations of this species were recorded in Section 10 between Lumleys Lane and Coolgardie Road and covers a total area of 20.8 hectares. Forty-seven per cent of this area (9.8 hectares) occurs within the project boundary.
- Subpopulations have been identified based on their spatial distribution with all occupied habitats within 150 metres of each other regarded as being part of the same subpopulation. Pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003).

Cyperus aquatilis

- This species was recorded at six locations in Section 6-7. The population of Cyperus aquatilis in the study area appears to be part of a larger population extending north east into Tabbimoble Swamp Nature Reserve and Bundjalung National Park

Water Nutgrass (Cyperus aquatilis) & Hairy-joint Grass (Arthraxon hispidus)

- This species is a cosmopolitan species which is relatively widespread throughout the northern states of Australia including Queensland, Western Australia and the Northern Territory, as well as occurring in New Guinea.
- *Cyperus aquatilis* appears during the wet summer period in ephemerally wet sites then dies off in early spring as the habitat dries out. Records from the coastal floodplain are nearly all from track ruts on recently disturbed, muddy access trails (Ecos Environmental 2007). It also occurs in seepage areas from small sandstone cliffs

Remaining uncertainties

- The area of unoccupied potential habitat is relatively extensive in the locality comprising wet areas in open paddocks and the edges of moist vegetation. However the potential occurrence of *Arthraxon hispidus* is likely to be dependent on numerous factors including grazing and maintenance regimes, hydrology and soils.
- There is potential for the distribution of these species to change over time associated with rainfall and dry periods and this may occur if there is a significant lag time before construction.

Impacts

- There is potential for indirect impacts to alter the existing habitat attributes such as hydrology regimes and weed invasion which may increase the overall proportion of occupied habitat impacted.
- As the existing populations are currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

Arthraxon hispidus

- The project would potentially impact around 47 per cent of the known extent of the species within and surrounding the project boundary.
- A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for subpopulations 1 (4.2 hectares), 2 (4.8 hectares) and 3 (2.9 hectares) with up to 68 to 71 per cent of these subpopulations being impacted. Only 17 per cent of the largest population (8.9 hectares) would be potentially impacted by the project.
- There is potential for the genetic diversity of these subpopulations to be depleted particularly for subpopulations 1, 2 and 3 which could lead to an inbreeding depression.
- Considering that the majority of the population adjacent to the project boundary occurs in low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off and altered hydrology.
- Subpopulations 2 and 3 would be dissected by the project, with individuals being retained on either side of the project. Impacts to subpopulations 1 and 4 would be restricted to one edge of the populations.
- Diseases which may impact Hairy-joint Grass include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.

Cyperus aquatilis

- Around 1.17 hectares of potential habitat for this species has been identified within and surrounding the project boundary, of which around 0.40 hectares would be impacted.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of the remaining individuals of this species affecting life-cycle attributes
- As the existing populations are currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Arthraxon hispidus

- Considering the majority of the population surrounding the corridor occurs in open paddock areas there is unlikely to be significant indirect impacts from edge effects such as increased sunlight.

Water Nutgrass (Cyperus aquatilis) & Hairy-joint Grass (Arthraxon hispidus)

Proposed mitigation and management measures

- Threatened flora management plan
- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Seed collection and a propagation strategy will successfully improve the population gene flow.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- The project would not significantly conflict with the recovery actions proposed for Hairy-joint Grass. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 640.50 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of Hairy-joint Grass and Water Nutgrass and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting a large number of Hairy-joint Grass and Water Nutgrass would contribute towards the recovery of these species.

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	HG	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	WN	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	HG	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	HG, WN	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	WN	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	HG, WN	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	HG	60.77	29.4	4:1	360.68	12998.7
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	WN	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	WN	34.70	30.6	4:1	261.20	35439.7

Water Nutgrass (Cyperus aquatilis) & Hairy-joint Grass (Arthraxon hispidus)						
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	WN	53.34	15.4	2:1	137.48	25073.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	HG, WN	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	HG	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	HG, WN	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	HG, WN	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	HG, WN	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	HG	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	HG, WN	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	WN	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	HG	8.60	4.3	4:1	51.60	6776.4

Slender Marsdenia (*Marsdenia longiloba)*

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Slender Marsdenia (*Marsdenia longiloba)*	E	V	Recorded in Section 10. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.3

Survey methods

The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken in section 8-11 at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:

- One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
- Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
- Several sites at south Coolgardie (ch:154500-155000) Section 10
- One site along Wardell Road (Wardell) (ch:152800) Section 10
- One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
- Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
- Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
- Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
- One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
- Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
- Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
- Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

Marsdenia longiloba is capable of dying back to its rootstock which is a pencil like tuber (Forster, 1995). Most plants are generally actively growing during an average summer and can be detected. Due to land access limitations it was not possible to assess the current populations

Vegetation / habitat types linked to *C. aquatilis* and *A. hispidus*	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	202.40	

Slender Marsdenia (*Marsdenia longiloba)*

Habitat

- This species was recorded in Section 10, comprising 1-3 individuals outside of the project boundary in moist forest on the edge of swamp forest with rainforest elements.
- The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. There is a possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.
- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary. There are also more extensive areas of potential habitat along the edges of swamp forests and moist drainage lines in dry sclerophyll forest.

Remaining uncertainties

There is potential for the distribution and abundance of this species to change over time if there is a significant lag time prior to construction

Impacts

- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of population.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project.
- Diseases which may impact the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.
- Impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact due to remaining individuals being present upslope.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management

Slender Marsdenia (*Marsdenia longiloba)*

actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 202.40 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Marsdenia longiloba* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting a large number of *Marsdenia longiloba* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Four-tailed Grevillea (Grevillea quadricauda) & Singleton Mint Bush (Prostanthera cineolifera)

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Four-tailed Grevillea (*Grevillea quadricauda)* (FG)	V	V	Found in Section 3, comprising of two sub-populations.	4.3.1.	6.3
Singleton Mint Bush (*Prostanthera cineolifera)* (SB)	V	V	Recorded in Section 7 at a single location. Population area and abundance was determined during targeted surveys	4.3.1.	6.3

Survey methods

Grevillea quadricauda

- This species had broad scale flora surveys in **Section 3-5** conducted during 2-7 July, 6-11 August and 14-19 October 2007 with a total of 550 working hours. Supplementary threatened species targeted and opportunistic surveys occurred in 16-19 November 2010, 21-25 November and 12-16 December 2011 contributing 14 days to survey effort.
- General traverses comprised random searches throughout targeted areas. These were used to develop a flora inventory and to complete searches for threatened species, as well as opportunistically record the distribution of vegetation communities; these also determined the density and distribution of threatened flora species.

Prostanthera cineolifera

- The first surveys implemented a meander traverse method based on Draft *Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004) with a total of 34 traverses varying from 1-3 km, collected over 15 days at Section 5-8 in May and July 2005. A further a eight days of supplementary targeted summer flowering flora was undertaken in summer 2006.
- Secondary targeted searches for threatened summer flowering species were undertaken in areas of suitable habitat on. Re-survey of previously identified threatened flora populations were undertaken to identify any change in distribution and abundance since the original survey on16-20 Jan 2012 (5 days) and 13-16 March 2012 (4 days).
- This species had targeted population surveys involving direct counts of the species in the project boundary. Surveys of the species were also conducted outside the boundary to gain an appreciation of the distribution and abundance of the species and assess the impact on the population. These involved direct counts of plants using a large plot (50 x 50 m) or where large aggregations were encountered population numbers were estimated.

Survey compliance / limitations

These species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling.

Vegetation / habitat types linked to *C. aquatilis* and *A. hispidus*	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	FG, SB	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	FG	2.0	4 (2.0ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	FG, SB	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	FG	44.5	3 (44.5ha)
	Total	184.40	

Four-tailed Grevillea (Grevillea quadricauda) & Singleton Mint Bush (Prostanthera cineolifera)

Habitat

Grevillea quadricauda

- This species grows in gravely loam, in the understorey of dry eucalypt forest, usually along or near creeks.
- Grevillea quadricauda was recorded in the project boundary at two different locations in Section 3. It occurs in moderate abundance in the project boundary comprising two subpopulations around 1.4 kilometres apart. One of these subpopulations is very small occurring in partially cleared disturbed habitats consisting of eight individuals and a larger population consisting of at least 200 individuals extending to the east of the project boundary.
- The southern population represents a relatively large abundance of individuals occurring in intact habitats on sandy slopes surrounding the project boundary. The occurrence of this population in the footprint is on the edge of an existing trail near a major creek line, evidence of selective logging was observed in areas of this population.

Prostanthera cineolifera

- *Prostanthera cineolifera* occurs in sclerophyll forests (Harden, 2002) and open woodlands on exposed sandstone ridges and is often found in association with shallow or skeletal sands.
- This species is known from one location, one on the Tabbimoble Creek south of Tullymorgan Road, inhabiting a narrow belt of deep, sandy soil along Tabbimoble Creek.
- The population in the project boundary represents the most northerly occurrence of *Prostanthera cineolifera* and is widely disjunct from its known distribution previously regarded as being restricted to only a few localities near Walcha, Scone and St Albans.
- The entire population in the known location is very large with the majority of the population occurring to the west of the project boundary in some areas forming a dense thicket of understory vegetation along Tabbimoble Creek. The population number is conservatively estimated to comprise 5000 to 8000 individuals occurring over 2.22 hectares. The population may extend further to the west along Tabbimoble Creek.
- The number of plants in the project boundary is estimated to comprise up to 250 individuals occurring over 0.41 hectares, with mainly the population on the western side of the existing highway potentially being impacted.

Remaining uncertainties

There is a possibility of moderate likelihood for this species to occur throughout the project boundary in suitable habitats of sandstone sclerophyll forests.

Impacts

- Diseases which may impact *Grevillea quadricauda* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Grevillea quadricauda

- The potential impacts of the project would result in the removal of a high proportion of individuals (62.5 per cent) from the northern population with only three individuals occurring outside of the project boundary. The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities.
- Only a small area of known habitat for the species would be impacted comprising a total of around 0.02 hectares from both populations representing around 3 per cent of the known area of habitat for both populations.
- The known habitat removal for the northern population represents around 92 per cent of the total area of known occupied habitat. This population is growing in partially cleared forested areas high on the bank of a major creek line. The known habitat removal for the southern population represents around 1.26 per cent of the total area of known occupied habitat.
- It is unlikely that cross-pollination would occur between the two known populations
- In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population.
- Habitat connectivity would be affected including potential habitat for *Grevillea quadricauda* and pollinator species.

Four-tailed Grevillea (Grevillea quadricauda) & Singleton Mint Bush (Prostanthera cineolifera)

Prostanthera cineolifera

- Of the 2.22 hectares of identified occupied habitat around 0.41 hectares (18.5 per cent) would potentially be impacted.
- Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Prostanthera cineolifera*.
- As the existing population is currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.
- The project is unlikely to significantly alter disturbance regimes.
- Considering that the majority of the population adjacent to the project boundary occurs upslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would not impact the remaining individuals.
- As the majority of the population occurs to the east of the project boundary areas of known habitat would not be fragmented from the project.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project would minimise the risk of the spread of disease from plant pathogens.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 184.40 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Four-tailed Grevillea (Grevillea quadricauda) & Singleton Mint Bush (Prostanthera cineolifera)

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Prostanthera cineolifera* and *Grevillea quadricauda* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Prostanthera cineolifera* and *Grevillea quadricauda* would contribute towards the recovery of the both species.

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	FG, SB	73.82	28.9	2:1	205.44	51812.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	FG	2.00	1.6	2:1	7.20	4095.5
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	FG, SB	53.34	15.4	2:1	137.48	25073.6
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	FG	37.97	17.6	2:1	111.14	2

Acronychia littoralis & Cryptocarya foetida & Macadamia tetraphylla

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC Act	EPBC Act		Impacts	Mitigation
Acronychia littoralis (AL)	E	E	Recorded outside of the project boundary at Section 8. Suitable habitat was extensively searched in targeted rainforest.	4.3.1.	6.3
Cryptocarya foetida (CF)	V	V	Seventeen individuals were recorded at Section 10 during targeted surveys in 2012.	4.3.1.	6.3
Macadamia tetraphylla (MT)	V	V	Recorded in Section 10. Field surveys determined sixty eight individuals with more than half occurring in the project boundary.	4.3.1.	6.3

Survey methods

- The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken in section 8-11 at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
  - One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
  - Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
  - Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
  - Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

- Complies with meandering search technique within suitable habitat.
- The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling.

Vegetation / habitat types linked to *C. aquatilis* and *A. hispidus*	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	AL, CF, MT	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	AL	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	CF	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	AL	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	MT	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	AL, CF, MT	2.0	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	AL, CF, MT	0.5	10 (0.5ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	AL	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	MT	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)

Acronychia littoralis & Cryptocarya foetida & Macadamia tetraphylla			
Red Mahogany open forest of the coastal lowlands of the North Coast	CF	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	AL	71.9	3 (49.6ha), 7 (22.3 ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	MT	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	MT	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	MT	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	CF	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	AL, CF, MT	44.5	3 (44.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	AL, CF, MT	8.6	10 (7.9ha), 11 (0.7ha)
Total		621	

Habitat

Acronychia littoralis

- The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area; however it is known to also occur in subtropical rainforest which is present in the study area. Around 94.62 hectares of potential rainforest habitat for this species has been identified.
- This species was recorded in Section 8, comprising one individual outside of the project boundary in subtropical rainforest.

Cryptocarya foetida

- Found mainly in littoral rainforest, usually on sandy soils and basalt soils.
- A total of 17 individuals were recorded in and surrounding the project boundary in Section 10 north of Coolgardie Road.
- Known to be the southern distributional limit.

Macadamia tetraphylla

- *Macadamia tetraphylla* is found in several regional ecosystems from complex notophyll vine forest to littoral rainforest to wet sclerophyll communities.
- *Macadamia tetraphylla* was recently recorded in supplementary surveys in patches of subtropical rainforest north of Coolgardie Road *(*BAAM 2012) comprising a total of 68 individuals.
- Total population size is estimated to be between 1000 and 2000 mature individuals with around 75 key populations with around 5 to 20 mature specimens at each locality (Costello et al 2009). Therefore the population in the study area could be regarded as a relatively large population and potentially represents up to 6.8 to 13.6 per cent of the entire population of which over half would potentially be impacted.
- The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Macadamia tetraphylla* is pollinated by both introduced European Honey Bee (*Apis mellifera*) and native bees (*Trigona* spp.) with native bees being the superior pollinators (Costello et al 2009).

Remaining uncertainties

Cryptocarya foetida

- Little or no experimental knowledge exists for the artificial propagation and translocation success of this species.

Impacts

- The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats.
- The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- Diseases which may impact these species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.

Acronychia littoralis & Cryptocarya foetida & Macadamia tetraphylla

Acronychia littoralis

- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.
- The project would result in the dissection of habitat for this species, however the population would not be dissected.

Cryptocarya foetida

- Around 94.62 hectares of potential Stinking Cryptocarya habitat occurs within and surrounding the project boundary. 10.33 hectares would be impacted.
- Rainforest habitat would be dissected with individuals being isolated on the eastern and western side of the project, resulting in further fragmentation.

Indirect impacts from edge effects and altered hydrology regimes and weed invasion may change the habitat of the remaining individuals of this species affecting life-cycle attributes. Depletion of genetic diversity.

Macadamia tetraphylla

- Of the 68 individuals, 37 individuals are within the project boundary, comprising over half of the known population.
- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Investigations into the reproduction of *Macadamia tetraphylla* suggest a pollen source from at least a two kilometres distance is an optimal outbreeding distance (Pisanu et al 2008). However, many wild populations do not have neighbouring populations at optimal distances owing to habitat fragmentation which may be the case with the population in the project boundary.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the remaining individuals.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Acronychia littoralis

- This individual occurs around 130 metres to the west of the proposed footprint and is considered unlikely to be directly or indirectly impacted. There is a low possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however these habitats are marginal and targeted surveys have not identified any populations within the project boundary.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Acronychia littoralis & Cryptocarya foetida & Macadamia tetraphylla

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project would minimise the risk of the spread of disease from plant pathogens.
- Mitigation through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RMS (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Acronychia littoralis

- Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the project would result in a long-term decrease in habitat availability.

Macadamia tetraphylla

- There is evidence indicating considerable pollination occurs between populations even in highly fragmented landscape (Neal 2007). These data indicate that the species may survive small population size if there is a network of small populations within a region; however larger distances between populations are not conducive to gene flow by pollen sufficient to maintain the genetic integrity of populations (Costello et al 2009).
- Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact.
- Highly disturbed populations have been observed to produce seed and are important as stepping stones for genetic flow between larger populations (Pisanu et al 2008).
- The population in the study area is towards the southern distributional limit for the species and is part of the southern group identified in the Southern Macadamia Species Recovery Plan (Costello et al 2009) which has a high priority for recovery actions.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 621 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Acronychia littoralis, Cryptocarya foetida* and *Macadamia tetraphylla* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Acronychia littoralis, Cryptocarya foetida* and *Macadamia tetraphylla* would contribute towards the recovery of the species.

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	AL, CF, MT	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	AL	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	CF	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	AL	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	MT	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	AL, CF, MT	2.00	1.6	2:1	7.20	4095.5

Acronychia littoralis & Cryptocarya foetida & Macadamia tetraphylla						
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	AL, CF, MT	0.50	0.3	4:1	3.20	1210
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	AL	53.34	15.4	2:1	137.48	25073.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	MT	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	CF	38.75	16.7	2:1	110.90	1665.2
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	AL	69.48	35.5	2:1	209.96	4922.7
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	MT	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	MT	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	MT	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	CF	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	AL, CF, MT	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	AL, CF, MT	8.60	4.3	4:1	51.60	6776.4

Square-stemmed Olax (Olax angulata) & Quassia sp. 'Moonee Creek'

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC Act	EPBC Act		Impacts	Mitigation
Square-stemmed Olax (*Olax angulata)* (SO)	V	V	One individual recorded in the project boundary at Section 2.	4.3.1.	6.3
Quassia sp. 'Moonee Creek' (Q)	E	E	One individual has been recorded in Section 3 outside of the project boundary	4.3.1.	6.3

Survey methods

Olax angulata

One individual of this species was identified in dry sclerophyll forest near Wells Crossing (Section 2) during follow-up surveys in 2010. Intensive general traverses were undertaken in areas radiating out from this single location in all directions to identify the spatial distribution and abundance. The survey was conducted by two botanists over a period of 8 hours. Further supplementary surveys during December 2011 failed to locate any additional individuals.

***Quassia* sp. 'Moonee Creek'**

- Survey investigation for **Section 1-2** was undertaken on 16-21 October 2006 and 18-24 February 2007 (13 days) with targeted searches for threatened flora along the entire length of the project using general meanders. Threatened flora species were again surveyed opportunistically on 19-24 August 2010 (6 days), and further re-surveys on 5-9 December 2011 of previously identified threatened flora populations to identify any change in abundance or distribution since original surveys.
- This species had broad scale flora surveys in **Section 3-5** conducted during 2-7 July, 6-11 August and 14-19 October 2007 with a total of 550 working hours. Supplementary threatened species targeted and opportunistic surveys occurred in 16-19 November 2010, 21-25 November and 12-16 December 2011 contributing 14 days to survey effort.
- General traverses comprised random searches throughout targeted areas. These were used to develop a flora inventory and to complete searches for threatened species, as well as opportunistically record the distribution of vegetation communities; these also determined the density and distribution of threatened flora species.
- The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
  - One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
  - Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
  - Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
  - Sites along Pacific Hwy Trustums Hill (ch:128200-129000) section 8.

Survey compliance / limitations

The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling.

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	SO, Q	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	Q	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)

Square-stemmed Olax (Olax angulata) & Quassia sp. 'Moonee Creek'

Coast Cypress Pine shrubby open forest of the North Coast Bioregion	SO	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	Q	2.0	4 (2.0ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	SO, Q	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	SO	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	SO	71.9	3 (49.6ha), 7 (22.3 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	Q	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	SO	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	SO	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	Q	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	Q	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	SO	10	6 (10ha)
	Total	561.3	

Habitat

Olax angulata

- One individual has been recorded in the project boundary north of Halfway Creek at Section 2, during surveys in September 2010 for this project.
- The main population near Minnie Waters is estimated to consist of around 5500 individuals with the nearest record around 20 kilometres to the east of the project boundary.
- There is likely to be other occurrences of the species closer to the project boundary from where the individual in the corridor has been recruited.
- The fleshy fruit of this species is potentially attractive to fruit-eating bird species and has dispersed into the project boundary from surrounding populations.
- *Olax angulata* was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*).
- The single plant in the project boundary is likely to represent the south-western distributional limit of the *Olax angulata*.

***Quassia* sp. 'Moonee Creek'**

- This species was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*) and Smudgy Apple (*Angophora woodsiana*). This vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.
- One individual has been recorded in Section 3 outside of the project boundary
- Potential habitat for this species is widespread in the locality, and there is likely to be a viable population in the locality, with around 70 records in the locality. This individual occurs around 230 metres to the east of the project boundary and is considered unlikely to be indirectly impacted.
- This species has a scattered distribution from the Moonee Creek area north of Coffs Harbour to north-east of Grafton. There are also records to the north of this known distribution surrounding Section 10 and 11.

Remaining uncertainties

***Quassia* sp. 'Moonee Creek'**

- There is a low possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

Square-stemmed Olax (Olax angulata) & Quassia sp. 'Moonee Creek'

Impacts

- As only one individual has been identified in the project boundary the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of these species affecting life-cycle attributes.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- Diseases which may impact *Isoglossa eranthemoides* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.
- Dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*) and Smudgy Apple (*Angophora woodsiana*) is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted for both species.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 561.3 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Square-stemmed Olax (Olax angulata) & Quassia sp. 'Moonee Creek'

Proposed Offset measures

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	SO, Q	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	Q	43.22	11.3	2:1	109.04	13765.5
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	SO	27.40	5	4:1	129.60	84.5
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	Q	2.00	1.6	2:1	7.20	4095.5
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	SO, Q	53.34	15.4	2:1	137.48	25073.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	SO	46.03	17.1	4:1	252.52	22199.4
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	SO	69.48	35.5	2:1	209.96	4922.7
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	Q	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	SO	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	SO	39.16	18.4	4:1	230.24	1483.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	Q	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	Q	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	SO	10.00	3.7	4:1	54.80	10800.2

Rusty Rose Walnut (Endiandra hayesii) & Red Lilly Pilly (Syzygium hodgkinsoniae) & Isoglossa (Isoglossa eranthemoides)

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC Act	EPBC Act		Impacts	Mitigation
Rusty Rose Walnut (*Endiandra hayesii)* (RW)	V	V	Recorded in Section 10. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.3
Red Lilly Pilly (*Syzygium hodgkinsoniae*) (RL)	V	V	Recorded in Section 10. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.3
Isoglossa (*Isoglossa eranthemoides*) (IE)	E	E	Recorded in Section 10. Targeted surveys were undertaken to approximate the area of suitable habitat within the project boundary.	4.3.1.	6.3

Survey methods

The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken in **Section 8-11** at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects (include:

- One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
- Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
- Several sites at south Coolgardie (ch:154500-155000) Section 10
- One site along Wardell Road (Wardell) (ch:152800) Section 10
- One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
- Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
- Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
- Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
- One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
- Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
- Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
- Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

The species was readily detectable irrespective of season and reproductive status.

Vegetation / habitat types	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	RW, RL, IE	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	RW, RL, IE	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	RL, IE	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	RW, RL, IE	2.0	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	RW, RL, IE	0.5	10 (0.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	RL	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	RL	28.5	1 (23.3ha), 2(5.2ha)

Rusty Rose Walnut (Endiandra hayesii) & Red Lilly Pilly (Syzygium hodgkinsoniae) & Isoglossa (Isoglossa eranthemoides)

Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	RL	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	RL	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	RW, RL, IE	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	RW, RL, IE	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	RW, RL, IE	44.5	3 (44.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	RW, RL, IE	8.6	10 (7.9ha), 11 (0.7ha)
Total		383.80	

Habitat

Endiandra hayesii

- Occurs on poorer soils derived from sedimentary, metamorphic, or acid volcanic rocks. Vegetation includes subtropical and warm temperate rainforests, and Brush Box (Lophostemon confertus) forests, including regrowth and highly modified forms of these habitats.
- Recorded in supplementary surveys in a patch of subtropical rainforest north of Coolgardie Road (Section 10) comprising a total of five larger individuals and three juveniles. Of these eight individuals, two larger individuals and three juveniles are within the project boundary, comprising around 62.5 per cent of the known population.
- Potentially larger population of this species occurring outside the project boundary in rainforest habitat.
- Known to be the southern distributional limit.

Syzygium hodgkinsoniae

- One individual was recorded in Section 10 comprising of a single individual in a patch of subtropical rainforest north of Coolgardie Road.
- It is found on deep rich alluvial and basalt soils.

Isoglossa eranthemoides

- This species was recorded in the project boundary in Section 10, comprising 1 individual outside of the project boundary in subtropical rainforest.
- The preferred habitat for this species is the understorey of lowland subtropical rainforest, in moist situations on floodplains and slopes. There is a possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however targeted surveys have not identified any populations within the project boundary.

Remaining uncertainties

- Little or no experimental knowledge exists for the artificial propagation and translocation success of this species.

Impacts

- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for remaining individuals.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project.
- Diseases which may impact the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.

Endiandra hayesii

- Around 94.62 hectares of potential Rusty Rose Walnut habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Rusty Rose Walnut (Endiandra hayesii) & Red Lilly Pilly (Syzygium hodgkinsoniae) & Isoglossa (Isoglossa eranthemoides)

Syzygium hodgkinsoniae

- Around 94.62 hectares of potential Red Lilly Pilly habitat occurs within and surrounding the project boundary. 10.33 hectares would be impacted.
- Rainforest habitat would be dissected with individuals being isolated on the eastern and western side of the project, resulting in further fragmentation.
- Any individuals present in areas surrounding the construction footprint could potentially be impacted by indirect impacts from edge effects and altered hydrology.

Depletion of genetic diversity.

Isoglossa eranthemoides

- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.
- The project would result in the dissection of habitat for this species; however the population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Isoglossa eranthemoides

- Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Rusty Rose Walnut (Endiandra hayesii) & Red Lilly Pilly (Syzygium hodgkinsoniae) & Isoglossa (Isoglossa eranthemoides)

Endiandra hayesii

- The seeds are readily distributed by fruit-eating bird species, indicating good potential propagation and natural regeneration success.

Syzygium hodgkinsoniae

- This species is insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals. Indicating good potential propagation and natural regeneration success in preserved rainforest habitat.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 383.80 hectares of native vegetation and habitat

The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	RW, RL, IE	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	RW, RL, IE	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	RL, IE	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	RW, RL, IE	2.00	1.6	2:1	7.20	4095.5
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	RW, RL, IE	0.50	0.3	4:1	3.20	1210
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	RL	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	RW, RL, IE	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	RL	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	RL	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	RL	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	RW, RL, IE	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	RW, RL, IE	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	RW, RL, IE	8.60	4.3	4:1	51.60	6776.4

Thorny Pea (Desmodium acanthocladum) & Swamp Mint Bush (Prostanthera palustris) & Arrow Head Vine (Tinospora tinosporoides)

Target species	Listed status		Status on project and additional species methods	Further reference	
	TSC / FM Act	EPBC Act		Impacts	Mitigation
Thorny Pea (*Desmodium acanthocladum)* (TP)	V	V	Recorded in Section 8.	4.3.1.	6.3
Swamp Mint Bush (*Prostanthera palustris*) (SB)	V	V	Recorded in Section 7	4.3.1.	6.3
Arrow Head Vine (*Tinospora tinosporoides*) (AV)	V	V	Recorded in Section 10	4.3.1.	6.3

Survey methods

Prostanthera palustris
Targeted searches for threatened flora were carried out in **Section 6-8** during May-June 2005 with a total of 34 transects varying in length from 1-3 kilometres. A re-survey was undertaken on 16-20 January 2012 to identify any change in distribution and abundance of threatened flora since original survey.
Desmodium acanthocladum* and *Tinospora tinosporoides
The overall survey effort was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken in Section 8-11 at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects (refer to Figure XX) include:

- One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
- Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
- Several sites at south Coolgardie (ch:154500-155000) Section 10
- One site along Wardell Road (Wardell) (ch:152800) Section 10
- One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
- Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
- Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
- Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9
- One site near Evans Head-Broadwater Road (Broadwater) (ch:142600-143000) Section 9.
- Sites in Broadwater NP along Pacific Hwy (ch:138600-139600) Section 9.
- Several sites near Pacific Hwy and Rileys Hill Road (Rileys Hill) (ch:136200-137300) Section 8
- Sites along Pacific Hwy Trustums Hill (ch:128200-129000) Section 8.

Survey compliance / limitations

The community was readily detectable irrespective of season and reproductive status.

Vegetation / habitat types	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	TP	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	TP	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	TP	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	SB	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	TP, AV	2.0	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	TP	0.5	10 (0.5ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	TP	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	TP	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)

Thorny Pea (Desmodium acanthocladum) & Swamp Mint Bush (Prostanthera palustris) & Arrow Head Vine (Tinospora tinosporoides)			
Tallowwood dry grassy forest of the far northern ranges of the North Coast	TP	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	TP, AV	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	SB	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	TP, AV	8.6	10 (7.9ha), 11 (0.7ha)
Total		271.8	

Habitat

- This species was recorded in Section 8, comprising around 15 individuals outside of the project boundary in subtropical rainforest derived vegetation along a drainage line.
- The preferred habitat for this species is dry rainforest and edges of subtropical rainforest on basalt derived soils which is present in the study area.
- Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area.

Remaining uncertainties

There is a low possibility this species is present in rainforest habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

Impacts

- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known population.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project.
- Diseases which may impact the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.

The project would result in the dissection of habitat for this species; however a population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation

Desmodium acanthocladum* and *Tinospora tinosporoides

- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Thorny Pea (Desmodium acanthocladum) & Swamp Mint Bush (Prostanthera palustris) & Arrow Head Vine (Tinospora tinosporoides)

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 271.80 hectares of native vegetation and habitat

The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

Biometric vegetation association	Species (Abbreviated)	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	TP	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	TP	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	TP	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	SB	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	TP, AV	2.00	1.6	2:1	7.20	4095.5
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	TP	0.50	0.3	4:1	3.20	1210
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	TP	38.75	16.7	2:1	110.90	1665.2
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	TP	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	TP	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	TP, AV	37.97	17.6	2:1	111.14	2

Thorny Pea (Desmodium acanthocladum) & Swamp Mint Bush (Prostanthera palustris) & Arrow Head Vine (Tinospora tinosporoides)						
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	SB	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	TP, AV	8.60	4.3	4:1	51.60	6776.4

White Lace Flower (*Archidendron hendersonii)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
White Lace Flower (*Archidendron hendersonii)*	V	-	Confirmed. Section 10-11, Targeted surveys were undertaken to quantify accurate numbers within the project boundary.	4.3.1.	6.3

Survey methods

- The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9

Survey compliance / limitations

Due to land access limitations it was not possible to assess some current populations

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	475.2 hectares	

White Lace Flower (*Archidendron hendersonii)*

Habitat

- This species was recorded in Section 10, comprising 11 individuals in subtropical rainforest north of Coolgardie Road *(*BAAM 2012).
- The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Archidendron hendersonii* is insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor
- *Archidendron hendersonii* is found on a variety of soils including coastal sands and those derived from basalt and metasediments. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary,
- This species occurs from north Queensland south to the Richmond River in north-east NSW. The occurrence in the project boundary potentially represents the current southern distributional limit for the species. There is one record around 150 kilometres to the south, however this record is from 1914 with no recent records present in this area.

Remaining uncertainties

- *Archidendron hendersonii* was also absent from some areas which appeared to support suitable habitat which makes it difficult to predict the distribution and abundance of the species. Further, there has not been any detailed soil landscape mapping undertaken for the Grafton and Bare Point 1:100 000 map sheets which cover Sections 3 to 5 of the study area, making it problematic to accurately predict and map the distribution of the species.
- Due to property access constraints several areas could not be assessed, therefore the average density was extrapolated across these areas where habitat appeared suitable.

Impacts

- The project would potentially have a significant impact to the eastern population of *Archidendron hendersonii,* as 6 of the 11 individuals are within the project boundary.
- .The remaining 5 individuals outside of the project could potentially be impacted by indirect impacts from edge effects and altered hydrology.
- There is potential for the genetic diversity of the local population of *Archidendron hendersonii* to be depleted
- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the remaining six individuals
- The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

White Lace Flower (*Archidendron hendersonii)*

Previous / known success of measures

- *Archidendron hendersonii* was recorded in current edge affected habitats in the study area including open paddocks. Therefore *Archidendron hendersonii i*s likely to be somewhat tolerant of edge effects and indirect impacts are not expected to significantly impact the life cycle attributes particularly with appropriate mitigation to reduce these edge effects such as weed treatment, water quality controls and native landscaping.
- Seed collection and a propagation strategy will successfully improve the population gene flow.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 475.2 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Archidendron hendersonii* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Archidendron hendersonii* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Swamp Foxglove (*Centranthera cochinchinensis*)

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
Swamp Foxglove (*Centranthera cochinchinensis*)	E	-	May potentially occur throughout project boundary.	4.3.1.	5.5 & 6.3

Survey methods

- Survey investigation for **Section 1-2** was undertaken on 16-21 October 2006 and 18-24 February 2007 (13 days) with targeted searches for threatened flora along the entire length of the project using general meanders. Threatened flora species were again surveyed opportunistically on 19-24 August 2010 (6 days), and further re-surveys on 5-9 December 2011 of previously identified threatened flora populations to identify any change in abundance or distribution since original surveys.
- This species had broad scale flora surveys in **Section 3-5** conducted during 2-7 July, 6-11 August and 14-19 October 2007 with a total of 550 working hours. Supplementary threatened species targeted and opportunistic surveys occurred in 16-19 November 2010, 21-25 November and 12-16 December 2011 contributing 14 days to survey effort.
- General traverses comprised random searches throughout targeted areas. These were used to develop a flora inventory and to complete searches for threatened species, as well as opportunistically record the distribution of vegetation communities; these also determined the density and distribution of threatened flora species.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	10	6 (10ha)
Total	300 hectares	

Habitat

- There is a possibility this species is present in suitable habitats within the project boundary which are widespread comprising moist paddocks and other open moist sites.
- There would be impacts to large areas of cleared paddocks and other open sites which would contain pockets of suitable habitat such as moist grassland/herbland. This species has been recorded in the Glenugie area growing in moister areas of open, cleared paddocks
- This species has a widespread distribution, but is limited to the north coast region of NSW north of Wooli. It also occurs in northern Australia and south-east Asia

Remaining uncertainties

Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species and the large areas of potential habitat suggest there is potential for the species to be present.

Impacts

- There would be impacts to large areas of cleared paddocks and other open sites which would contain pockets of suitable habitat such as moist grassland/herbland.
- Any potential populations at the southern end of the project boundary would be at the known southern distribution.
- Vegetation clearing would potentially contribute to further invasion of Lantana camara and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

Swamp Foxglove (*Centranthera cochinchinensis*)

- As no individuals have been identified adjacent to or within the project boundary, the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- Diseases which may impact these species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 300 hectares of native vegetation and habitat

The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Centranthera cochinchinensis* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Centranthera cochinchinensis* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2

Spider Orchid (*Dendrobium melaleucaphilum)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
Spider Orchid (*Dendrobium melaleucaphilum)*	E	-	Potential habitat in Section 1-11.	4.3.1.	6.3

Survey methods

The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:

- One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
- Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
- Several sites at south Coolgardie (ch:154500-155000) Section 10
- One site along Wardell Road (Wardell) (ch:152800) Section 10
- One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
- Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
- Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
- Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9

Survey compliance / limitations

The cryptic nature and mid storey/canopy habitat made detecting the species in preferred habitat difficult.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	10	6 (10ha)
Total	300.0 hectares	

Habitat

- No individuals have been recorded in the project boundary. Three species were identified within 10km of the project.
- Habitats for this species are widespread comprising the trunks of Prickly-leaved paperbark (Melaleuca styphelioides) in sheltered forests. There are records for this species surrounding the project boundary at various locations. Prickly-leaved paperbark trees are relatively common along the length of the project, mainly occurring in gullies and along drainage lines.
- *Dendrobium melaleucaphilum* occurs in coastal districts and nearby ranges, extending from Queensland south to its distributional limit in the lower Blue Mountains

Spider Orchid (*Dendrobium melaleucaphilum*)

Remaining uncertainties

- Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species and the widespread areas of potential habitat suggest there is potential for the species to be present.

Impacts

- The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- This species has potential habitat in various locations throughout the project boundary where Prickly-leaved paperbark trees occur.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 300 hectares of native vegetation and habitat

The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Spider Orchid (*Dendrobium melaleucaphilum*)

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Dendrobium melaleucaphilum* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Dendrobium melaleucaphilum* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2

Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *Bracteata)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC Act	EPBC Act		A	B
Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *Bracteata)*	E	-	Confirmed. Section 5 and section 10, Targeted surveys were undertaken to quantify accurate numbers within the project boundary.	4.3.1.	6.3

Survey methods

- The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2	4 (2.0ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	162.3 hectares	

Habitat

- *Endiandra muelleri* subsp. *bracteata* was recorded to the west of the project boundary at Maclean Section 5 and at Section 10. Recorded in a patch of subtropical rainforest north of Coolgardie Road comprising five large individuals and three juveniles. Of the eight individuals three large individuals and three small individuals are within the project boundary.
- The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10
- *Endiandra muelleri* subsp. *bracteata* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.
- *Endiandra muelleri* subsp. *bracteata* occurs in subtropical rainforest or wet eucalypt forest, chiefly at lower altitudes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary.
- *Endiandra hayesii* is known from a restricted distribution in northern NSW and southern Queensland (Hyland, 1989). Records of this species are clustered in the Border Ranges and Nightcap Ranges area, and at a few scattered near-coastal locations. Harden (1990) gives the Clarence River as the southern limit.

Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *Bracteata)*

- *Endiandra hayesii* has been previously recorded in the local area (10 kilometre radius) to the south east of the subject population near Iluka and there is also a record from 1997 near Coffs Harbour. The individuals recorded in the project boundary are around 55 kilometres north of the southern distribution specified in Harden (1990) at the Clarence River near Iluka.

Impacts

- Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for remaining individuals
- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

Avoidance

- The route selection process aimed to avoid and minimise impacts on vegetation and habitat and the presence of species and ecological communities of conservation significance
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The project design includes recommendations from the Biodiversity Connectivity Strategy.
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 162.3 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *Bracteata)*

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Endiandra muelleri* subsp. *bracteata* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Endiandra muelleri* subsp. *bracteata* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss	Edge effects	Offset ratio	Offset target	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Slender Screw Fern (Lindsaea incisa) & Maundia triglochinoides

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC Act	EPBC Act		Impacts	Mitigation
Slender Screw Fern *(Lindsaea incisa)* (SF)	E	-	Recorded in Sections 1, 2, 3 and 6. In 2011 targeted surveys determined proportion of habitat within project boundary.	4.3.1.	6.3
Maundia triglochinoides (MT)	V	-	Confirmed records in Sections 2, 3 and 7. Targeted surveys were conducted in preferred species habitat (i.e. drainage lines creeks, rivers) to quantify population densities within project boundary	4.3.1	6.3

Survey methods

- Both species were found to be restricted to narrow riparian habitats associated with creeks and drainages swales in varying abundance. Targeted surveys concentrated on these suitable habitat types where crossed by the project using a general traverse approach.
- Survey investigation for **Section 1-2** was undertaken on 16-21 October 2006 and 18-24 February 2007 (13 days) with targeted searches for threatened flora along the entire length of the project using general meanders. Threatened flora species were again surveyed opportunistically on 19-24 August 2010 (6 days), and further re-surveys on 5-9 December 2011 of previously identified threatened flora populations to identify any change in abundance or distribution since original surveys.
- This species had broad scale flora surveys in **Section 3-5** conducted during 2-7 July, 6-11 August and 14-19 October 2007 with a total of 550 working hours. Supplementary threatened species targeted and opportunistic surveys occurred in 16-19 November 2010, 21-25 November and 12-16 December 2011 contributing 14 days to survey effort.
- Where encountered the distribution of the species was mapped using a pre-determined abundance scale through the collection of a series of waypoints. For larger distributions an area was attributed to the point data (ie c. 20 m x 10 m area). In some areas where larger populations were observed polygons were mapped onto GIS software using aerial photography interpretation.
- *Maundia triglochinoides* was also targeted in two main surveys of Section 8-10; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9.

Survey compliance / limitations

Lindsaea incisa are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling. *Maundia triglochinoides* has been observed to vary in abundance seasonally and with filling and drying of freshwater wetlands

Vegetation / habitat types linked to target species	Species (Abbreviated	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	SF	79.7	1 (33.6ha), 2 (7.2ha), 3 (11.8ha), 6 (4.3ha), 7 (22.8ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	SF	27.4	9 (22.9ha), 10 (3.4ha), 11 (1.1ha)
Coastal floodplain sedgelands, rushlands, and forblands	MT	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	SF	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	SF	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	SF, MT	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8

Slender Screw Fern (Lindsaea incisa) & Maundia triglochinoides

			ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	SF	48.2	3 (9.7ha), 4 (17.7ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	SF, MT	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	SF	58.2	1 (16.6ha), 2 (26.1ha), 3 (14.6ha), 7 (0.9ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	SF	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	SF, MT	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	SF	71.9	3 (49.6ha), 7 (22.3 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	SF	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	SF	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	SF, MT	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	SF, MT	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	MT	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	SF	44.5	6 (10ha)
	Total	836.7 hectares	

Habitat

Lindsaea incisa

- Populations were found along the edges of drainage swales with sandy soils. The four locations comprise:
  - A large population extending into the boundary on the western side of the highway opposite Lemon Tree Road in Section 1.
  - A small patch 12 metres upstream to the east of the project boundary on an elevated area in the centre of Halfway Creek, Section 2.
  - A large population 20 metres downstream to the west of the project boundary near Tucabia in section 3.
  - A large population extending into the project boundary in Mororo State Forest in Section 6.
- *Lindsaea incisa* grows in damp sandy places in dry eucalypt forest on sandstone and moist shrubby eucalypt forest on meta-sediments. It is usually found in waterlogged or poorly drained sites along creeks, where ferns, sedges and shrubs grow thickly
- In the study area, *Lindsaea incisa* was associated with the edges of drainage swales on sandy soils within and on the edges of swamp forest communities and moist sclerophyll forest. Numerous locations were within previously disturbed areas with an open canopy.

Maundia triglochinoides

- *Maundia triglochinoides* has been recorded at 13 locations in close proximity to the project boundary during the supplementary surveys in 2011 and 2012, of which eight are within the project boundary
- *Maundia triglochinoides* grows in swamps, creeks or shallow freshwater 30 to 60 centimetres deep on heavy clay with low nutrients. In the study area it was observed growing in major creeks and rivers or lagoons associated with these such as Halfway Creek, Wells Crossing, Coldstream River and Chaffin Creek. It was also associated with smaller drainage lines and areas of swamp forest at several locations. Several of the locations appeared to have sandy soils rather than heavy clay.
- *Maundia triglochinoides* is suspected to be wind pollinated and therefore all occurrences within 150 metres of each other have been regarded as a single population, based on evidence of pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003).

Slender Screw Fern (Lindsaea incisa) & Maundia triglochinoides

- There is around 2,183 metres squared of occupied habitat for *Maundia triglochinoides* in the project boundary, representing around seven per cent of the total area of occupied habitat identified during recent surveys.
- The populations in the study area are within the central areas of the distribution of the species.

Remaining uncertainties

- *Lindsaea incisa* could not be directly counted in the field as there were a large number of fronds/leaves which emerge from the ground/creek bed along a creeping rhizome making it impossible to delineate individuals without digging up the plants.

Impacts

- Considering that the species occurs in drainage lines and other low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off, sedimentation and altered hydrology.
- Habitat connectivity would be somewhat impacted from the project with individuals being present on both sides of the project boundary at some locations

Lindsaea incisa

- Two of the four populations would potentially be impacted from the project, comprising Population 1 and Population 4.
- Around 53 per cent of Population 1 would potentially be impacted, representing a significant proportion of the available gene pool and occupied habitat. There are potentially other locations of this species in adjacent areas of habitat not surveyed which would reduce the proportion of the population being impacted. The project boundary is relatively broad in this area (up to 215 metres wide) and should be reduced to avoid significantly impacting this population.
- Around 18 per cent of Population 4 would potentially be impacted representing a relatively significant proportion of the available gene pool, however it is likely that there are other locations of *Lindsaea incisa* in adjacent areas of habitat not surveyed which would reduce the proportion of the population being impacted. The project boundary in this area includes several large water quality ponds which increases the impact on *Lindsaea incisa*. These sediment basins should be relocated to avoid impacts to *Lindsaea incisa*.

Maundia triglochinoides

- The project would potentially result in the total removal of the entire area of two populations (Population 8 and 12), a large proportion (10 to 50 per cent) of three populations (Population 2, 4 and 10), moderate impacts (five to 10 per cent) to three populations (Population 6, 9 and 11) and low level impacts (two per cent) to Population 1..
- The proposed impact boundary at Population 4 and 12 includes large sediment basins which increases the impact on *Maundia triglochinoides*. These sediment basins should be relocated to avoid impacts to *Maundia triglochinoides*.
- There is around 2,183 metres squared of occupied habitat for *Maundia triglochinoides* in the project boundary, representing around seven per cent of the total area of occupied habitat identified during recent surveys. There would be a substantial proportion of potential habitat unoccupied by *Maundia triglochinoides* impacted from the project including creek lines and other areas of standing water such as lagoons, wetlands, swamp forest and dams.
- Considering that the species occurs in drainage lines and other low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off, sedimentation and altered hydrology

Avoidance

Lindsaea incisa

Targeted survey of *Lindsaea incisa* during the detailed design stage in Sections 1, 2, 3 and 6, to physically survey and map the specific location of individuals and patches along the edges of the project boundary. The objective of the survey was to further refine the detailed design to avoid and minimise removal of the species.

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Slender Screw Fern (Lindsaea incisa) & Maundia triglochinoides

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)
- The project boundary in section 1 to be reviewed to identify any opportunities to avoid significant impacts to the existing populations of *Lindsaea incisa* (B63)
- project boundary and placement of sedimentation basins would be evaluated to minimise impacts to *Lindsaea incisa* (B64)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 836.7 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

- To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Lindsaea incisa* and *Maundia triglochinoides* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Lindsaea incisa* and *Maundia triglochinoides* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	73.82	28.9	2:1	205.44	51812.3
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal floodplain sedgelands, rushlands, and forblands	3.00	0.8	4:1	15.20	6668.3
Coastal heath on sands of the North Coast	0.20	2	2:1	4.40	14610.8
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	2.00	1.6	2:1	7.20	4095.5
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence	44.97	7.1	2:1	104.14	2840.2

Slender Screw Fern (Lindsaea incisa) & Maundia triglochinoides					
Lowlands of the North Coast					
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	53.34	15.4	2:1	137.48	25073.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	46.03	17.1	4:1	252.52	22199.4
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	69.48	35.5	2:1	209.96	4922.7
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	37.97	17.6	2:1	111.14	2
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2

Weeping Paperbark *(Melaleuca irbyana)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
Weeping Paperbark *(Melaleuca irbyana)*	E	-	Confirmed. Section 7. Targeted surveys were undertaken to quantify accurate numbers within the project boundary.	4.3.1.	6.3

Melaleuca irbyana **survey methods**

A population was first identified in the project corridor for Section 7 in 2006 (Eco 2006). A survey of the population was conducted and spatial data was recorded in GDA data format with a hand-held GPS, which generally displayed an accuracy of 5-10 metres. Point co-ordinates were recorded every 5-10 metres and a tally kept of the number of individuals. Polygons within the population were defined by recording individuals on the edge of the polygon, then counts were made of individuals within the polygon to identify an overall population distribution and abundance. Field surveys aimed at establishing a population estimate for individuals within the project boundary

The population was re-surveyed in summer 2012 to assess any change in distribution and abundance since the original survey and to establish an accurate depiction of the distribution and abundance of the species, direct counts were also undertaken at this time focused on the concept design project boundary

Survey compliance / limitations

The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	0.2	9 (0.2 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.8ha), 4 (17.8ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)

Weeping Paperbark *(Melaleuca irbyana)*

Swamp Oak swamp forest of the coastal lowlands of the North Coast		56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast		53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
	Total	642.2 hectares	

Habitat

- Approximately 800 individuals on either side of the Pacific Highway opposite and immediately to the south of the New Italy Rest Area for a distance of approximately 400 metres parallel with the highway.
- *Melaleuca irbyana* was recorded at several locations surrounding the project boundary in Section 3 and a large population is present within the project boundary at New Italy. Large populations have also been recorded at Glenugie west and east of Pacific Highway
- *Melaleuca irbyana* occurs in open eucalypt forest on poorly drained clay soils. Populations within and surrounding the project boundary were observed in ecotonal areas between Spotted Gum – Ironbark and swamp forest/floodplain forest communities. Populations observed in and surrounding the project boundary co-occurs with Prickly-leaved Paperbark (*Melaleuca nodosa*).
- The only population known to occur in the project boundary is at New Italy and is currently bisected by the existing Pacific Highway with individuals occurring on both sides of the highway. The population extends into private property to the west of the project boundary occurring in modified habitats including semi-mature forest and unmaintained areas. The New Italy population contains around 800 individuals, spread over around 1.5 hectares with around 400 individuals.
- Habitat for *Melaleuca irbyana* is in a higher condition on the western side of the highway comprising mature Spotted Gum-Ironbark forest with little weed invasion.
- The study area is towards the known southern extent of the species; however there are populations in Glenugie State Forest about 82 kilometres to the south of New Italy. Additionally there are also several populations between 13 and 35 kilometres to the west of the project boundary. There are no records to the east of the project boundary at New Italy and therefore the population at New Italy may represent the eastern extent of *Melaleuca irbyana* in this area.

Remaining uncertainties

- Considering the suckering nature of *Melaleuca irbyana,* it can be difficult delineate between individuals and to count individuals occurring as dense clusters. Therefore, estimates have been made for individuals occurring on the eastern side of the highway where a large number of suckering plants are present in powerline easement and within the existing highway reserve.

