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technical report

KEMPSEY TO EUNGAI – UPGRADING THE PACIFIC HIGHWAY

TECHNICAL REPORT 3 NOISE & VIBRATION ASSESSMENT

TA546-07F03 (REV 9) EA NV REP

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Prepared for:

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EXECUTIVE SUMMARY

The Roads and Traffic Authority (RTA) is developing a project to provide a 40.6 kilometre upgrade of the Pacific Highway, between Kempsey and Eungai on the mid north coast. The proposed Upgrade will increase the traffic carrying capacity of the Pacific Highway, however it is not anticipated to change the traffic mix or cause a significant increase in traffic volumes, other than through natural growth.

The purpose of this report is to assess the potential noise and vibration impacts associated with the construction and operation of the proposed Pacific Highway Upgrade – Kempsey to Eungai. Road traffic noise impacts are assessed in accordance with the:

- NSW Environmental Criteria for Road Traffic Noise (ECRTN), Environment Protection Authority, 1999.
- Environmental Noise Management Manual (ENMM), Roads & Traffic Authority, 2001.

Construction noise, vibration and blast impacts are assessed in accordance with:

- NSW Environmental Noise Control Manual (ENCM), Environment Protection Authority, 1994.
- Australian Standard AS2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites".
- "Assessing Vibration: a technical guideline", NSW Department of Environment and Conservation, 2006
- German Standard DIN 4150-Part 3: 1999 "Structural vibration - Effects of vibration on structures".
- British Standard BS7385: Part 2 "Evaluation and measurement of vibration in buildings".
- Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (Australian & New Zealand Environment Council, 1990)

Long-term unattended noise monitoring was undertaken at representative locations to determine the existing acoustic environment along the proposed Upgrade route. The measured levels were used to establish applicable road traffic noise criteria and construction noise criteria for the proposed Upgrade.

The United Kingdom Department of Environment manual entitled "Calculation of Road Traffic Noise (1988)" or CoRTN (1988) method, adapted to Australian conditions, was the selected traffic noise prediction model for the proposed Upgrade. Future traffic noise levels as a result of the proposed Upgrade were predicted based on traffic volume and road concept design information provided by Parsons Brinckerhoff. Noise levels were predicted for the year of the Proposed Upgrade opening and for ten years after the Proposed Upgrade opening, for both Un-Staged and Staged options.

Noise modelling of the proposed Upgrade project, prior to any further noise mitigation measures, found that a number of residences would be exposed to road traffic noise levels in excess of the NSW traffic noise criteria. Ten years after opening, year 2021, up to 55% of the 120 identified noise receivers during the day and 73% of the 116 identified residences at night would be exposed to traffic noise levels in excess of the NSW traffic noise criteria. Assessment of other sensitive receivers along the route found that the Kempsey Adventist Church would also be exposed to traffic noise levels that marginally exceed suitable traffic noise criteria in year 2021.

Noise contour maps presenting road traffic noise generated by the proposed Upgrade for the years 2011 and 2021 are provided in Appendix E.

Due to the sparse density of residential premises along the route, it was generally found that provision of 'at-road' noise mitigation treatment such as low-noise pavement and noise barriers was not reasonable. Where residences are gathered in groups of more than 3, the use of noise barriers to reduce road traffic noise levels was investigated. There may be an option to provide noise barriers, or a combination of noise barriers and low-noise pavement at Noise Catchment Areas (NCAs) 6, 7, 8 and 9 (between stations 3500 and 5700). For other, usually stand alone residences along the route, 'at-house' or architectural treatment can be provided to reduce the impacts of road traffic noise on internal noise levels. Further investigation of noise mitigation treatment should be undertaken at the detailed design phase.

Construction noise is likely to impact residences located close to the proposed Upgrade route. As residential premises along the proposed Upgrade route are at distances of approximately 30m or more from the proposed road works to the nearest residences, it is unlikely that vibration generated by construction activity will exceed the limits for human comfort as set by the NSW Department of Conservation. In-principle noise and vibration mitigation measures are provided to reduce noise and vibration impacts during construction to acceptable levels.

There is potential for blasting impact to occur, should blasting be required to remove hard rock material from two cuttings south of the Macleay River, at STN 1300 and STN 300. Recommendations have been provided for the management of blast impact. Further predictions of noise and vibration from blasting should be conducted once more details of blasting usage during the proposed Upgrade are known, so that buffer zones and blast charge limits can be set.