Impacts

- The total population size is estimated to be 800 individuals occurring over two hectares of which 530 individuals occurring over 1.16 hectares comprising 207 individuals within mature forest areas on the western side and 307 individuals on the eastern side of the highway would be impacted from the project. Therefore the individuals potentially impacted from the project comprise around 66 per cent of the local population and 58 per cent of the area of occupied habitat.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability
- As the existing population is currently fragmented by the existing highway, the project would result in further fragmentation of individuals, however individuals would only be retained on the western side of the project boundary.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Weeping Paperbark *(Melaleuca irbyana)*

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 642.2 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Melaleuca irbyana and* habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Melaleuca irbyana* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4

Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3

Red flowered King of the Faires (*Oberonia titania)*

Target species	Listed status		Status on project and additional species methods	Further reference*	
	TSC / FM Act	EPBC Act		A	B
Red flowered King of the Faires (*Oberonia titania)*	V	-	Recorded outside the project boundary in Section 10 during 2010 and in Section 7 during 2005. Further targeted surveys in 2012 could not relocate these records.	4.3.1.	6.3

Survey methods

- This species is an epiphytic orchid which is known to grow on several different host tree species occurring in swamp forest and other wet sclerophyll forest types conducive to ephiphytes. Considering the large area of potential habitat for this species across the project as whole, representative survey sites were selected focusing on least one site per 50 hectares in known locations. In addition known locations as determined by the initial preferred route studies and review of the atlas of NSW wildlife were targeted using direct counts of individuals and a general meandering technique. Searches for the species were conducted continuously while traversing all properties and habitats in the study area over a period of 117 days across all seasons.
- The first surveys implemented a meander traverse method based on Draft *Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004) with a total of 34 traverses varying from 1-3 km, collected over 15 days at **Section 5-8** in May and July 2005. A further a eight days of supplementary targeted summer flowering flora was undertaken in summer 2006.
- Targeted re-survey in **Section 6-8** for threatened cryptic flora species such as *Oberonia titania* was carried out in suitable habitat to identify any change to abundance and distribution since original survey.
- The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9

Survey compliance / limitations

The small size of this species and its potential to grow high in the canopy make it difficult to survey.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.2ha), 9 (1.3ha), 10 (22.7ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	0.2	9 (0.2 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.8ha), 4 (17.8ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)

Red flowered King of the Faires (*Oberonia titania)*		
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.9ha), 2 (37.9ha), 3 (68 ha), 4 (6.8ha), 6 (1.9ha), 7 (12.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	650.8 hectares	

Habitat

- *Oberonia titania* is an epiphytic orchid which is known to grow on several different host tree species occurring in swamp forest and other wet sclerophyll forest types conducive to ephiphytes
- .A small population of *Oberonia titania* was recorded to the east of the construction footprint in Section 10 during 2010 and it was also recorded east of the corridor in Section 7 but could not be relocated during surveys in 2012
- In Section 10, it was mainly recorded growing on the small rainforest tree (*Trochocarpa laurina*) and several plants were also recorded growing on moss and lichens on Bangalow Palm (*Archontophoenix cunninghamiana*) and Brush Kurrajong (*Commersonia fraseri*) in an area of swamp sclerophyll forest with rainforest elements. The population was restricted to two small areas growing on three trees in one area around 100 to 120 metres from the construction footprint consisting of up to 370 individuals, and up to 10 plants growing on two trees around 12 metres from the edge of the construction footprint
- *Oberonia titania* occurs on the NSW north coast north from Kendall, and also in Queensland and Norfolk Island. It is known from 10 locations in NSW, two of which occur within Dorrigo National Park and Washpool National Park. The population in the study area is not at the distributional limit for the species

Remaining uncertainties

Due to land access limitations it was not possible to assess the current populations of *Oberonia titania*

Impacts

- The total area of potential habitat for this species impacted by the project comprises over 100 hectares of rainforest and swamp sclerophyll forest, and there is an additional 100 hectares of floodplain forest of which some areas may have suitable habitat attributes for *Oberonia titania*. There would be impacts to potential habitat for the species in the local area
- Vegetation clearing for the project would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.
- There would be some impacts to connectivity with impacts significant areas of potential habitat for *Oberonia titania*. However, impacts are mostly limited to edges of these habitats and there would not be significant amounts of fragmentation of existing larger vegetation patches

Red flowered King of the Faires (*Oberonia titania)*

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Previous / known success of measures

- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project would minimise the risk of the spread of disease from plant pathogens.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.

Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 650.8 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Oberonia titania and* habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Oberonia titania* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	43.22	11.3	2:1	109.04	13765.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Coastal Heath on Sands of the North Coast	0.20	2	2:1	4.40	14610.8
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	44.97	7.1	2:1	104.14	2840.2
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7

Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	2.25	6	4:1	33.00	5824.1
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	38.75	16.7	2:1	110.90	1665.2
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	0.02	10.3	2:1	20.64	16215.6
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	87.13	124.2	2:1	422.66	113919.9
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	53.00	23	2:1	152.00	1065.3
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Peristeranthus hillii					
Target species	**Listed status**		**Status on project and additional species methods**	**Further reference***	
	TSC / FM Act	**EPBC Act**		**A**	**B**
Peristeranthus hillii	V	-	No individuals have been recorded in the project boundary. Potential habitat found in Section 9-11	4.3.1.	6.3

Survey methods

- Survey investigation for **Section 1-2** was undertaken on 16-21 October 2006 and 18-24 February 2007 (13 days) with targeted searches for threatened flora along the entire length of the project using general meanders. Threatened flora species were again surveyed opportunistically on 19-24 August 2010 (6 days), and further re-surveys on 5-9 December 2011 of previously identified threatened flora populations to identify any change in abundance or distribution since original surveys.
- This species had broad scale flora surveys in **Section 3-5** conducted during 2-7 July, 6-11 August and 14-19 October 2007 with a total of 550 working hours. Supplementary threatened species targeted and opportunistic surveys occurred in 16-19 November 2010, 21-25 November and 12-16 December 2011 contributing 14 days to survey effort.
- The first surveys implemented a meander traverse method based on Draft *Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004) with a total of 34 traverses varying from 1-3 km, collected over 15 days at **Section 5-8** in May and July 2005. A further a eight days of supplementary targeted summer flowering flora was undertaken in summer 2006.
- The overall survey effort for **Section 8-11** was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted for 8 days on the 6-10 February and 13-16 March 2012. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include:
  - One site west of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11.
  - Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11.
  - Several sites at south Coolgardie (ch:154500-155000) Section 10
  - One site along Wardell Road (Wardell) (ch:152800) Section 10
  - One site near Thurgates Lane (Wardell) (ch:151100) Section 10.
  - Two sites on Old Bagotville Road (Wardell) (ch:149800) Section 10.
  - Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10
  - Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9

Survey compliance / limitations

The small size of this species and its potential to grow high in the canopy make it difficult to survey.

Vegetation / habitat types linked to target species	**Area in project boundary (ha)**	**Project Section (extent in hectares)**
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)
Total	69.7 hectares	

Peristeranthus hillii

Habitat

- This species is an epiphyte, growing in clumps on tree trunks and thick vines in lowland rainforest. Found in north-eastern NSW, north from Port Macquarie.
- There are records for this species surrounding the project boundary at various locations. No individuals have been recorded in the project boundary.
- Although targeted surveys have not identified any populations within the project boundary. There is a possibility of moderate likelihood for this species to occur throughout the project boundary in suitable habitats of sandstone sclerophyll forests however targeted surveys have not identified this species at any additional locations in the corridor.
- The study area doesn't represent the distributional limit of the species.
- There is a possibility of moderate likelihood for this species to occur throughout the project boundary in suitable habitats of sandstone sclerophyll forests however targeted surveys have not identified this species at any additional locations in the corridor.

Remaining uncertainties

- There is a possibility this species is present in suitable habitats within the project boundary comprising coastal and near-coastal environments, particularly in Lowland Rainforest.

Impacts

- Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.
- Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

Avoidance

The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposal, comprises:

- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.
- There is currently a high degree of habitat fragmentation across much of the study area. Further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection
- The location of exclusion zones would be determined and established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.
- The project is unlikely to significantly alter disturbance regimes.

Proposed mitigation and management measures

- Exclusion zones (B29)
- Weed management (B32)
- Monitoring Strategy (B1)
- Re-establishment of native vegetation(B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Pathogen management (B34)

Peristeranthus hillii

Previous / known success of measures

- There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.
- Weed management would be implemented during the construction phase of the project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.
- Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised.
- Monitoring and management actions for the retained populations as part of the mitigation measures of the project should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.
- Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 69.7 hectares of native vegetation and habitat
- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.

Proposed Offset measures

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Peristeranthus hillii and* habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Peristeranthus hillii* would contribute towards the recovery of the species.

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Threatened ecological communities

Species	Status		Status on project
	TSC / FM Act	EPBC Act	
Threatened ecological communities			
Subtropical Coastal Floodplain Forest (SCFF)	E		Recorded in all sections
Swamp Sclerophyll Forest (SSF)	E		Recorded in all sections
Swamp Oak Floodplain Forest (SOFF)	E		recorded in Sections 1, 3-5, and 8-11
Freshwater Wetlands (FW)	E		Recorded in Sections 3, 4, 8 and 9
Lowland Rainforest (LR)	E	CE	Recorded in Sections 3 and 8-11
Coastal Cypress Pine Forest (CCPF)	E		Recorded in Sections 8-11

Survey methods

- Mapping and detailed descriptions of vegetation communities using ground-truthed data and Aerial Photography Interpretation (API) was undertaken throughout the study area and any gaps identified were assessed in the field to determine the type and extent of vegetation communities present including threatened ecological communities.
- General traverses/transects across the entire project boundary were used to determine vegetation community boundaries.
- Quadrat sampling (20 x 20 m) to describe the vegetation communities were undertaken and are consistent with DEC survey guidelines (2004).
- Vegetation community mapping and ground-truthing undertaken in areas that were not mapped adequately in 2006-07.
- Statistical analysis of quadrat data was used to classify vegetation communities in Section 9 to 11.

Project section	Survey date	Overview of survey methods and effort
1-2	16-21 Oct 2006 18-24 Feb 2007 (13 days)	• Mapping and detailed descriptions of vegetation communities using ground-truthed data and Aerial Photography Interpretation (API). Comparison with council vegetation mapping between Coffs Harbour and Red Rock (Coffs Harbour City Council 2005). • General traverses/transects across the entire project boundary up to 75 m from the project centreline using two observers that collectively surveyed the entire alignment. • Quadrat sampling (20 x 20 m) to describe the vegetation communities and consistent with DEC (2004). Either one or two quadrats per vegetation stratification unit were sampled. No unit was greater than 50 hectares in size. 22 quadrats were sampled in total and this density exceeded the DEC (2004) survey guidelines.
1-2	5-9 Dec 2011 (5 days)	• Vegetation community mapping and ground-truthing undertaken in areas that were not mapped adequately in 2006-07.
3-5	2-7 July 2007, 6-11 Aug 2007, 14-19 Oct 2007 (18 days)	• Mapping and detailed identification of vegetation communities by ground-truthing up to 500 m from the centre line and Aerial Photography Interpretation (API). • General traverses/transects up to 100 m from the project centreline. • Quadrat sampling undertaken to describe the vegetation communities.
3-5	23-27 Aug 2010 (5 days)	• Fine-scale vegetation mapping including quadrat sampling to describe the vegetation communities and flora species around potential cut and fill locations (early works).
6-8	May-June 2005 (15 days)	• Vegetation mapping adapted from CRAFTI and Forests NSW data and Aerial Photography Interpretation (API) • A total of 34 traverses, which varied in length from 1-3 kilometres. • Quadrats undertaken where threatened species or EECs observed.
9-11	14-25 March 2005 (12 days)	• Mapping and detailed descriptions of vegetation communities using Aerial Photography Interpretation (API) and statistical analysis of quadrat data
9-11	30-3 Aug-Sept 2010 (5 days)	• Fine-scale vegetation mapping including quadrat sampling to describe the vegetation communities at potential cut and fill locations. • Targeted searches for threatened flora species at potential cut and fill locations. • Added to general flora species inventory established from the project boundary.

Threatened ecological communities

Survey compliance / limitations

- Survey methods and effort were conducted in accordance with the guidance of DEC (2004).
- Further surveys would be conducted for the Lowland Rainforest community to identify the condition and area of high quality habitats

Vegetation / habitat types linked to target species	Species (Abbreviated)	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	LR	1.4	3 (1.4ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	CCPF	27.4	9 (22.9 ha), 10 (3.4 ha), 11 (1.1 ha)
Coastal floodplain sedgelands, rushlands, and forblands	FW	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	SCFF	73.9	1(4.8 ha), 2 (0.9 ha),3 (38.5 ha),4 (0.8 ha), 5 (2.4 ha),6 (18.8 ha) ,7 (0.1 ha),10 (5.7 ha),11 (1.9 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	LR	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	SCFF	34.7	6 (9.6ha), 7 (14.7ha), 8 (10.4ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	SFF	49.5	1 (10.5ha), 2 (3.5ha), 3 (1.2ha), 4 (0.3ha), 6 (1.9ha), 7 (20.6ha), 8 (11.2ha), 10 (0.3ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	SCFF	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	SSF	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	SOFF	56.2	1 (0.9 ha), 3 (12.9 ha), 4(1.6 ha), 5(11.8 ha), 8(12.3 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	FW	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	LR	8.6	10 (7.9ha), 11 (0.7ha)
	Total	337.9 hectares	

Remaining uncertainties

- Considering the relatively large area covered by the surveys and the age of some of the data (up to 7 years old) the indicated boundaries of threatened ecological communities are likely to require refinement during detailed design
- The extent and severity of edge effects
- It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs.

Impacts

- Total area of potential direct impact to these ecological communities within the project boundary is 337.9 hectares
- Prone to impacts from altered hydrology and water quality
- Indirect impacts may result on remaining areas through edge effects

Avoidance

- The proposed upgrade has been designed to minimise vegetation clearing where possible and minimise potential impacts to specific threatened species and ecological communities present in the study area.
- Avoidance of identified areas of habitat currently or potentially occupied by threatened species during the route selection and concept design phase.
- Further minimise vegetation/habitat clearing where possible to minimise impacts to numerous threatened fauna and flora species which potentially utilise these habitats as part of the detailed design phase.

Threatened ecological communities

- The connectivity and mitigation strategies have focused on the residual impacts identified after avoidance measures have been implemented.
- There is currently a high degree of habitat fragmentation across much of the study area and further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.
- The location of exclusion zones would be determined and established to avoid damage to any remaining adjacent areas of these ecological communities.

Proposed mitigation and management measures

- Re-establishment of native vegetation (B11)
- Minimising loss of vegetation and habitat (B17)
- Pre-clearing surveys (B28)
- Exclusion zones (B29)
- Weed and pathogen management (B32-35)
- Reuse of woody debris and bushrock (B31)

Previous / known success of measures

- Previous large-scale road upgrades have successfully re-established native vegetation to provide a buffer to existing habitats limiting edge effects and restore threatened ecological communities
- Pre-clearing surveys have successfully been utilised to identify important biodiversity attributes such as threatened ecological communities to be retained, protected and avoided
- Previous large-scale road upgrades have successfully avoided important biodiversity features during detailed design including retaining threatened ecological communities where possible
- The procedures used for exclusion zones, and weed and pathogen management have been documented in the RMS biodiversity guidelines (RTA, 2011) and are based on best practice procedure

Residual impacts

- Impacts on biodiversity are expected to remain significant
- Loss of about 337.9 hectares of threatened ecological communities
- High to moderate indirect impacts associated with edge effects for the project

Proposed Offset measures

Biometric vegetation association	Direct loss (ha)	Edge effects (ha)	Offset ratio	Offset target (ha)	Area (hectares) in 30 km radius
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.40	0.5	4:1	7.60	57.6
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	27.40	5	4:1	129.60	84.5
Coastal Floodplain Sedgelands, Rushlands, and Forblands	3.00	0.8	4:1	15.20	6668.3
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	60.77	29.4	4:1	360.68	12998.7
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	0.50	0.3	4:1	3.20	1210
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	34.70	30.6	4:1	261.20	35439.7
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	46.03	17.1	4:1	252.52	22199.4
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	27.16	0	4:1	108.64	80.5
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	39.16	18.4	4:1	230.24	1483.1
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	56.20	21.5	4:1	310.80	9670.1
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	10.00	3.7	4:1	54.80	10800.2
White Booyong - Fig Subtropical Rainforest of the North Coast	8.60	4.3	4:1	51.60	6776.4

Appendix N Threatened species habitat matrix and survey locations

BIOMETRIC VEGETATION / HABITAT TYPE	
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	2
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	3
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	4
Coastal Floodplain Sedgelands, Rushlands, and Forblands	5
Coastal Heath on Sands of the North Coast	6
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	7
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	8
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	9
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	10
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	11
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	12
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	13
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	14
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	15
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	16
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	17
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	18
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	19
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	20
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	21
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	22
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	23
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	24
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	25
White Booyong - Fig Subtropical Rainforest of the North Coast	26
Cleared and Modified	27

Threatened species and linkages to biometric vegetation types (refer Figures following the table for distribution of vegetation communites and survey locations

Species	Common name	TSC Act / EPBC Act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
THREATENED FAUNA																													
Wetland birds																													
Anseranas semipalmata	Magpie Goose	V					■			■				■										■			■		
Ephippiorhynchus asiaticus	Black-necked stork	E					■			■			■	■			■					■	■	■			■		
Grus rubicundus	Brolga	V					■																	■			■		
Irediparra gallinacea	Comb-Crested Jacana	V					■										■						■	■			■		
Ixobrychus flavicollis	Black Bittern	V					■			■			■	■			■					■	■	■			■		
Amaurornis molucanna	Pale-vented Bush Hen	V		■			■		■				■				■						■	■	■	■	■	■	
Botaurus poiciloptilus	Australasian Bittern	E, E					■			■			■	■			■					■	■	■			■		
Rostratula australis	Australian Painted Snipe	E, E, M					■																	■					
Large forest owls																													
Ninox strenua	Powerful Owl	V	■	■	■	■	■		■	■		■		■	■	■	■	■	■	■	■	■	■	■	■	■		■	
Ninox connivens	Barking Owl	V	■	■	■	■	■	■		■	■	■		■	■	■	■	■	■	■	■	■	■	■	■				
Tyto novaehollandiae	Masked Owl	V	■	■	■	■	■		■	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■		■	
Tyto tenebricosa	Sooty Owl	V	■		■		■		■	■		■		■			■	■				■	■	■	■	■		■	
Fruigivorous rainforest birds																													
Ptilinopus magnificus	Wompoo fruit-Dove	V	■		■				■			■						■							■	■		■	
Ptilinopus regina	Rose-crowned Fruit Dove	V	■		■				■			■						■							■	■		■	
Ptilinopus superbus	Superb fruit-Dove	V	■		■		■		■	■		■		■			■	■				■	■	■	■	■		■	
Coracina lineata	Barred cuckoo-shrike	V																											
Cyclopsitta diophthalma coxeni	Double-Eyed Fig-Parrot	E, E	■		■				■			■						■							■	■		■	
Cave-roosting microbats																													
Chalinolobus dwyeri	Large-eared Pied Bat	V, V	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Miniopterus australis	Little Bent-wing Bat	V	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	

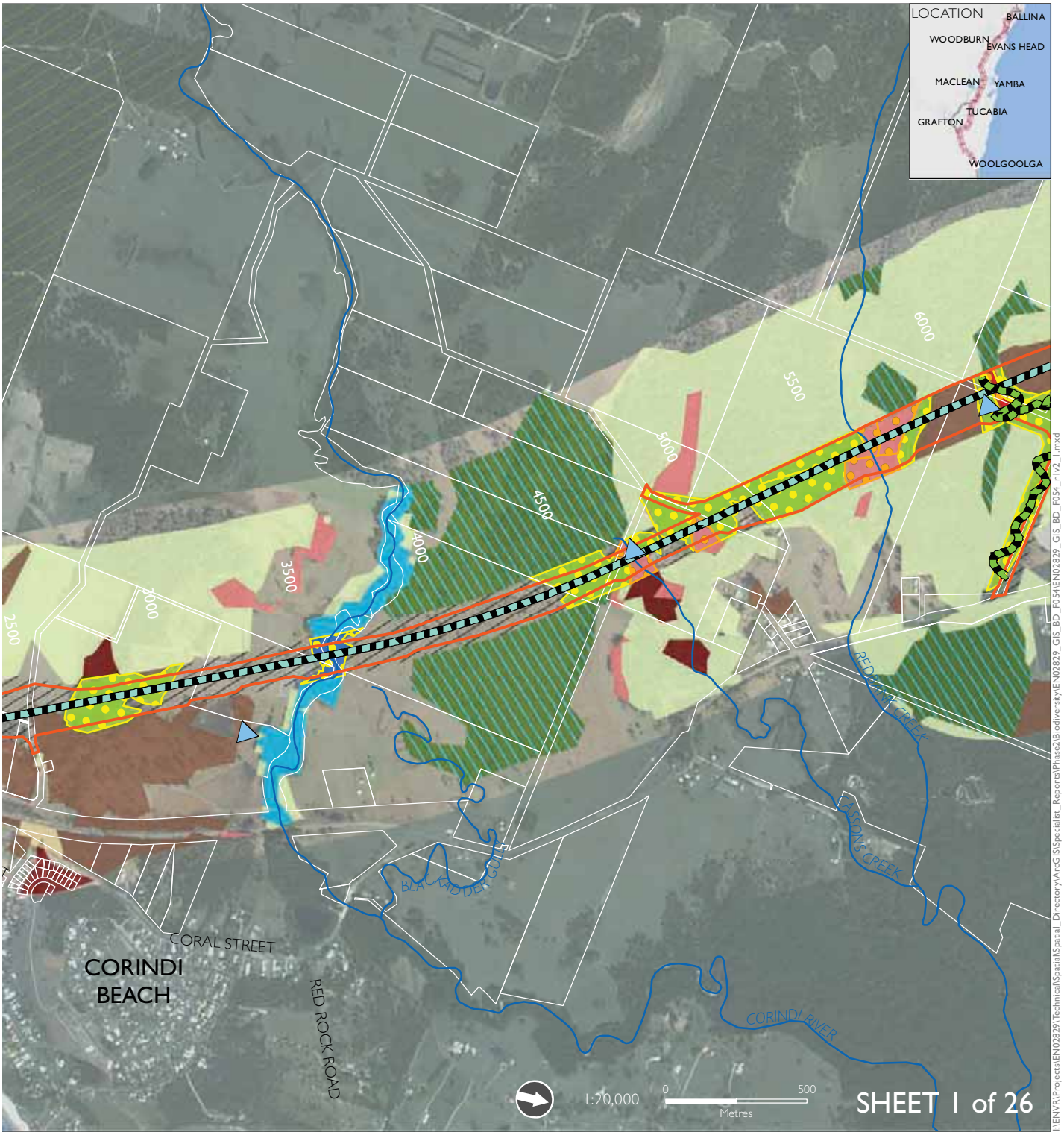
Species	Common name	TSC Act / EPBC Act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	V																											
Myotis macropus	Southern Myotis	V																											
Vespadelus troughtoni	Eastern Cave Bat	V																											
Tree-roosting microbats																													
Chalinolobus nigrogriseus	Hoary Wattled Bat	V																											
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V																											
Kerivoula papuensis	Golden-tipped Bat	V																											
Mormopterus beccarii	Beccari's Freetail-Bat	V																											
Mormopterus norfolkensis	Eastern Freetail-Bat	V																											
Nyctophilus bifax	Eastern Long-Eared Bat	V																											
Saccolaimus flaviventris	Yellow-bellied Sheathtail-Bat	V																											
Scoteanax rueppellii	Greater Broad-nosed Bat	V																											
Arboreal snakes																													
Hoplocephalus bitorquatus	Pale-headed Snake	V																											
Hoplocephalus stephensii	Stephens' banded snake	V																											
Diurnal raptors																													
Hieraaetus morphnoides	Little Eagle	V																											
Lophoictinia isura	Square-tailed Kite	V																											
Erythrotriorchis radiatus	Red Goshawk	E, V																											
Other fauna																													
Calyptorhynchus lathami	Glossy black-cockatoo	V																											
Dromaius novaehollandiae	Coastal Emu	E2																											
Lichenostomus fasciogulari	Mangrove Honeyeater	V																											

Species	Common name	TSC Act / EPBC Act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Pandion haliaetus	Eastern Osprey	V																											
Pezoporus wallicus wallicus	Ground Parrot	V																											
Potorous tridactylus	Long-nosed Potoroo	V, V																											
Tyto capensis	Eastern Grass Owl	V																											
Syconycteris australis	Common Blossom-Bat	V																											
Aepyprymnus rufescens	Rufous Bettong	V																											
Cercartetus nanus	Eastern Pygmy-Possum	V																											
Petaurus australis	Yellow-bellied Glider	V																											
Petaurus norfolcensis	Squirrel Glider	V																											
Phascogale tapoatafa	Brush-tailed Phascogale	V																											
Phascolarctos cinereus	Koala	V, V																											
Planigale maculata	Common Planigale	V																											
Crinia tinnula	Wallum Froglet	V																											
Litoria brevipalmata	Green-thighed Frog	V																											
Litoria olongburensis	Olongburra Frog	V																											
Mixophyes iteratus	Giant Barred Frog	E. E																											
Pteropus poliocephalus	Grey-headed Flying-fox	V, V																											
Dasyurus maculatus	Spotted-tailed Quoll	E, E																											
Lathamus discolor	Swift Parrot	E, E, M																											
Anthochaera phrygia	Regent Honeyeater	E, E, M																											
Petalura litorea	Coastal Petaltail	E, E																											
Glossopsitta pusilla	Little Lorikeet	V																											
Climacteris picumnus	Brown Treecreeper	V																											
Melithreptus gularis gularis	Black-chinned Honeyeater	V																											
Burhinus grallarius	Bush stone-curlew	E																											
Pomatostomus temporalis temporalis	Grey-crowned Babbler	V																											

Species	Common name	TSC Act / EPBC Act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Nurus atlas	Atlas Rainforest Ground Beetle	E																											
Phyllodes imperialis	Pink Underwing Moth	E, E																											
THREATENED FLORA																													
Acronychia littoralis	Scented Acronychia	V, E																											
Angophora robur	Sandstone Rough-barked Apple	V, V																											
Arthraxon hispidus	Hairy Joint Grass	V, V																											
Archidendron hendersonii	White Lace Flower	V																											
Centranthera cochinchinensis	Swamp Foxglove	E																											
Cryptocarya foetida		V, V																											
Cyperus aquatilis	Water Nutgrass	E																											
Dendrobium melaleucaphilum	Spider Orchid	E																											
Desmodium acanthocladum	Thorny Pea	V, V																											
Endiandra hayesii	Rose Walnut	E, V																											
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	E																											
Eucalyptus tetrapleura	Square-fruited Ironbark	V, V																											
Grevillea quadricauda	Four-tailed grevillea	V, V																											
Isoglossa eranthemoides	Isoglossa	E, E																											
Lindsaea incisa	Slender Screw Fern	E																											
Macadamia tetraphylla	Macadamia	V, V																											
Marsdenia longiloba	Slender Marsdenia	E, V																											
Maundia triglochinoides	-	V																											
Melaleuca irbyana	Weeping Paperbark	E																											
Oberonia titania	Red flowered King of the Fairies	V																											

Species	Common name	TSC Act / EPBC Act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Olax angulata	Square-stemmed Olax	V																											
Peristeranthus hillii		V																											
Prostanthera cineolifera	Singleton Mint Bush	V, V																											
Prostanthera palustris	*Swamp Mint Bush*	V, V																											
Quassia sp. 'Moonee Creek'	Moonie Quassia	E, E																											
Syzygium hodgkinsoniae	Red Lily Pilly	V, V																											
Tinospora tinosporoides	Arrow Head Vine	V, V																											

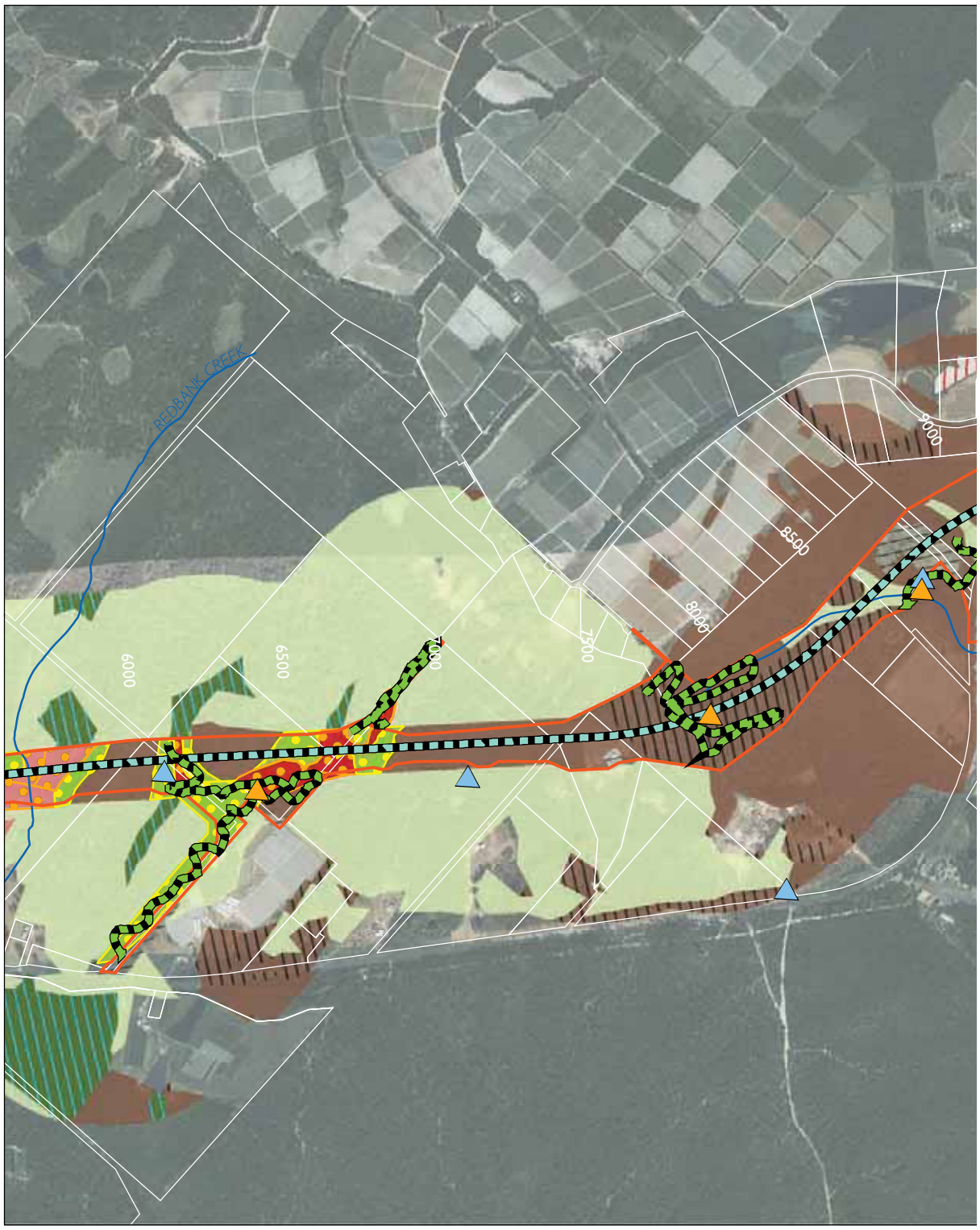
Figure 2-1 Flora survey methods in the study area

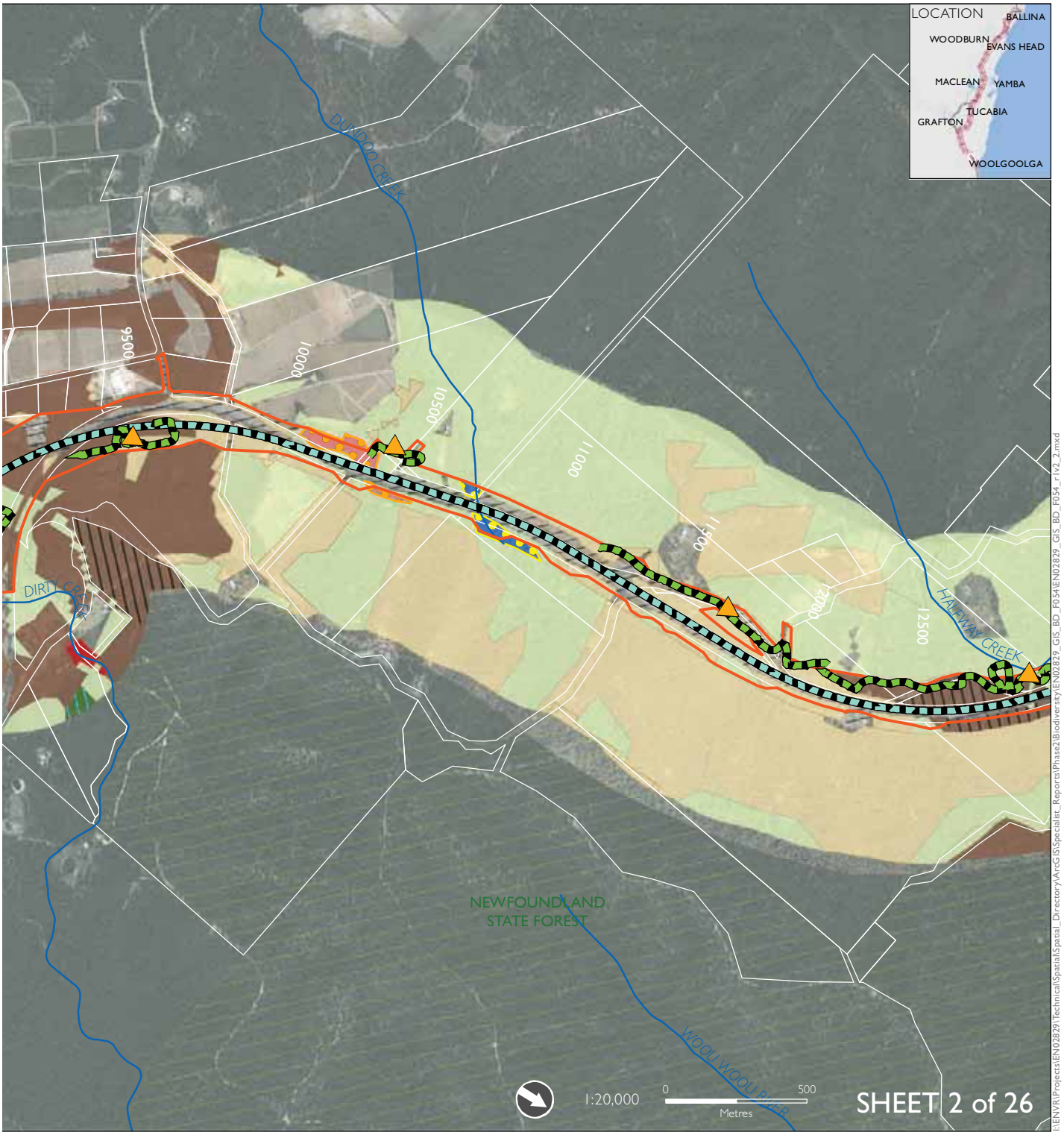


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-2 Flora survey methods in the study area





Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-3 Flora survey methods in the study area

Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-4 Flora survey methods in the study area

Flora survey methods

- Primary flora survey site (2005)
- Supplementary vegetation mapping (2011)
- Targeted threatened flora search (2011)
- Flora survey traverse (2007)
- Targetted flora survey traverse (2011)
- Flora Traverses (2006/2007) under taken in this area 75 m either side of centreline

Threatened ecological communities

- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered,TSC Act)
- Swamp Sclerophyll Forest on Coastal Floodplains (Endangered,TSC Act)

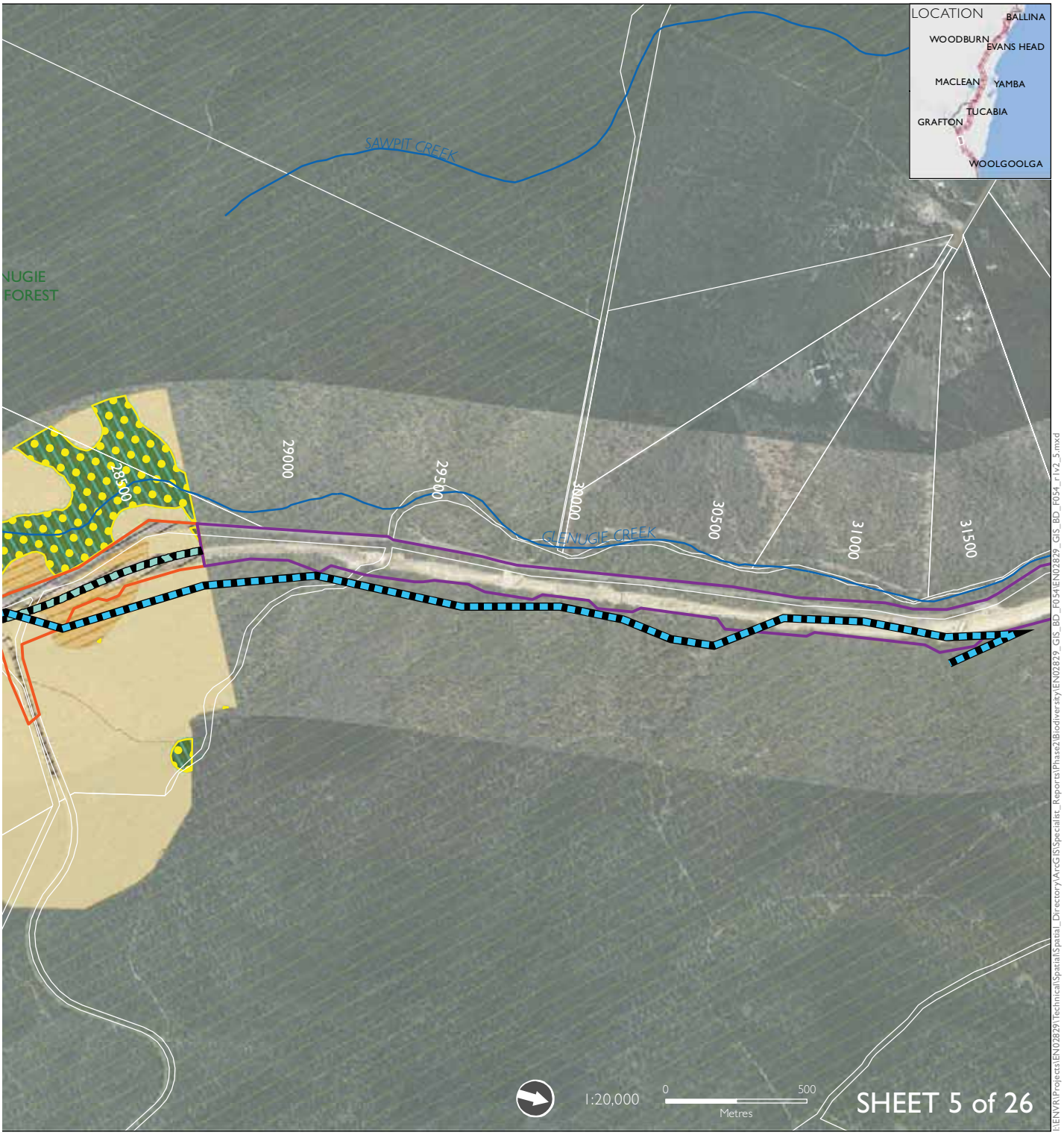
Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Orange Gum (Eucalyptus bancroftii) open forest of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-5 Flora survey methods in the study area

Flora survey methods
- Flora survey traverse (2007)
- Targetted flora survey traverse (2011)
- Flora Traverses (2006/2007) under taken in this area 75 m either side of centreline

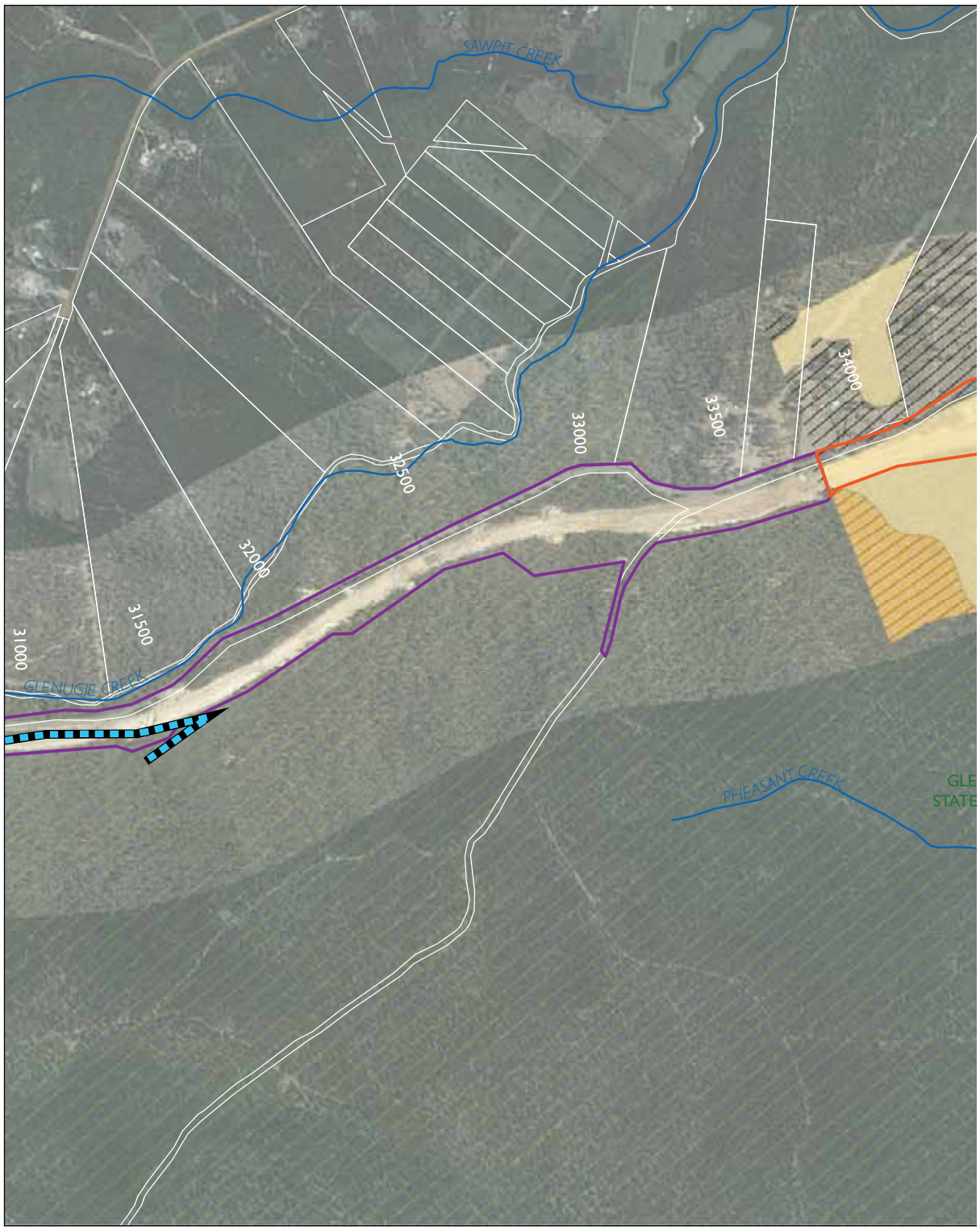
Threatened ecological communities
- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)

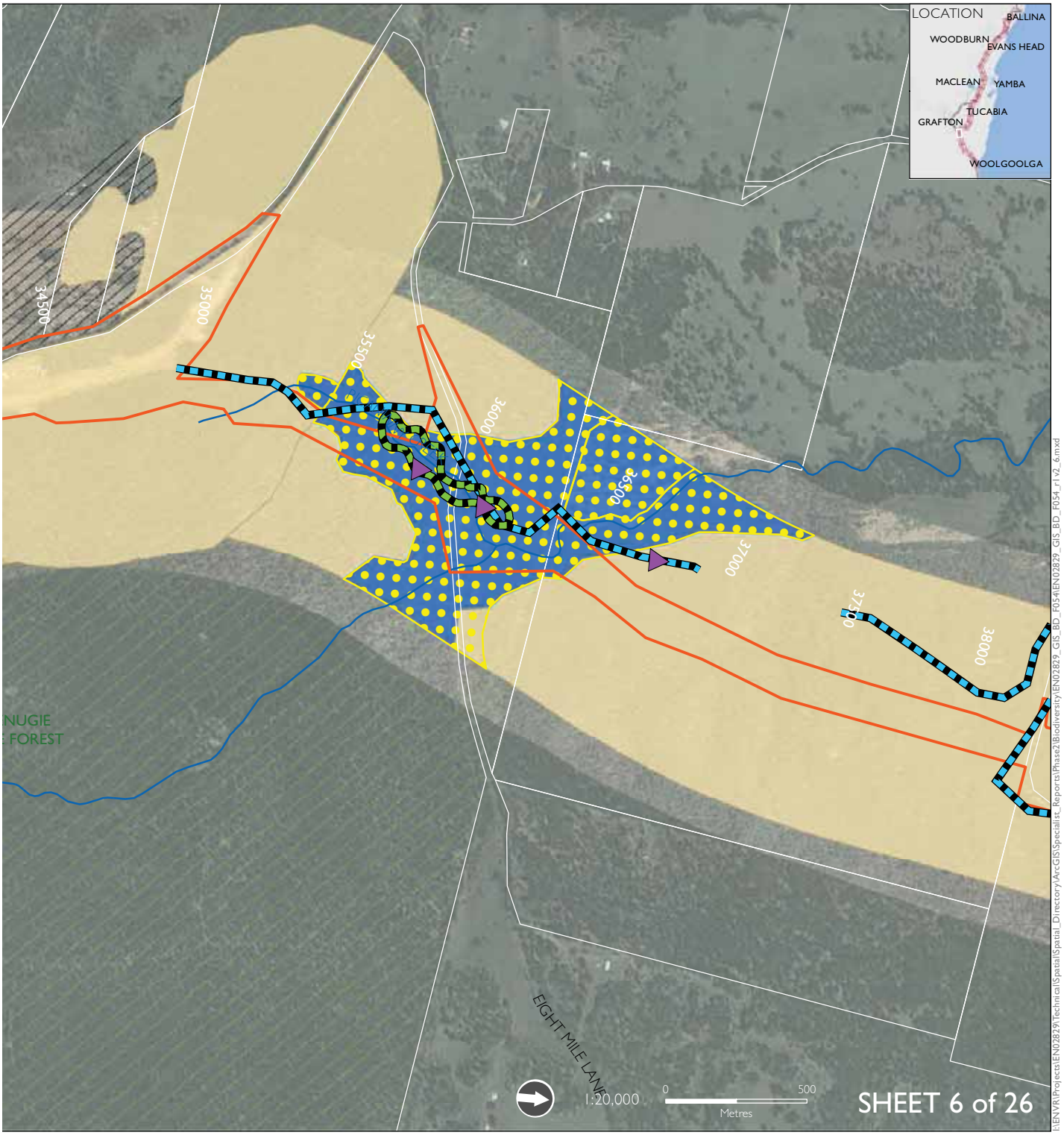


Vegetation communities

- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Orange Gum (Eucalyptus bancroftii) open forest of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-6 Flora survey methods in the study area

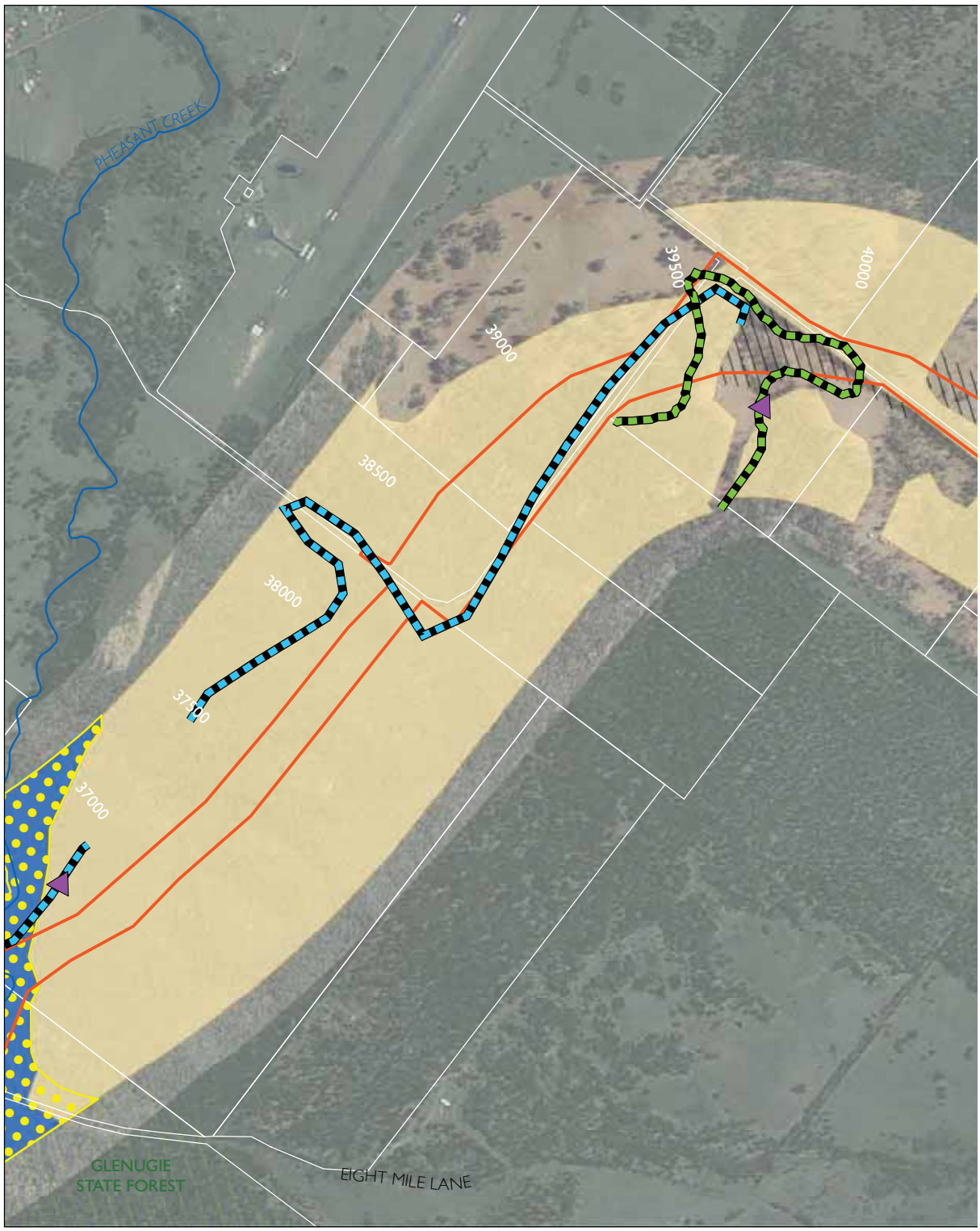


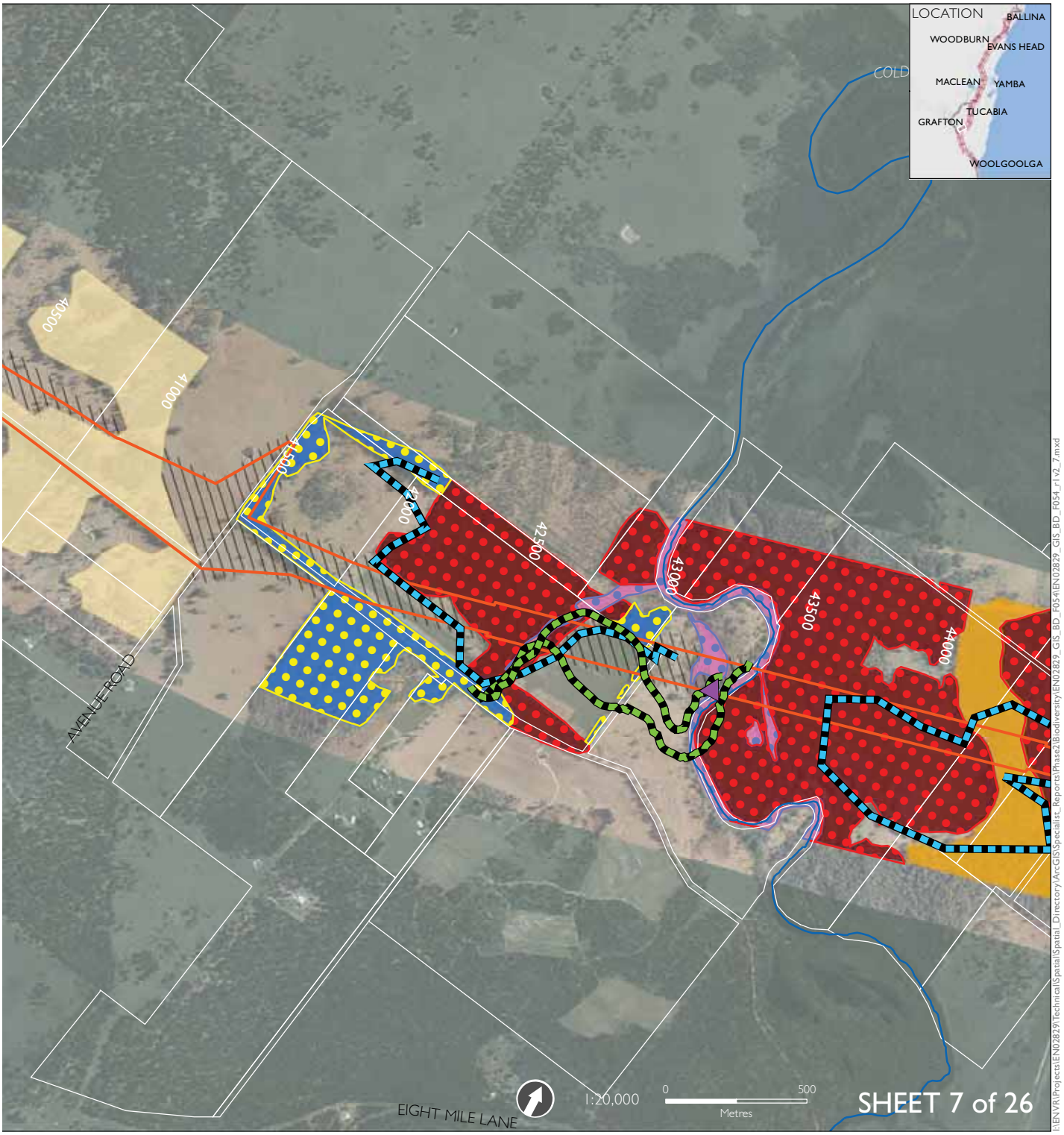


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-7 Flora survey methods in the study area