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1. INTRODUCTION

1.1 OVERVIEW

In July 2004, the NSW Minister for Roads announced the eastern route (passing east of Kempsey and Frederickton) and sub-options as the preferred route for the proposed Kempsey to Eungai Pacific Highway Upgrade (the 'proposed Upgrade').

Since the announcement of the preferred route, the NSW Roads and Traffic Authority (the RTA) has conducted extensive community consultation, environmental and engineering investigations to help develop a concept design for the proposed Upgrade. The design reflects a sustainable and acceptable outcome by minimising impacts on the environment and the local community.

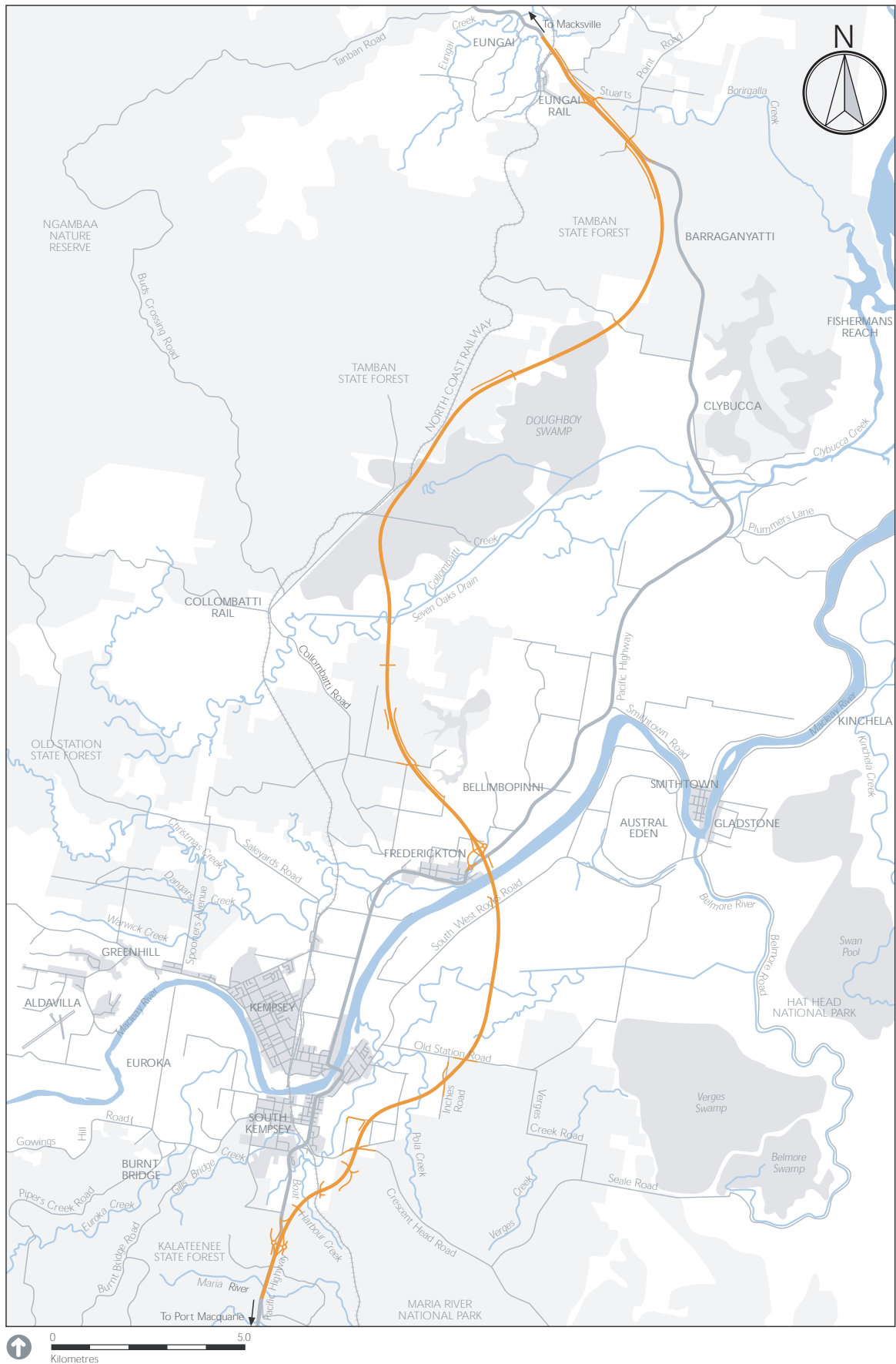
The proposed Upgrade involves the construction of approximately 40 kilometres of four-lane divided carriageway (capable of being upgraded to six lanes), from the existing Pacific Highway dual carriageway south of Kempsey, to the existing Pacific Highway dual carriageway north of Eungai Rail. The proposal is shown in Figure 1.

The proposed Upgrade would diverge in an easterly direction from the existing Pacific Highway south of Kempsey, pass over the Macleay River flood plain and cross the Macleay River north-east of Frederickton. From Frederickton, the proposed Upgrade would move to the west of the existing Pacific Highway through Collombatti and the edge of the Tamban State Forest, and north through Barraganyatti and Eungai Rail to join the existing highway.

Other features of the proposed Upgrade include:

- construction of bridging over the Macleay River and its flood plain in the Frogmore area
- provision of 20-year flood immunity for the highway south of the Macleay River crossing and 100-year flood immunity for the highway north of the Macleay River crossing
- provision of grade-separated interchanges at three locations:
 - o at South Kempsey — south of the South Kempsey industrial area providing access to the town of Kempsey
 - o at Frederickton — between Frederickton Golf Course and sewage treatment plant, providing access to the town of Frederickton, Smithtown and Gladstone
 - o at Stuarts Point Road — south of Eungai Rail, connecting the areas of Barraganyatti and Eungai Rail to the highway and providing access to Stuarts Point.
- construction of a flood levee at Frederickton, providing 100-year flood immunity to residential and commercial premises.

The alignment would be integrated with the existing terrain and landscape, retaining views across the flood plain, rural areas and bushland. Rest areas, emergency access and U-turn facilities would be provided at appropriate locations along the highway.



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Figure 1 : Locality Map

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: NTS

Ref : TA546-07P01 (rev 0)

1.2 PURPOSE OF THE REPORT

The Pacific Highway is the main transport corridor serving the north coast of New South Wales. It provides a major transport link between Sydney and Brisbane. The highway carries significant traffic volumes, particularly during holiday periods.

The proposed Upgrade will increase the traffic carrying capacity of the Pacific Highway, however it is not anticipated to change the traffic mix or cause a significant increase in traffic volumes, except that which occurs through natural or background growth. The proposed Upgrade, which will improve traffic conditions through both Frederickton and Kempsey, will provide improved road safety, reduced travel times and, in terms of acoustic impact, will significantly improve the acoustic environment of many residential and commercial premises currently affected by the Pacific Highway.

The purpose of this report is to assess the potential noise and vibration impacts associated with the construction and operation of the proposed Pacific Highway Upgrade – Kempsey to Eungai. The study identifies sensitive locations and assesses potential noise and vibration impacts against noise and vibration criteria developed by the NSW Department of Environment and Conservation (DEC, previously Environment Protection Authority). The issues addressed in this study include:

- Noise emissions during construction of the proposed Upgrade, which are assessed using criteria in the NSW *Environmental Noise Control Manual* (1994);
- Vibration emissions during construction of the proposed Upgrade, which are assessed using criteria in the NSW DEC's *Assessing Vibration: A Technical Guideline* (2006); and
- Noise emissions from traffic travelling along the proposed Upgrade after its completion, which are assessed using criteria in the NSW *Environmental Criteria for Road Traffic Noise* (1999).

The NSW RTA's *Environmental Noise Management Manual* (2001) also provides guidance on the application of the *Environmental Criteria for Road Traffic Noise* and other road traffic noise matters.

1.3 SCOPE AND APPROACH

The scope and approach to assessing noise impact from the proposed Upgrade was to firstly quantify the existing acoustic environment through noise monitoring. This was used to establish project specific noise criteria for the proposed Upgrade. Noise models were then established for the construction and operation phases. Finally, the results of the noise modelling were assessed and recommendations were provided to reduce noise impacts where they occur.

Initially, aerial photographs, topographic maps and the concept design of the preferred route were reviewed to determine possible Noise Catchment Areas (NCA) along the route. Each NCA extends a minimum of 300m from the proposed road alignment, as most noise models are not capable of predicting reliable results beyond this distance. A total of 31 NCAs were identified along the route. This was followed by a detailed site inspection of the study area, during which suitable noise monitoring locations were selected. Noise monitoring was carried out at the identified locations to quantify the existing acoustic environment along the proposed Upgrade.