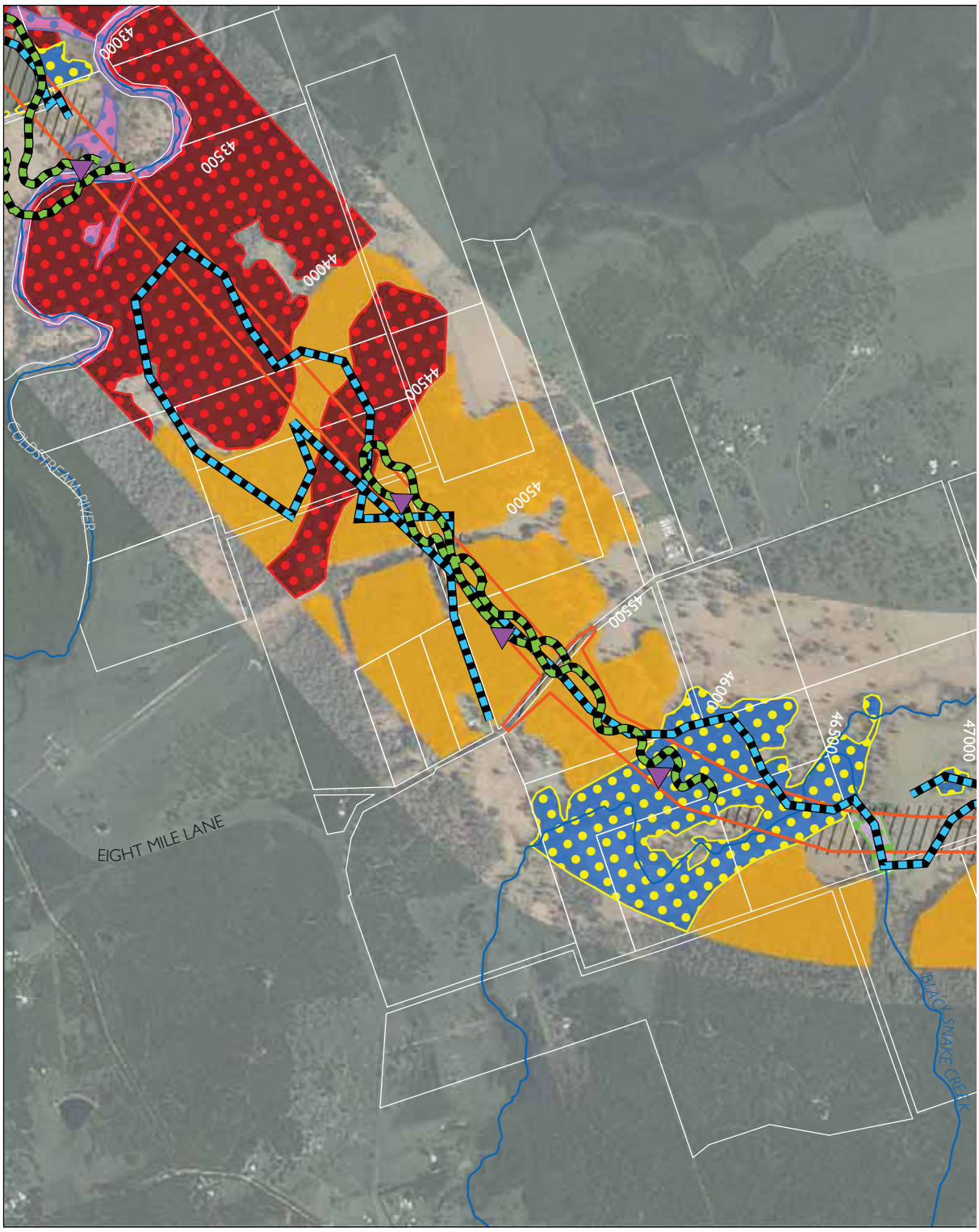


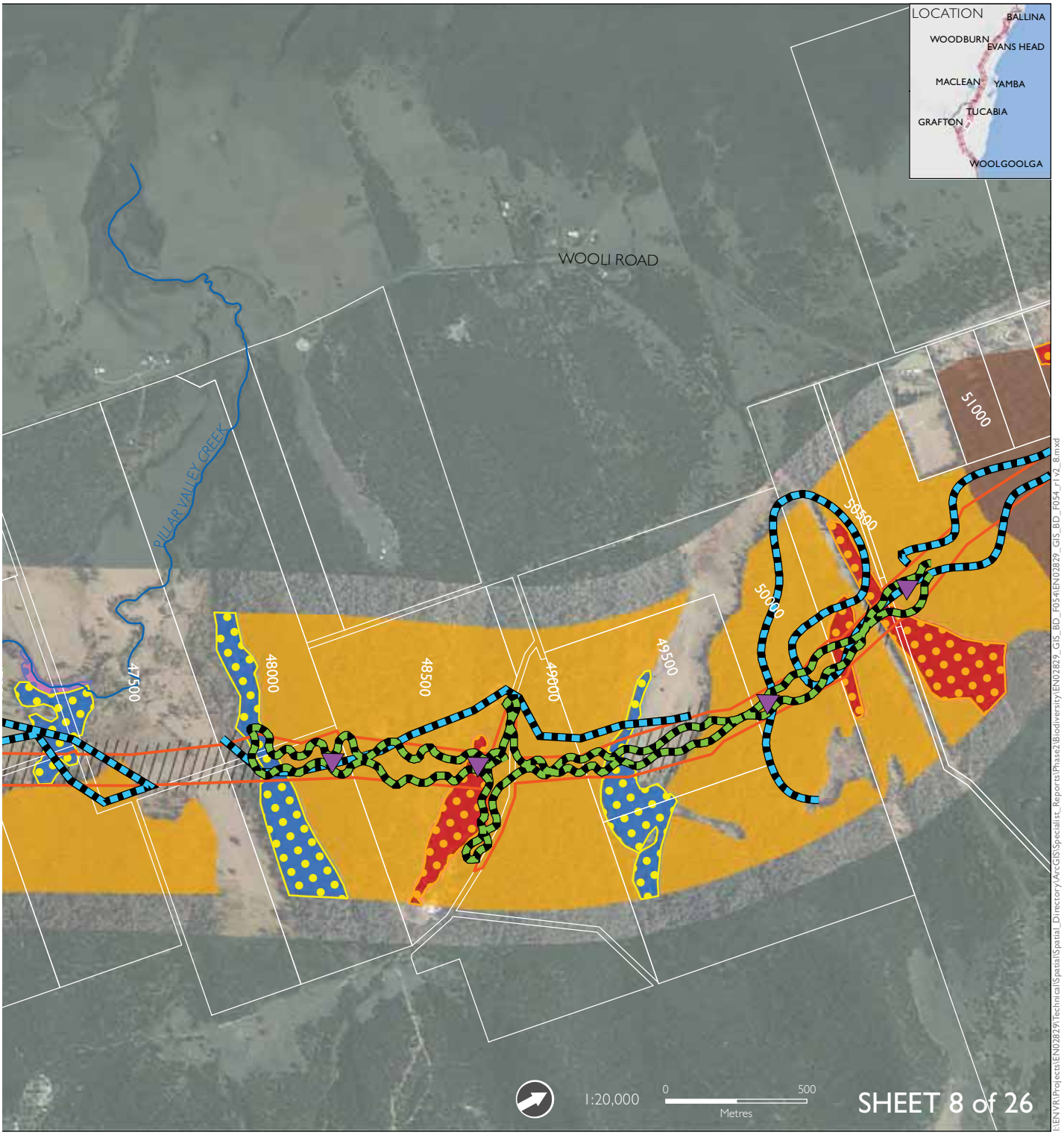


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-8 Flora survey methods in the study area





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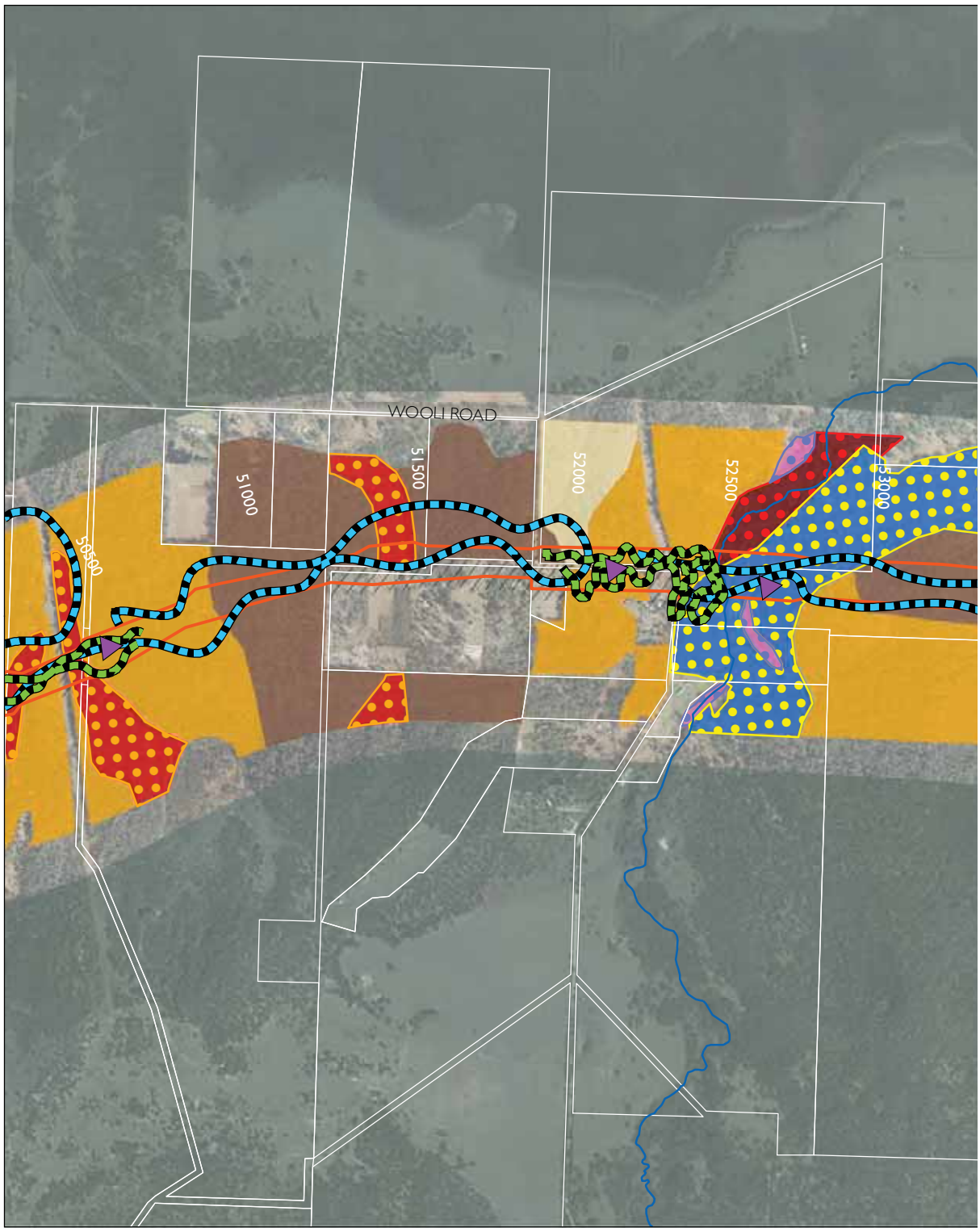
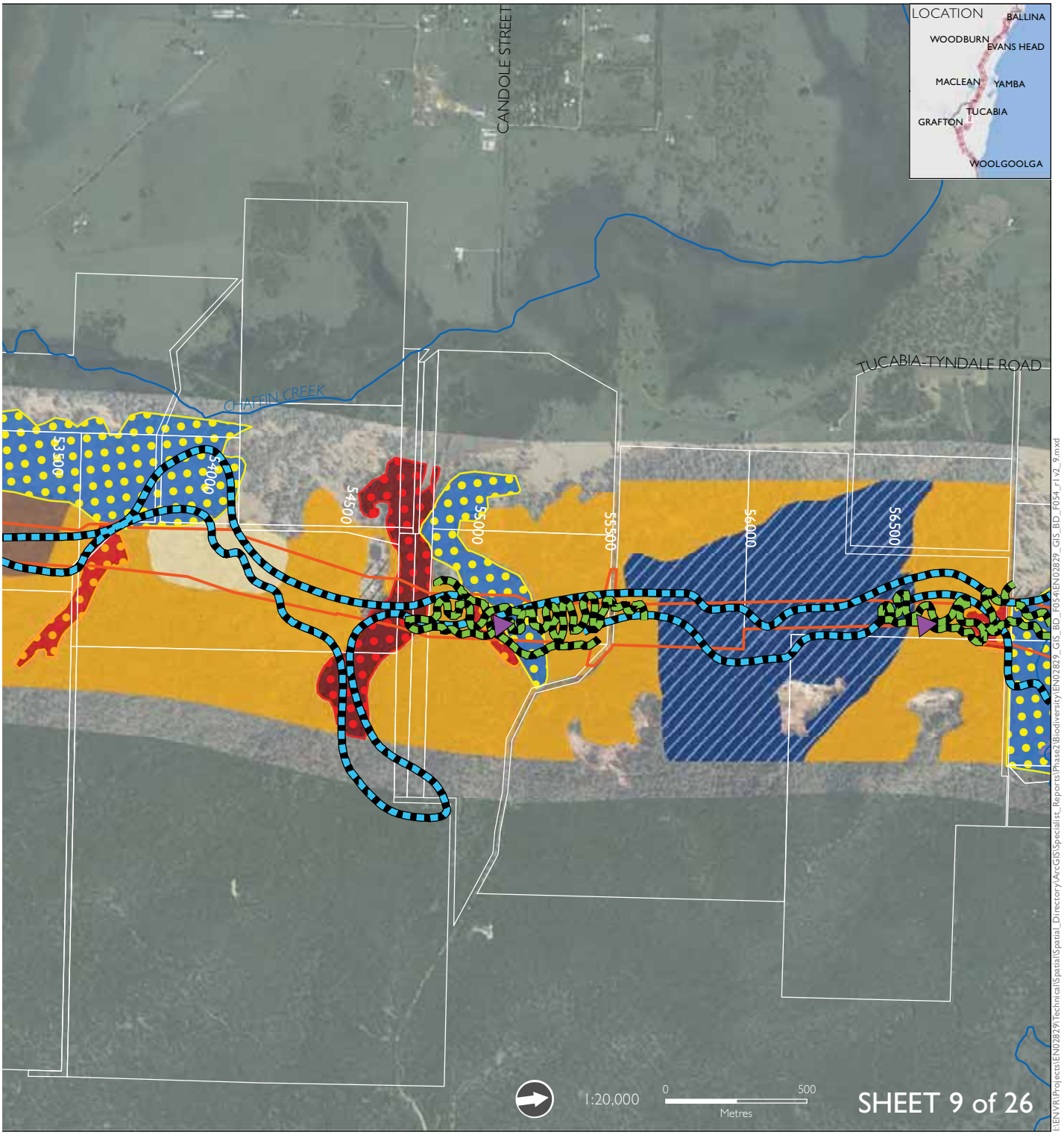
Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-9 Flora survey methods in the study area

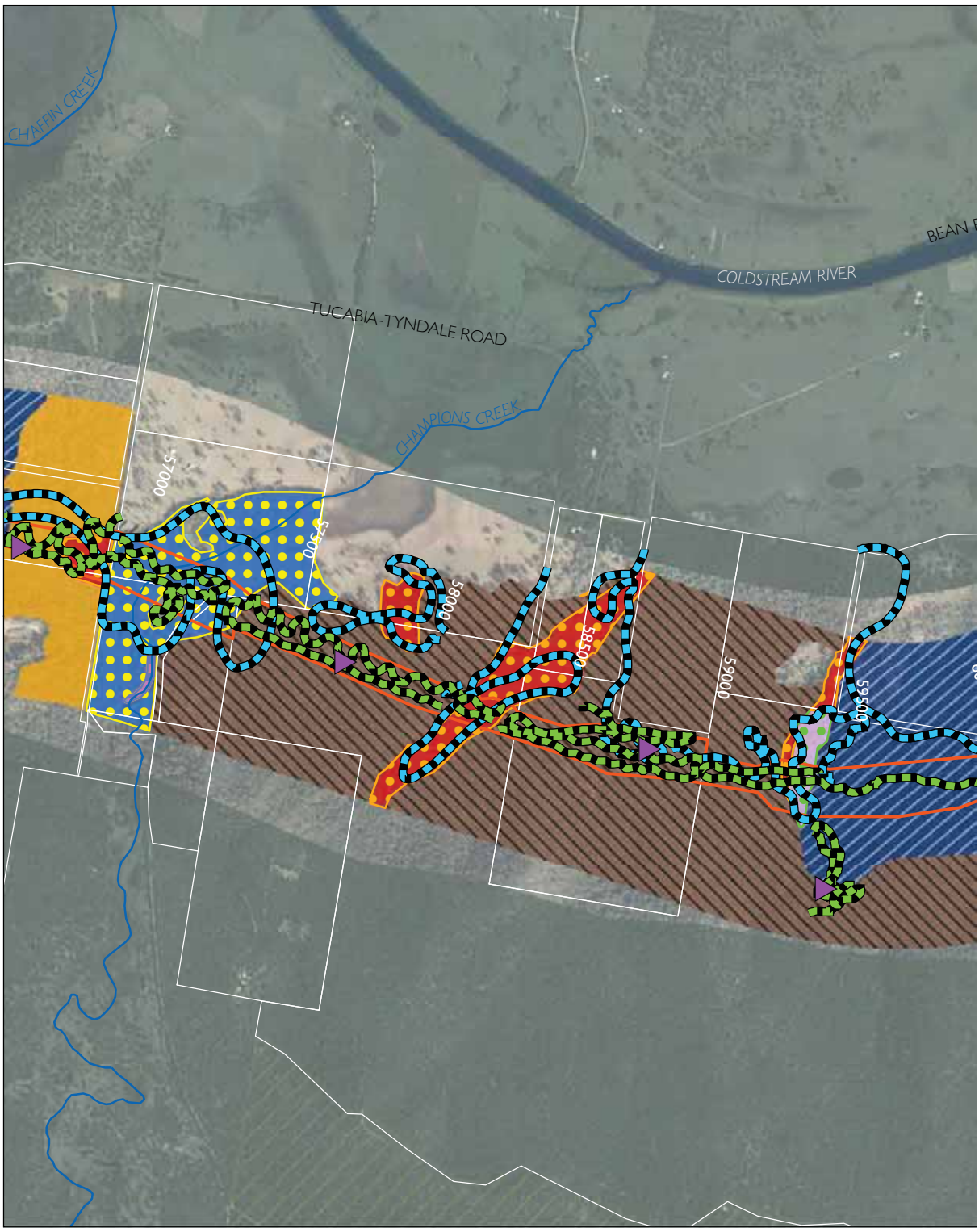


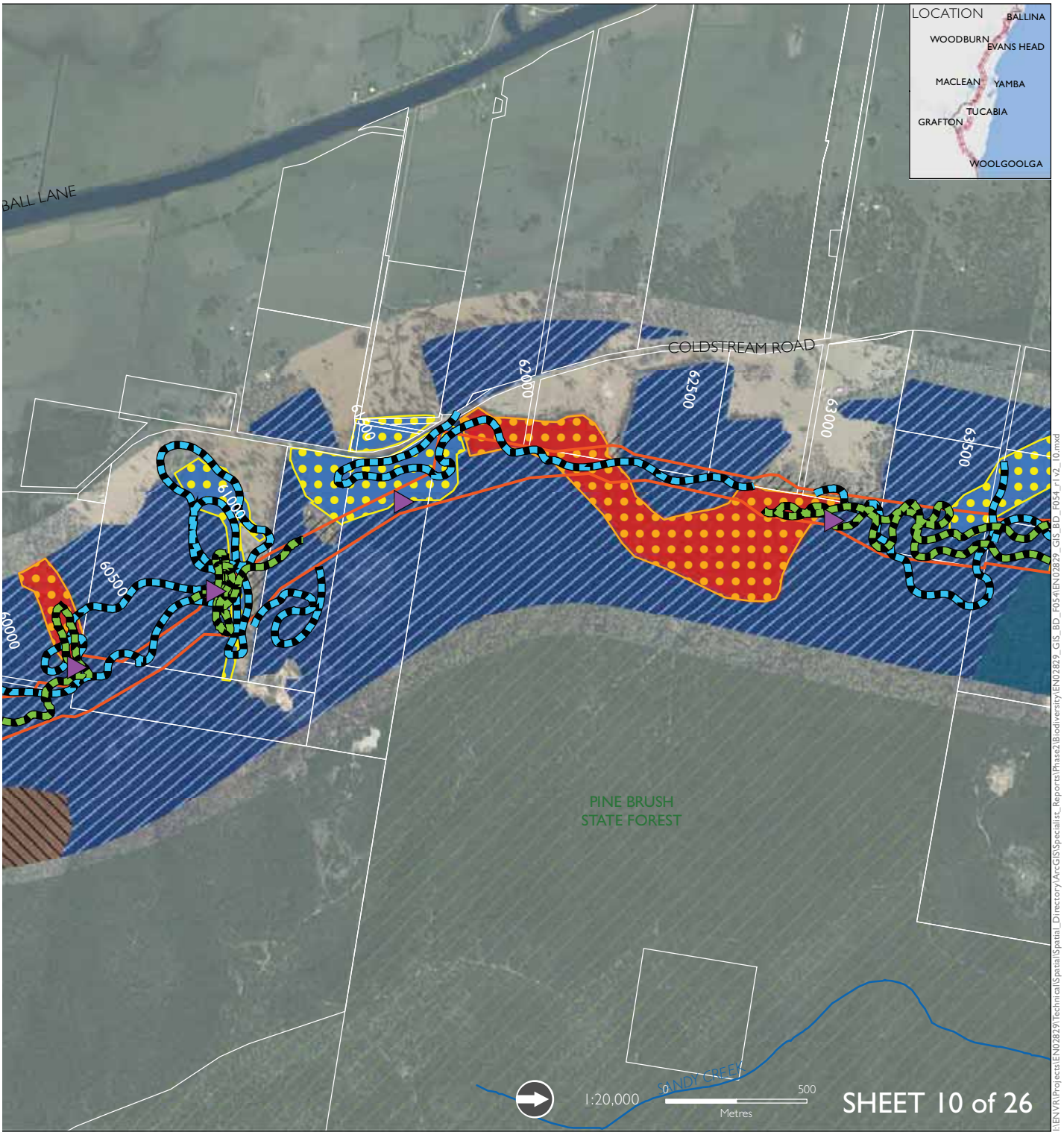


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-10 Flora survey methods in the study area

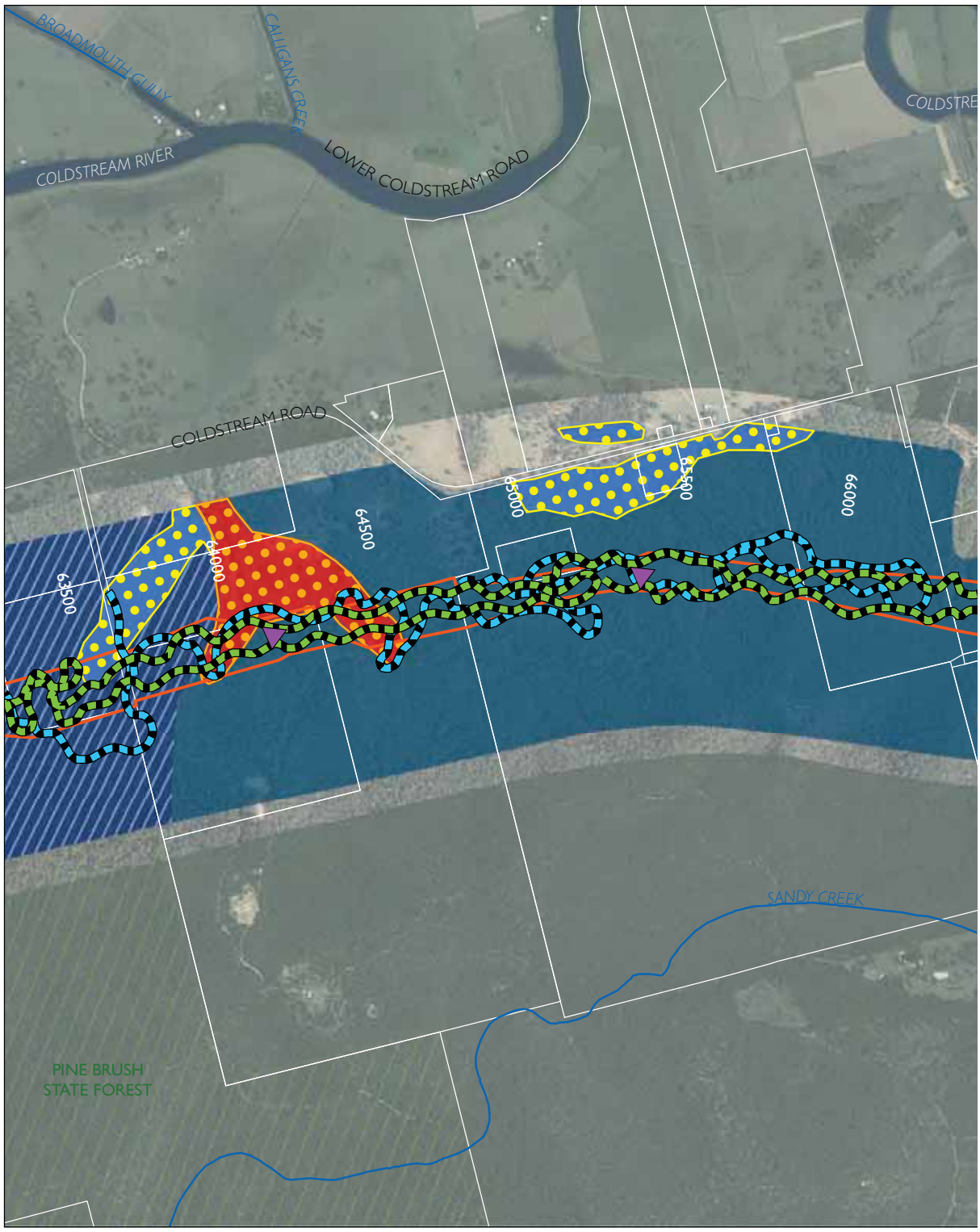


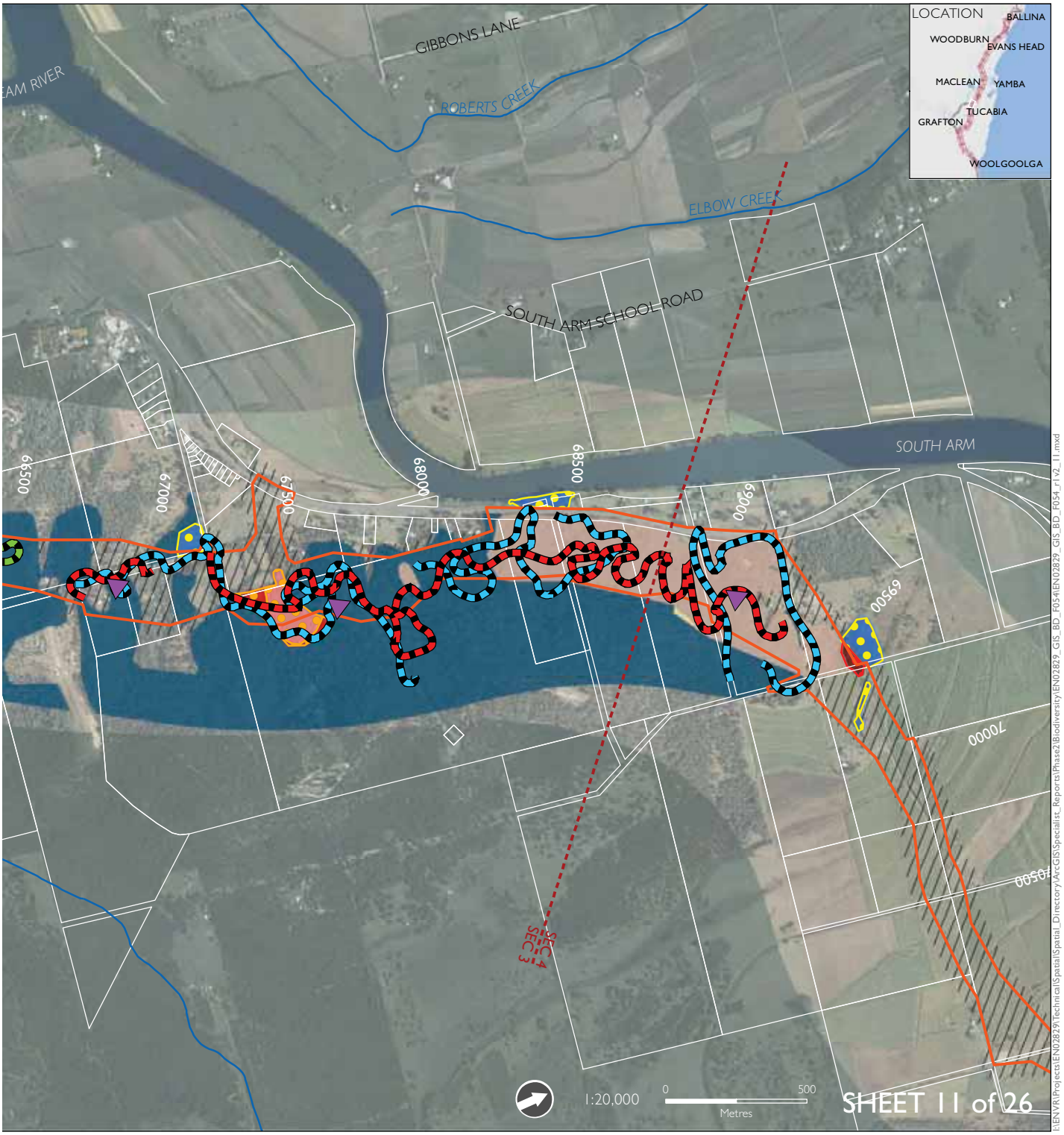


Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-11 Flora survey methods in the study area

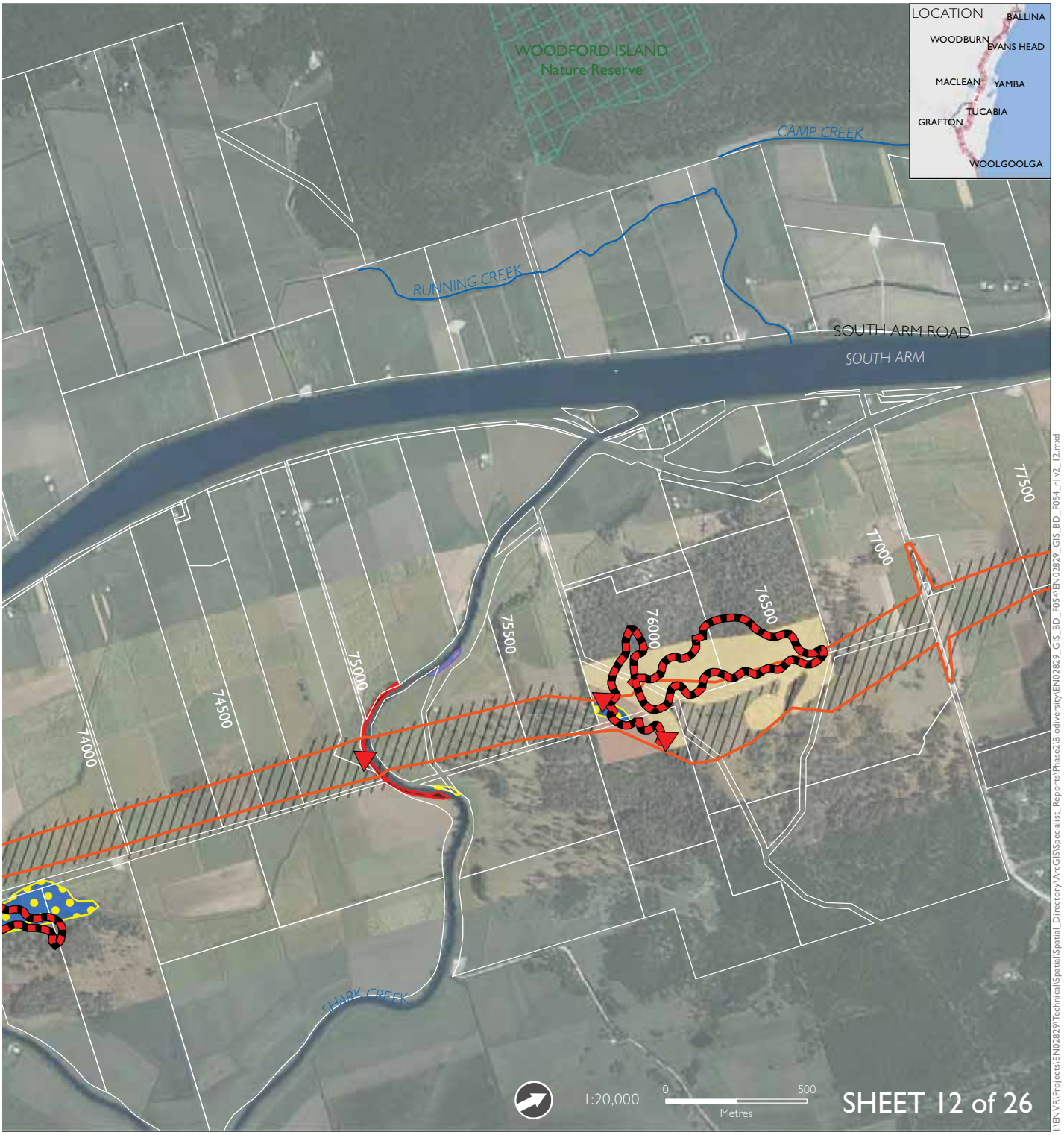




Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

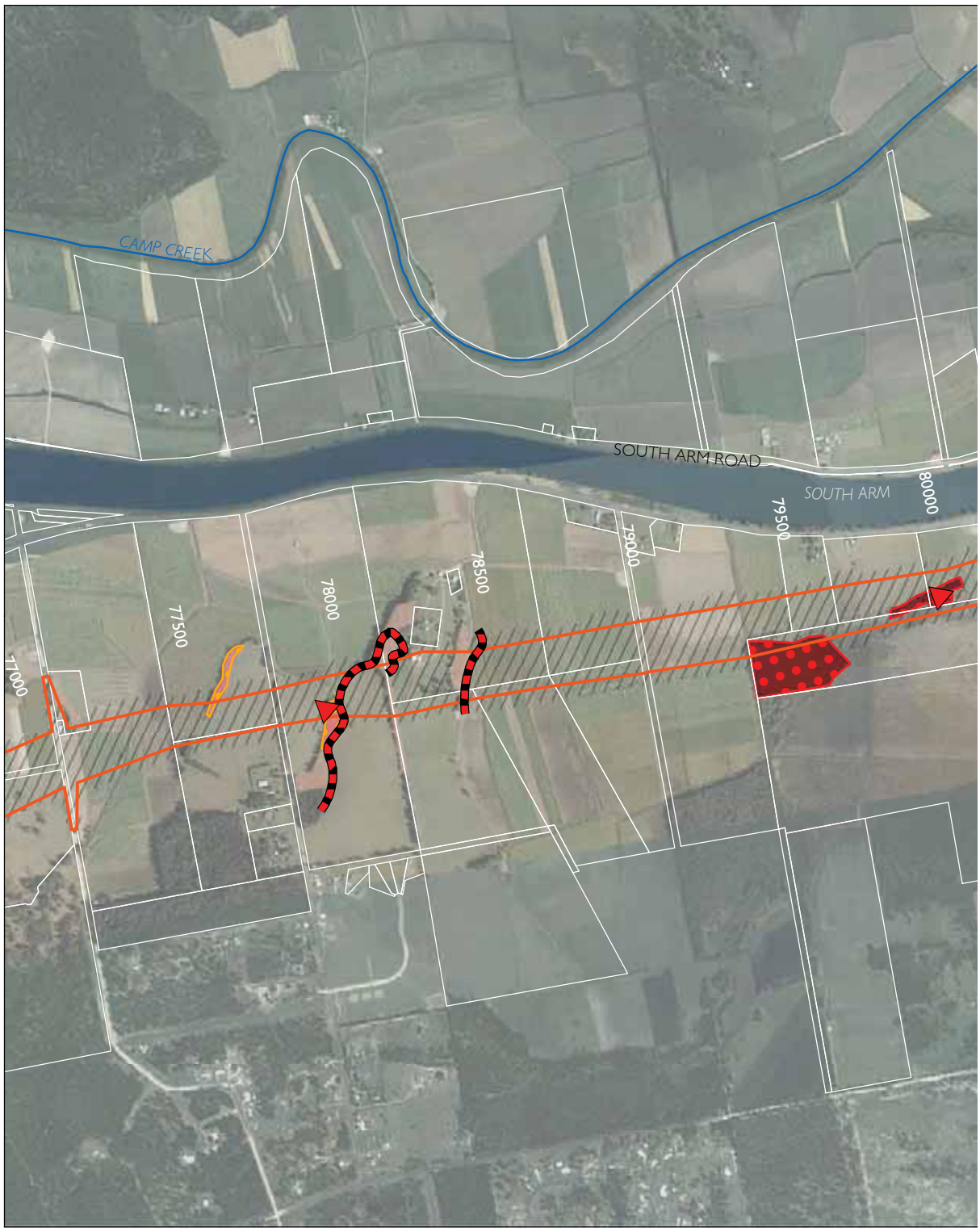
Figure 2-12 Flora survey methods in the study area

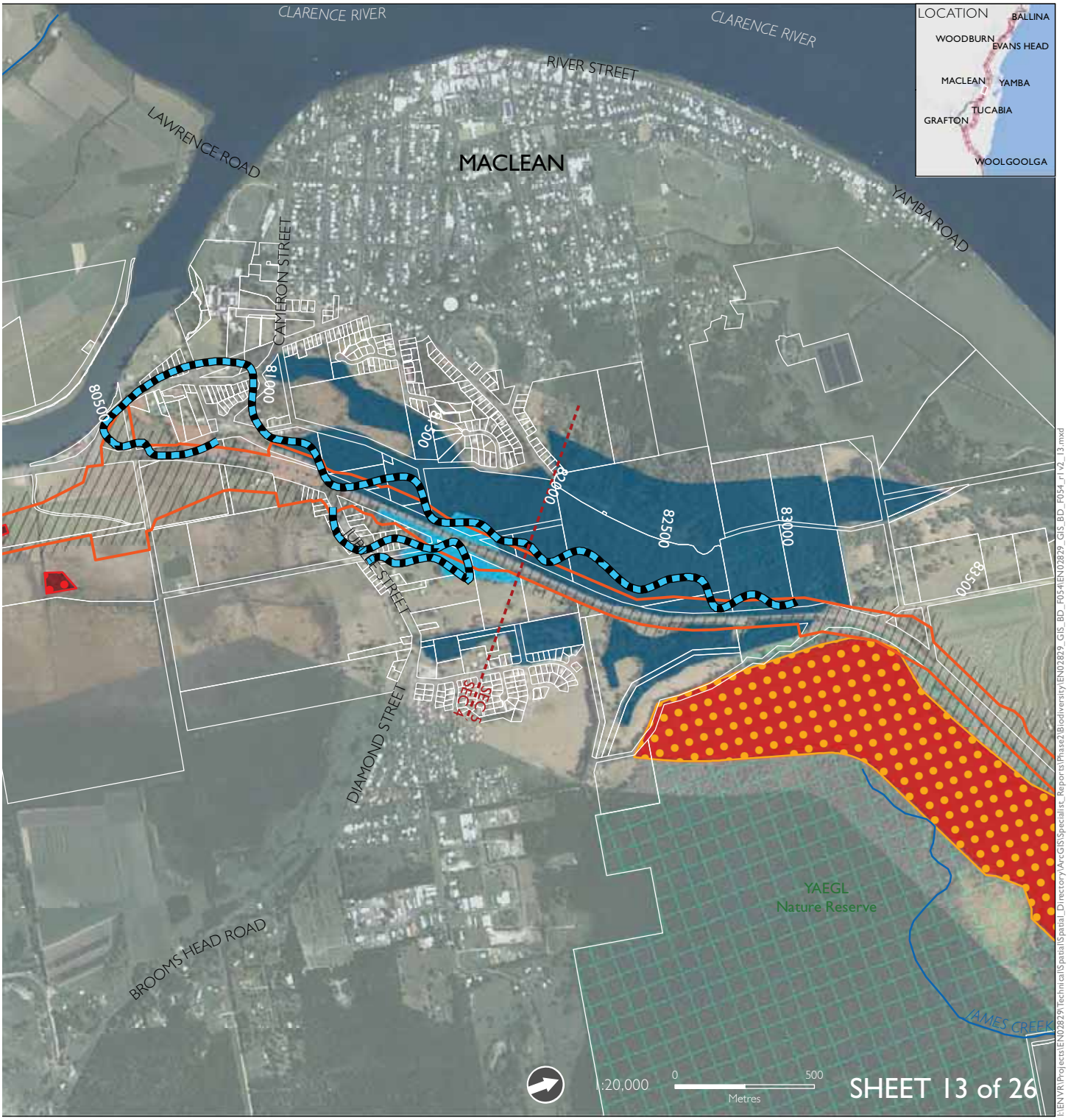


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-13 Flora survey methods in the study area

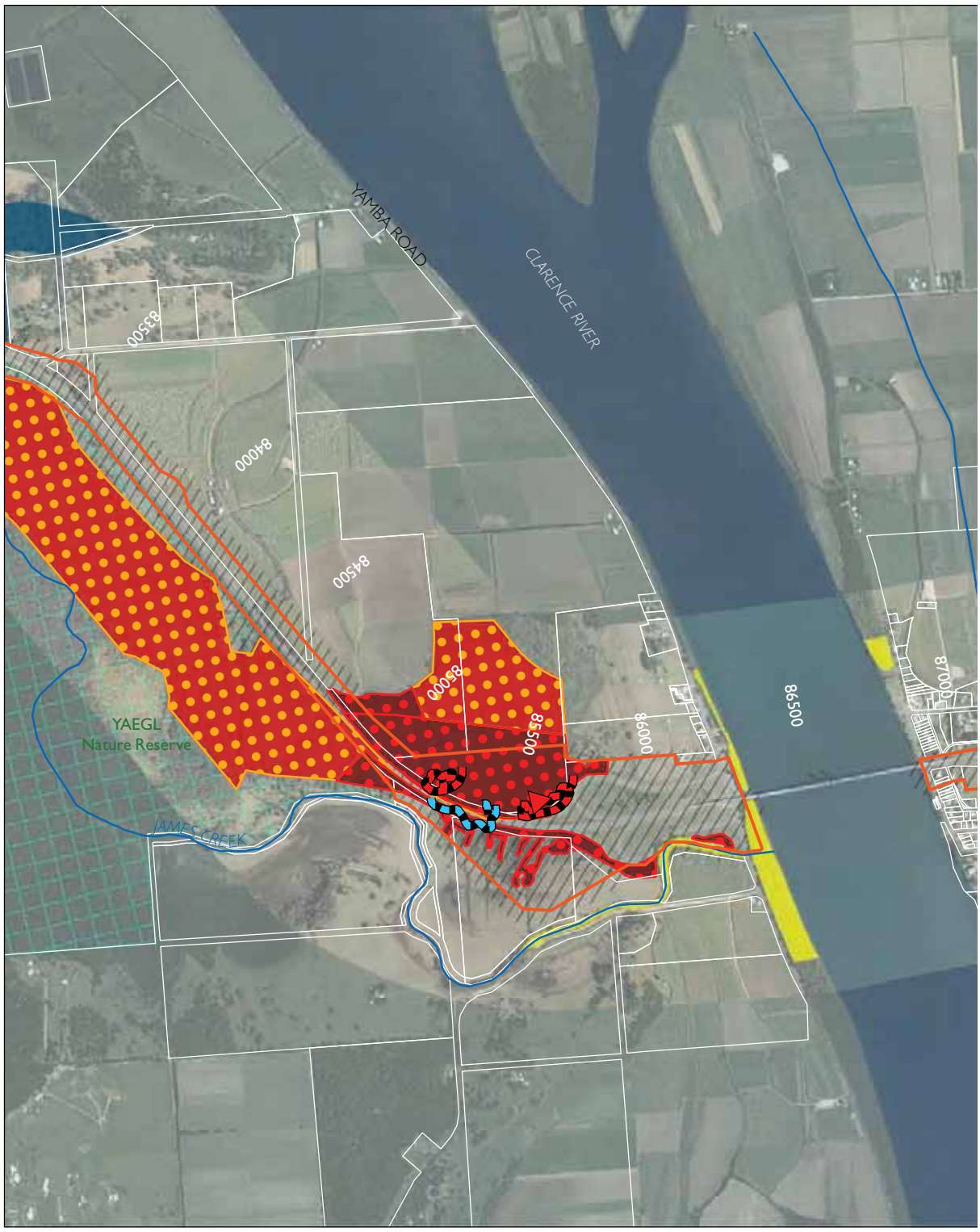




Vegetation communities

- Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-14 Flora survey methods in the study area



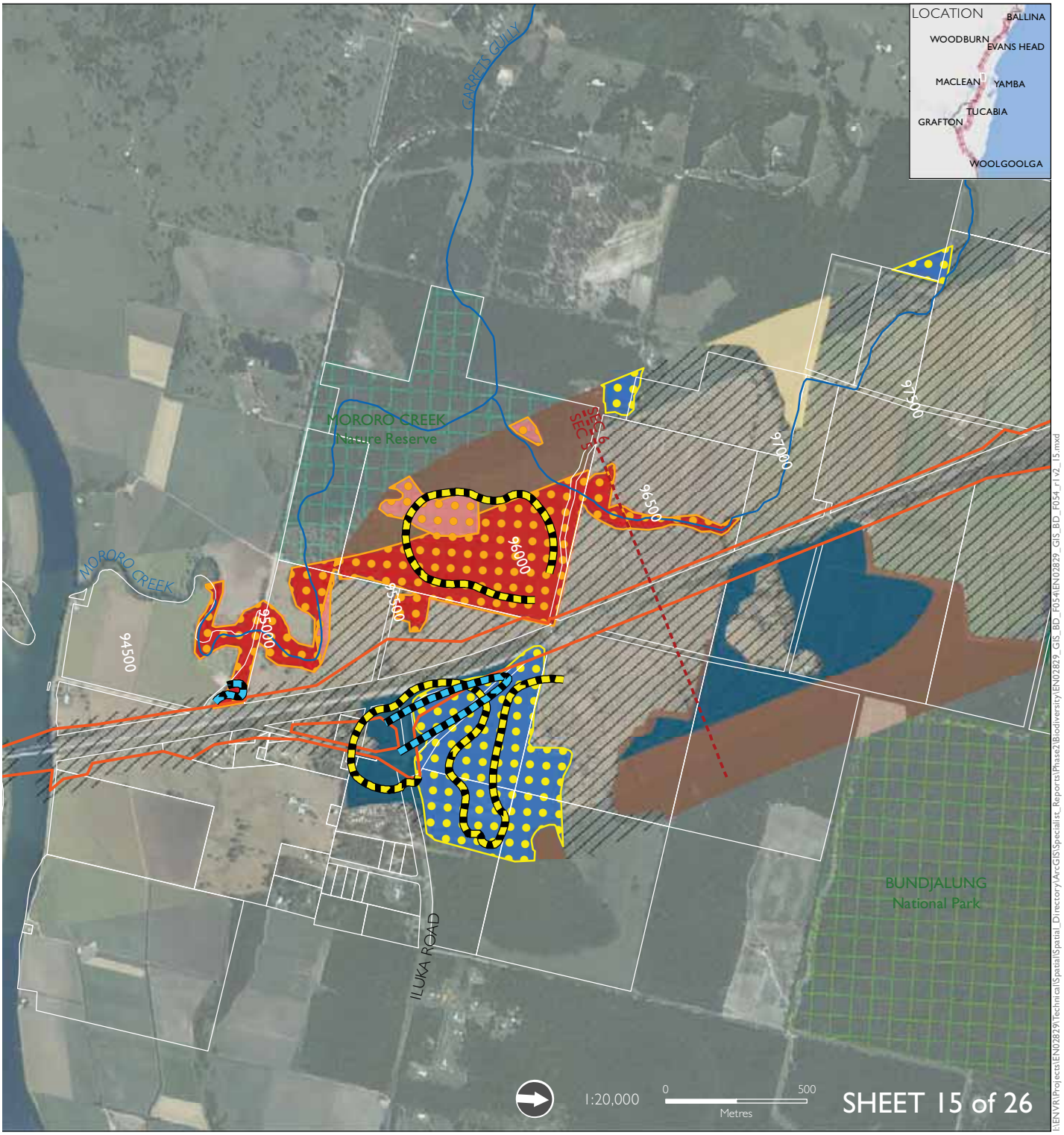
Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Cleared/modified