Measured noise levels were used to set suitable traffic noise goals for each NCA in accordance with the NSW *Environmental Criteria for Road Traffic Noise* (ECRTN) and RTA's *Environmental Noise Management Manual* (ENMM). Construction noise goals were also set based on the noise monitoring data, in accordance with the NSW *Environmental Noise Control Manual* (ENCM).

Road traffic noise modelling was carried out using the Road Traffic Noise Module in the SoundPLAN noise modelling software. The module uses the United Kingdom Department of Environment 'Calculation of Road Traffic Noise' known as the CoRTN method. The CoRTN method is recognised and accepted by the Roads and Traffic Authority and the Department of Environment and Conservation, and is considered appropriate to suit the circumstances of this particular project. Using information gathered during the site inspection, and traffic flow data (including volume, speed and mix), topographical and road design data provided by Parsons Brinckerhoff, a computer noise model was established to calculate traffic noise levels for 2004/5 (existing), the year of Project opening (2011) and 10 years after Project opening (2021).

Predicted noise levels from the operation of the proposed Upgrade were assessed against the noise goals recommended by the ECRTN. In addition, prevailing maximum noise level impacts and changes in impacts attributable to the project were evaluated to assess the likelihood and extent of maximum noise impacts, in accordance with the ENMM. Where predicted noise levels were found to be in excess of the recommended operational noise goals, reasonable and feasible options for reducing noise impacts were investigated, and a set of preferable options, based on assessment of likely effectiveness, costs and practicality was developed.

Information from Parsons Brinckerhoff regarding the construction of the road, including the proposed method of construction, likely plant and equipment, and the location of possible blasting activity to be used during construction was used to establish a computer noise model to calculate noise and vibration impacts arising from construction activities, including blasting, pile driving, crushing, batch plant and general road construction activities.

Noise and vibration generated during the construction period were assessed against the construction noise and vibration goals at critical receiver areas. Where non-compliance with recommended construction noise and vibration goals was found, options for reducing impacts, including community consultation; construction noise control best practice measures; erection of temporary barriers; timing of construction of permanent barriers, house treatments and other attenuation measures were investigated.

The work documented in this report was carried out in accordance with the requirements of the Roads and Traffic Authority's 'Environmental Noise Management Manual' and Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

1.4 STRUCTURE OF THE REPORT

Section 1 of this report provides an overview of the project and of this report.

Section 2 details the methodology and results of noise monitoring to establish the existing acoustic environment at sensitive receivers along the route.

Section 3 addresses operational noise from the completed Upgrade. It details the road traffic noise modelling methodology, results of noise modelling and assessment of impacts. Road traffic noise mitigation options are also investigated in this section.

Section 4 investigates noise and vibration impacts during the construction phase of the proposed Upgrade.

Section 5 concludes the report.

2. EXISTING NOISE ENVIRONMENT

2.1 STUDY AREA

This study concentrates on the area of Pacific Highway and proposed Upgrade route between South Kempsey and Eungai Rail. Specifically, this study investigates traffic noise impacts at sensitive receivers along the proposed Upgrade route.

The highway upgrade works commence at Old Coast Road, South Kempsey, joining the existing dual carriageway. The proposed Upgrade continues along the existing Pacific Highway for approximately 500 metres north from Old Coast Road, where it then deviates to the east bypassing the denser residential areas of South Kempsey and Kempsey. The proposed Upgrade travels north through rural land with scattered residential properties, where there is minimal existing road traffic noise.

At the Macleay River crossing, east of Frederickton, residential premises potentially affected by the proposed Upgrade are currently exposed to traffic noise from the existing Pacific Highway. In some cases the proposed Upgrade works will change the direction in which traffic noise travels to residential properties. That is, a different facade of the residence (and possibly different rooms within the residence) will become exposed to traffic noise. The existing exposed facade will be exposed to significantly less noise, as the old Pacific Highway route becomes a local service road with minor traffic flows.

Approximately 20 kilometres along the route, near Colombatti Rail, residential properties are sparser for about 10 to 12 kilometres. In this area there is currently virtually nil road traffic noise. At Barraganyatti the proposed Upgrade rejoins the Pacific Highway, where the road is then upgraded to meet the existing dual carriageway north of Eungai Rail. Through this area, many residences are currently exposed to traffic noise from the Pacific Highway.

The study identified approximately 120 residential properties potentially affected by the construction of the proposed Upgrade, 75 percent of which are currently unexposed, or exposed to only low levels of road traffic noise. Site inspection indicated that residences in the study area are both single and double storey. In many cases, particularly in the low lying areas, residences are single storey, but elevated above ground level by up to approximately 2 metres. A number of schools were also identified as potentially affected by the proposed Upgrade.

2.2 NOISE CATCHMENT AREAS

To facilitate the assessment of noise impacts from the proposed Upgrade, residential areas along the route have been divided into Noise Catchment Areas (NCA's).

NCA's are areas that are likely to have similar noise exposures, on the basis of factors such as topography, road design (cuttings, embankments, intersections etc), setbacks, and types of residences or other noise receptors. For the purpose of this assessment, the catchments were defined as within 300m of the road alignment. 300 metres is the distance within which most road traffic noise models are capable of producing reliable results (ENMM p97).

A total of 31 noise catchment areas were identified along the proposed Upgrade route, shown in Figure 2 following. Further to this there were 116 residential premises identified along the route by Parsons Brinckerhoff. Residences identified in the NCAs along the proposed Upgrade are mostly single storey. Five two-storey residences or residences elevated on stilts were identified. These residences are summarised in Appendix B and shown on Figure 2.

As part of the noise impact assessment process, NCAs are further divided into sub-catchments of similar noise impacts, approximately within a 5dB(A) range. This process is undertaken following road traffic noise modelling of the concept design and preparation of road noise contour drawings, and is detailed in Section 3.5 of this report.

Other noise sensitive receivers identified in the study area that may potentially be affected by traffic noise generated by the proposed Upgrade include:

- Kempsey Seventh Day Adventist Church, 108 Crescent Head Road, Kempsey;
- Kempsey Adventist Primary School, 108 Crescent Head Road, Kempsey;
- Frederickton Public School, Great North Road, Frederickton; and
- Frederickton Golf Course, Yarrabinndinni Road, Frederickton.

There are a number of residential and other sensitive receiver locations along the existing Pacific Highway that will receive a net noise benefit as a result of the proposed Upgrade, as traffic is diverted off the Pacific Highway and onto the proposed Upgrade road. These include:

- Numerous residential premises;
- Frederickton Uniting Church, Macleay Street (Pacific Highway), Frederickton
- East Kempsey Cemetery, Naiooka Street, Kempsey
- Frederickton Cemetery, Great North Road, Frederickton
- Bellimbopinni Public School, Pacific Highway, Bellimbopinni;
- Kempsey East Public School, Innes Street, Kempsey.

2.3 NOISE MONITORING LOCATIONS

To determine the existing acoustic environment along the proposed Upgrade, long-term unattended noise monitoring was undertaken at representative locations identified along the route. Where possible, noise monitoring was conducted at a representative location (typically 'worst affected') in each NCA. However, due to the sparse distribution of residential premises and the low existing traffic noise along much of the proposed route, in many cases a single location was selected as representative of the NCA on either side of the proposed route. The table below summarises the noise monitoring locations selected and adopted noise monitoring period.