Figure 2-15 Flora survey methods in the study area

Flora survey methods
- Flora survey traverse (2005)
- Flora survey traverse (2007)

Threatened ecological communities
- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
- Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)



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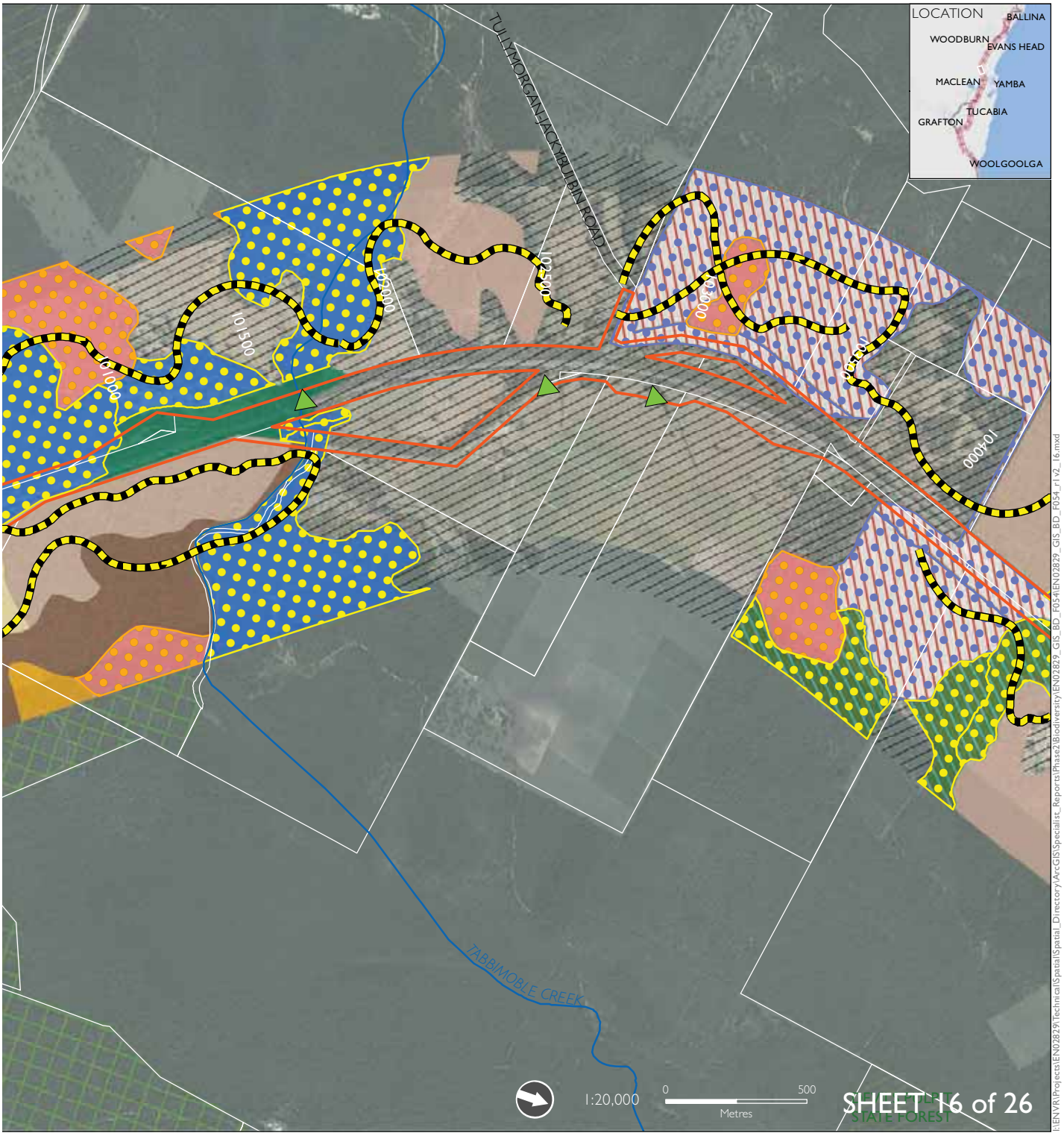
Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

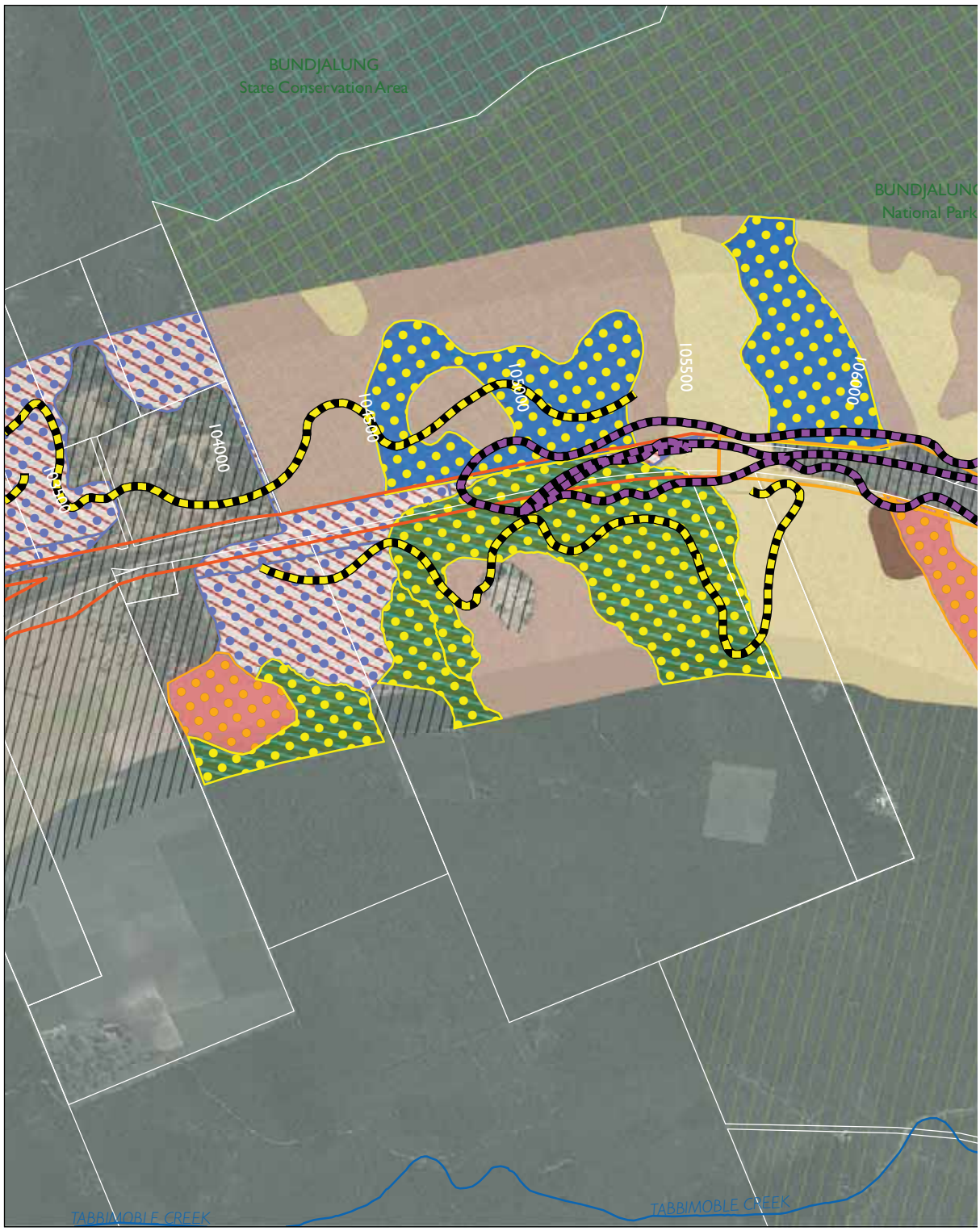
Figure 2-16 Flora survey methods in the study area



Vegetation communities

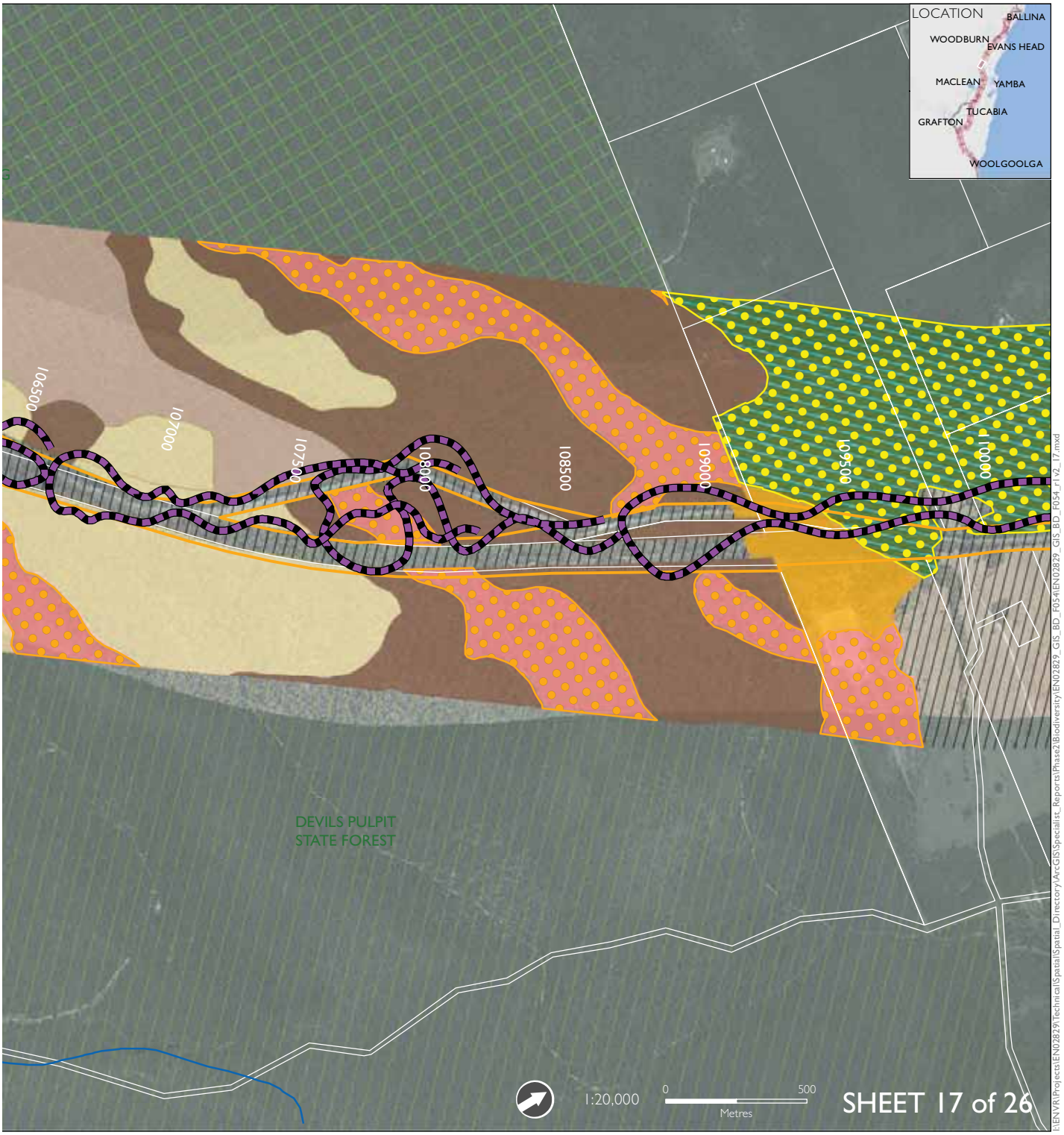
- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-17 Flora survey methods in the study area



Flora survey methods
- Flora survey traverse (2005)
- General traverse (2009)

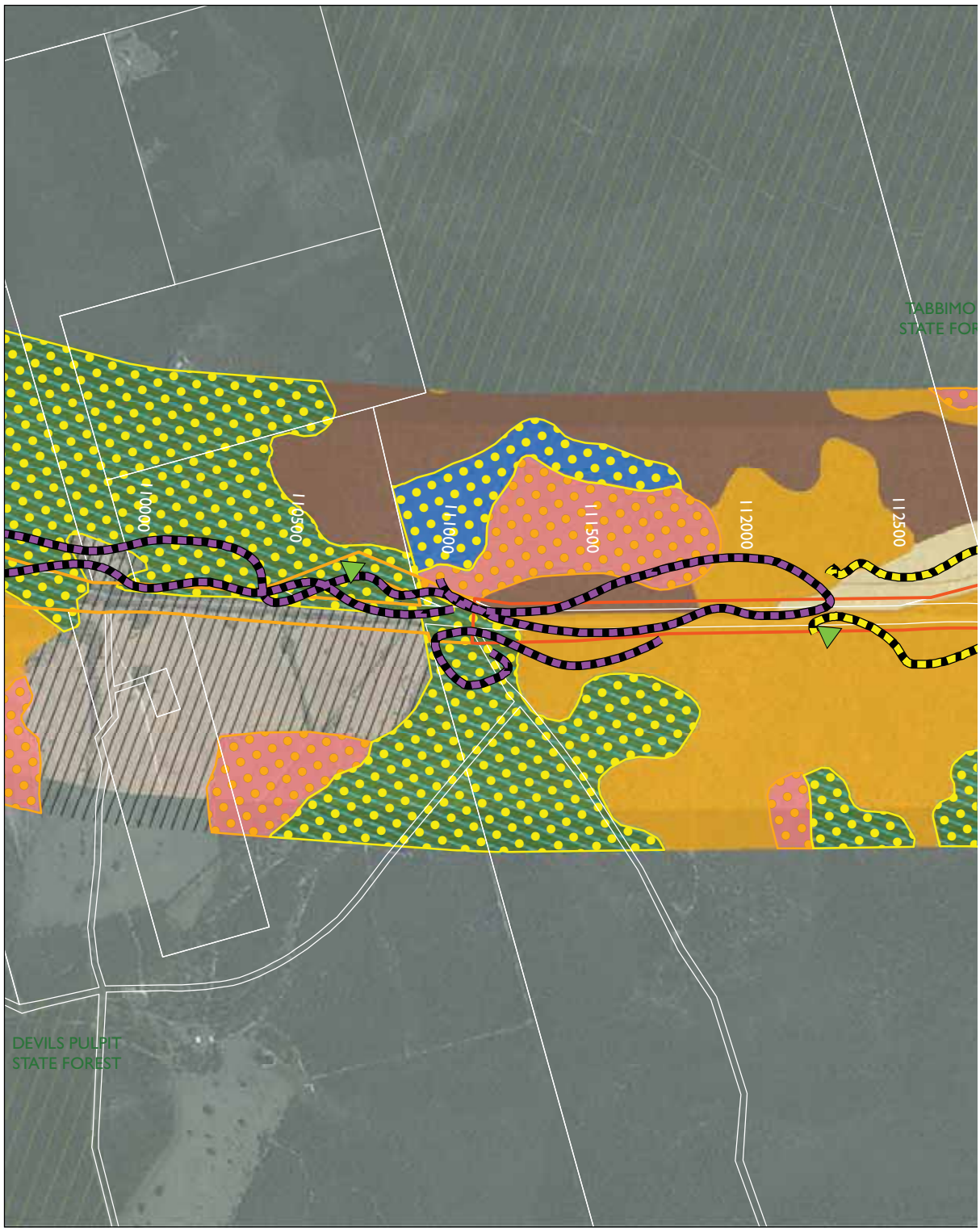
Threatened ecological communities
- Freshwater Wetlands on Coastal Floodplains (Endangered,TSC Act)
- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered,TSC Act)
- Swamp Sclerophyll Forest on Coastal Floodplains (Endangered,TSC Act)

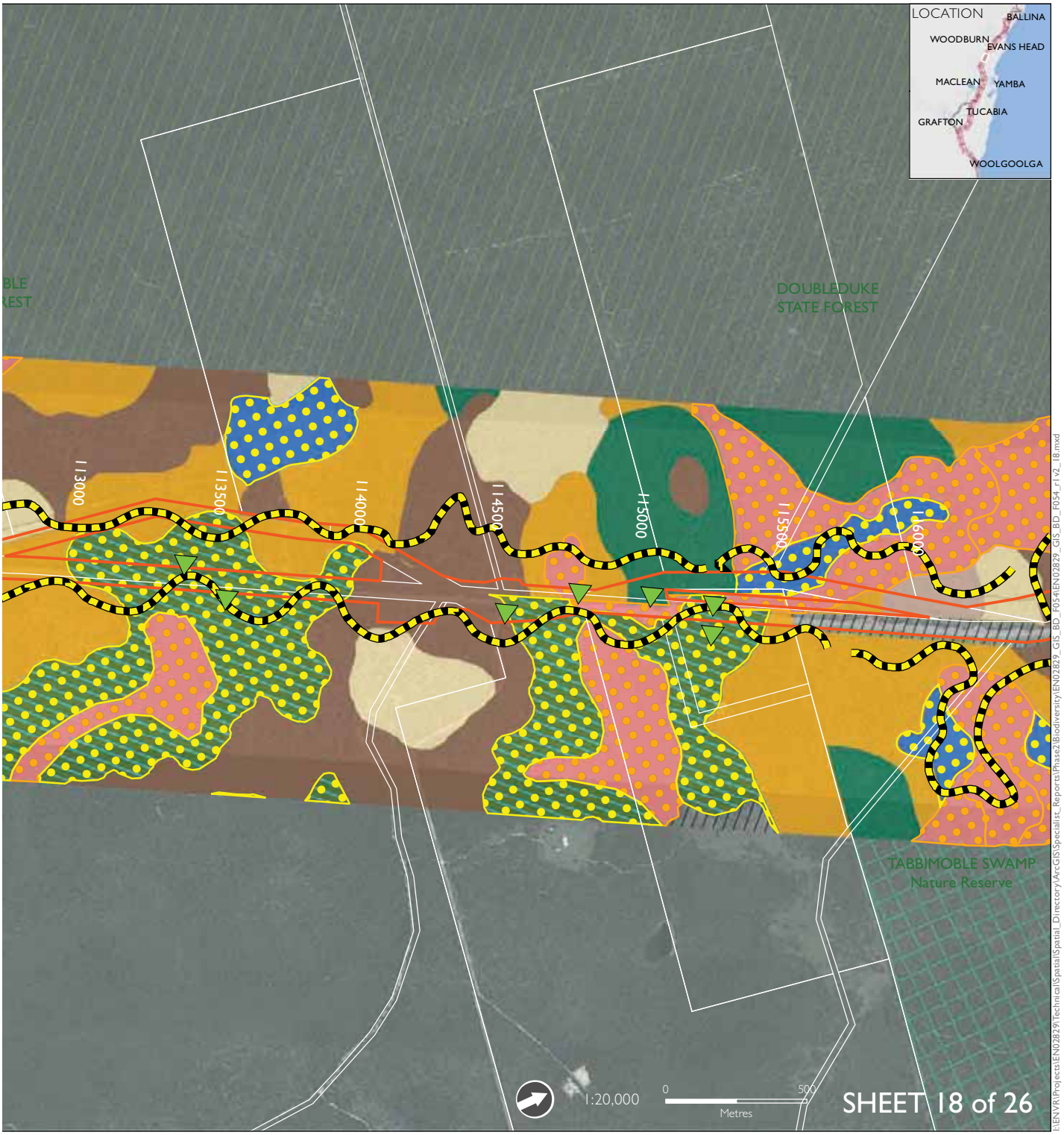


Vegetation communities

- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-18 Flora survey methods in the study area

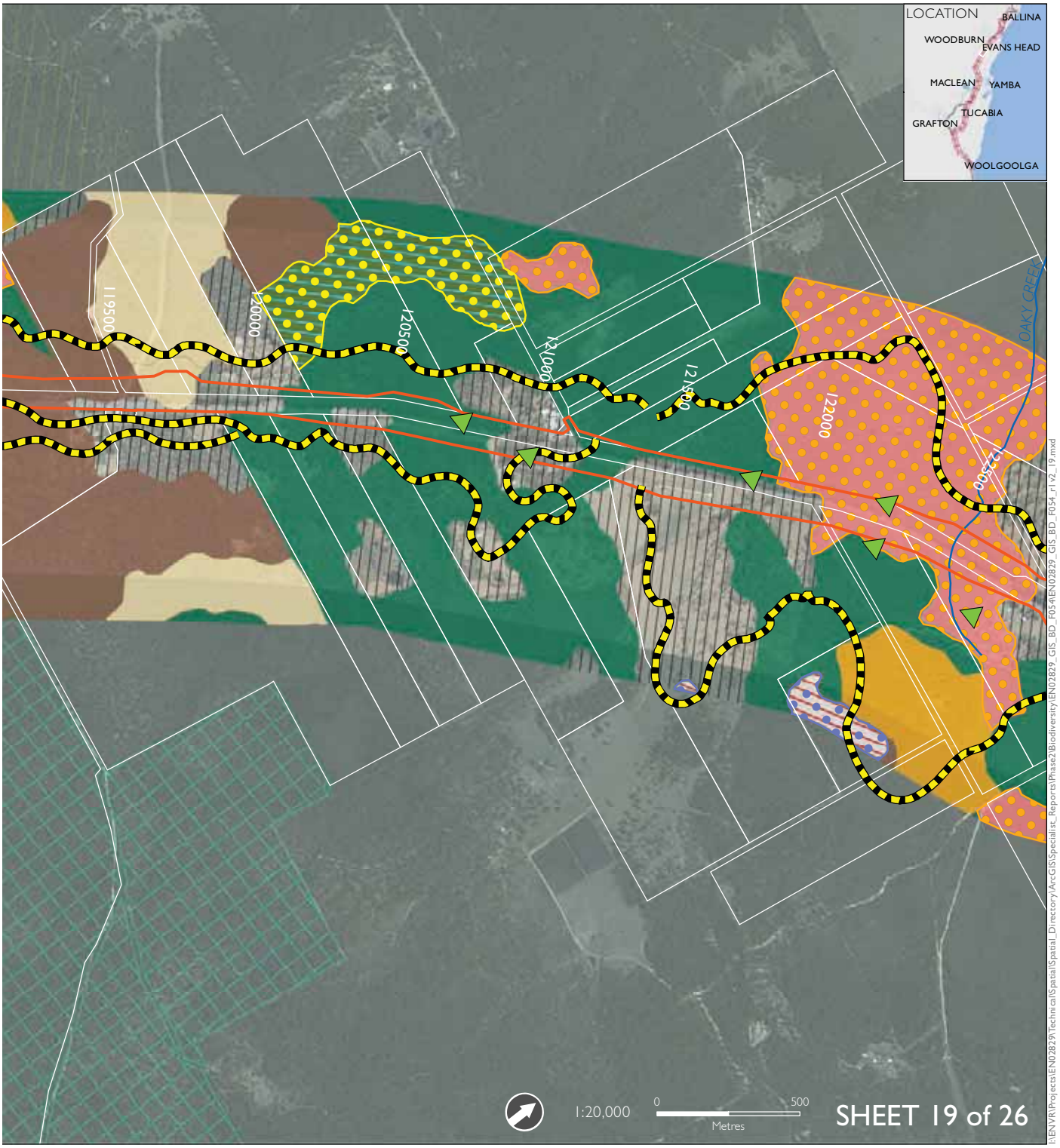




Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

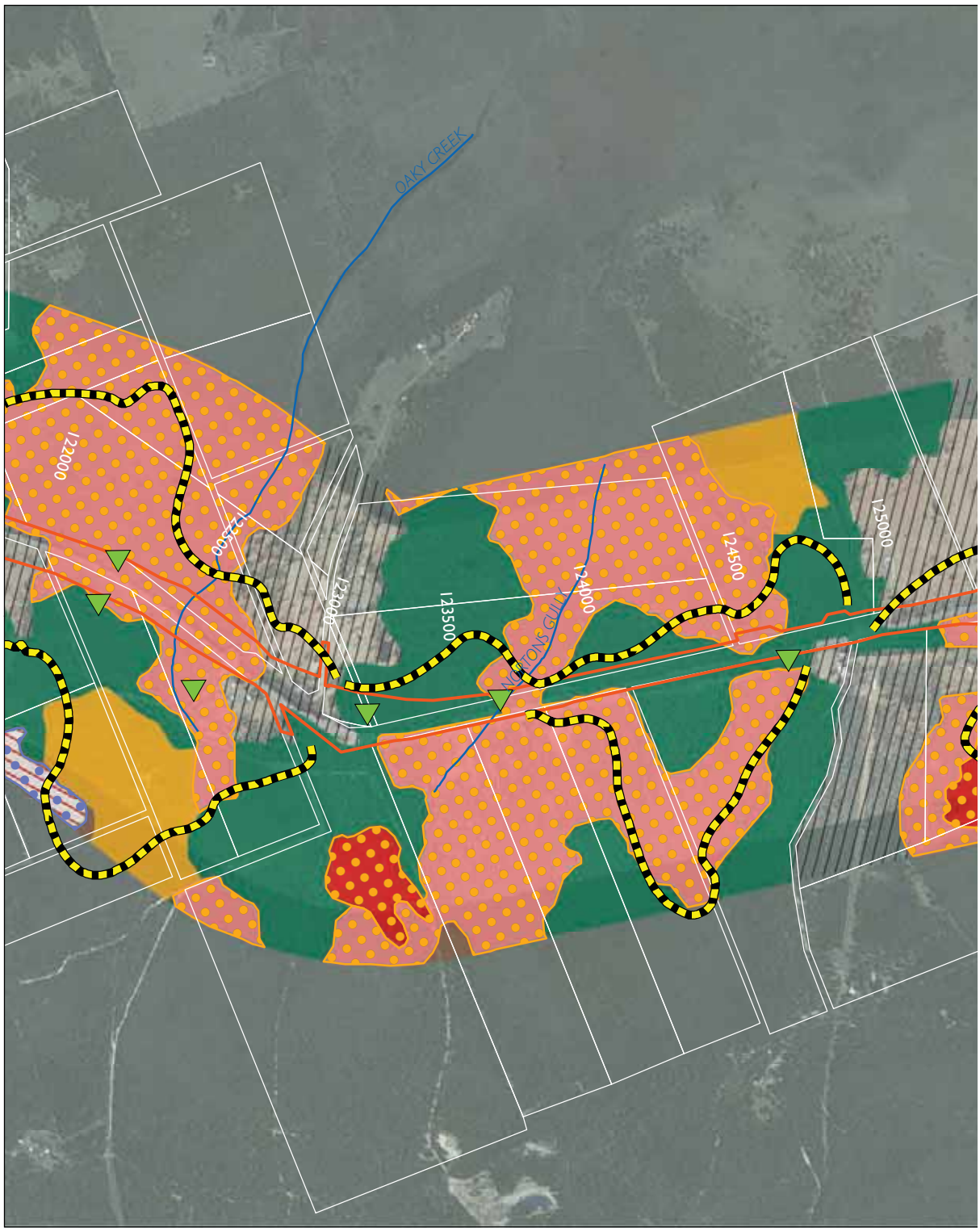
Figure 2-19 Flora survey methods in the study area

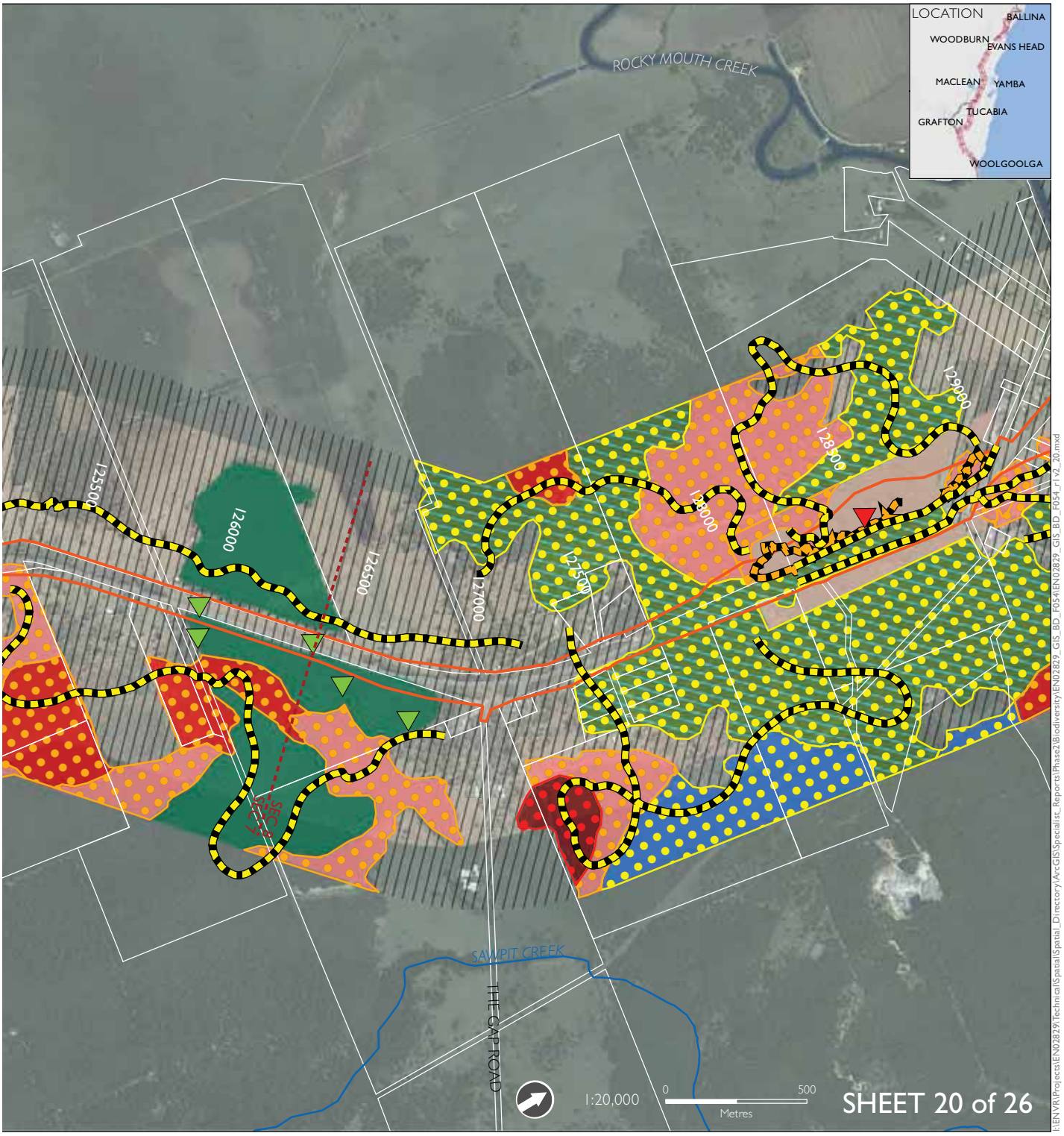


egetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-20 Flora survey methods in the study area

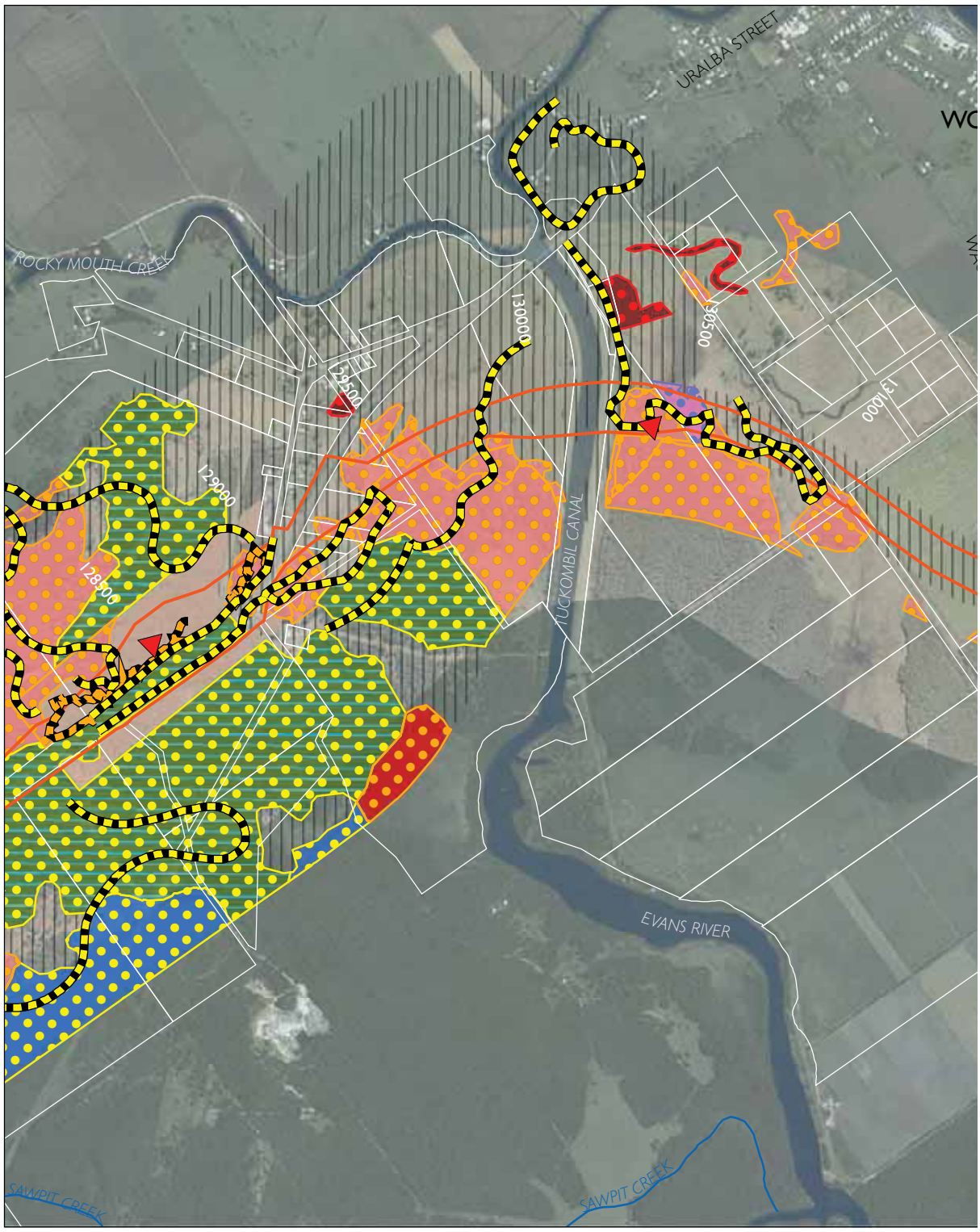




Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-21 Flora survey methods in the study area

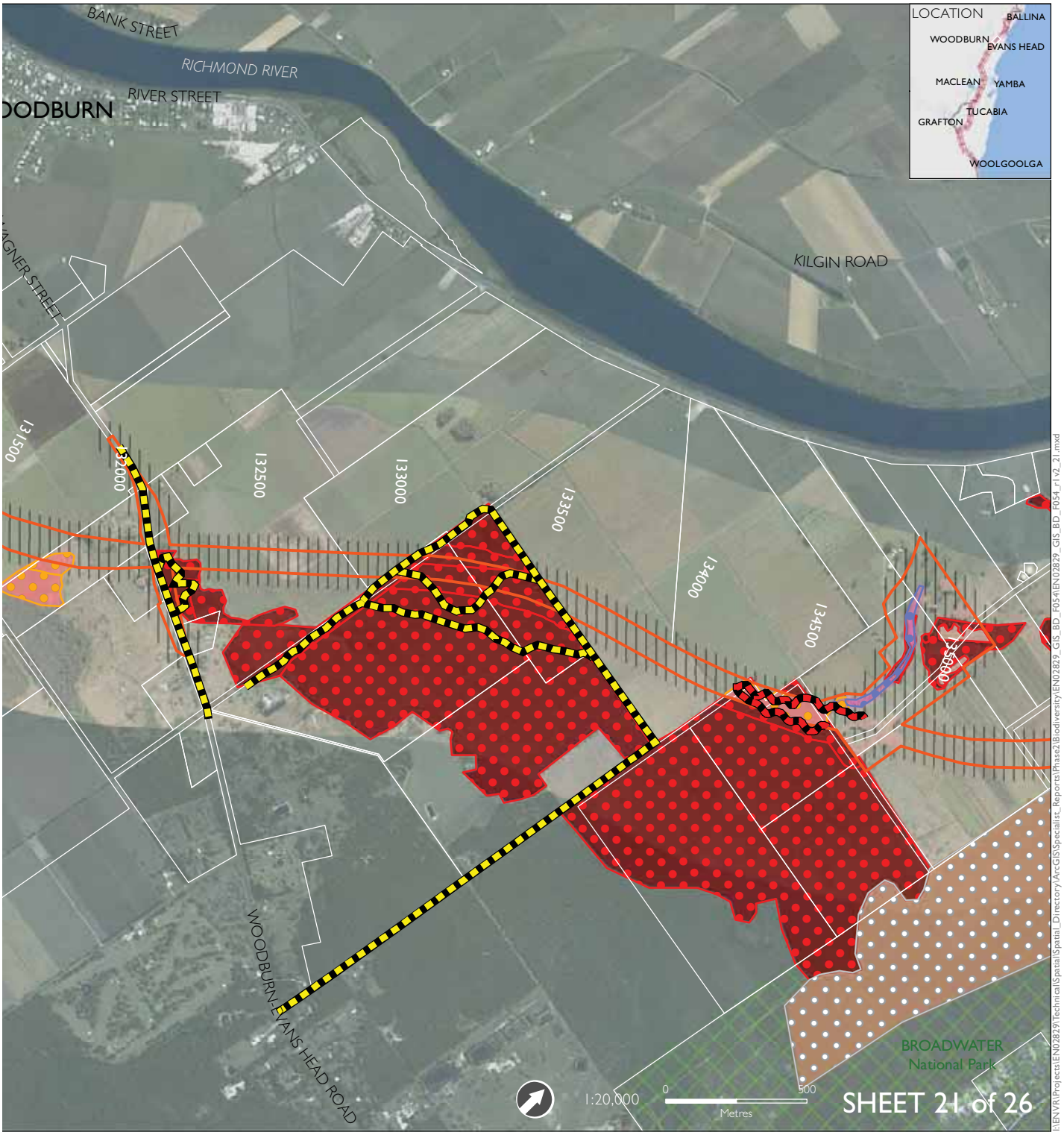


Flora survey methods

- Targeted threatened flora search (2010)
- Flora survey traverse (2005)
- Supplementary flora survey traverse (2012)
- Targetted flora survey traverse (2010)

Threatened ecological communities

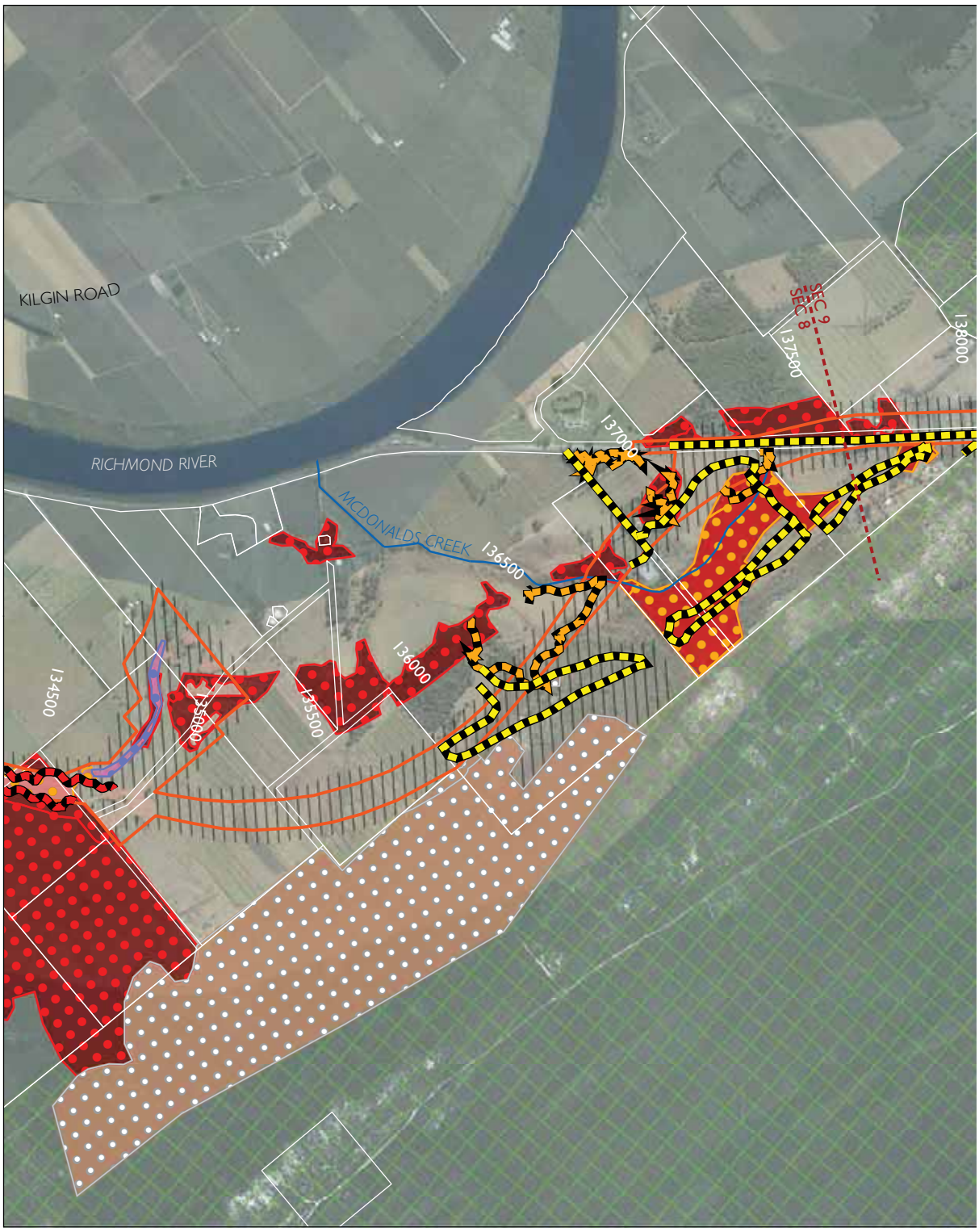
- Coastal Cypress Pine Forest in NSW North Coast Bioregion (Endangered, TSC Act)
- Freshwater Wetlands on Coastal Floodplains (Endangered, TSC Act)
- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
- Swamp Oak Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
- Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)



Vegetation communities

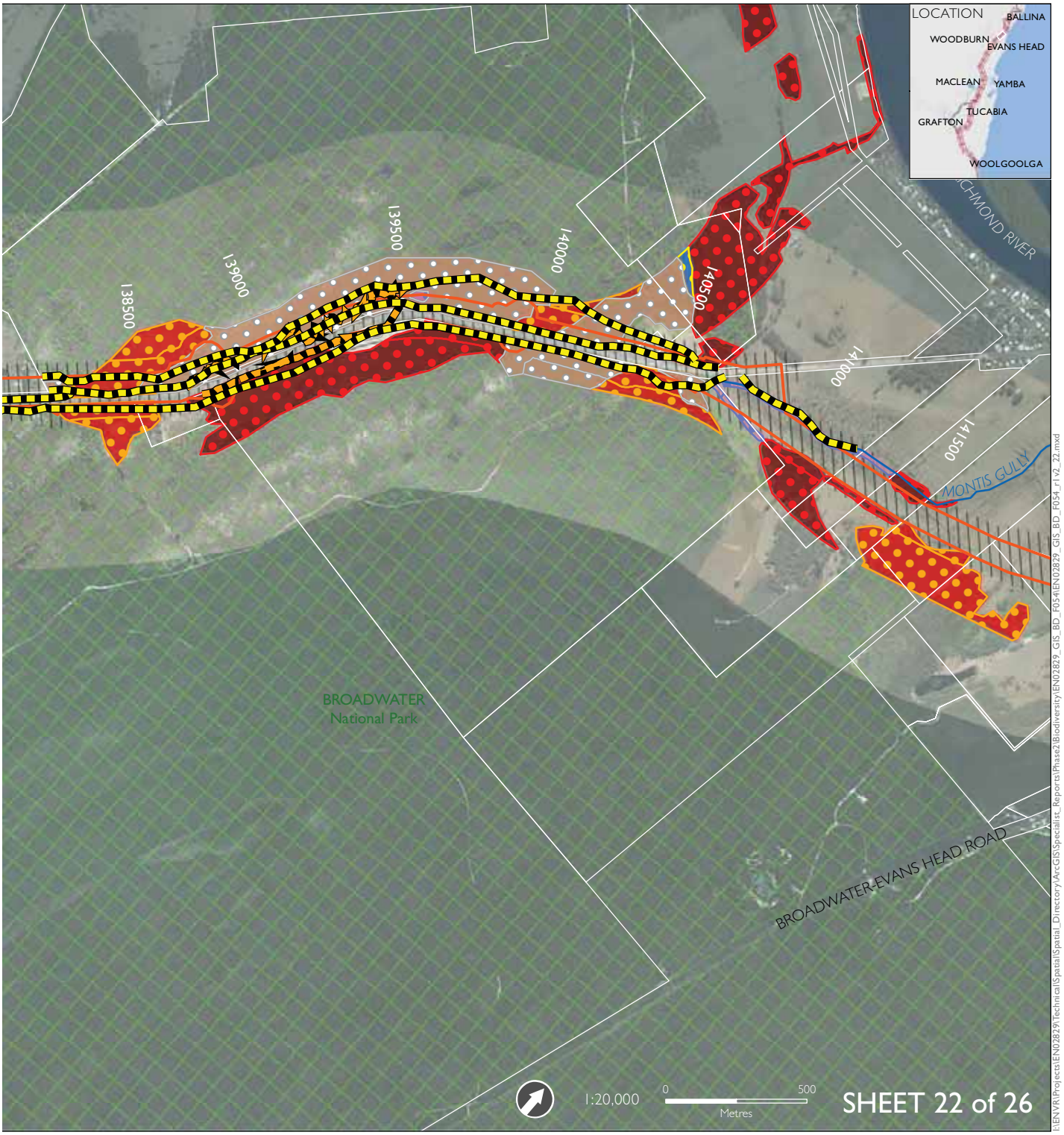
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-22 Flora survey methods in the study area



Flora survey methods
- Flora survey traverse (2005)
- Supplementary flora survey traverse (2012)
- Targetted flora survey traverse (2010)

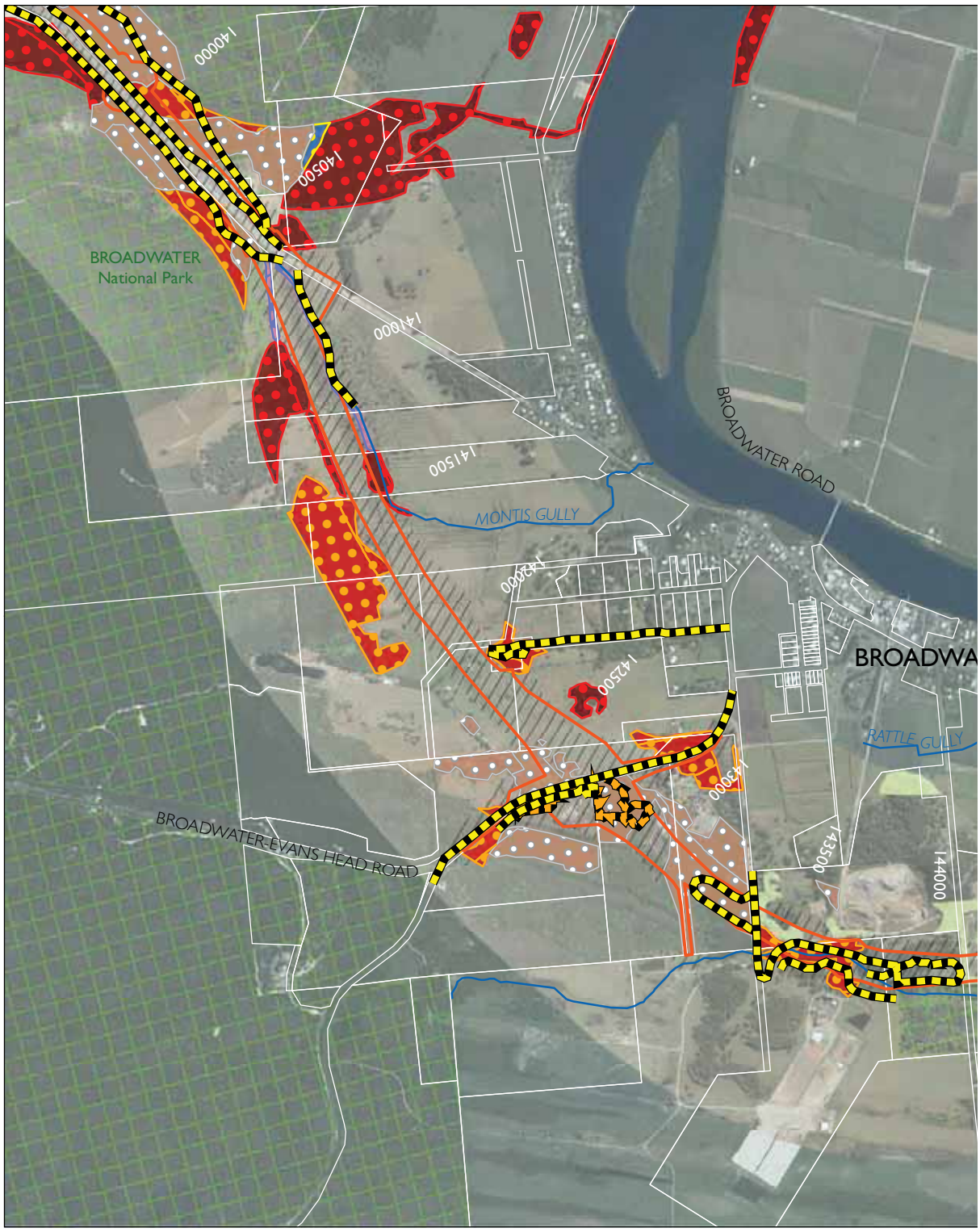
Threatened ecological communities
- Coastal Cypress Pine Forest in NSW North Coast Bioregion (Endangered, TSC Act)
- Freshwater Wetlands on Coastal Floodplains (Endangered, TSC Act)
- Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
- Swamp Oak Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
- Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)