Table 2.1 – Long Term, Unattended Noise Monitoring Locations

NCA ¹	Side of Upgrade	Approx Station	Noise Monitoring Location & Description	Monitoring Period	Monitoring Purpose ²
1	West	-500	702 Pacific Highway South Kempsey 1m from facade, facing Pacific Hwy, approx 50m from the existing highway. Traffic noise dominates.	7-17 Feb 2005	Traffic + L _{max} Validation Background
2	East	800	511 Pacific Highway, South Kempsey. 1m from facade, facing Pacific Hwy, approx 100m from the existing highway. Traffic noise dominates.	11-20 Dec 2004	Traffic Validation Background
3	West	1000	479 Pacific Highway, South Kempsey. Rear yard, 1m from facade, facing Upgrade and shielded from existing Pacific Hwy (approx 110m). Existing Hwy traffic noise dominates. Some noise from squash courts + natural sounds and insect noise.	3-10 Dec 2004	Traffic Validation Background
4 (&5)	East	2000	28 Shannon Close, South Kempsey. Front yard, 1m from facade, facing Upgrade and existing Pacific Hwy (approx 400m). Traffic noise from Hwy audible, but mostly natural sounds and insect noise.	3-12 Dec 2004	Traffic Background
6 (&7)	East	4000	7 Bruces Lane, Kempsey. Rear yard, 5m from facade, facing Upgrade. Traffic noise from Crescent Head Rd audible, but mostly natural sounds and insect noise.	4-12 Dec 2004	Background
8 (&9)	East	4500	63 Bruces Lane, Kempsey. Rear yard, 5m from facade, facing Upgrade. Traffic noise inaudible, mostly natural sounds and insect noise.	4-11 Dec 2004	Background
10 (&11)	East	7000	80 Inches Road, Kempsey. Rear yard, 1m from facade, facing Upgrade. Traffic noise inaudible, mostly natural sounds and insect noise.	11-20 Dec 2004	Background
13 (&12)	West	12400	575 South West Rocks Road, Gladstone. Rear yard, 1m from facade, facing Upgrade. Traffic noise from Pacific Hwy & South West Rocks Rd audible. Some noise from residents, natural sounds and insect noise.	3-10 Dec 2004	Background (Traffic)
15 (&14)	West	12500	2/DP623487, Lawson Street, Fredrickton. Free field, facing existing Pacific Hwy (approx 300m) & Upgrade (representative of residences in Lawson St). Traffic noise from existing highway dominates. Natural sounds and insect noise.	4-11 Dec 2004	Traffic Background
16	East	13100	921 Pacific Highway, Frederickton. 1m from side facade, facing Upgrade and at ~90° from existing Pacific Hwy (approx 30m away). Traffic noise dominates.	3-10 Dec 2004	Traffic + L _{max} Validation Background
17	West	13500	KSC Fredrickton Golf Club, Yarrabandini Road, Frederickton. 1m from facade facing Upgrade and at ~90° from existing Pacific Hwy (approx 500m away). Traffic noise from highway audible, but mostly noise from golf club activities, natural sounds and insect noise.	11-20 Dec 2004	Background (Traffic)
21 (&18 -20)	West	16500	26 Seashore Lane, Frederickton. 1m from facade facing Upgrade. Distant traffic noise from highway just audible, but mostly noise from residents (dog), natural sounds and insect noise.	3-10 Dec 2004	Background

NCA ¹	Side of Upgrade	Approx Station	Noise Monitoring Location & Description	Monitoring Period	Monitoring Purpose ²
22 (&23)	East	22700	Seven Hills Road, Tamban. Free field, facing Upgrade. Traffic noise inaudible, only natural sounds and insect noise.	11-20 Dec 2004	Background
24 (&25)	West	30500	269 Cooks Lane, Tamban 1m from facade facing Upgrade. Traffic noise inaudible, mostly noise from residents, natural sounds and insect noise.	11-20 Dec 2004	Background
26 (&27)	West	33100	80 Hills Lane, Barraganyatti. Free field facing Upgrade and existing Pacific Hwy (approx 500m away). Traffic noise from highway audible, but mostly natural sounds and insect noise.	8-17 Feb 2005	Background (Traffic)
28	East	34700	2925 Pacific Hwy, Barraganyatti. Free field facing Upgrade and existing Pacific Hwy (approx 300m away). Traffic noise from highway audible, also natural sounds and insect noise.	8-17 Feb 2005	Traffic Background
29	West	39000	3381 Pacific Highway, Eungai Rail. 1m from facade, facing Pacific Hwy, approx 34m from the existing highway. Traffic noise dominates.	9-17 Feb 2005	Traffic + L _{max} Validation Background
30	East	37500	21 Stuarts Point Road, Eungai Rail. Front yard, 1m from facade, facing Pacific Hwy, approx 190m from the existing highway. Traffic noise dominates, also noise generated by residents, natural sounds and insect noise.	3-10 Dec 2004	Traffic Background
31	East	38500	29 Brushbox Rd, Eungai Rail. Front yard, 1m from facade, facing Pacific Hwy, approx 250m from the existing highway. Traffic noise dominates. Also natural sounds and insect noise.	3-10 Dec 2004	Traffic Validation Background

Notes: 1. NCA in brackets () refers to catchments where noise monitoring was not conducted. Measured noise levels are assumed to be representative of this catchment.

2. (Traffic) refers to locations where existing road traffic noise is slight or barely audible over ambient noise at the measurement location.

Figure 2 shows the noise monitoring locations and the NCAs on an aerial photograph.