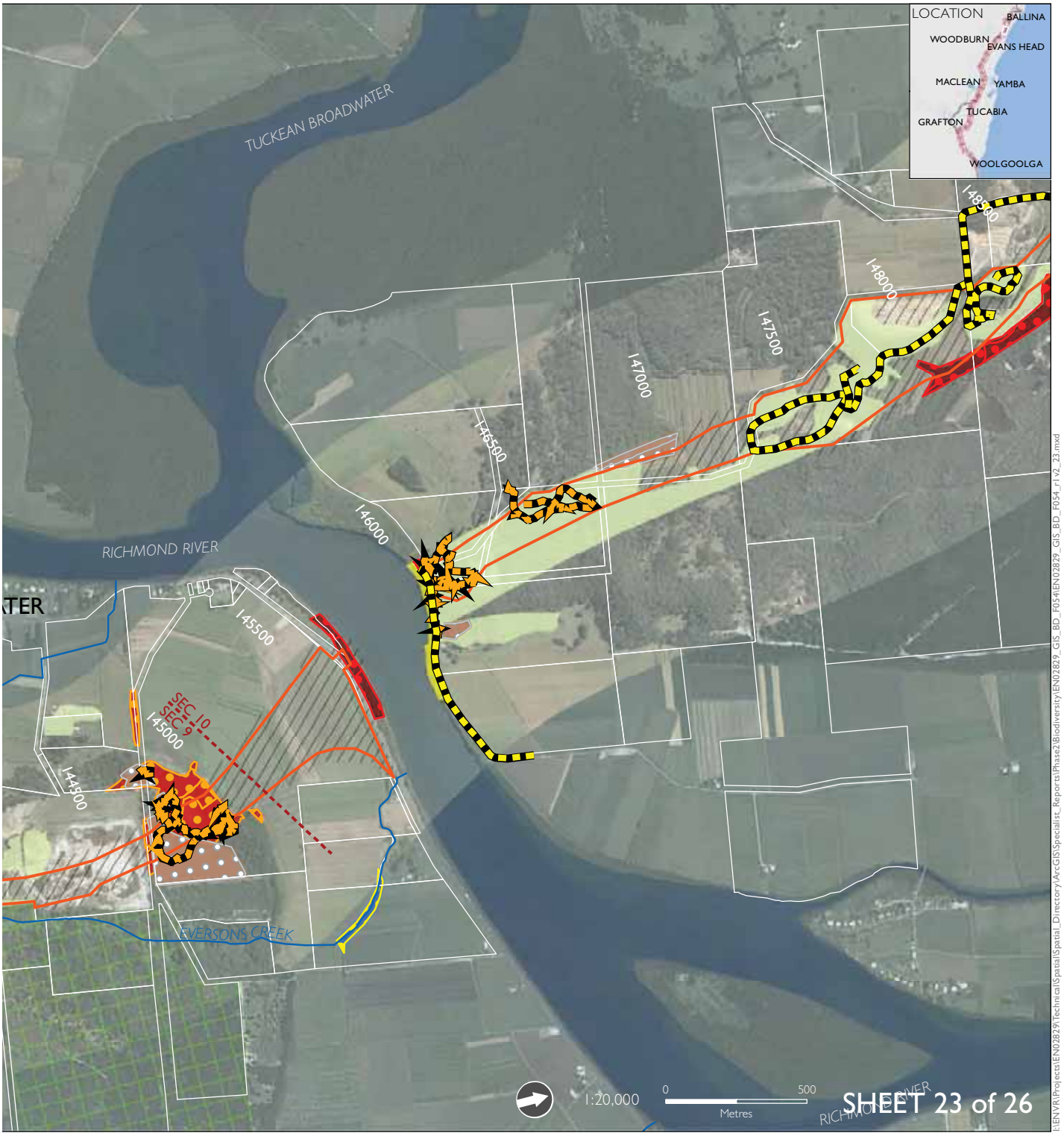


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-23 Flora survey methods in the study area

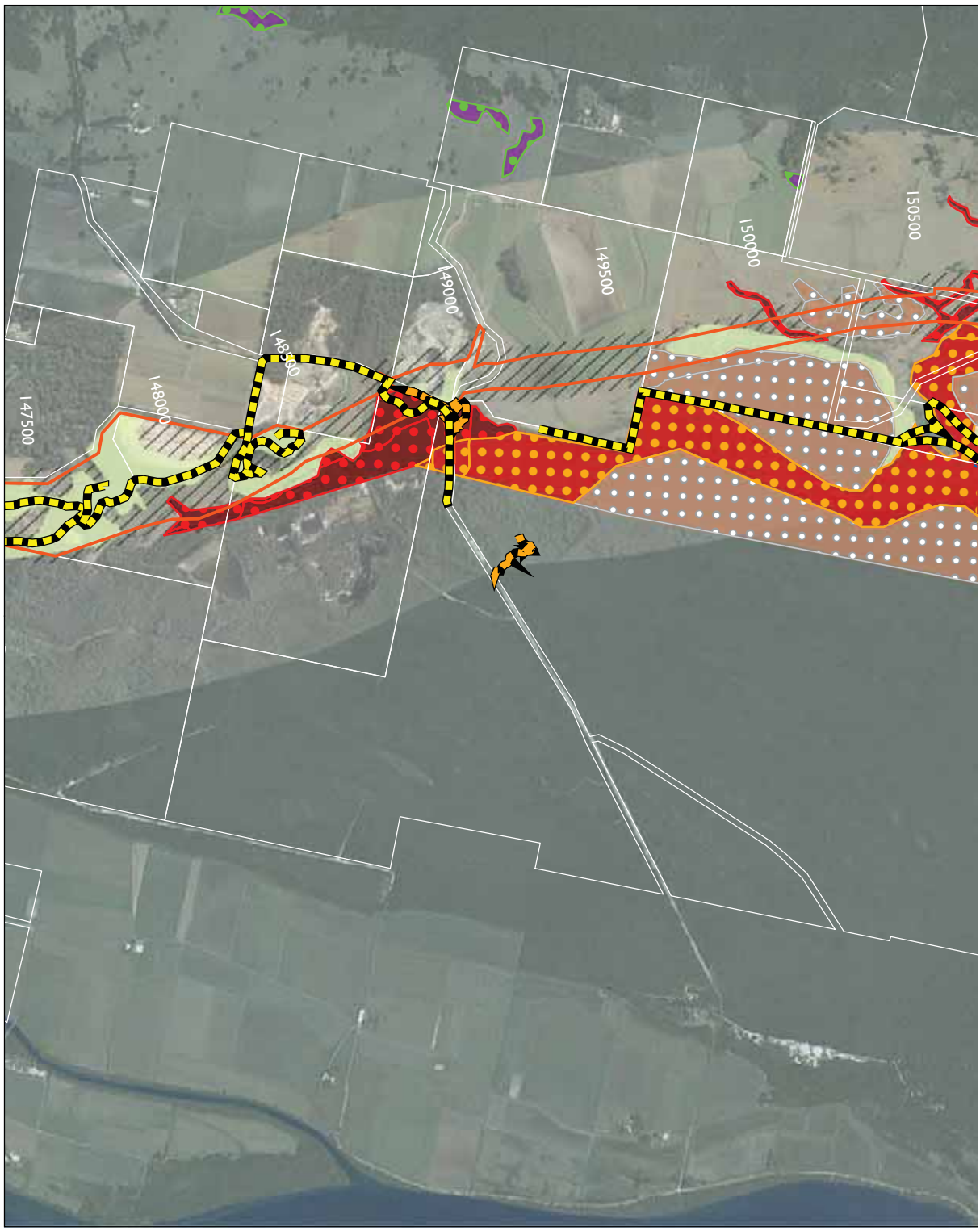


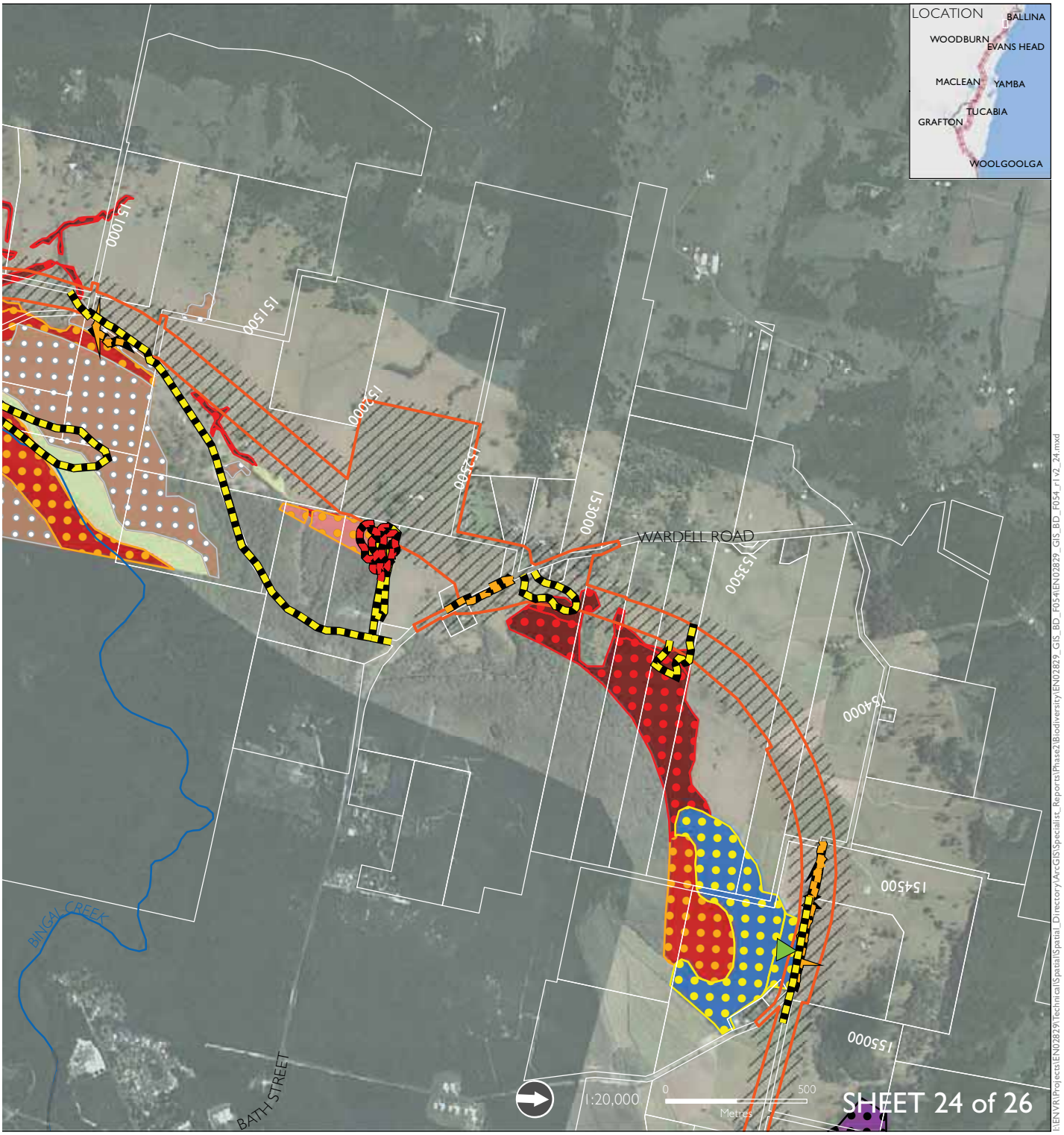


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Cleared/modified

Figure 2-24 Flora survey methods in the study area





Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)

Swamp Oak Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)

Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)

Vegetation communities

Blackbutt grassy open forest of the lower Clarence Valley of the North Coast

Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast

Paperbark swamp forest of the coastal lowlands of the North Coast

Swamp Mahogany swamp forest of the coastal lowlands of the North Coast

Swamp Oak swamp forest of the coastal lowlands of the North Coast

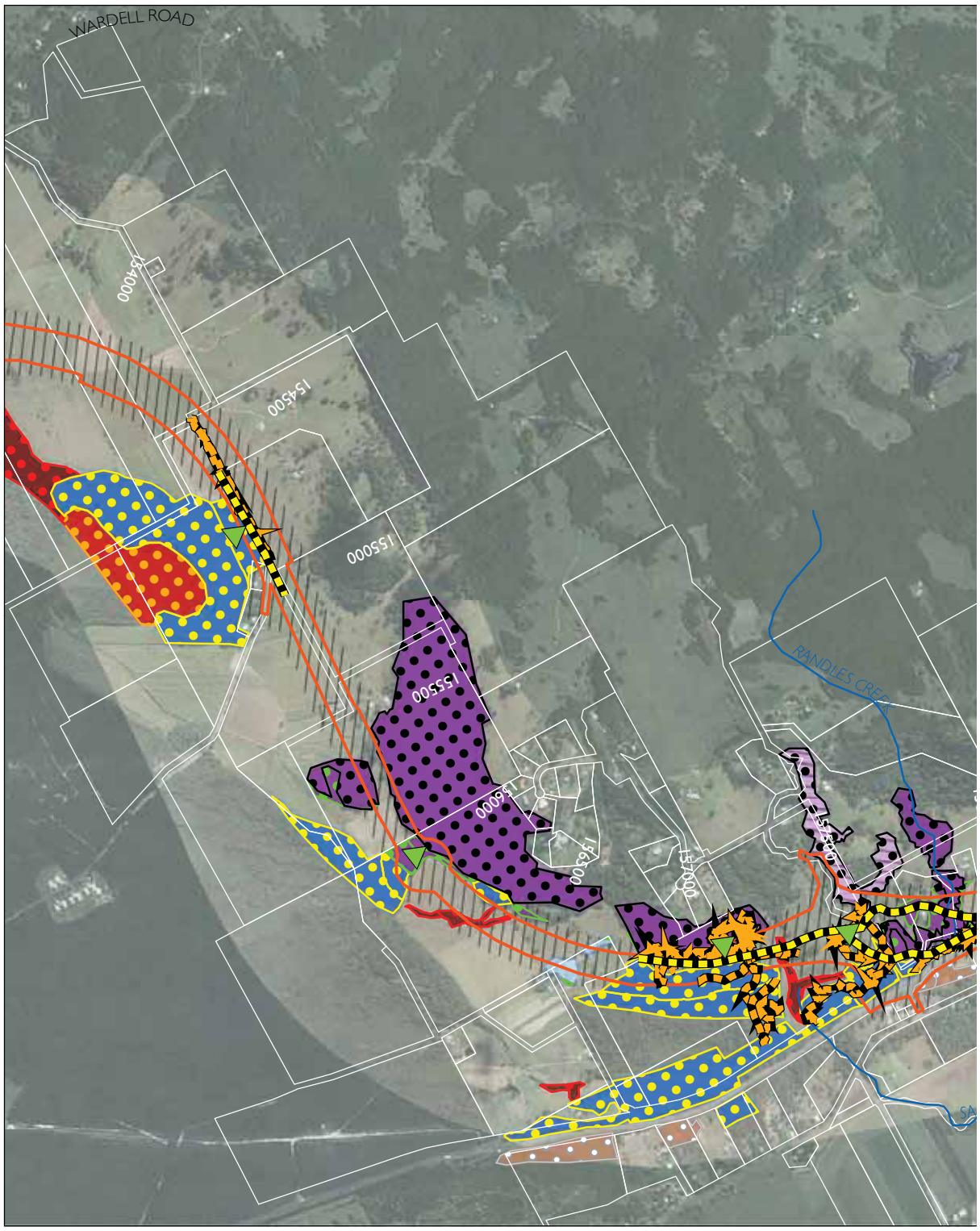
White Booyong - Fig subtropical rainforest of the North Coast

Coast Cypress Pine shrubby open forest of the North Coast Bioregion

Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast

Cleared/modified

Figure 2-25 Flora survey methods in the study area

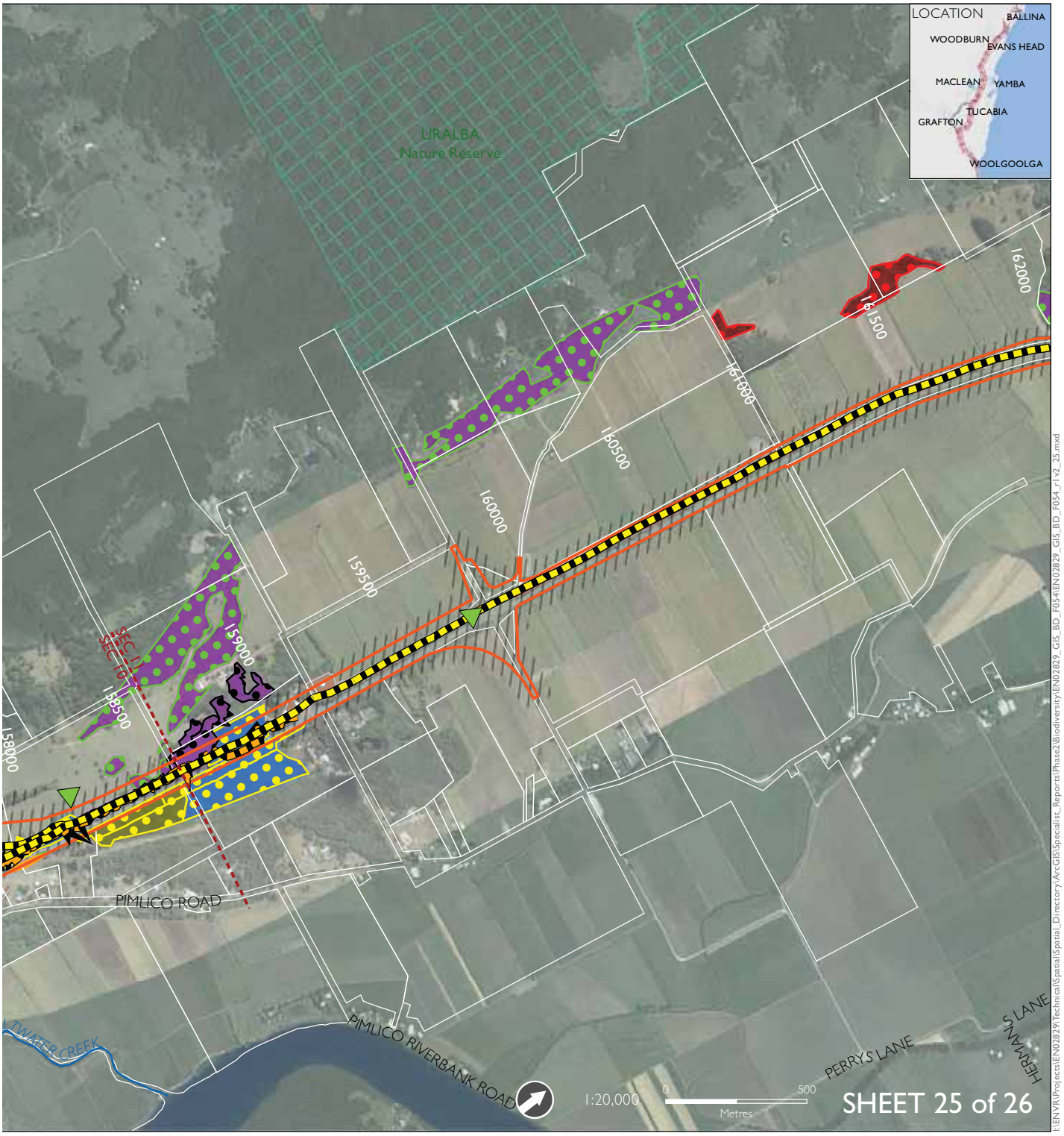


Flora survey methods

- Targeted threatened flora search (2012)
- Flora survey traverse (2005)
- Supplementary flora survey traverse (2012)

Threatened ecological communities

- Coastal Cypress Pine Forest in NSW North Coast Bioregion (Endangered, TSC Act)
- Lowland Rainforest on Coastal Floodplains (Endangered, TSC Act)
- Lowland Rainforest of Subtropical Australia (Critically Endangered, EPBC Act) and Lowland Rainforest on Coastal Floodplains (Endangered, TSC Act)



Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)

Swamp Oak Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)

Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)

Vegetation communities

Blackbutt - Paperbark Moist Open Forest

Brush Box tall moist forest of the northern ranges of the North Coast

Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast

Paperbark swamp forest of the coastal lowlands of the North Coast

Swamp Mahogany swamp forest of the coastal lowlands of the North Coast

Swamp Oak swamp forest of the coastal lowlands of the North Coast

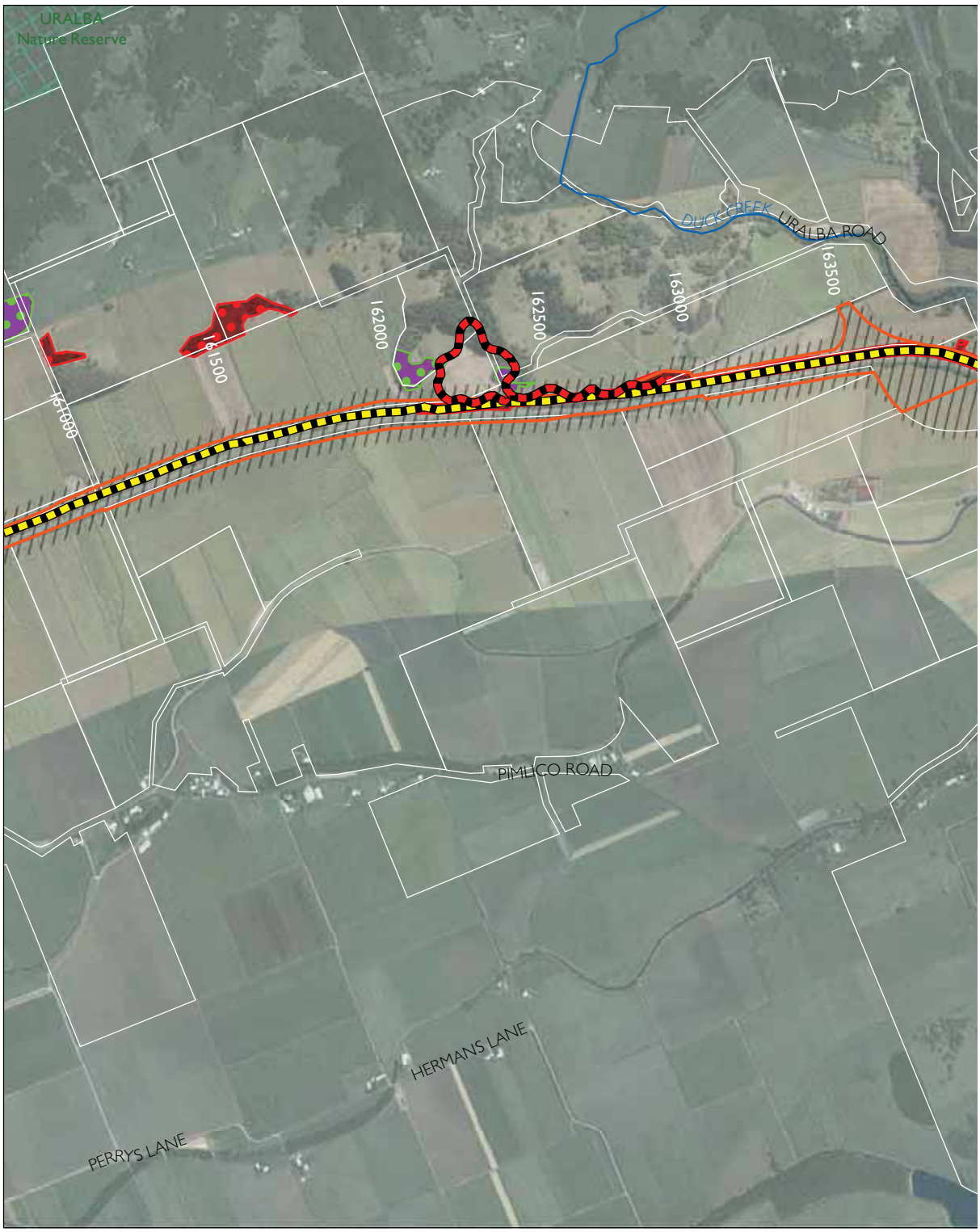
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast

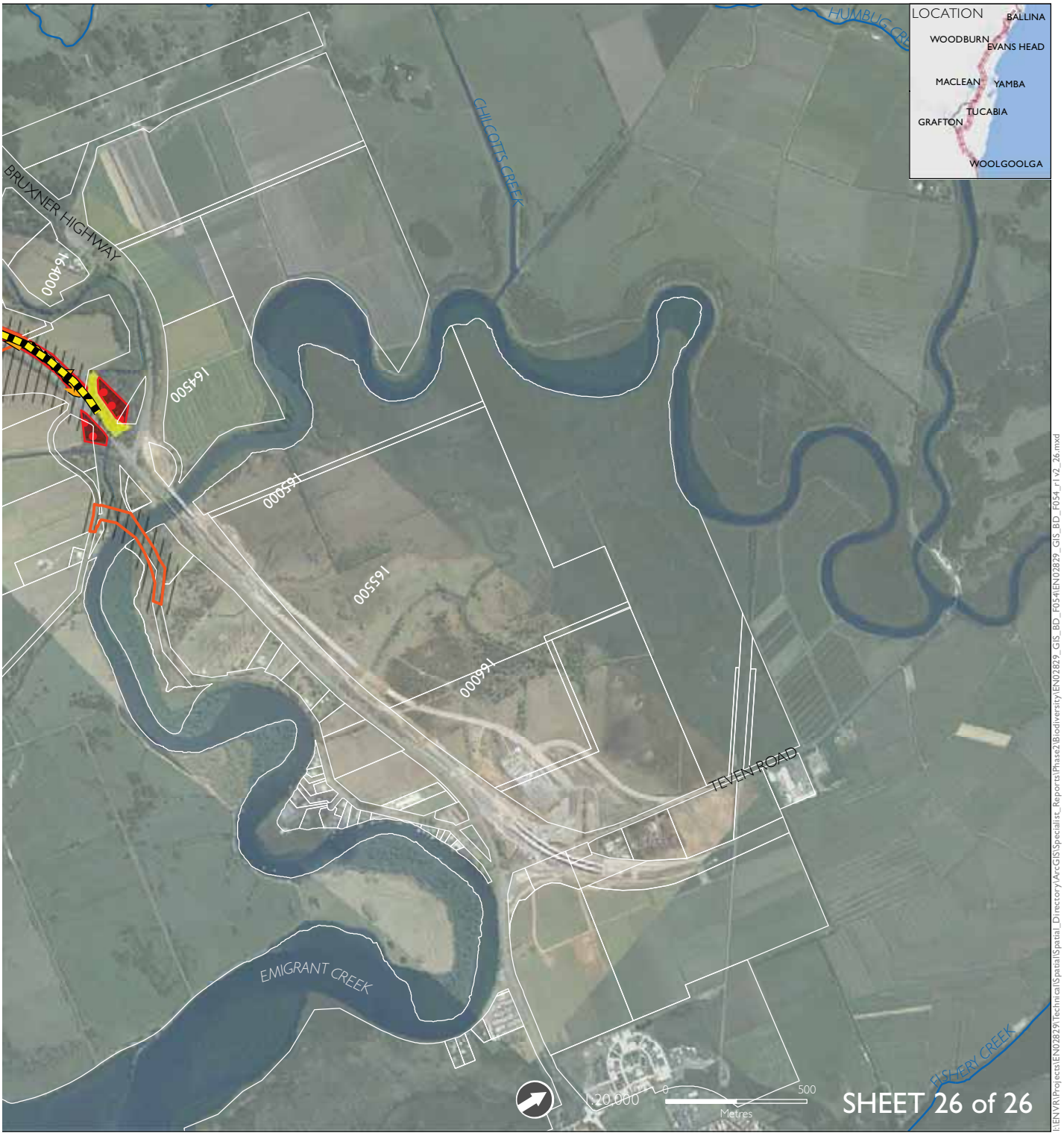
White Booyong - Fig subtropical rainforest of the North Coast

Coast Cypress Pine shrubby open forest of the North Coast Bioregion

Cleared/modified

Figure 2-26 Flora survey methods in the study area

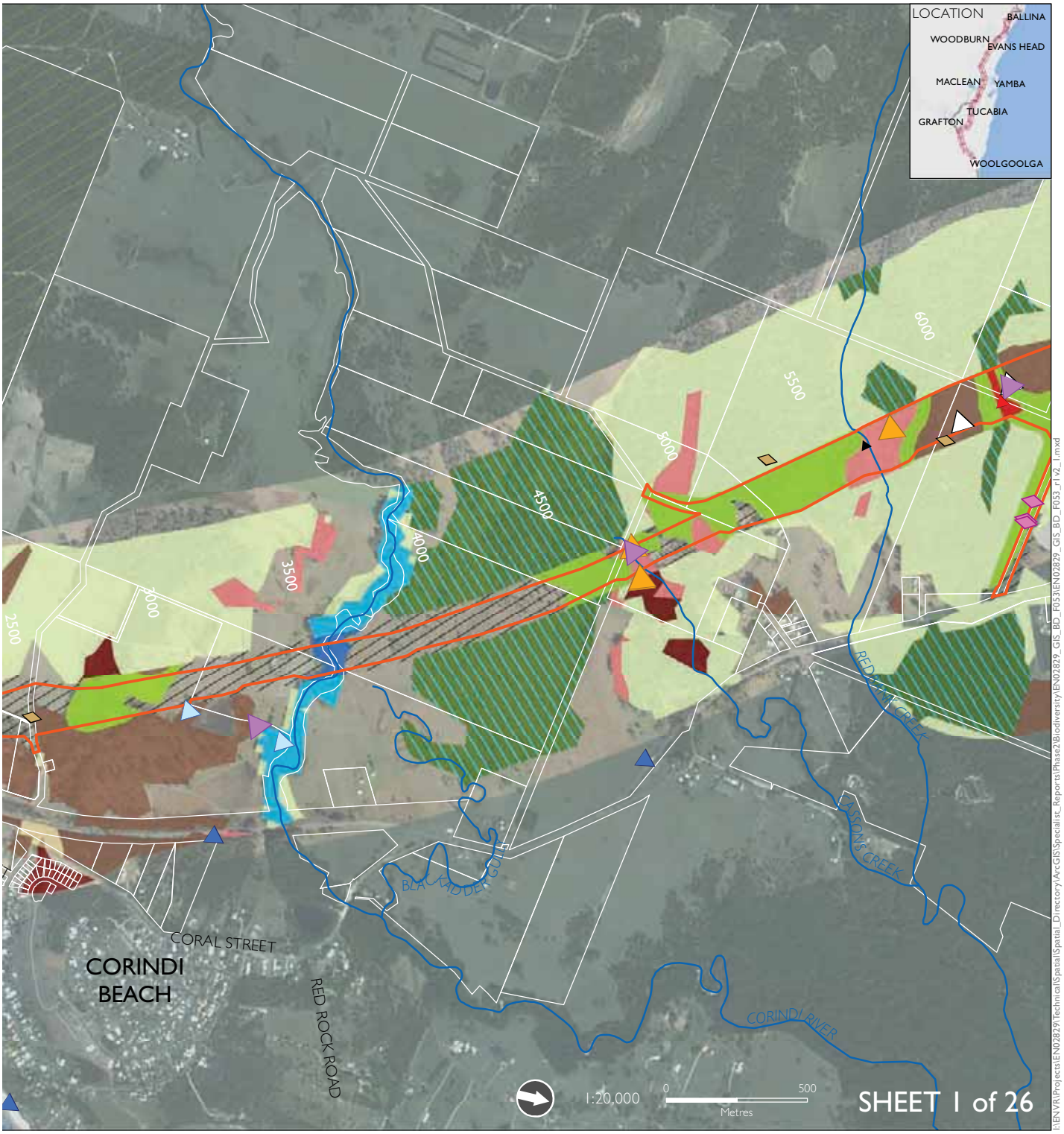




Vegetation communities

- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- White Booyong - Fig subtropical rainforest of the North Coast
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Cleared/modified

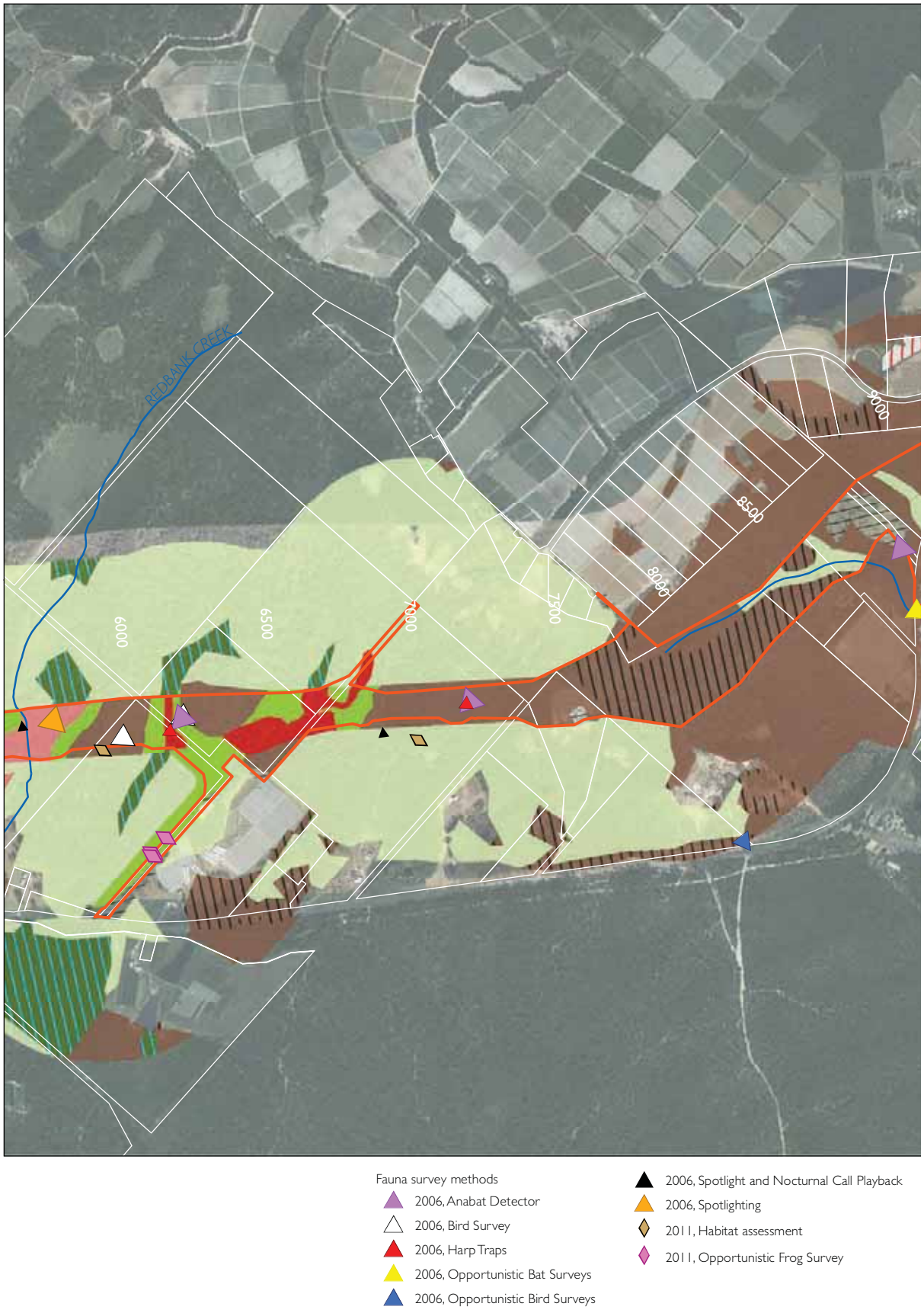
Figure 2-27 Fauna survey methods in the study area

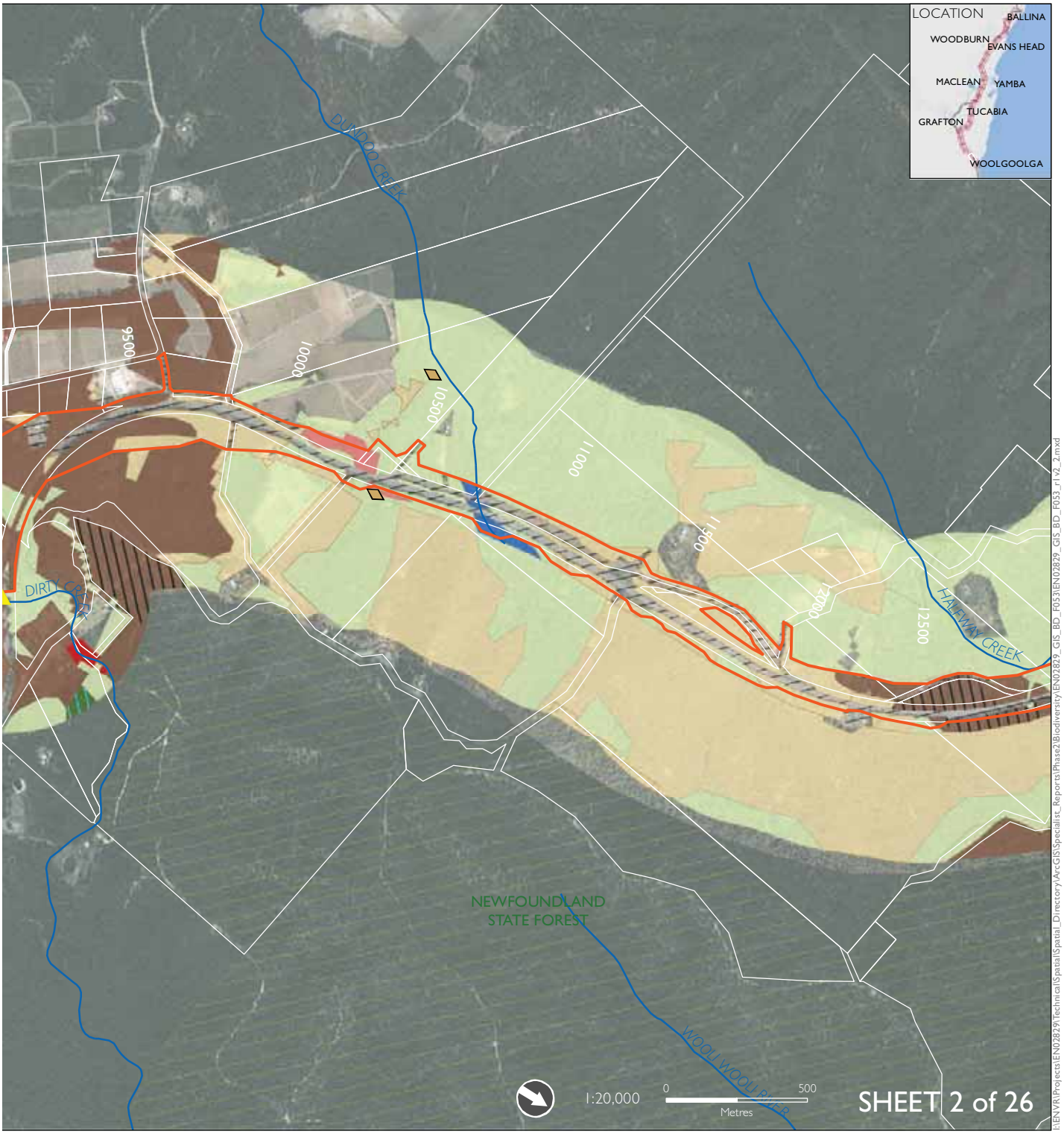


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-28 Fauna survey methods in the study area





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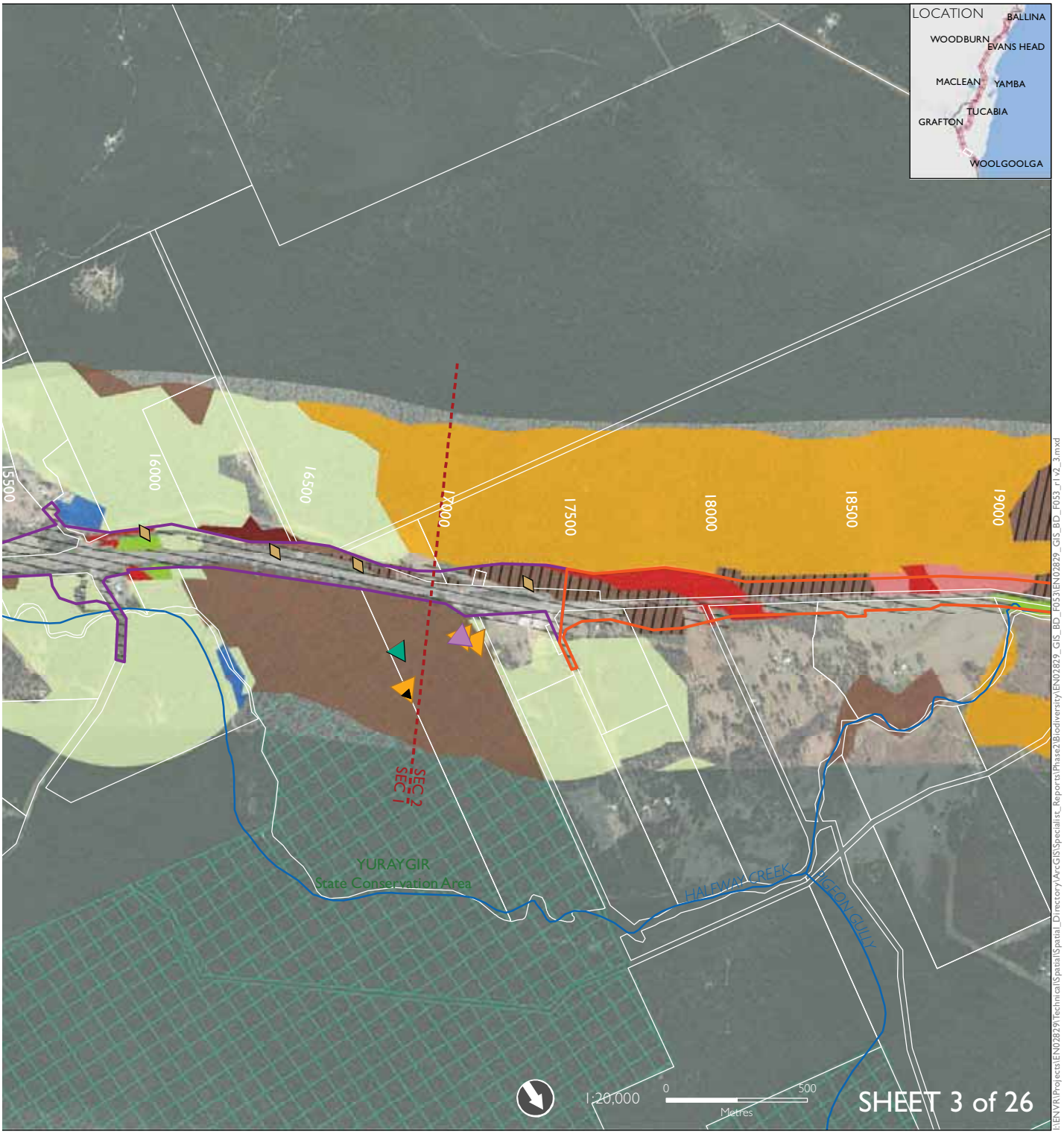
Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

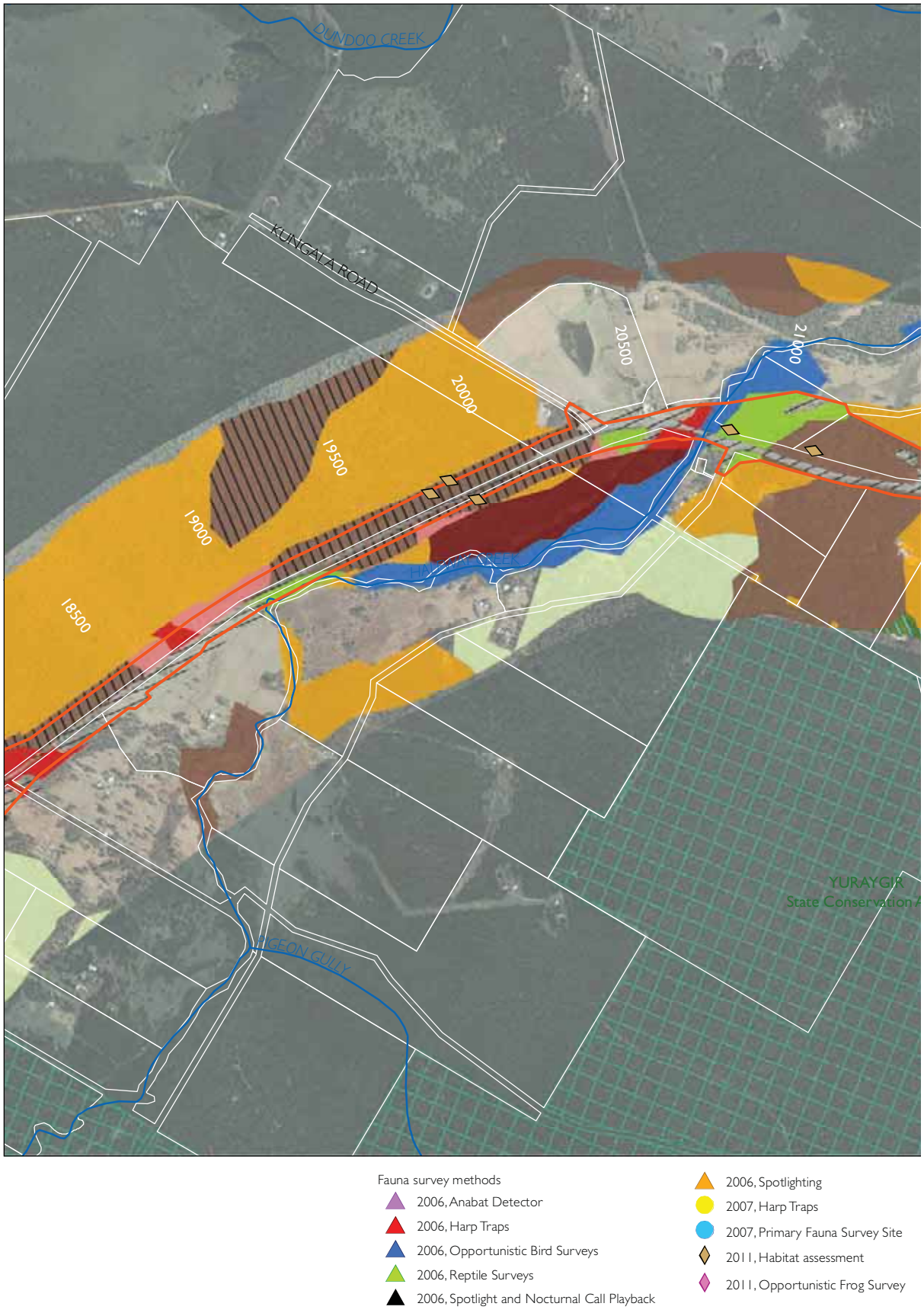
Figure 2-29 Fauna survey methods in the study area

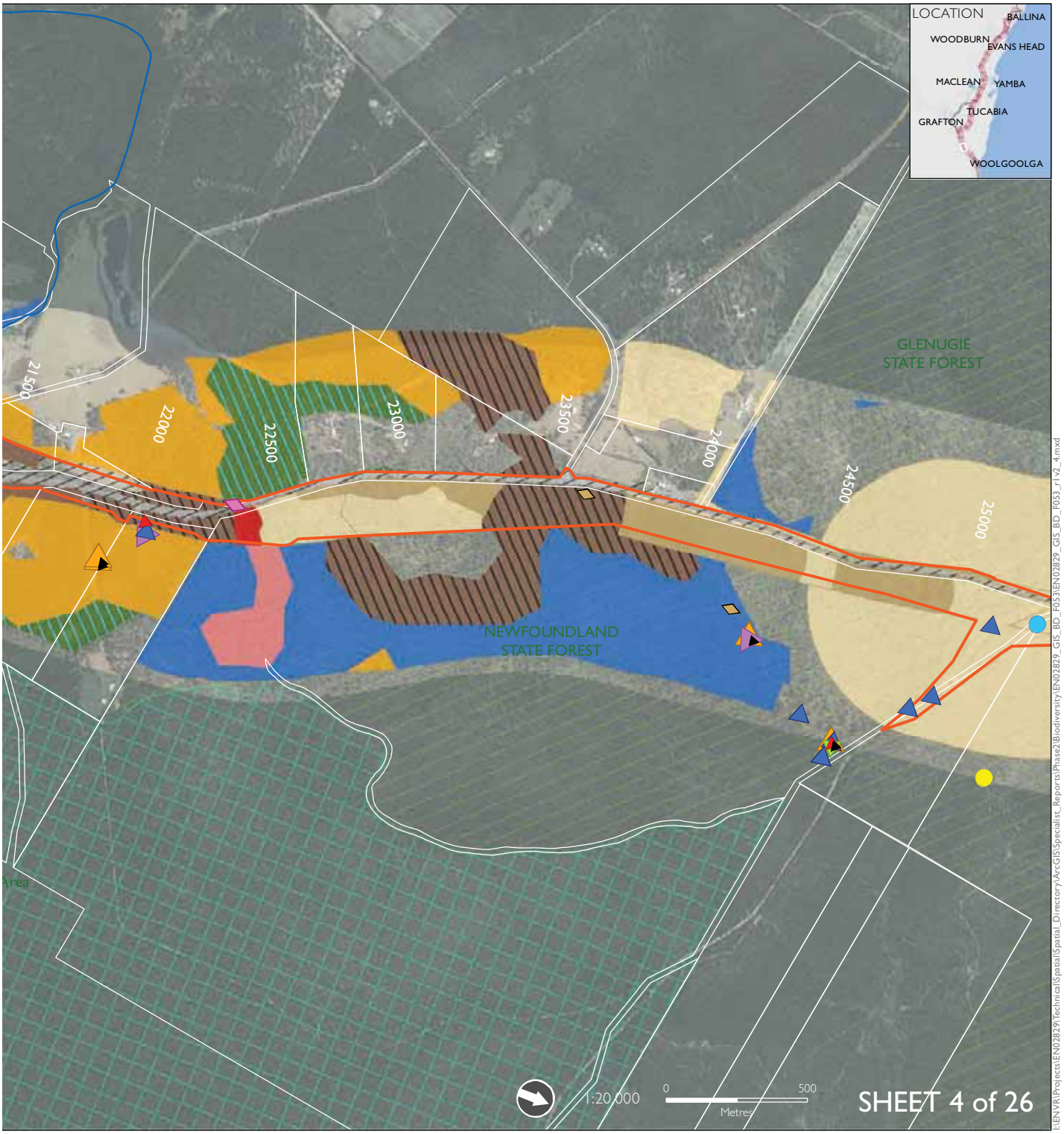


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-30 Fauna survey methods in the study area

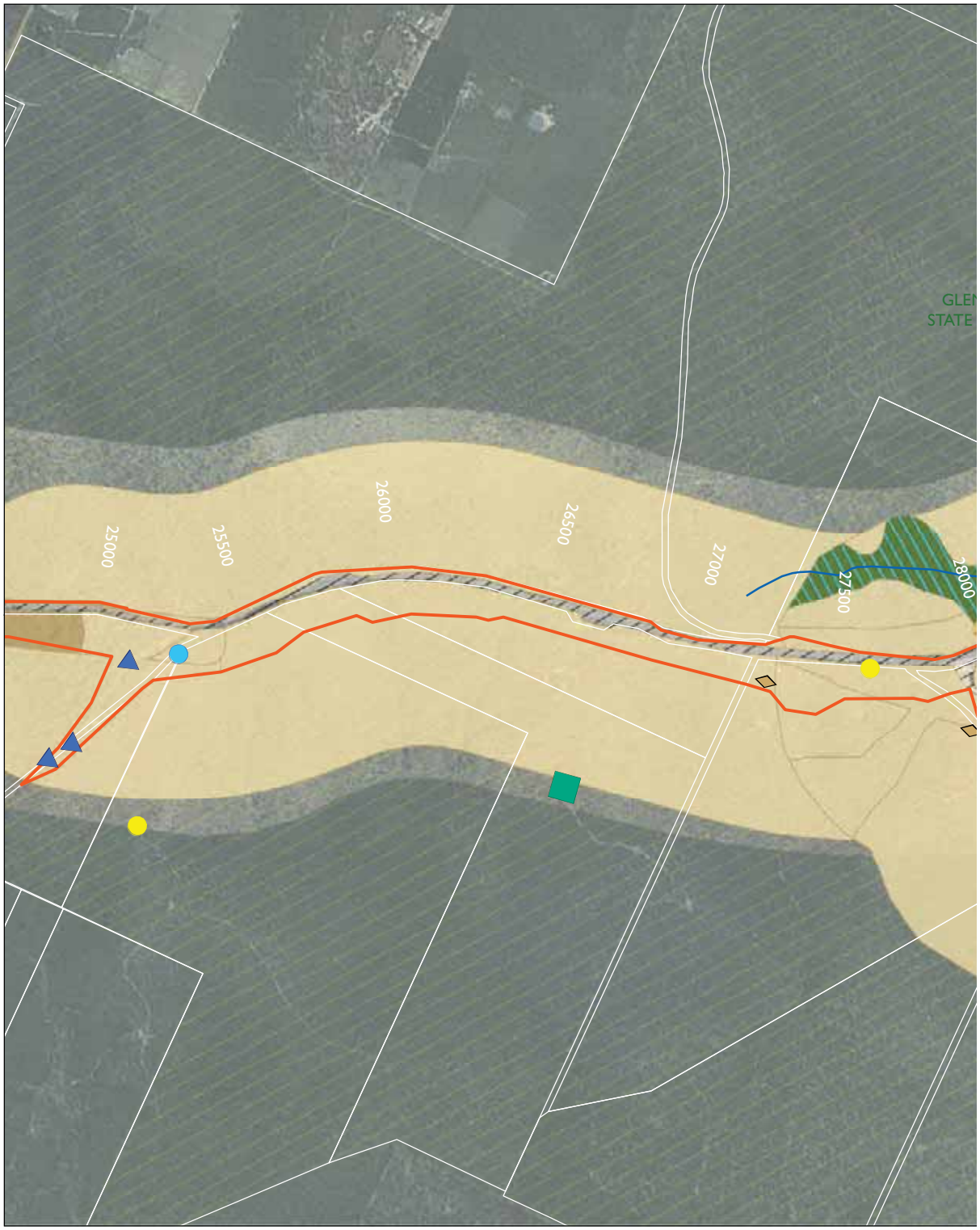




Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Swamp Box swamp forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Orange Gum (Eucalyptus bancroftii) open forest of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

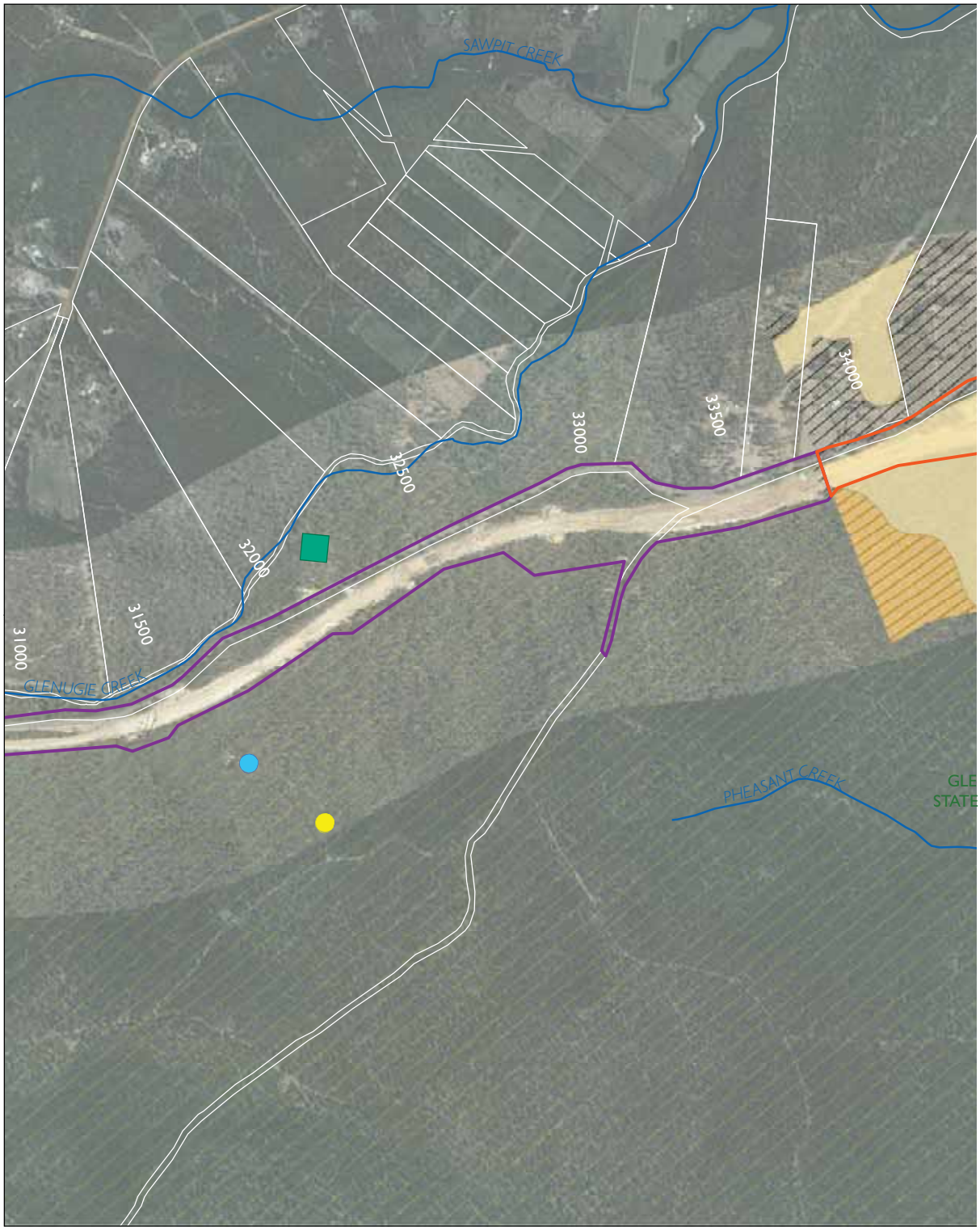
Figure 2-31 Fauna survey methods in the study area

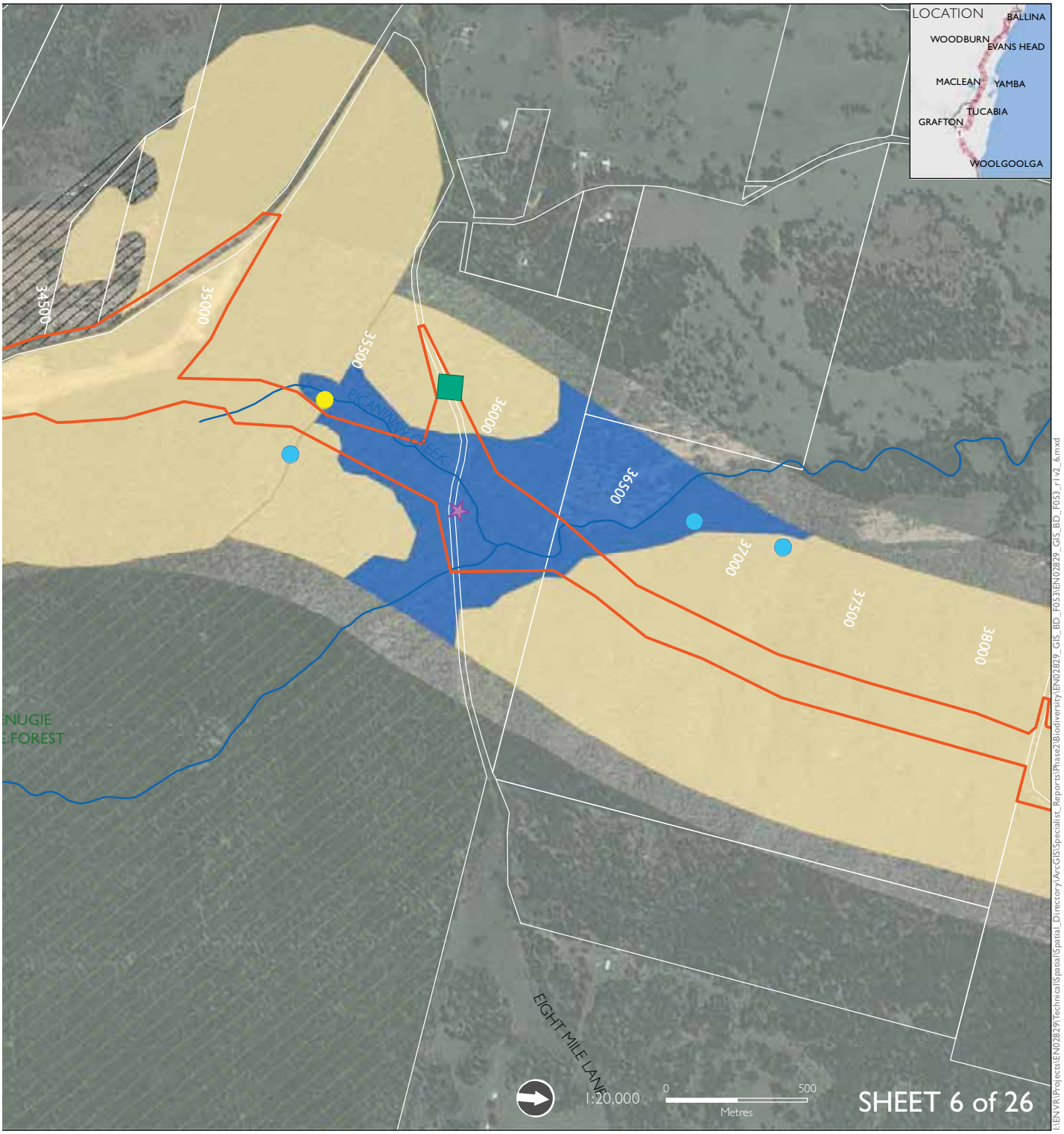


Vegetation communities

- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Orange Gum (Eucalyptus bancroftii) open forest of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-32 Fauna survey methods in the study area

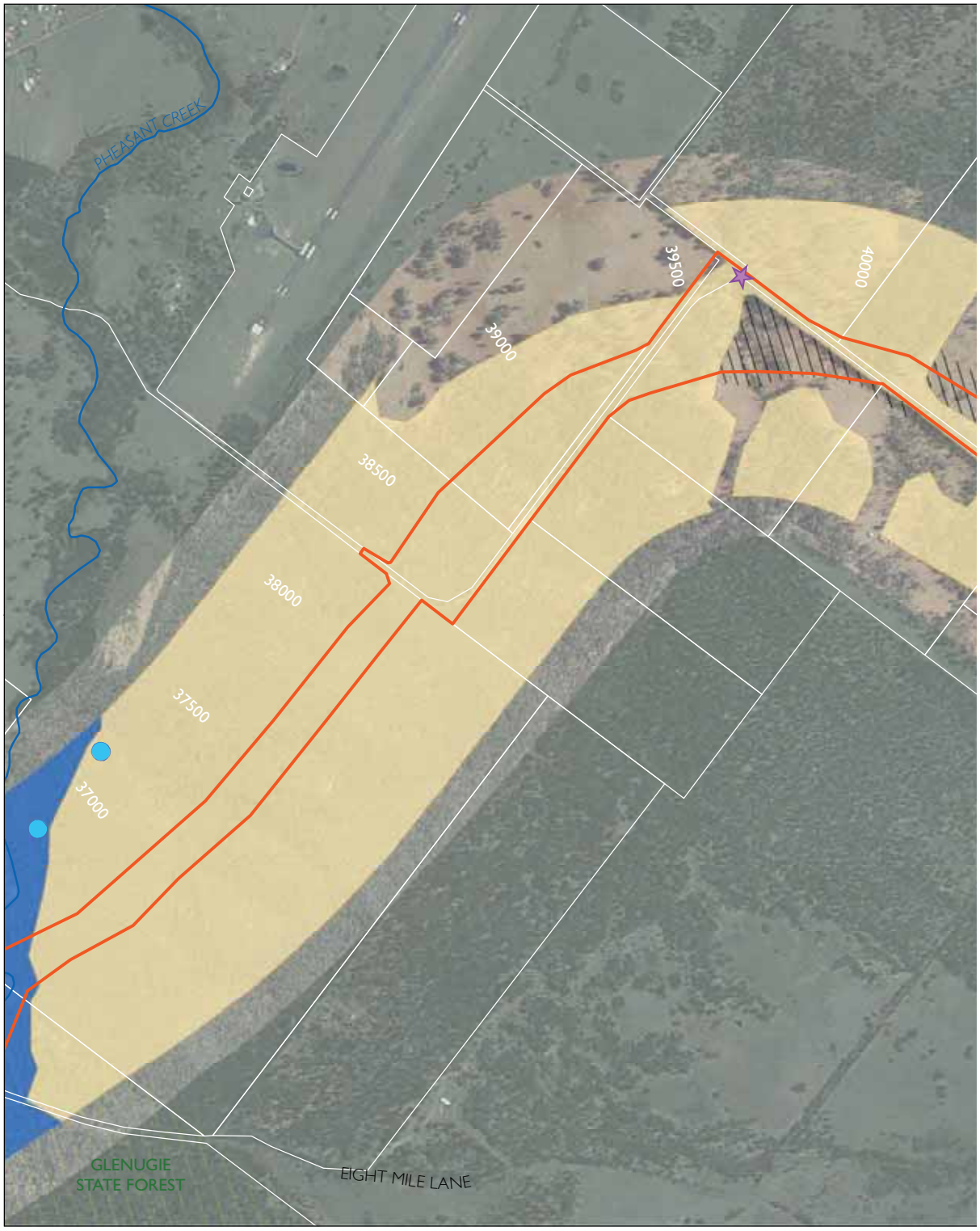


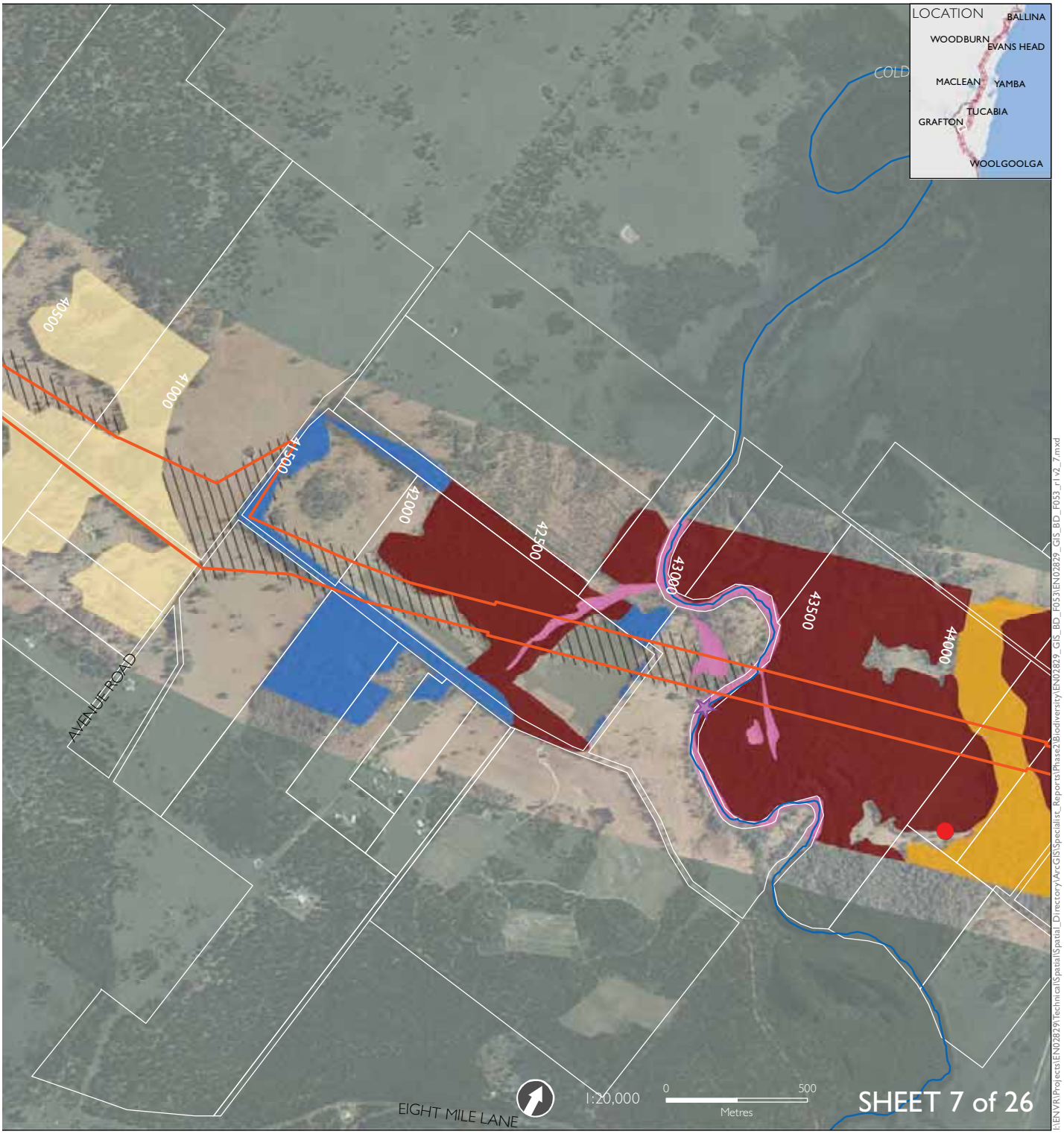


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-33 Fauna survey methods in the study area

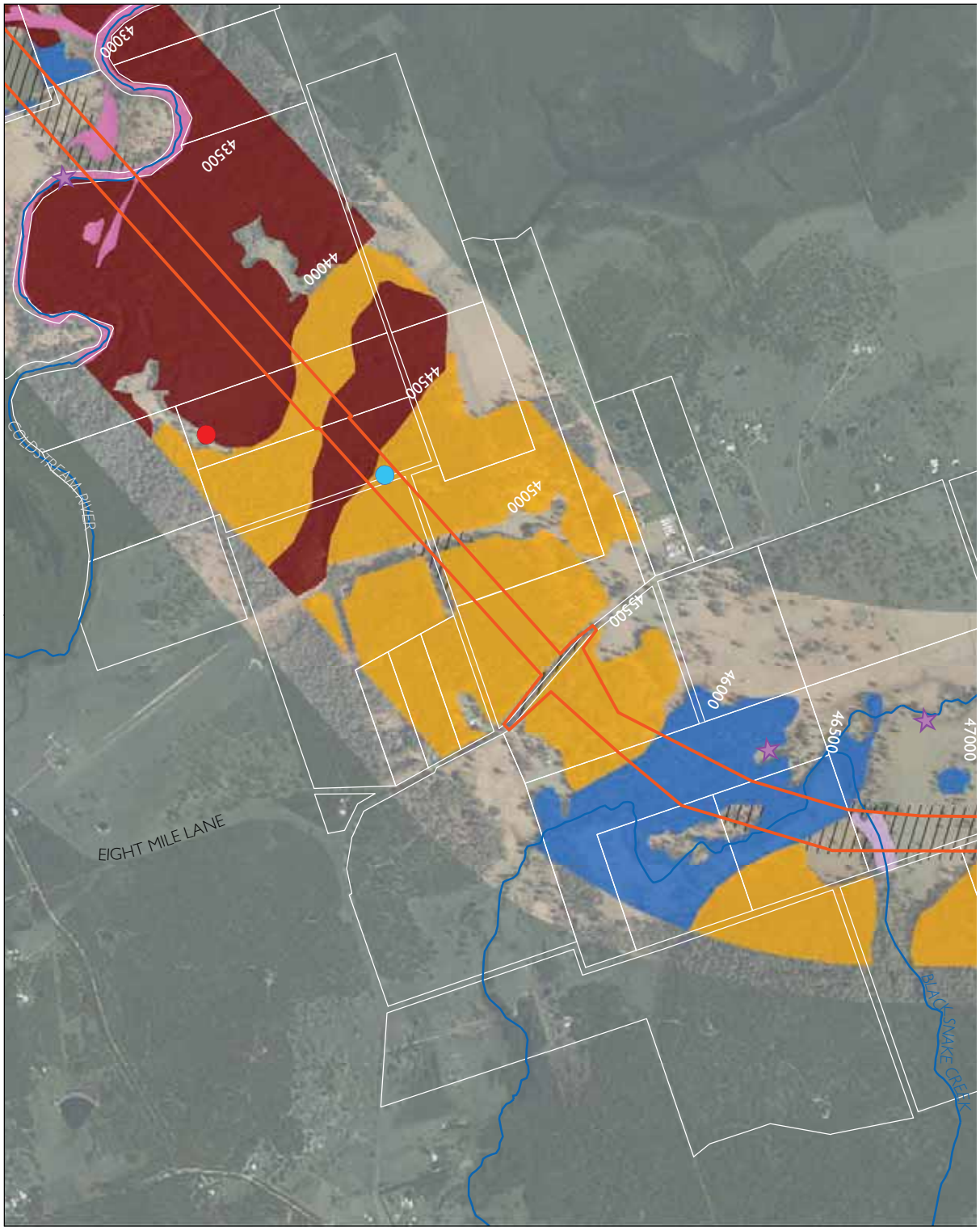


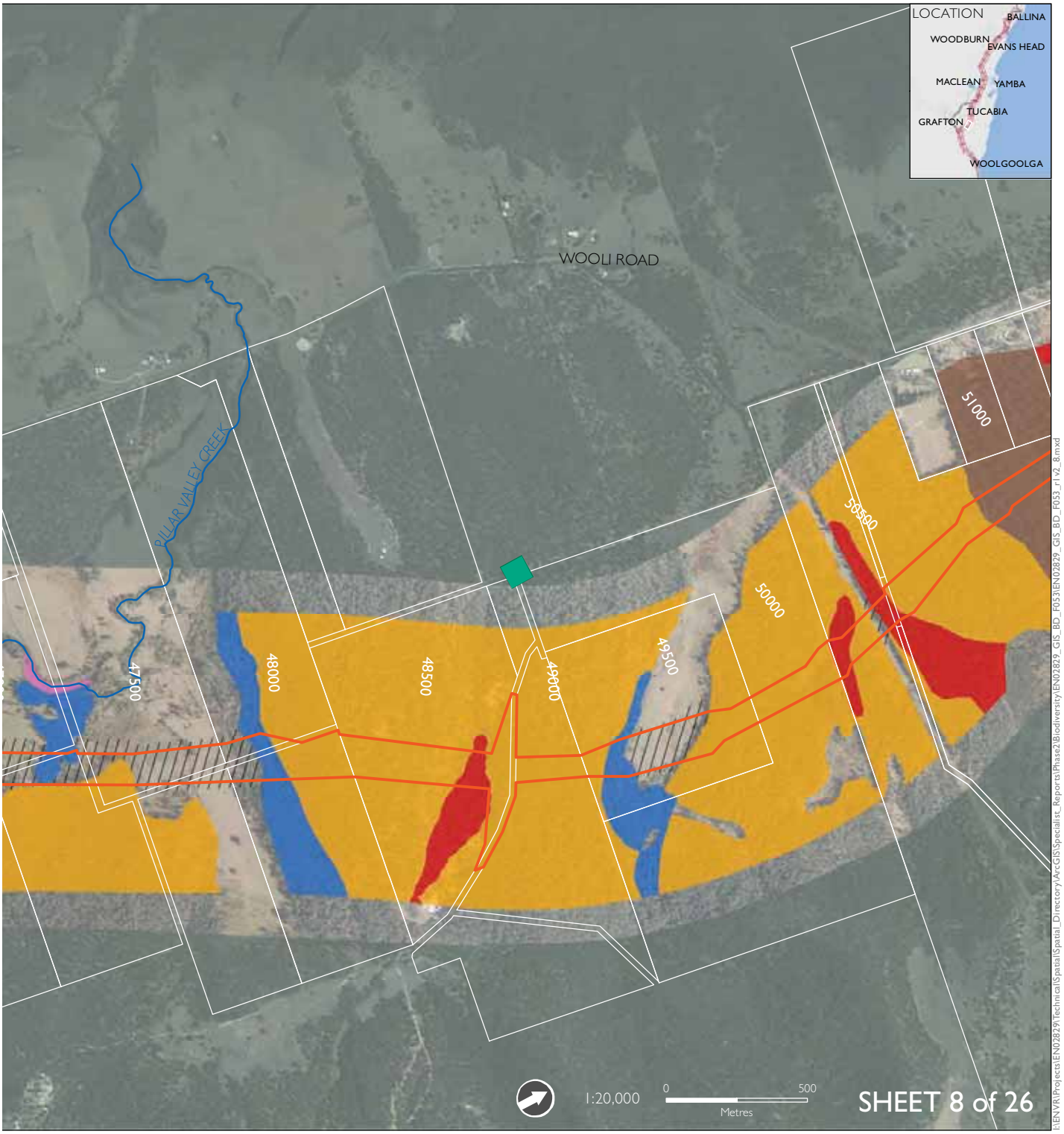


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-34 Fauna survey methods in the study area

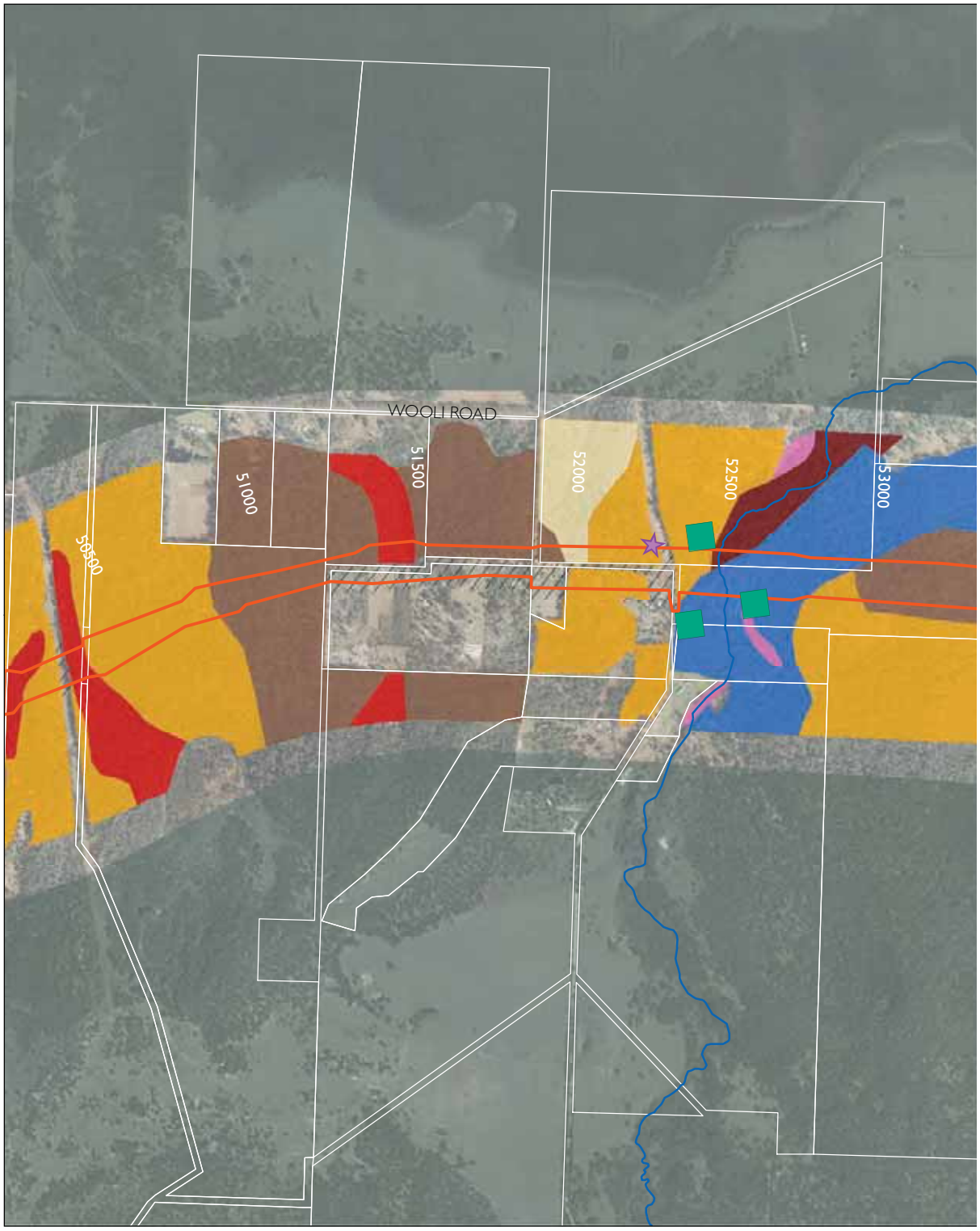


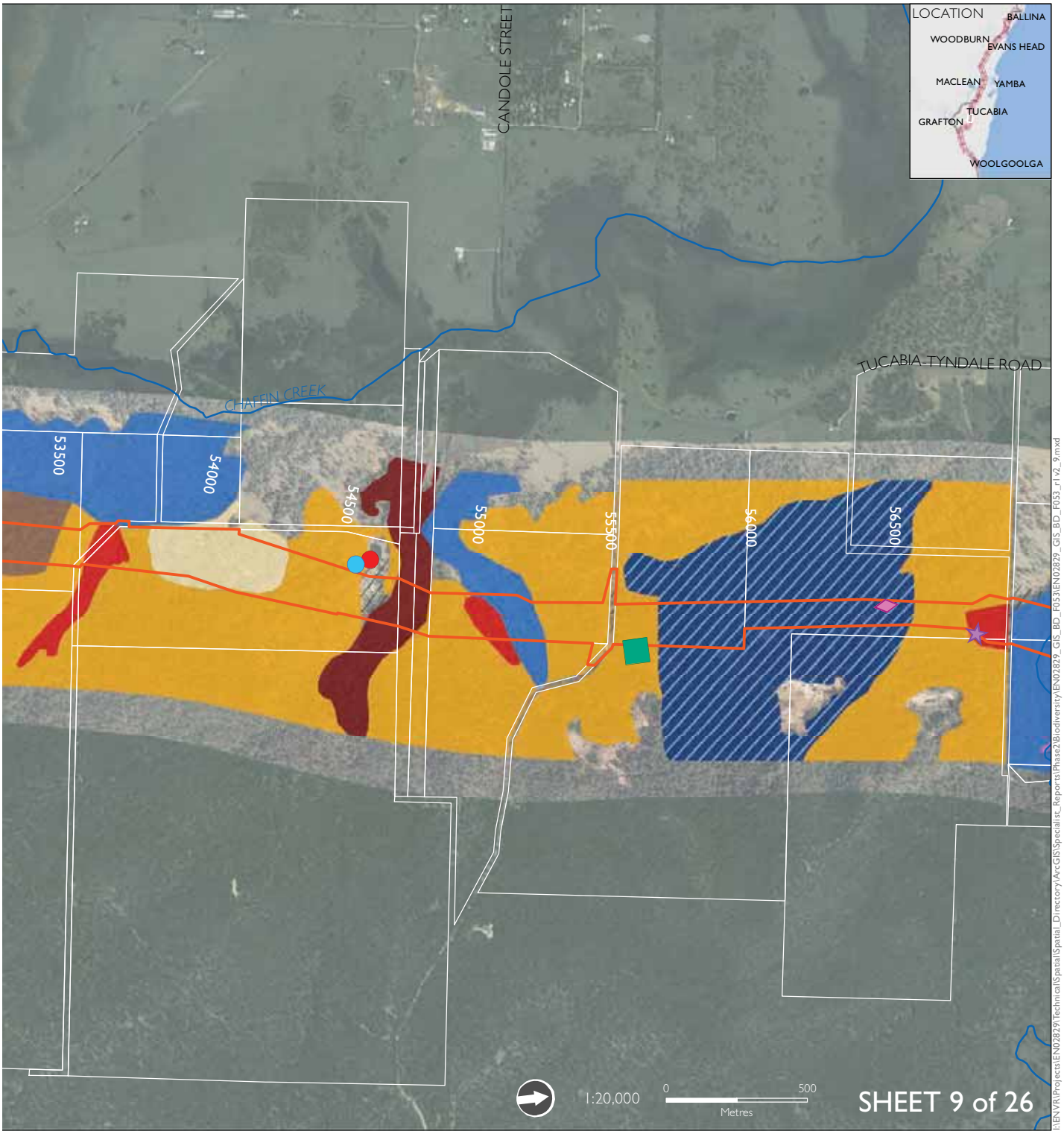


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-35 Fauna survey methods in the study area

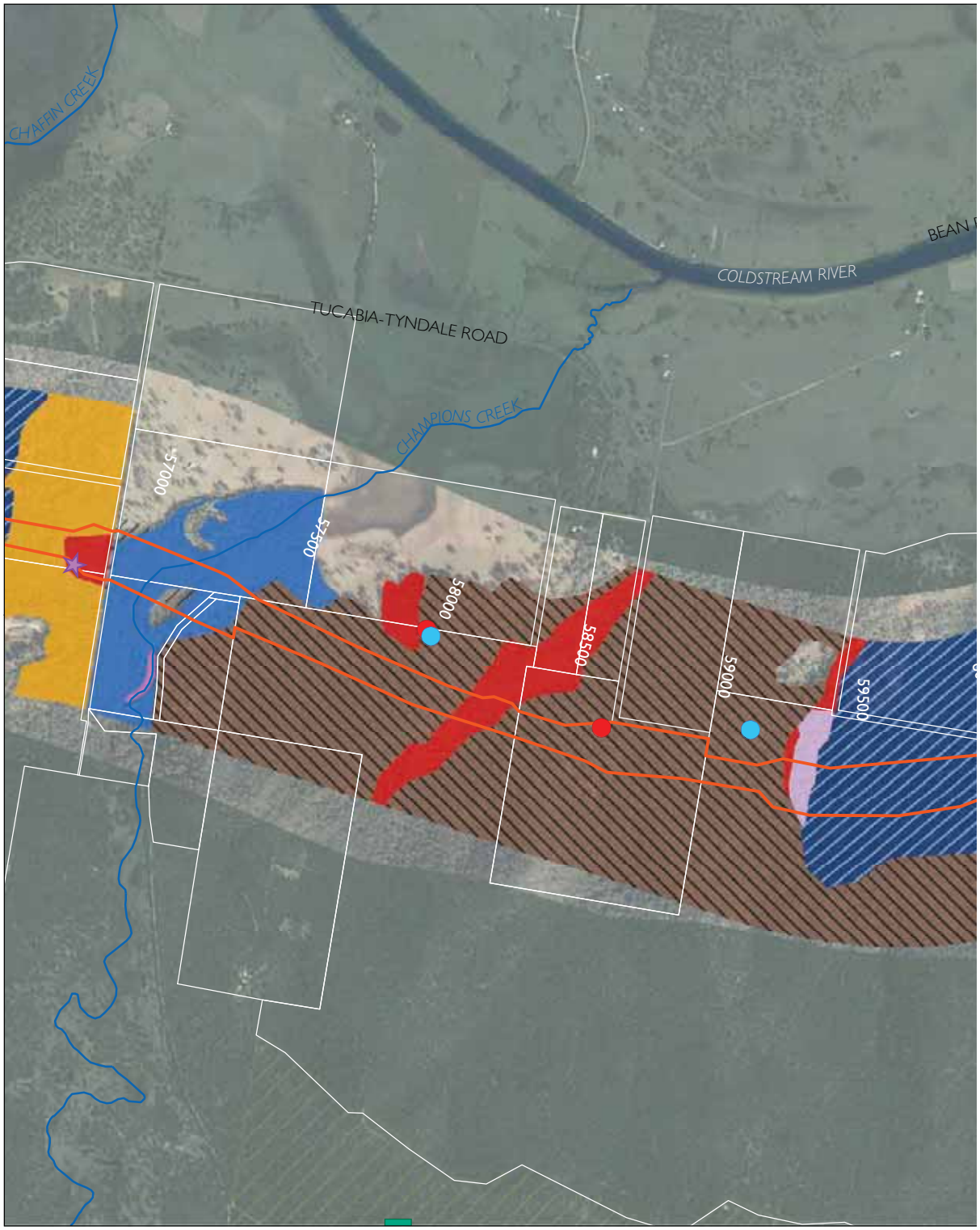


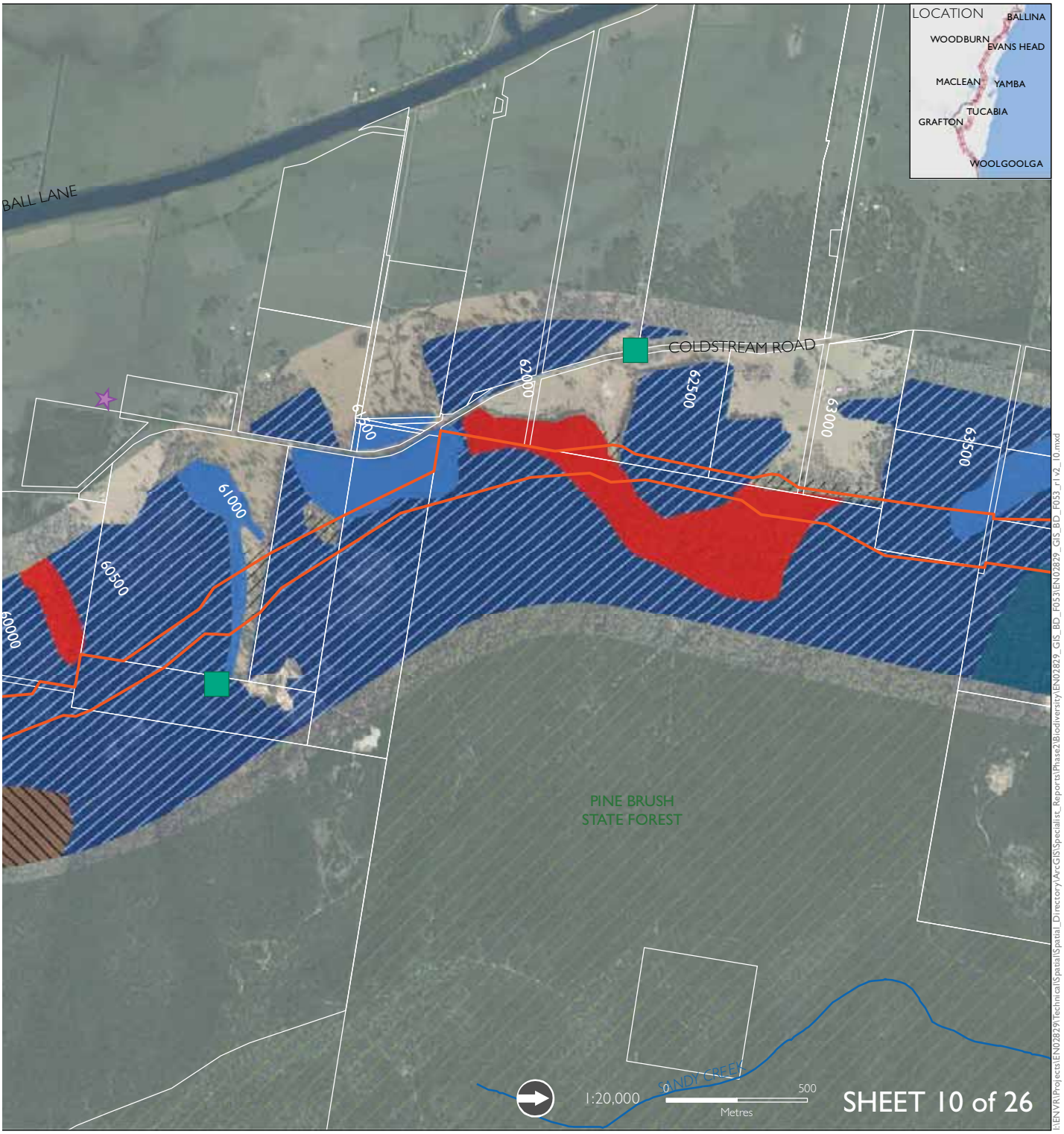


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-36 Fauna survey methods in the study area

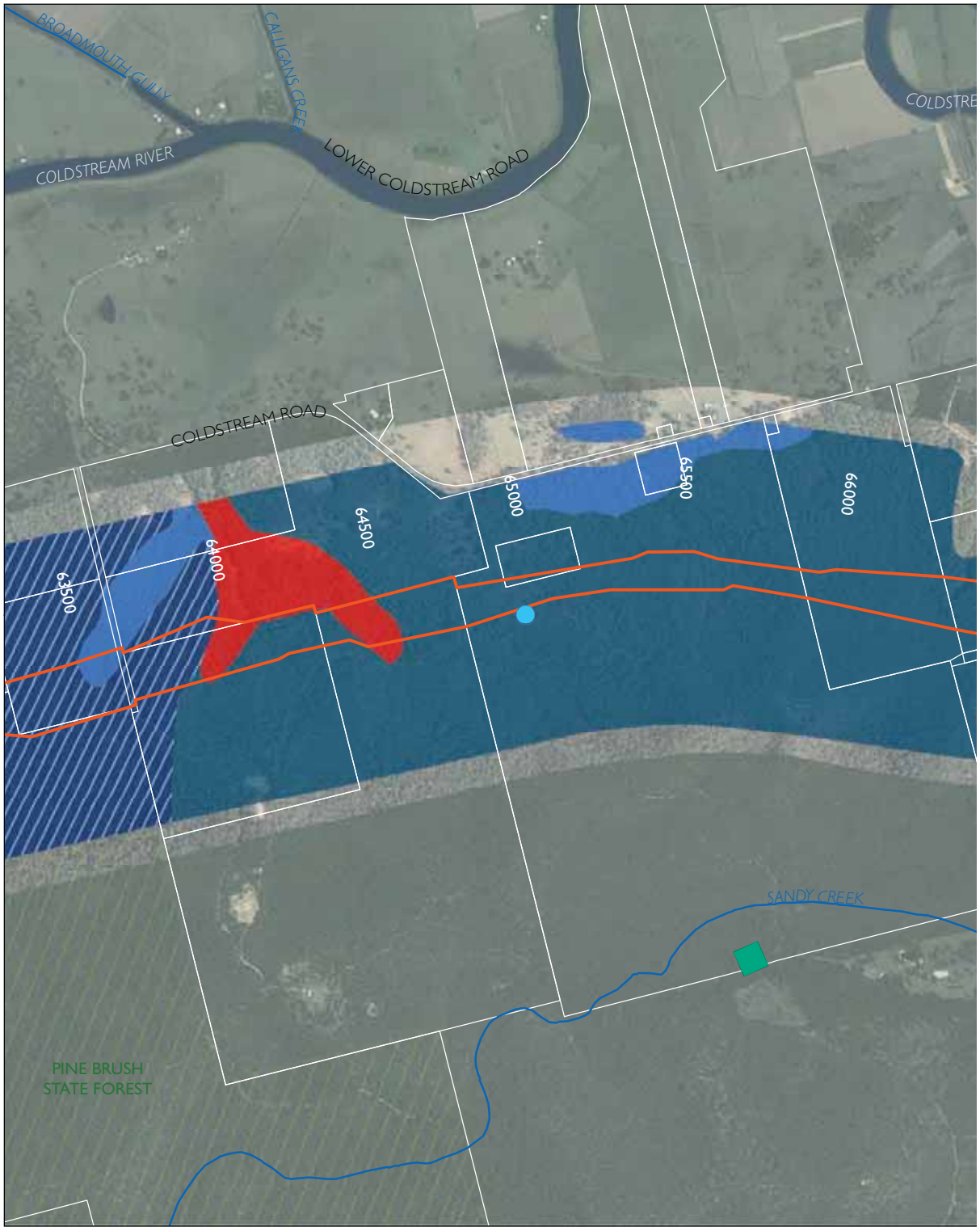


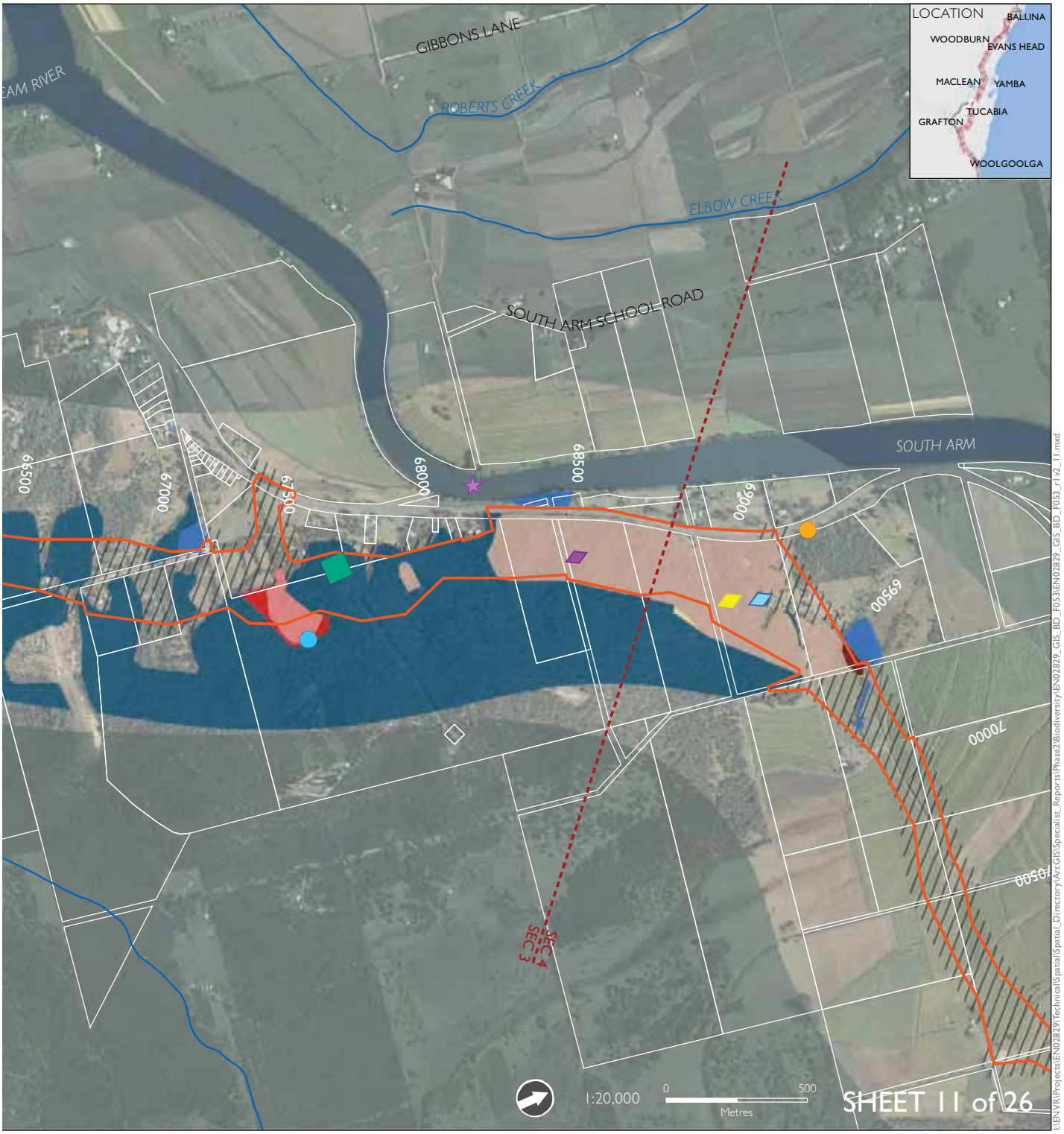


Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-37 Fauna survey methods in the study area

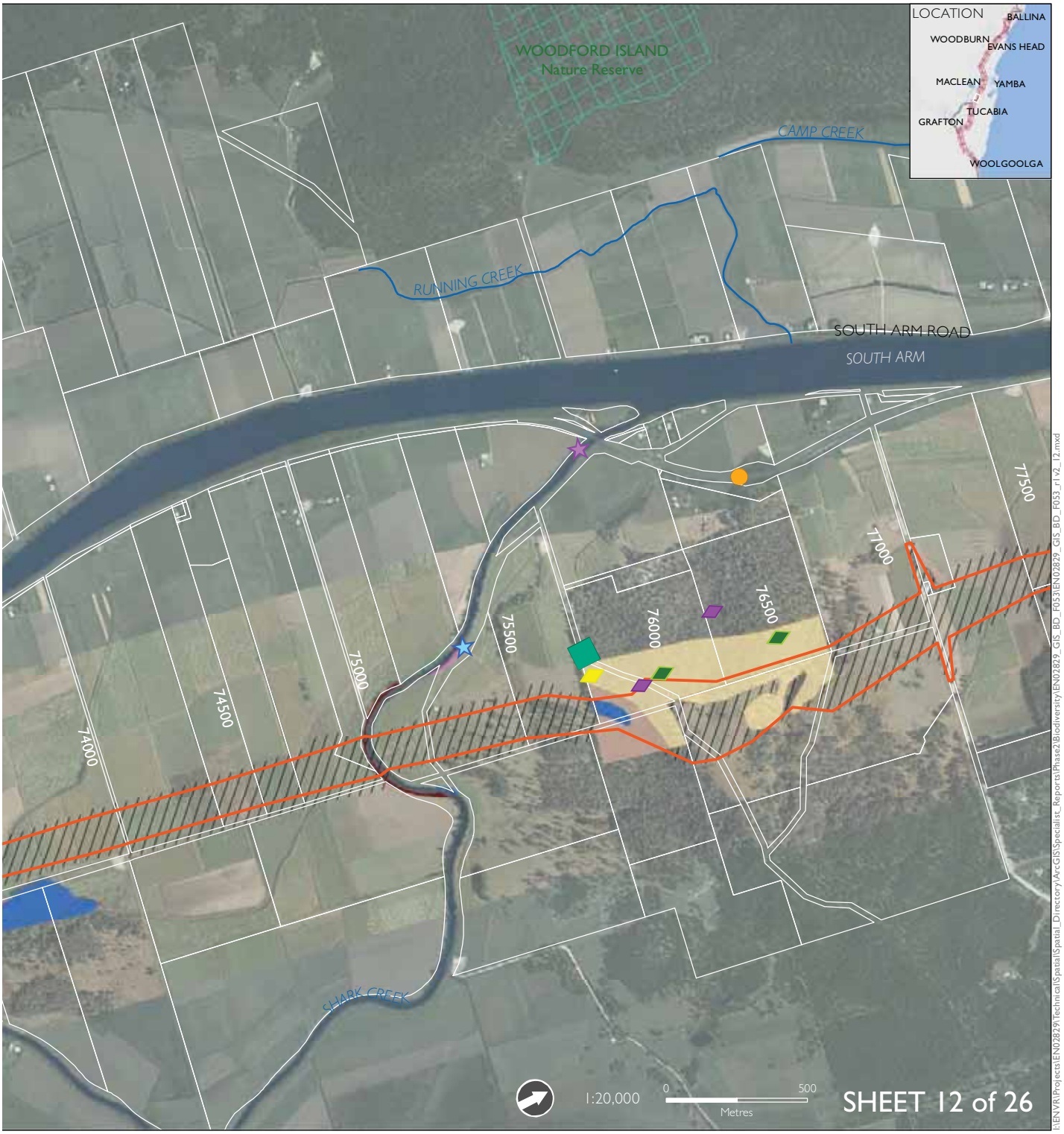




Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Turpentine moist open forest of the coastal hills and ranges of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

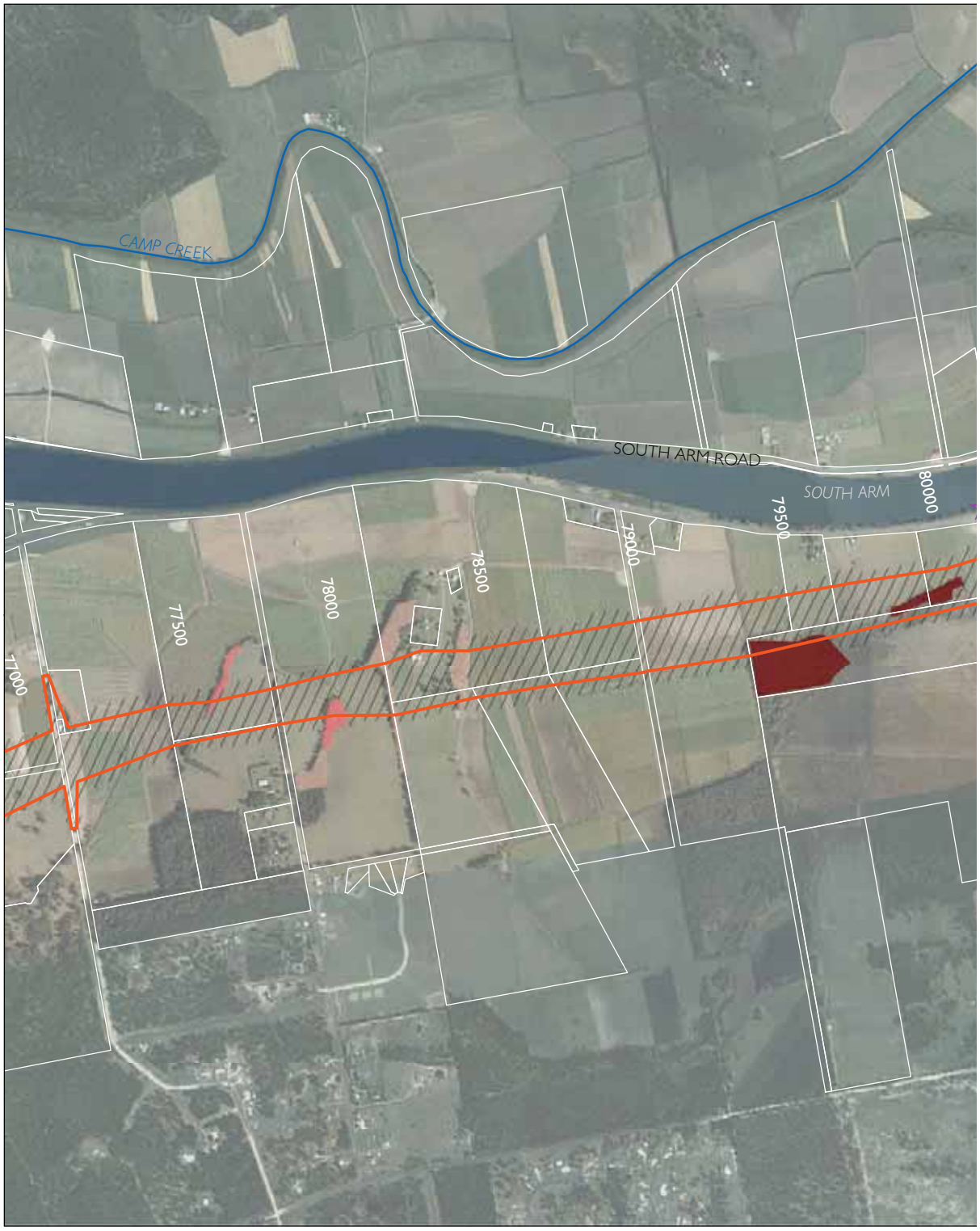
Figure 2-38 Fauna survey methods in the study area

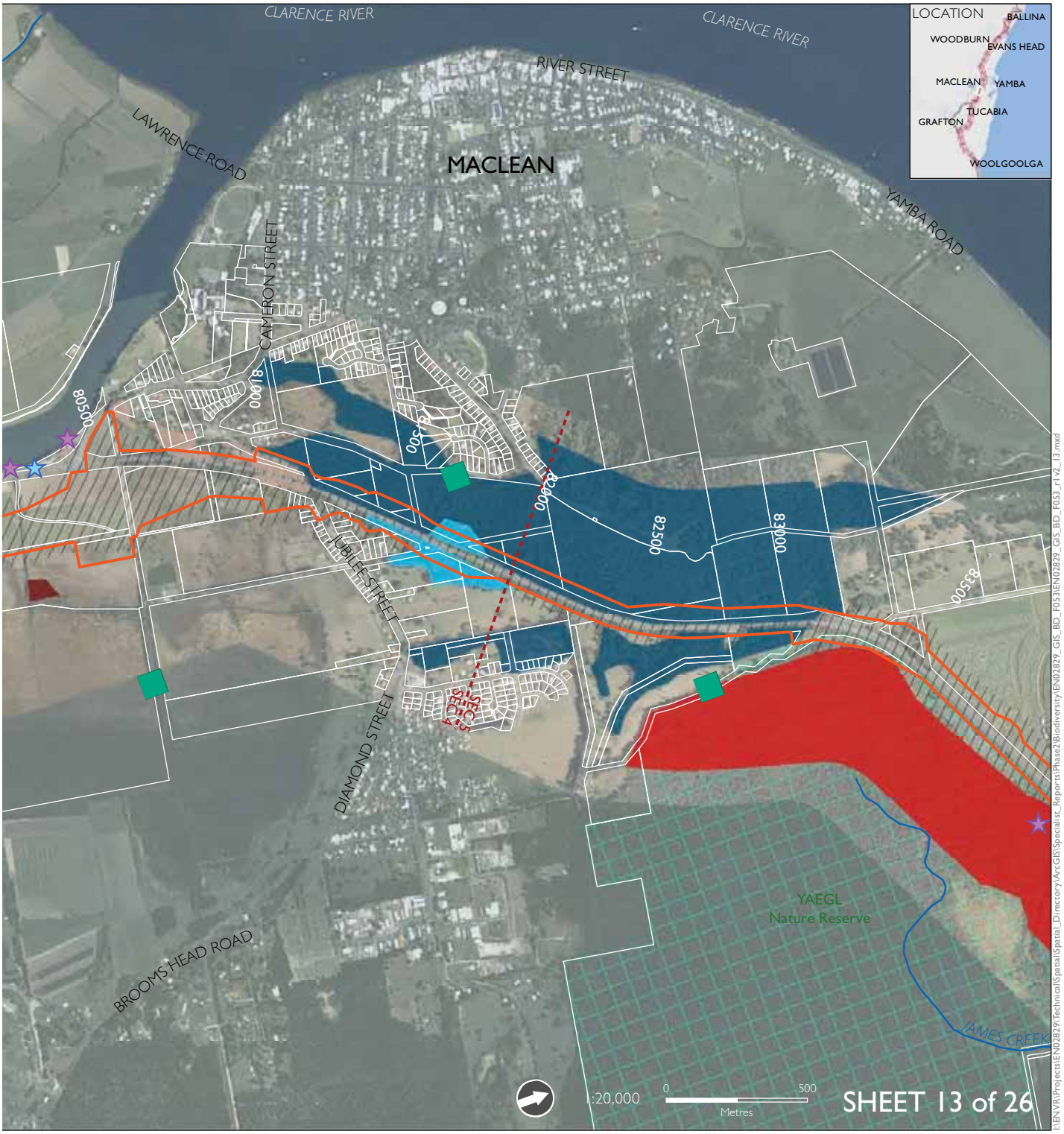


Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

Figure 2-39 Fauna survey methods in the study area





Vegetation communities

- Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

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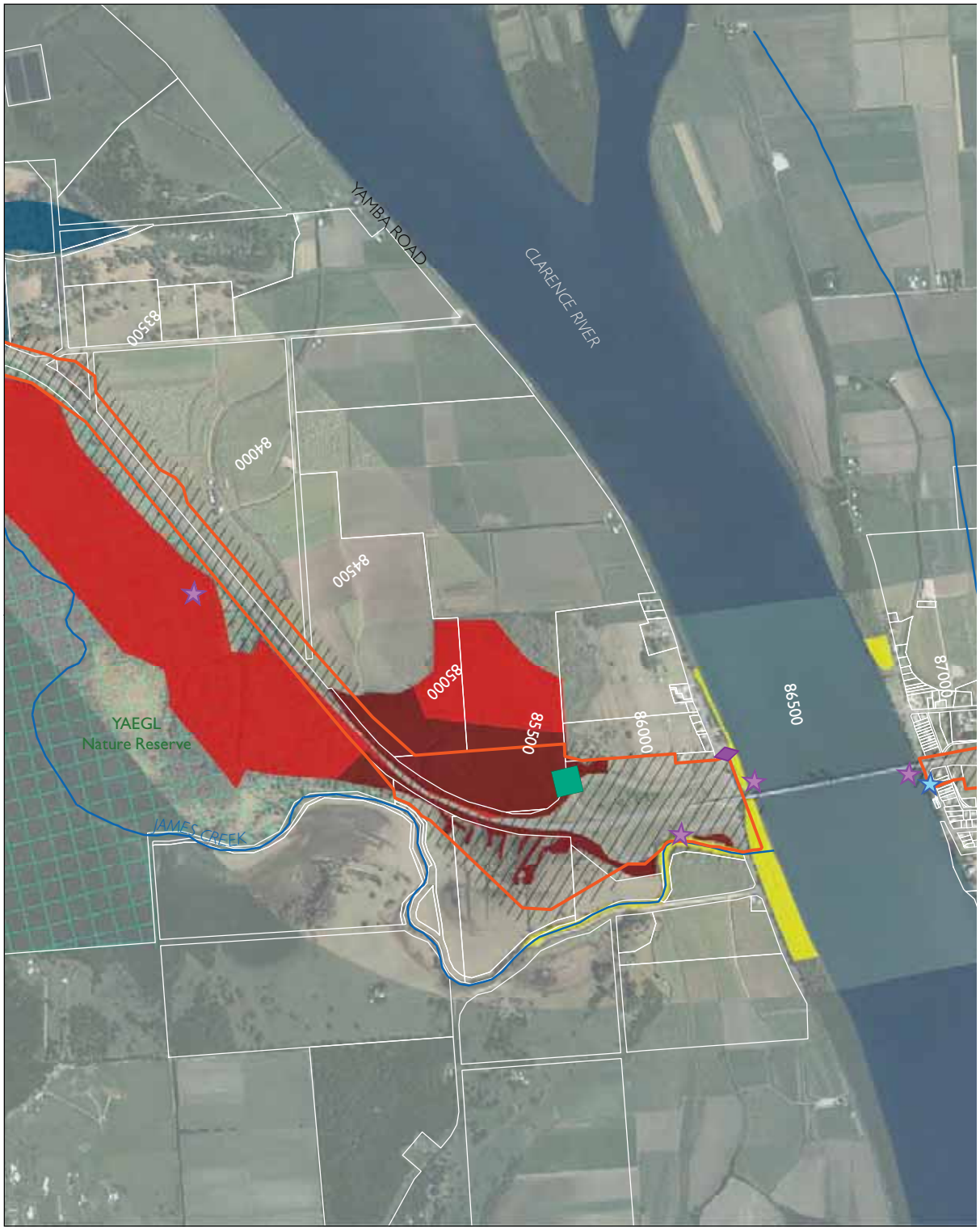
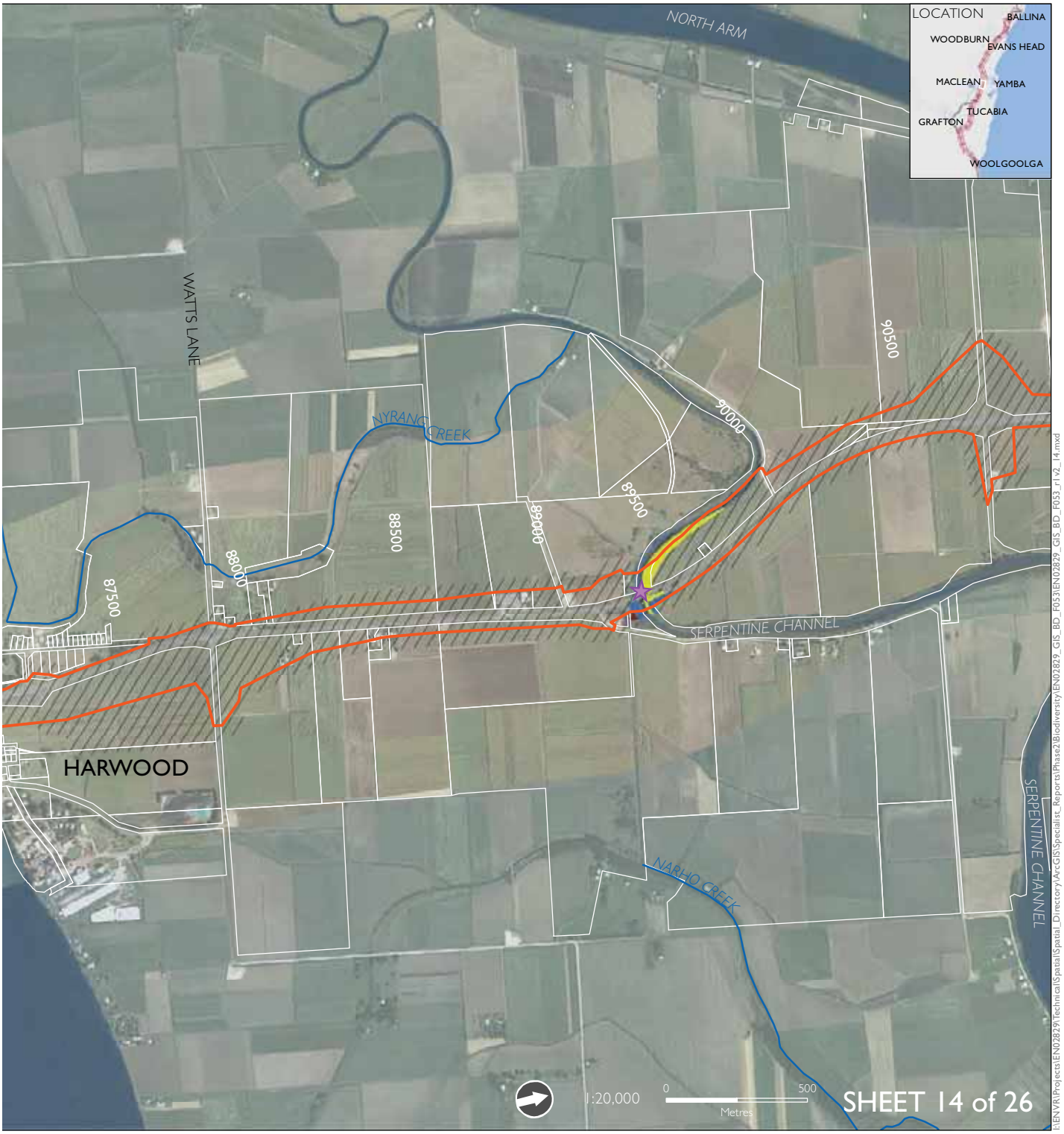
Figure 2-40 Fauna survey methods in the study area

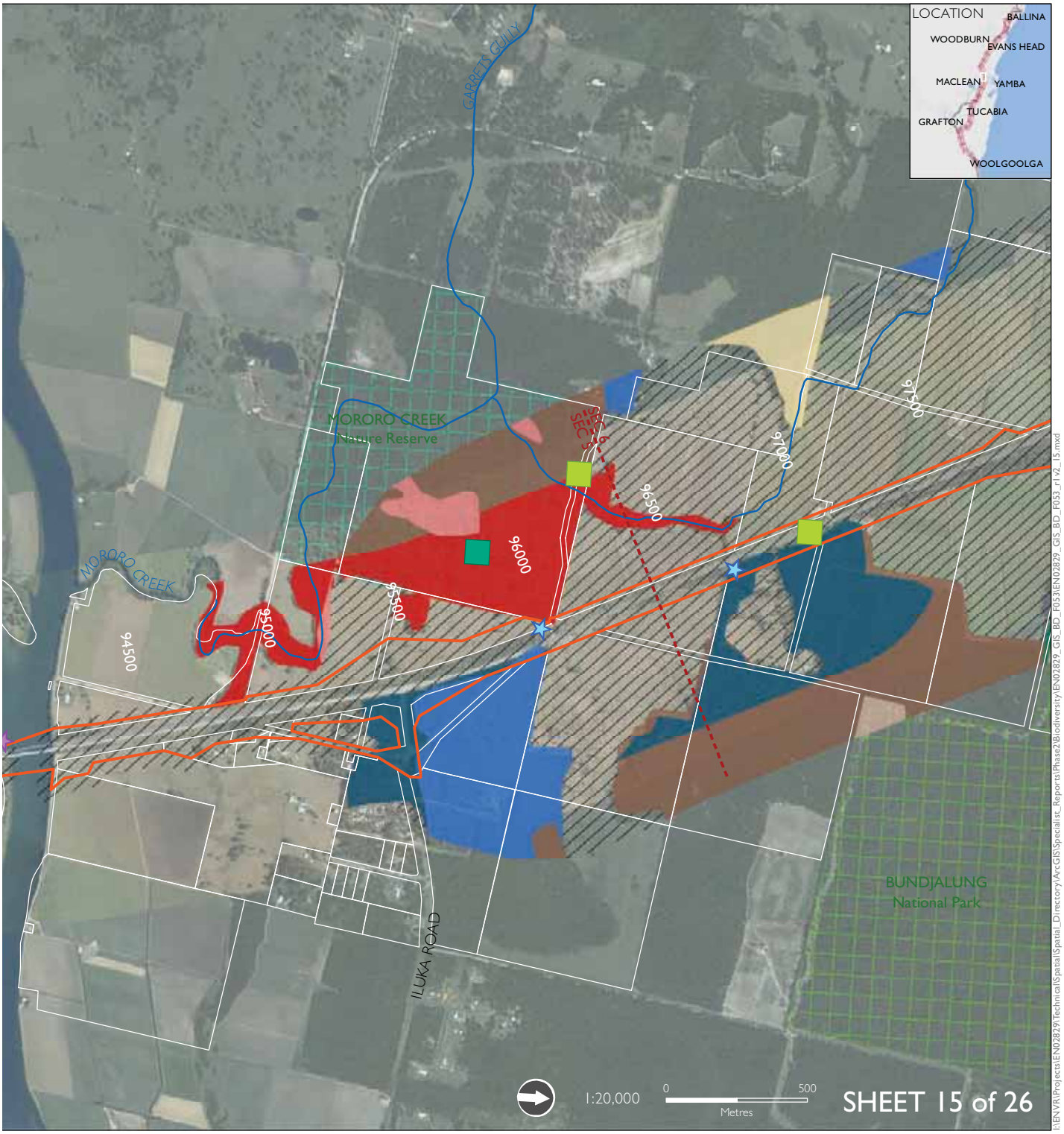




Vegetation communities

- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Cleared/modified

Figure 2-41 Fauna survey methods in the study area



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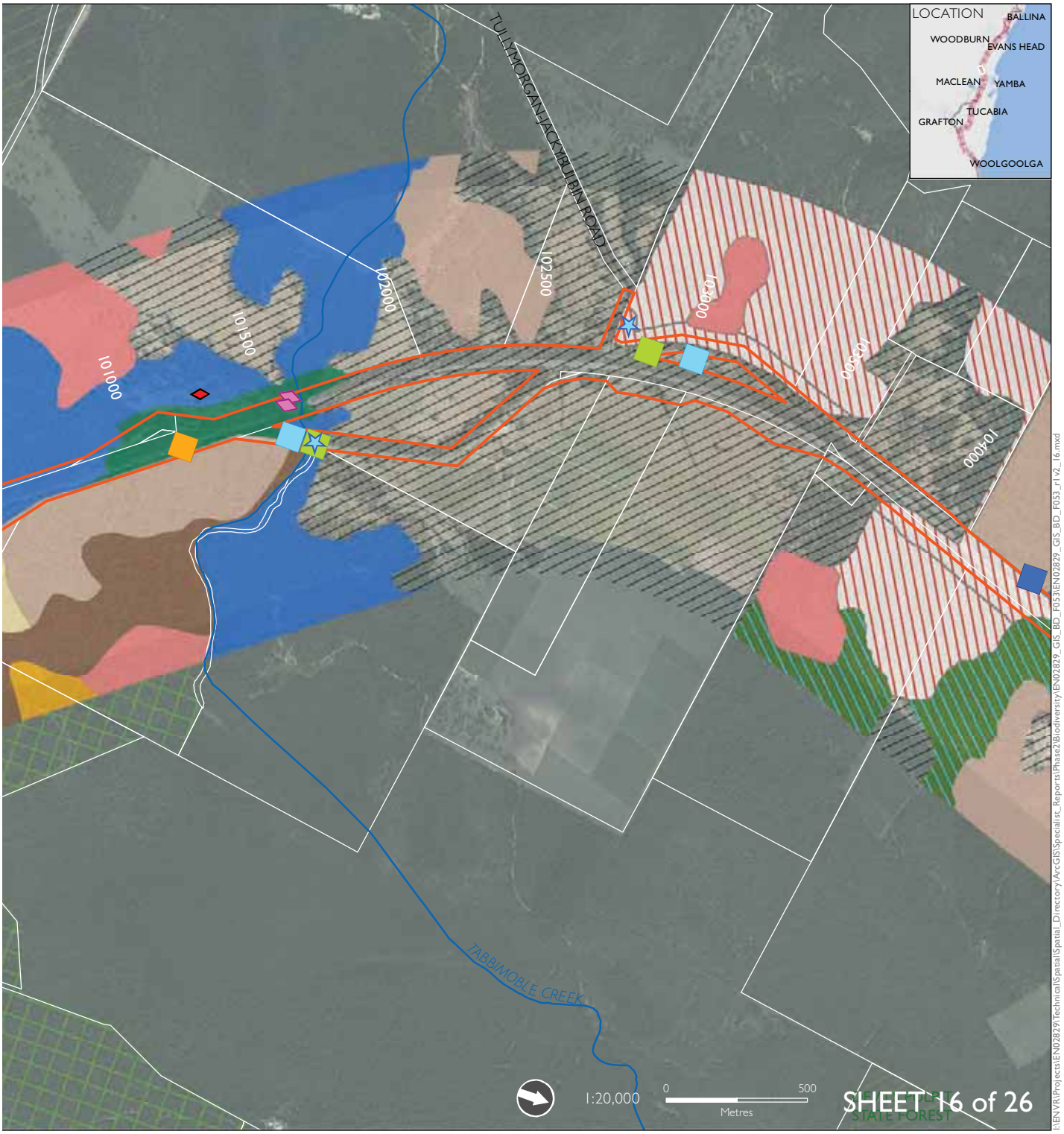
Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Cleared/modified

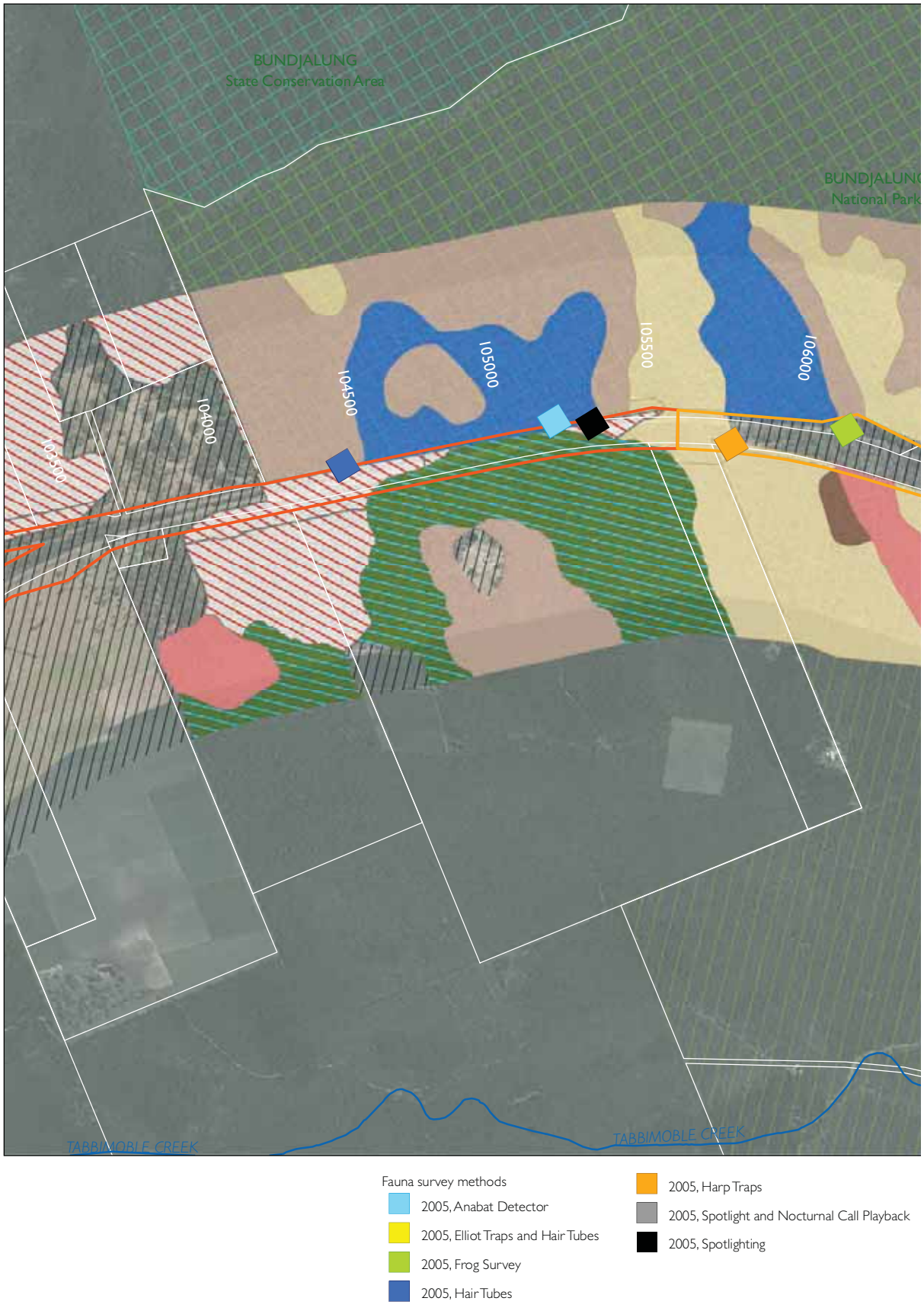
Figure 2-42 Fauna survey methods in the study area

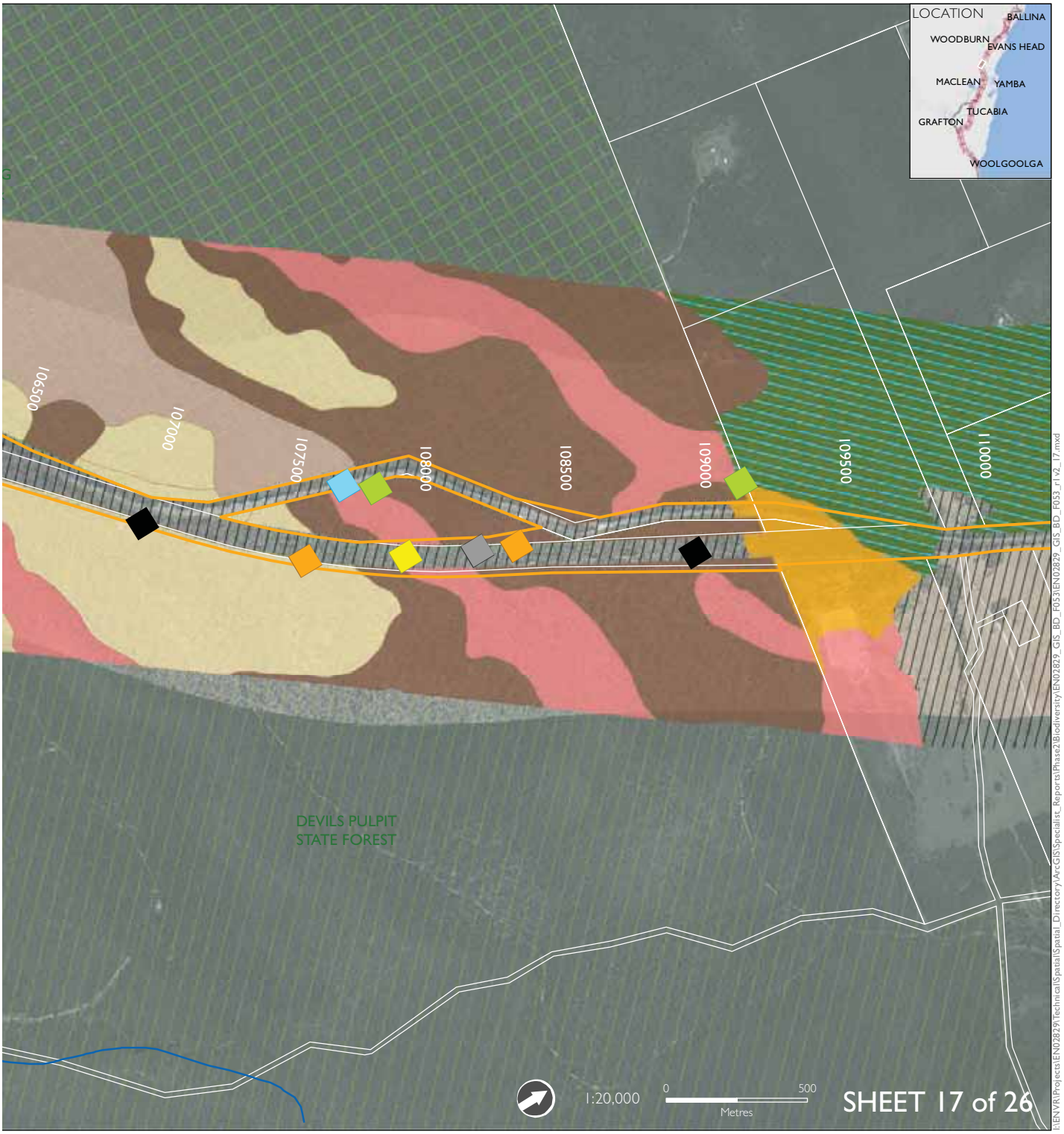


Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Tallowwood dry grassy forest of the far northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-43 Fauna survey methods in the study area

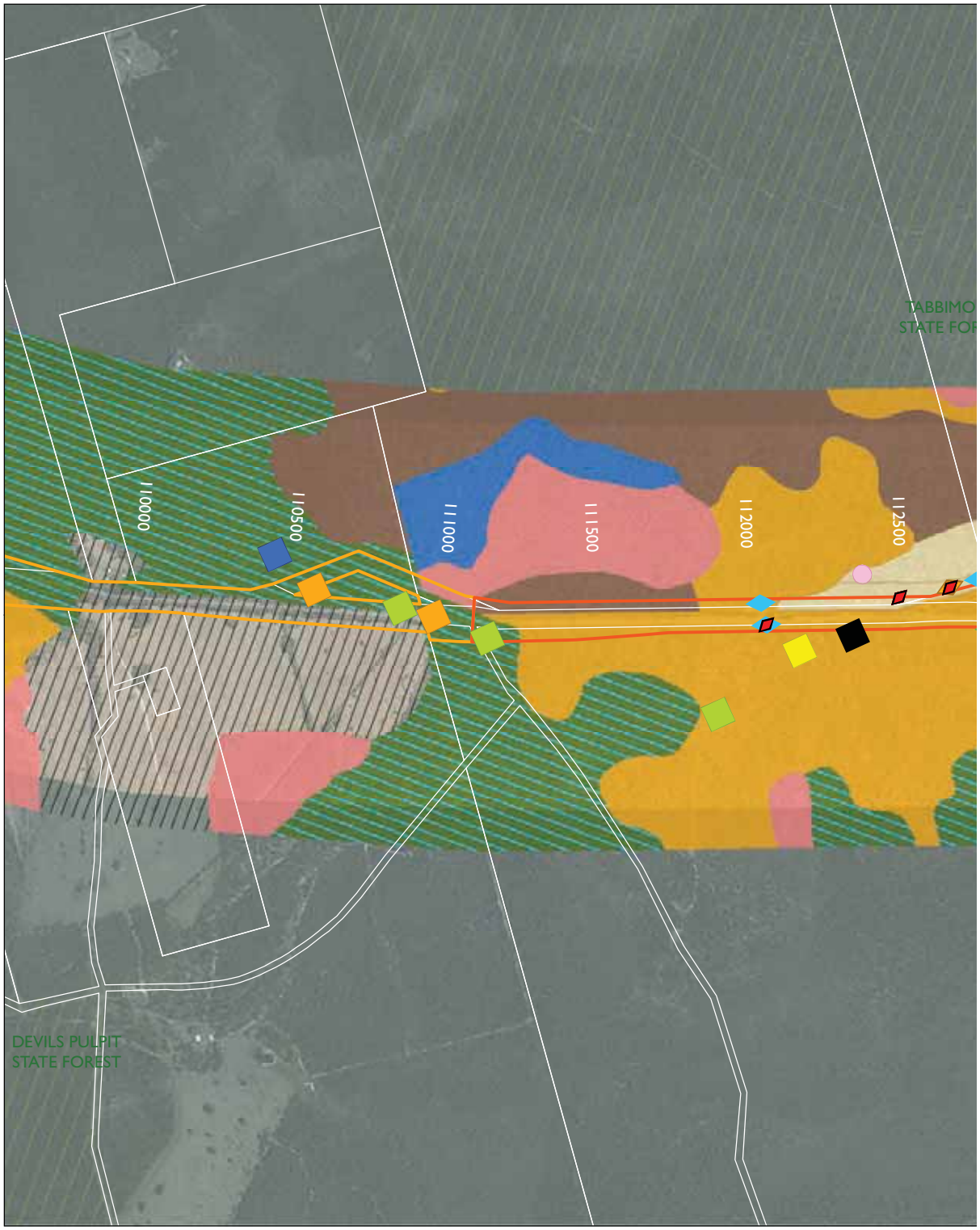




Vegetation communities

- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-44 Fauna survey methods in the study area

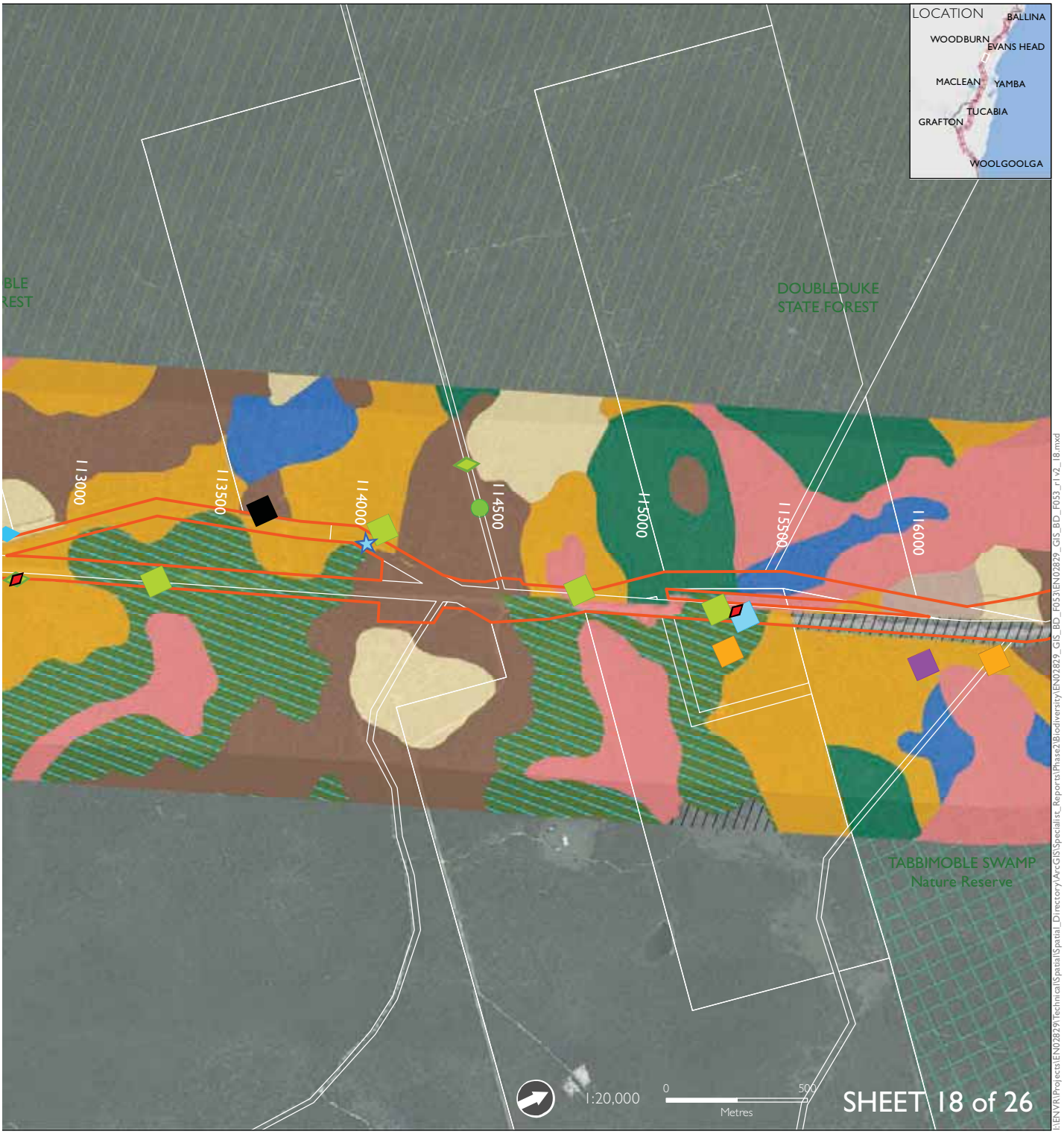


Fish survey site

2011

Fauna survey methods

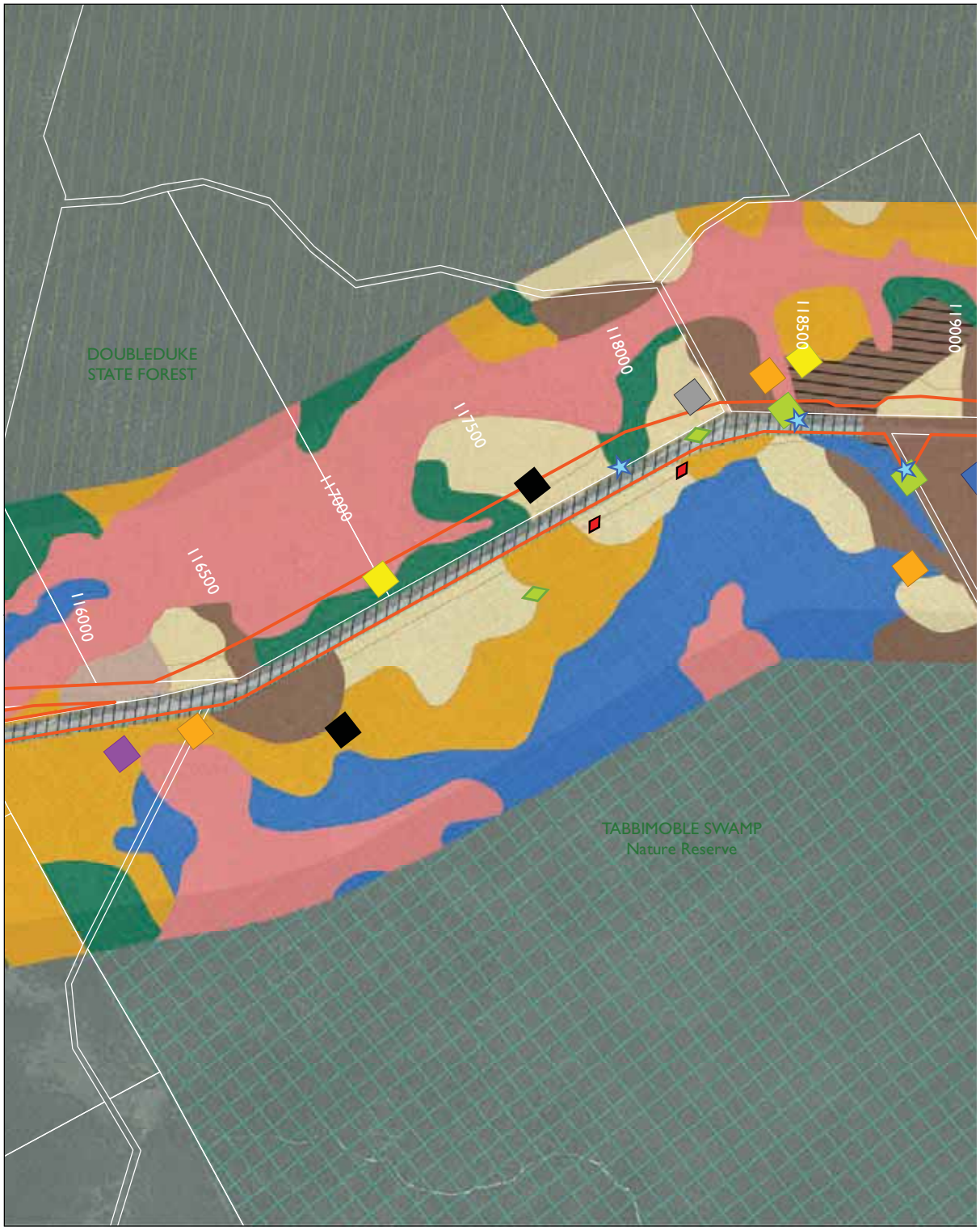
2005, Anabat Detector
2005, Elliot Traps
2005, Elliot Traps and Hair Tubes
2005, Frog Survey
2005, Hair Tubes
2005, Harp Traps
2005, Spotlighting
2009, Elliot Traps
2009, Habitat Assessment
2012, Bird Survey
2012, Elliot Traps
2012, Spotlight and Nocturnal Call Playback
2012, Spotlighting

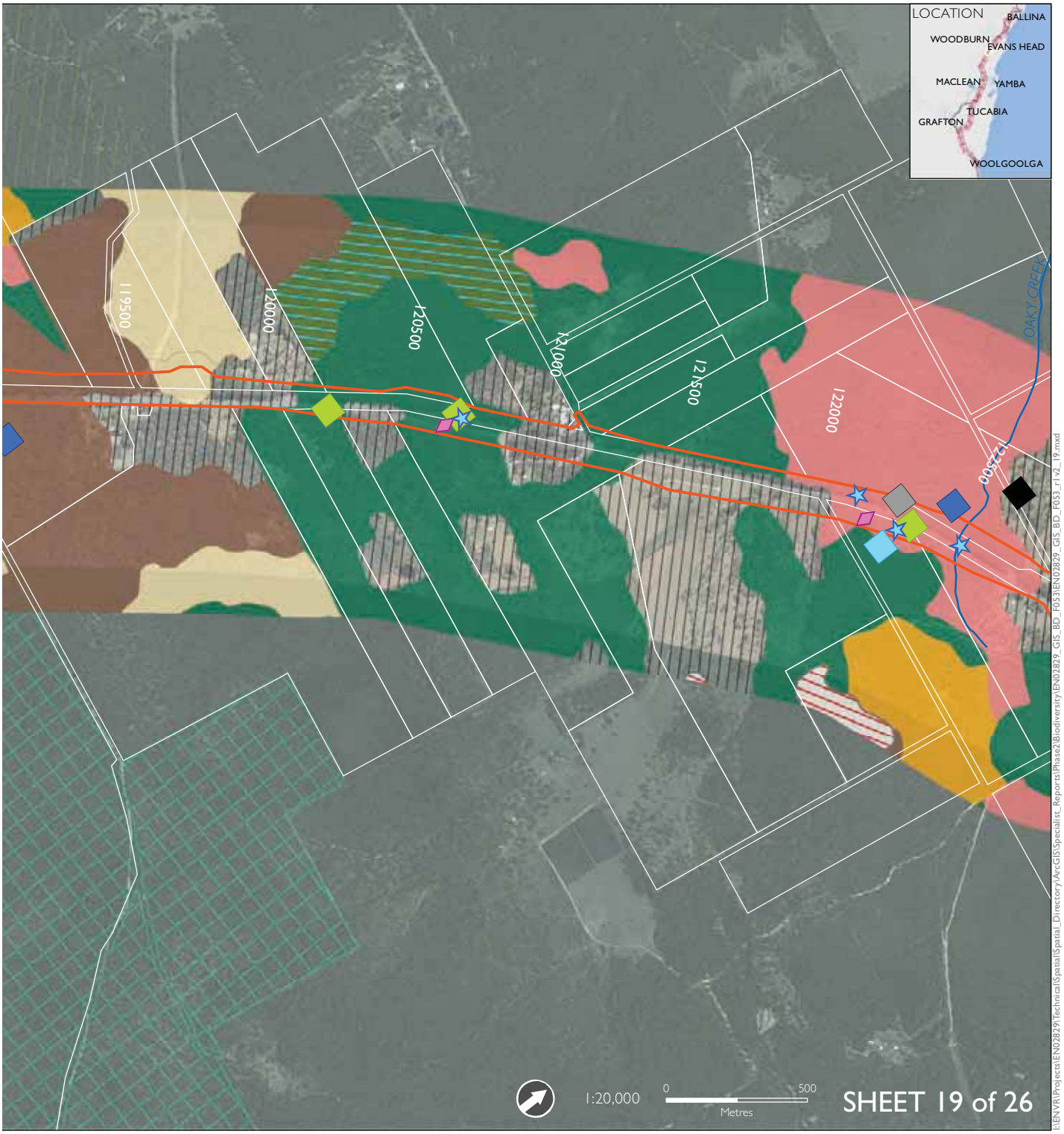


Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-45 Fauna survey methods in the study area

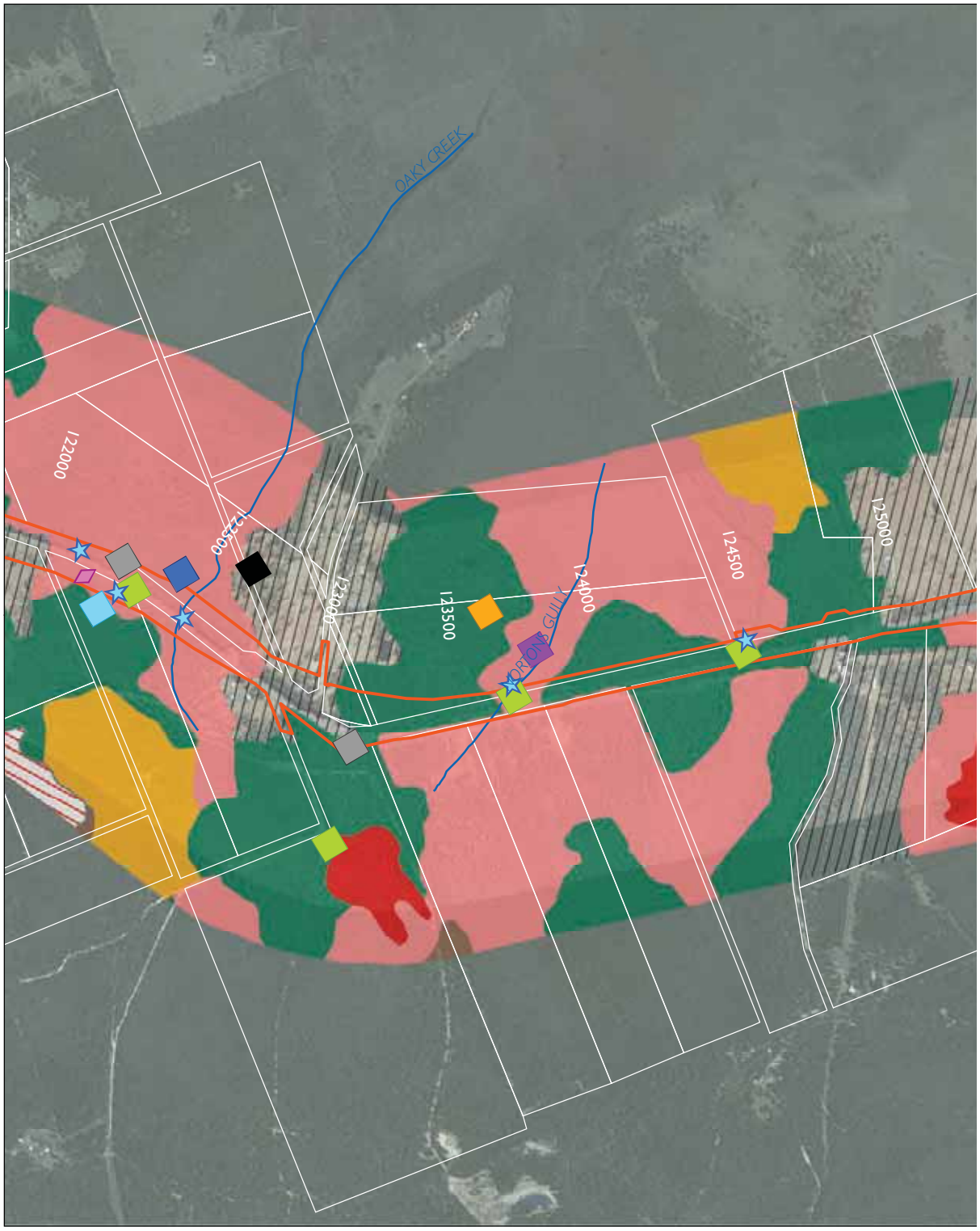


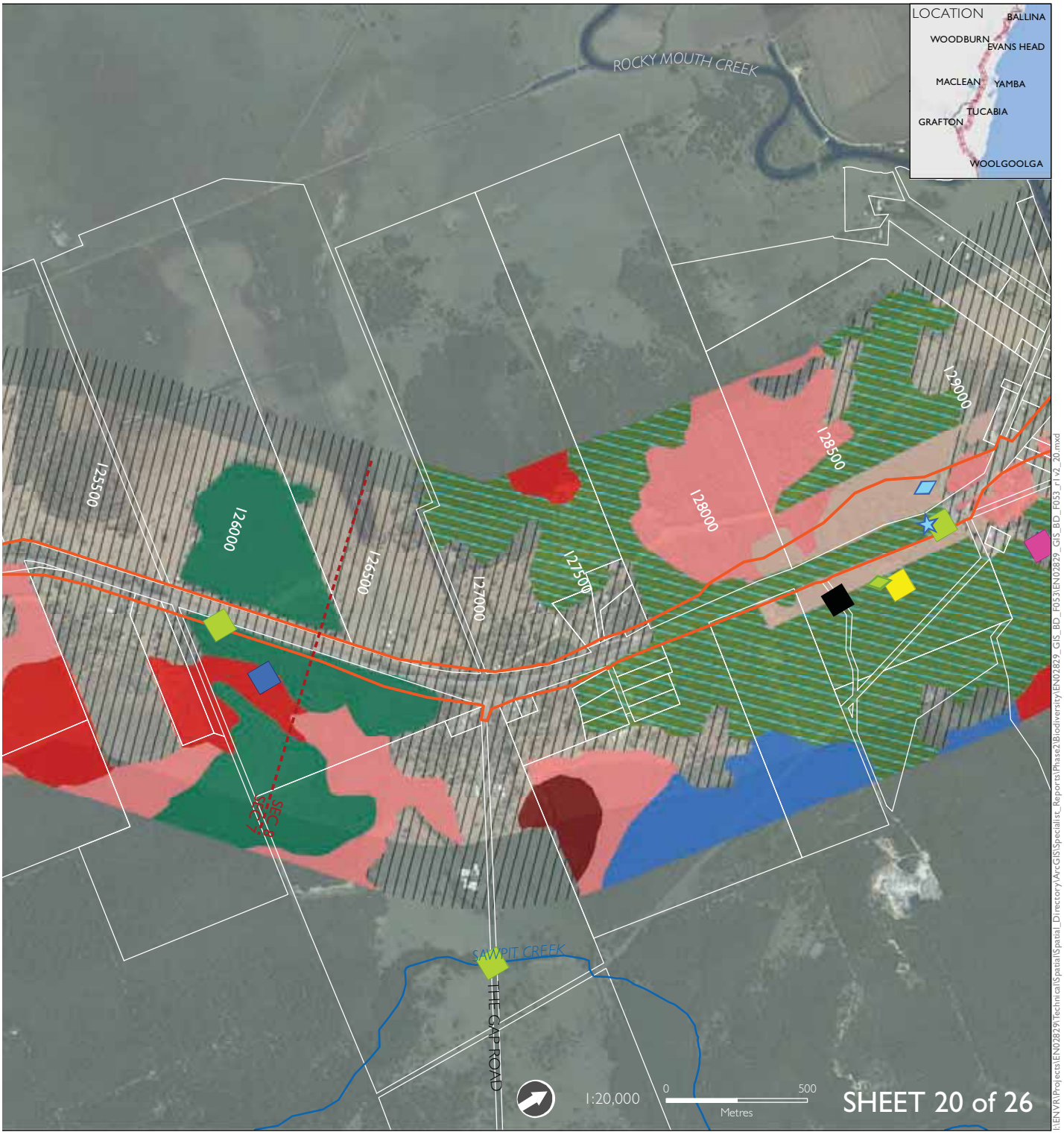


Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
- Cleared/modified

Figure 2-46 Fauna survey methods in the study area

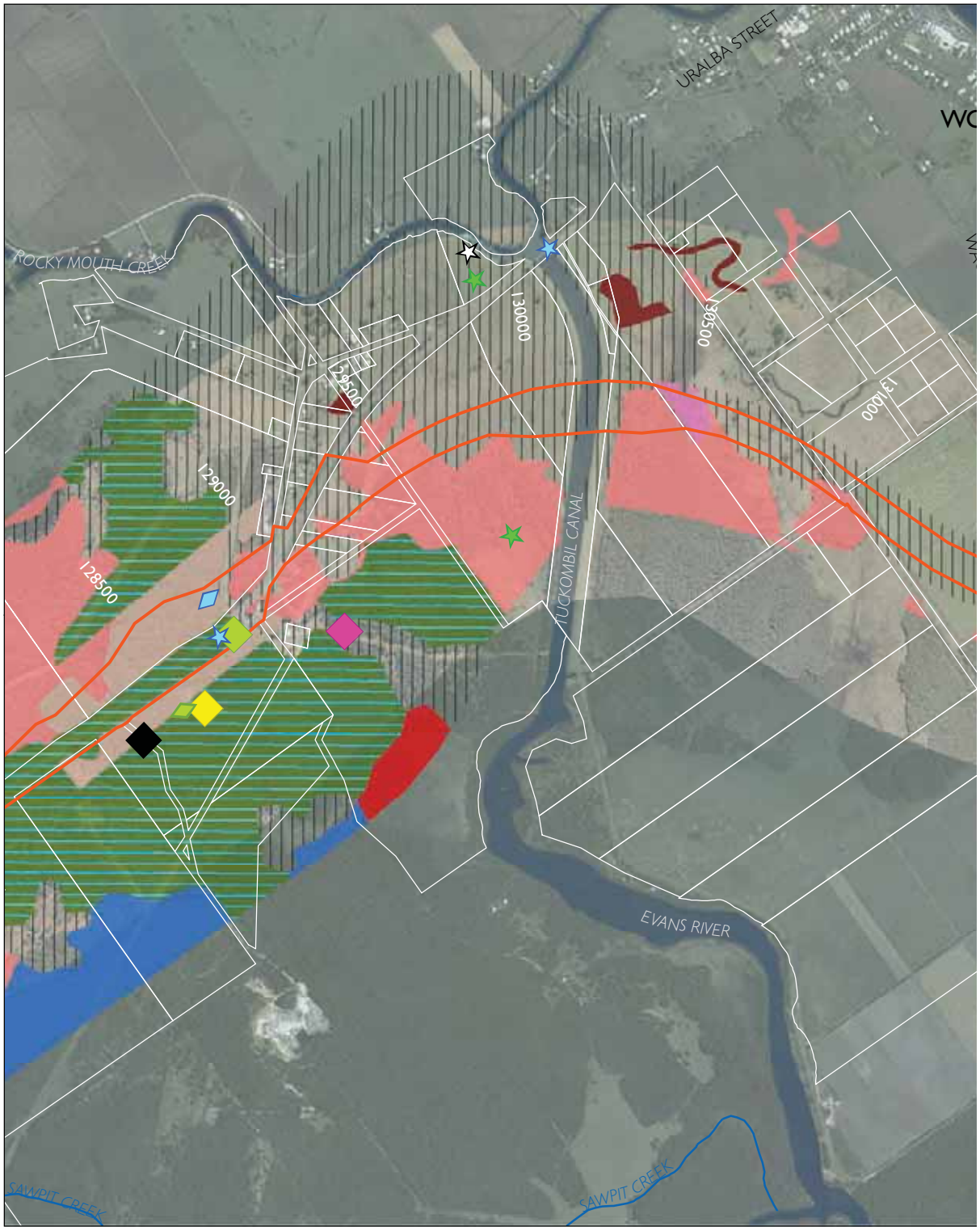


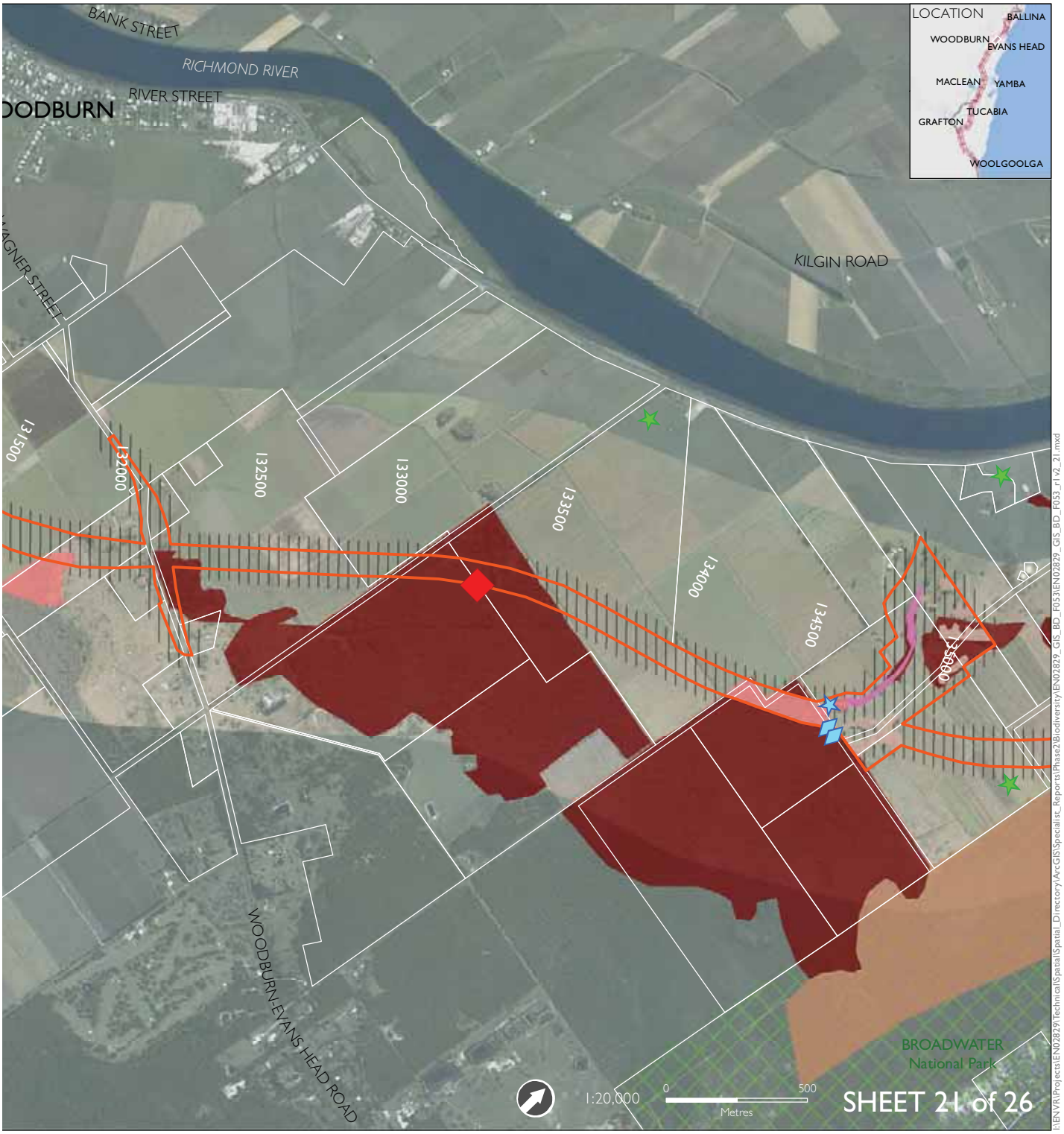


Vegetation communities

- Red Mahogany open forest of the coastal lowlands of the North Coast
- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Wet heathland and shrubland of coastal lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
- Cleared/modified

Figure 2-47 Fauna survey methods in the study area

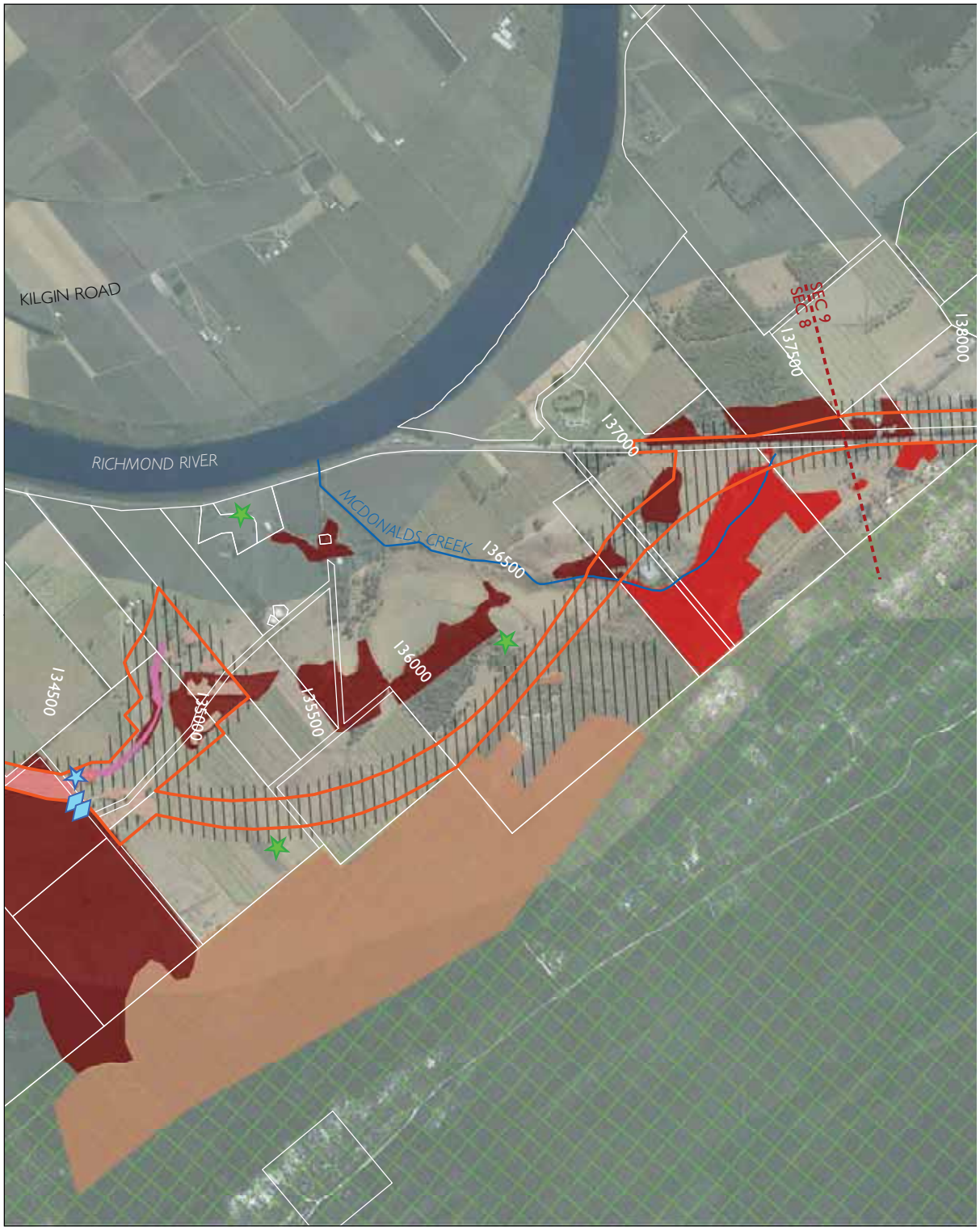


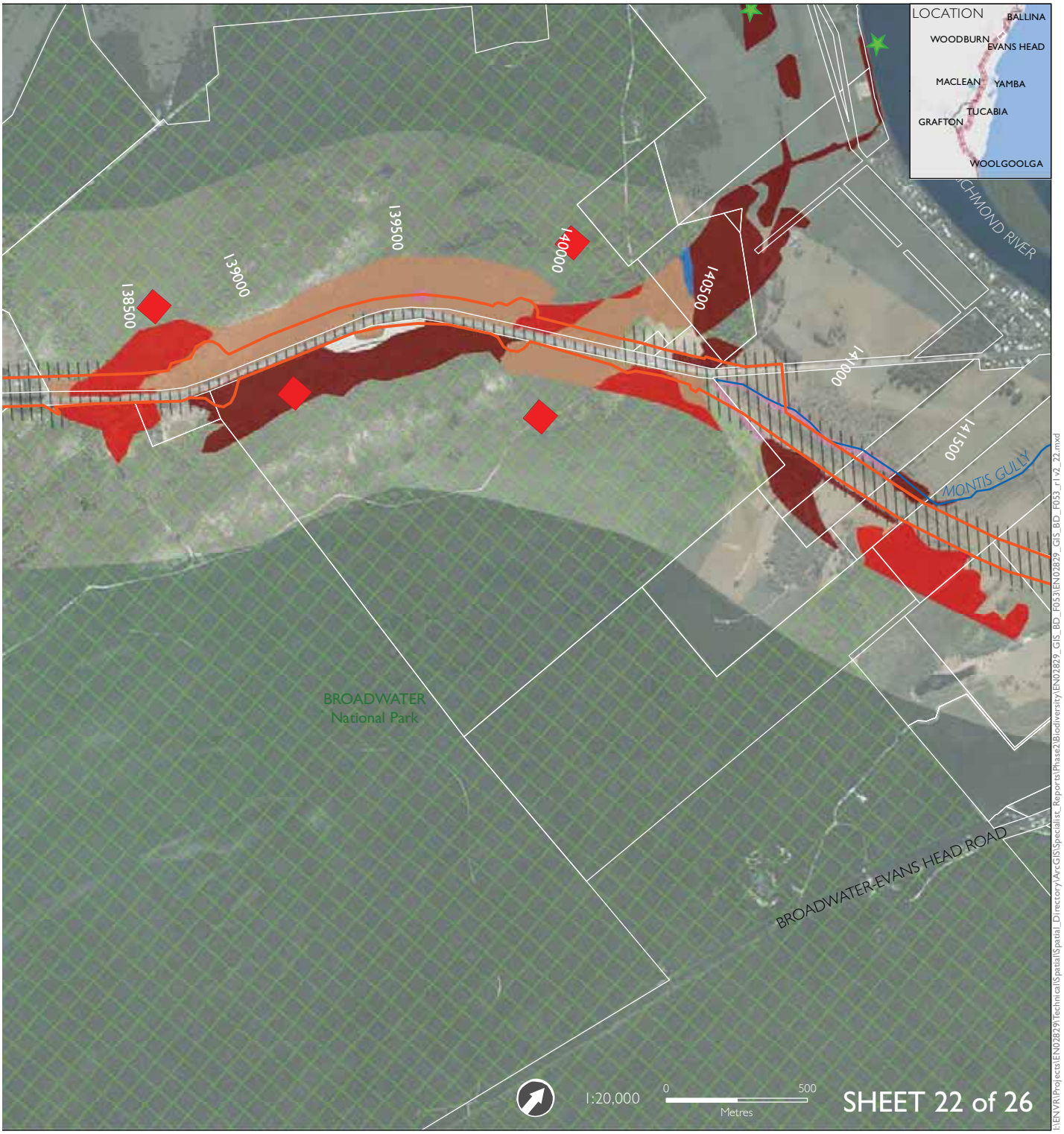


Vegetation communities

- Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-48 Fauna survey methods in the study area





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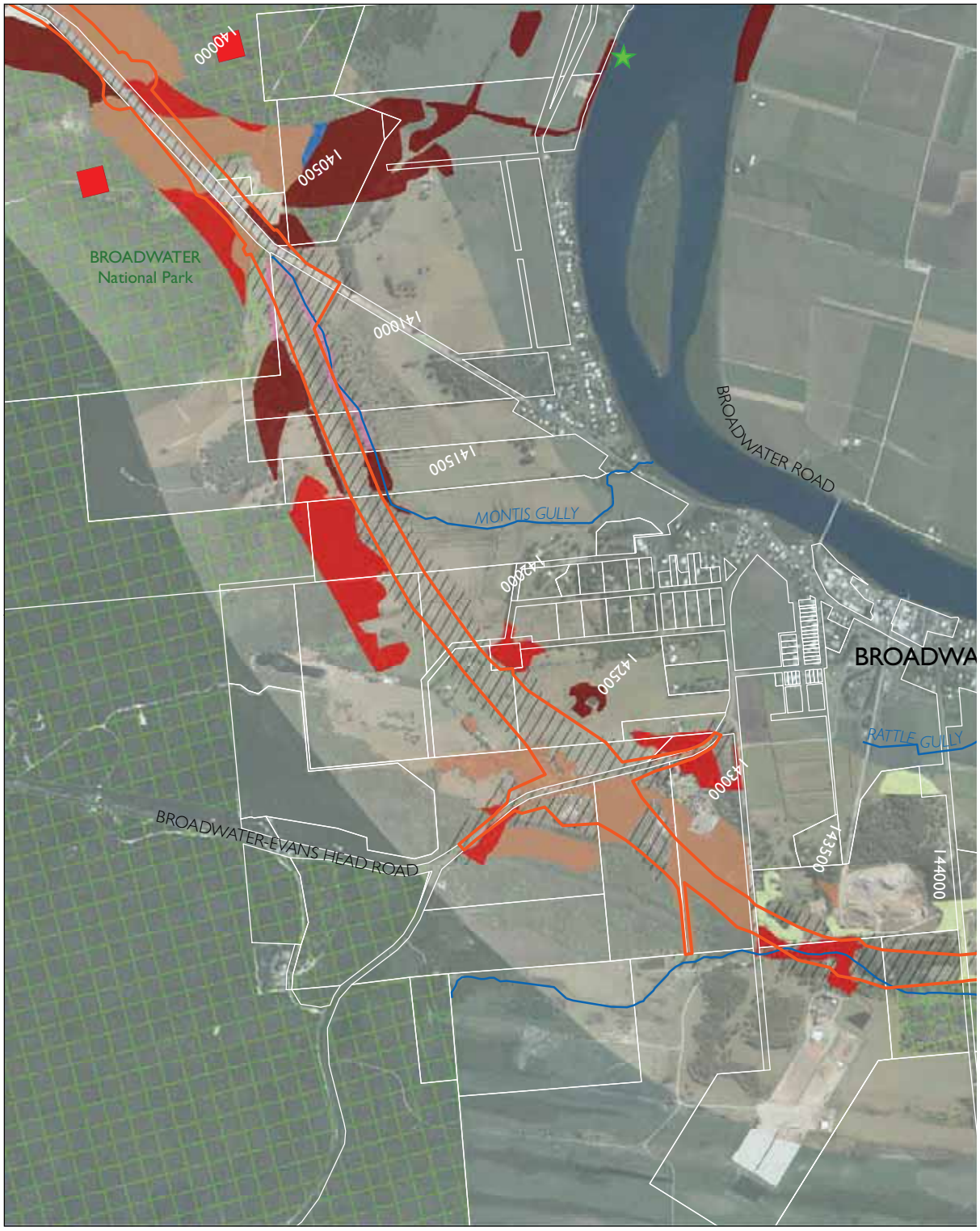
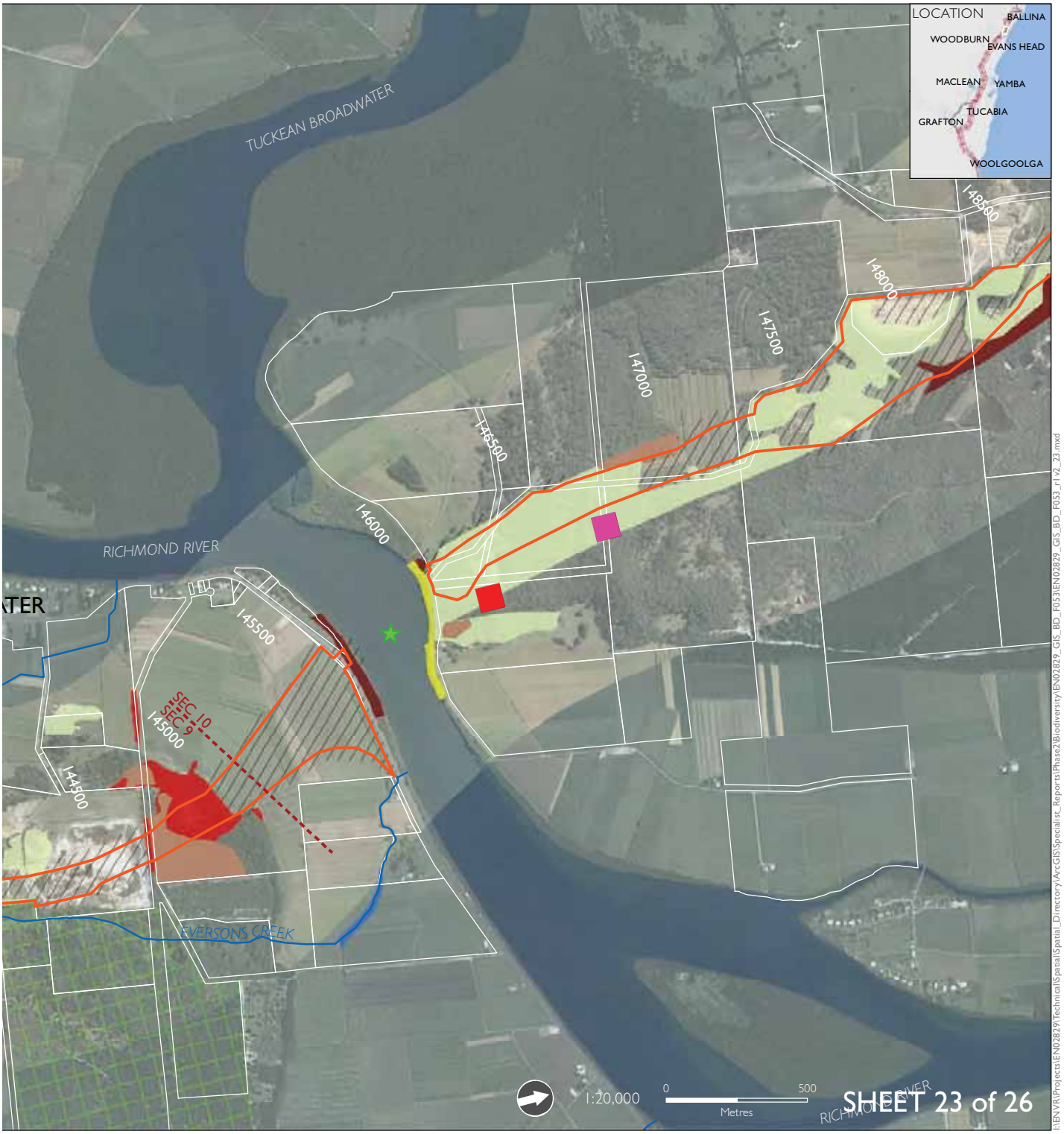
Vegetation communities

- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-49 Fauna survey methods in the study area

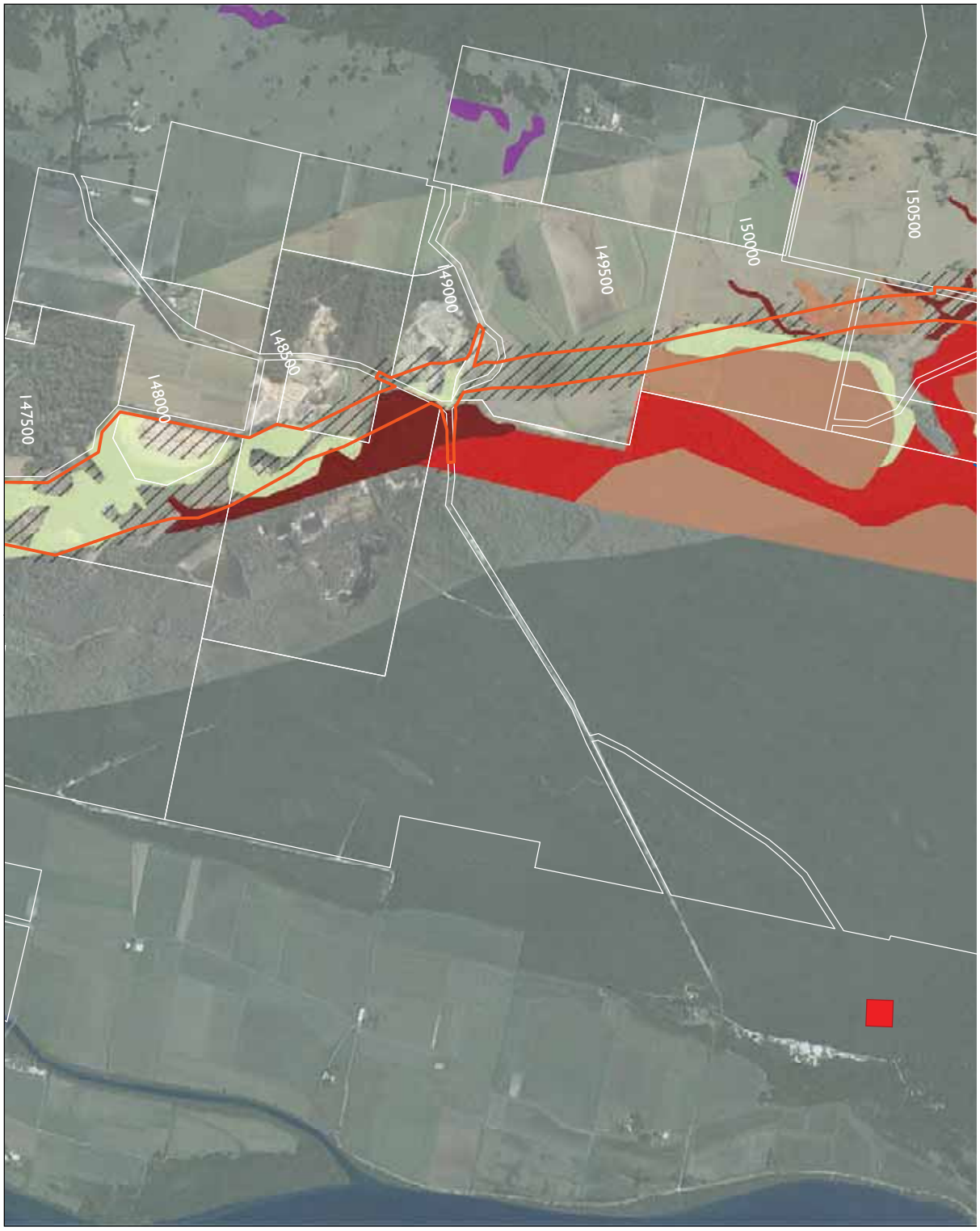


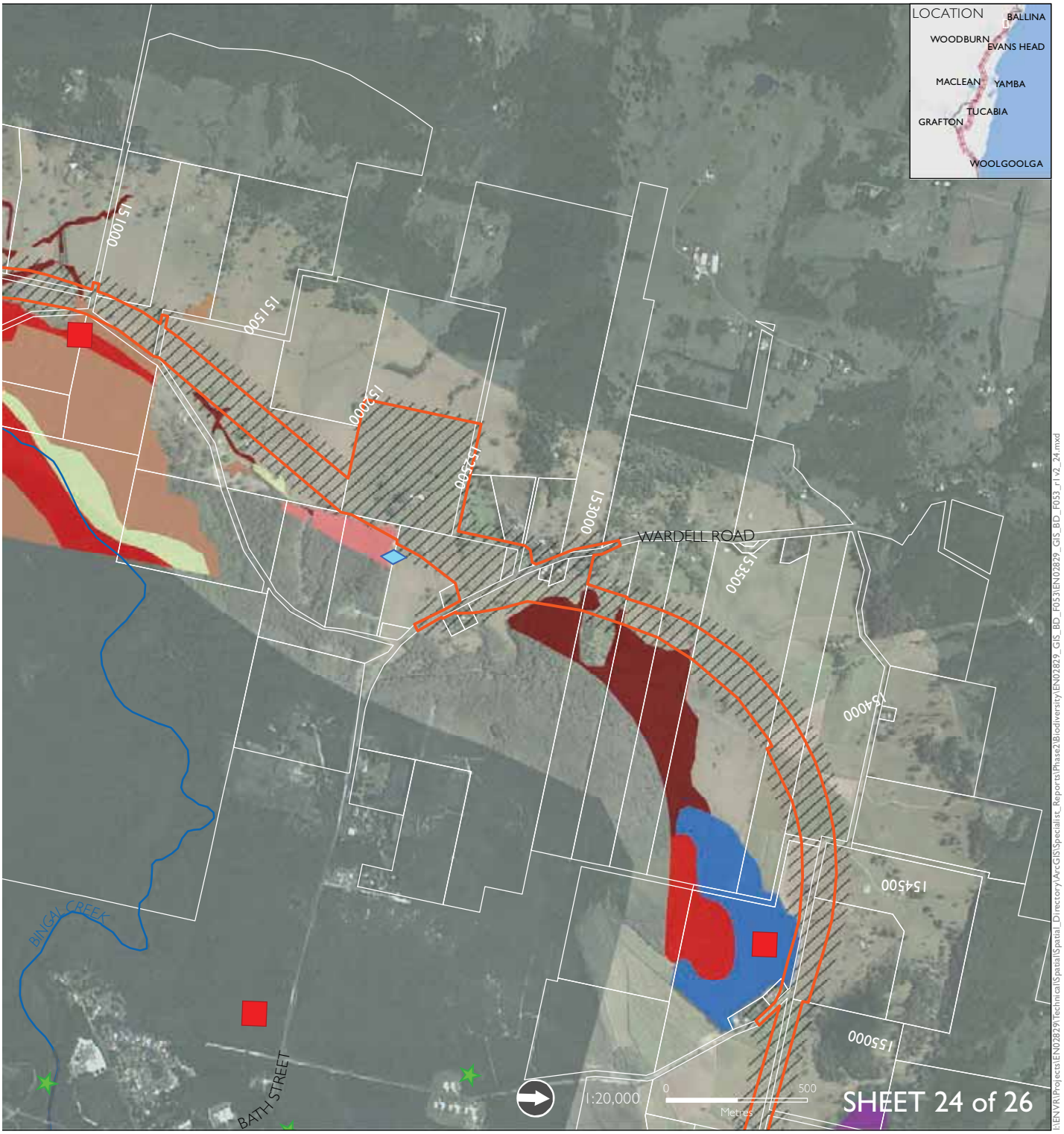


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Coastal heath on sands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Coastal floodplain sedgelands, rushlands, and forblands
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Cleared/modified

Figure 2-50 Fauna survey methods in the study area

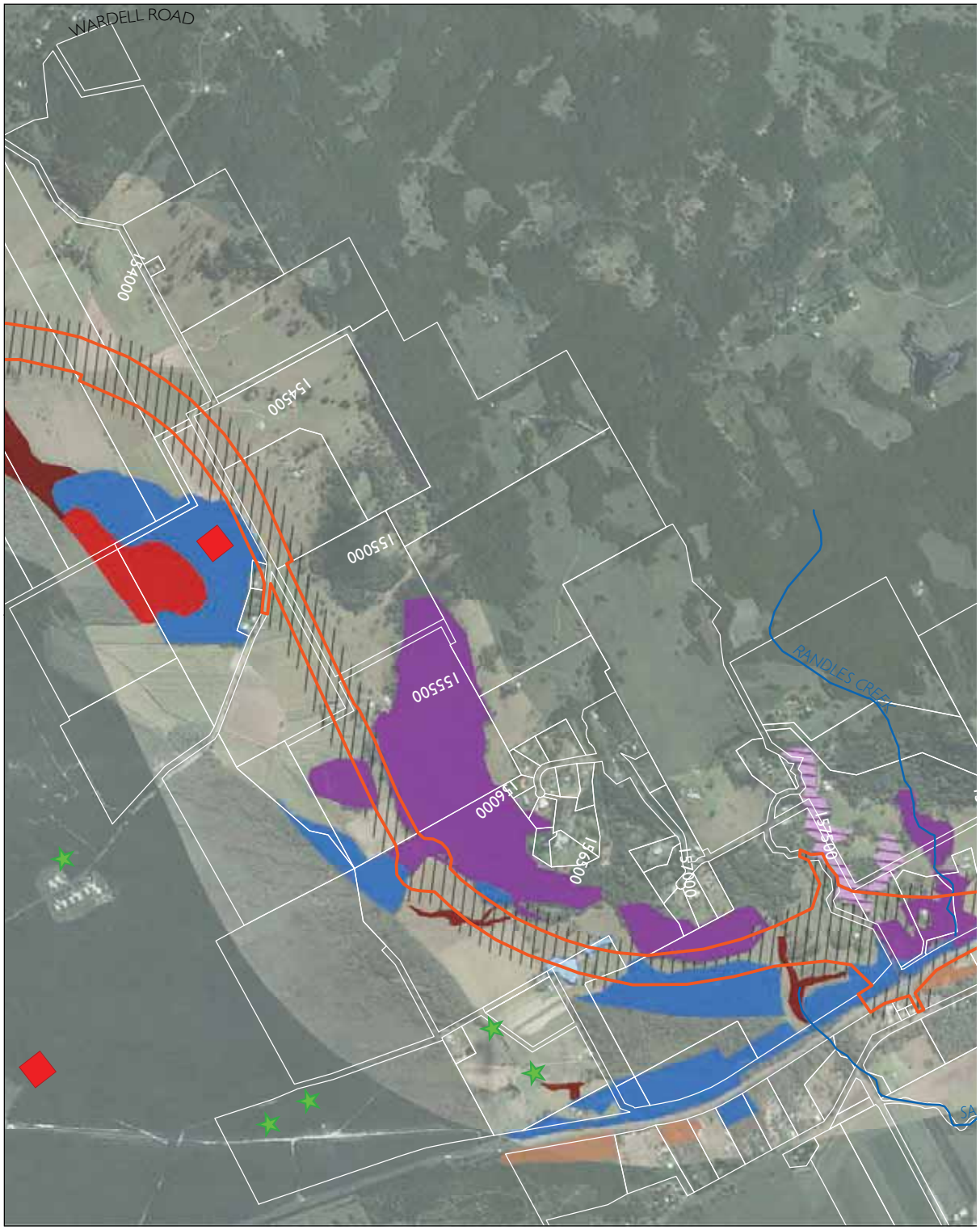


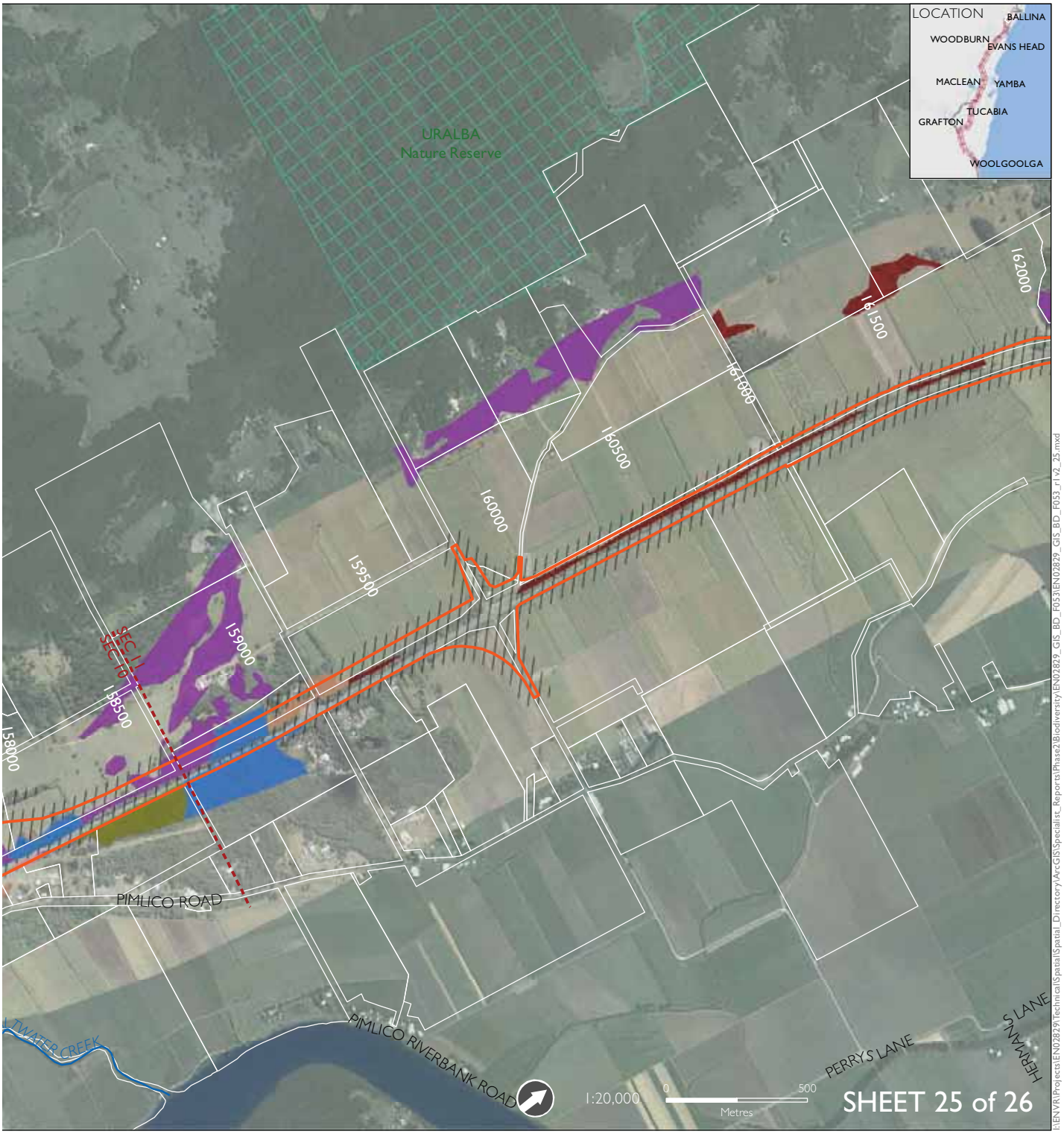


Vegetation communities

- Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- White Booyong - Fig subtropical rainforest of the North Coast
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
- Cleared/modified

Figure 2-51 Fauna survey methods in the study area





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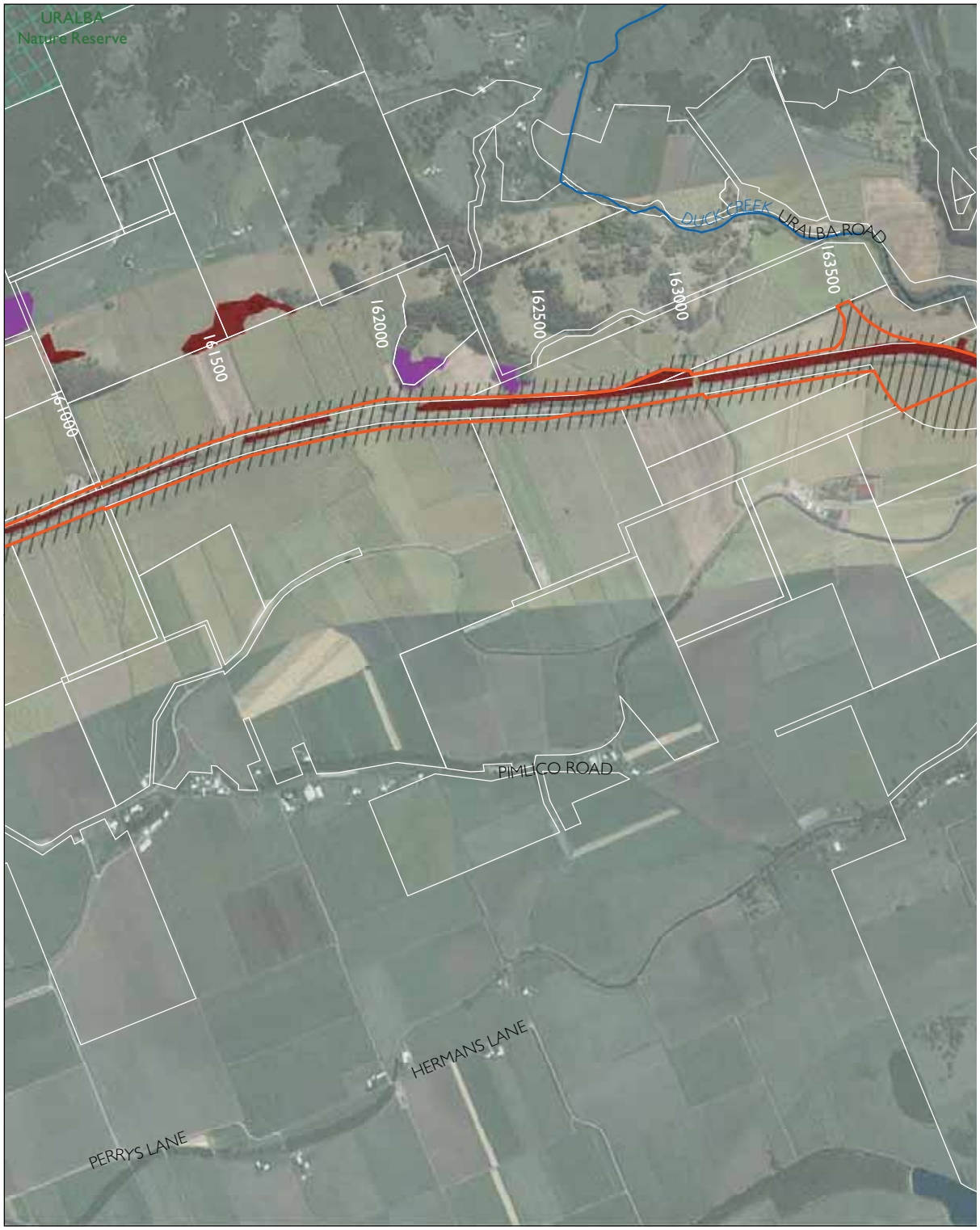
Vegetation communities

- Blackbutt - Paperbark Moist Open Forest
- Brush Box tall moist forest of the northern ranges of the North Coast
- Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
- Paperbark swamp forest of the coastal lowlands of the North Coast
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast
- White Booyong - Fig subtropical rainforest of the North Coast
- Coast Cypress Pine shrubby open forest of the North Coast Bioregion
- Cleared/modified

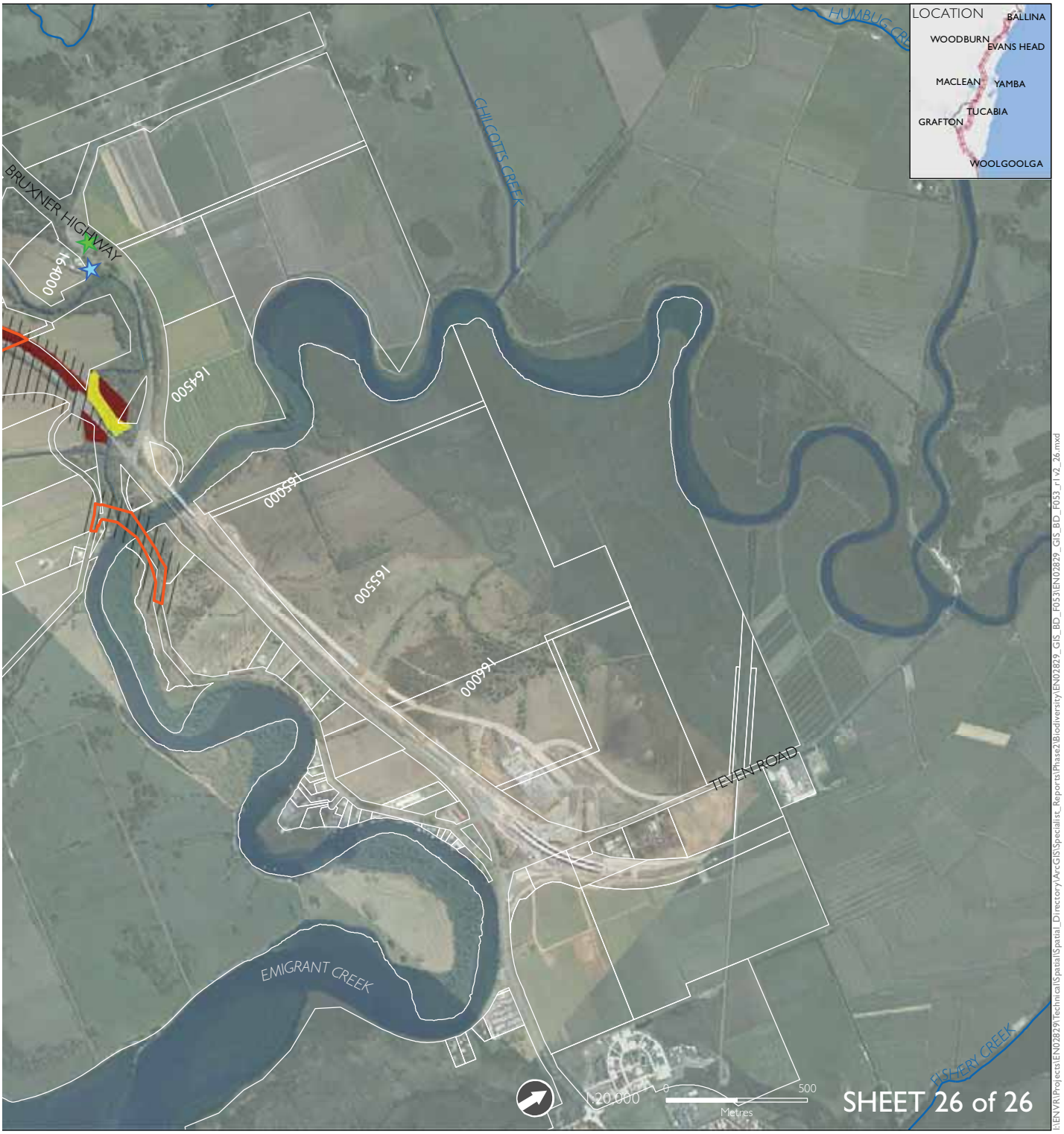
Figure 2-52 Fauna survey methods in the study area



Fish survey site

2005

2011



Vegetation communities

- Swamp Oak swamp forest of the coastal lowlands of the North Coast
- White Booyong - Fig subtropical rainforest of the North Coast
- Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
- Cleared/modified