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Figure 2a : Aerial Photograph and NCA 1 - 9

Date : 23/12/05

Scale: 1:20000

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Figure 2b : Aerial Photograph and NCA 9 - 13

Date : 23/12/05

Scale: 1:20000

Project : Pacific Highway Upgrade - Kemsey to Eungai

Ref : TA546-07P03 (rev 1)

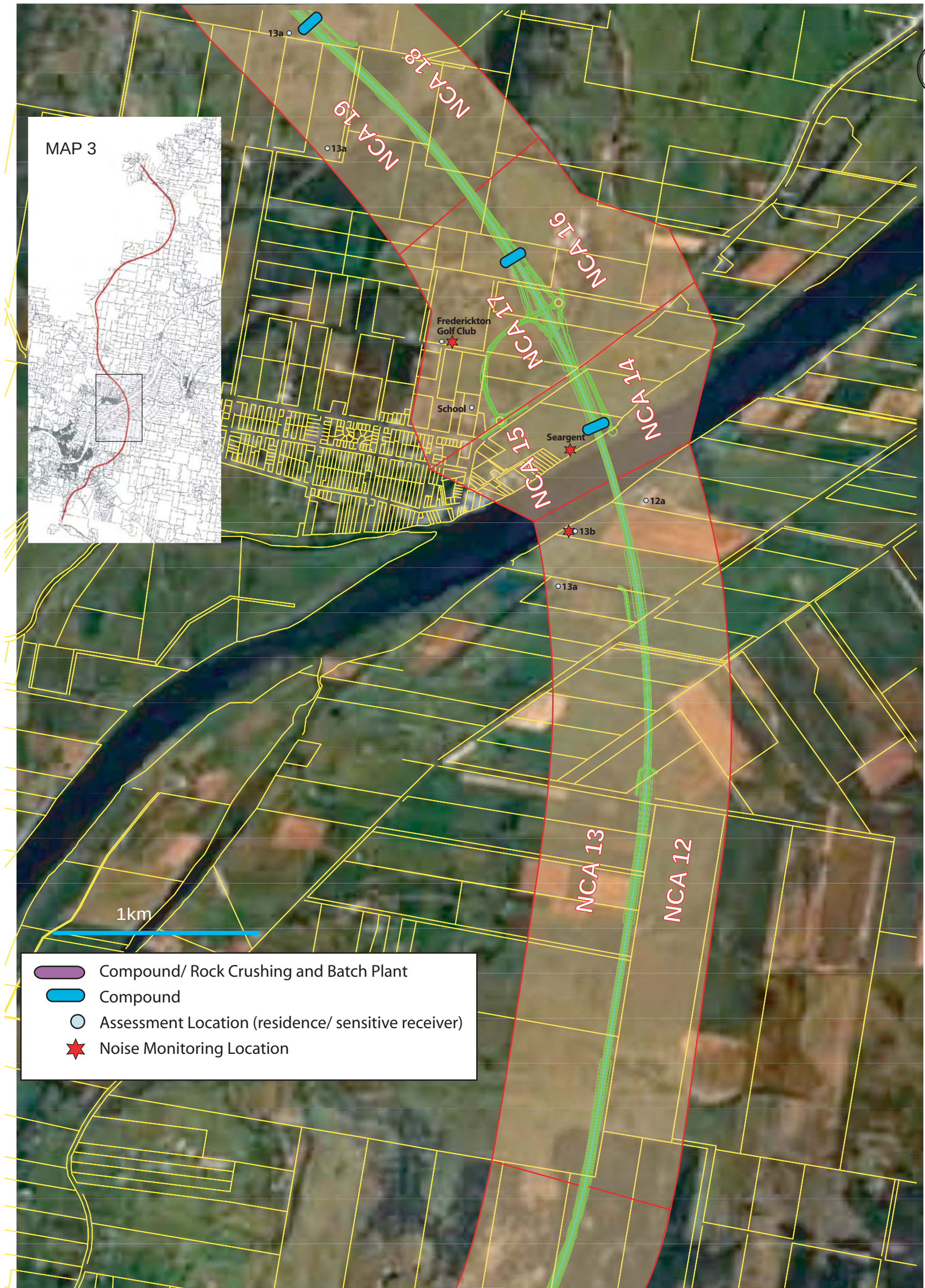


Figure 2c : Aerial Photograph and NCA 13 - 19

Date : 23/12/05

Scale: 1:20000

Project : Pacific Highway Upgrade - Kemsey to Eungai

Ref : TA546-07P04 (rev 1)



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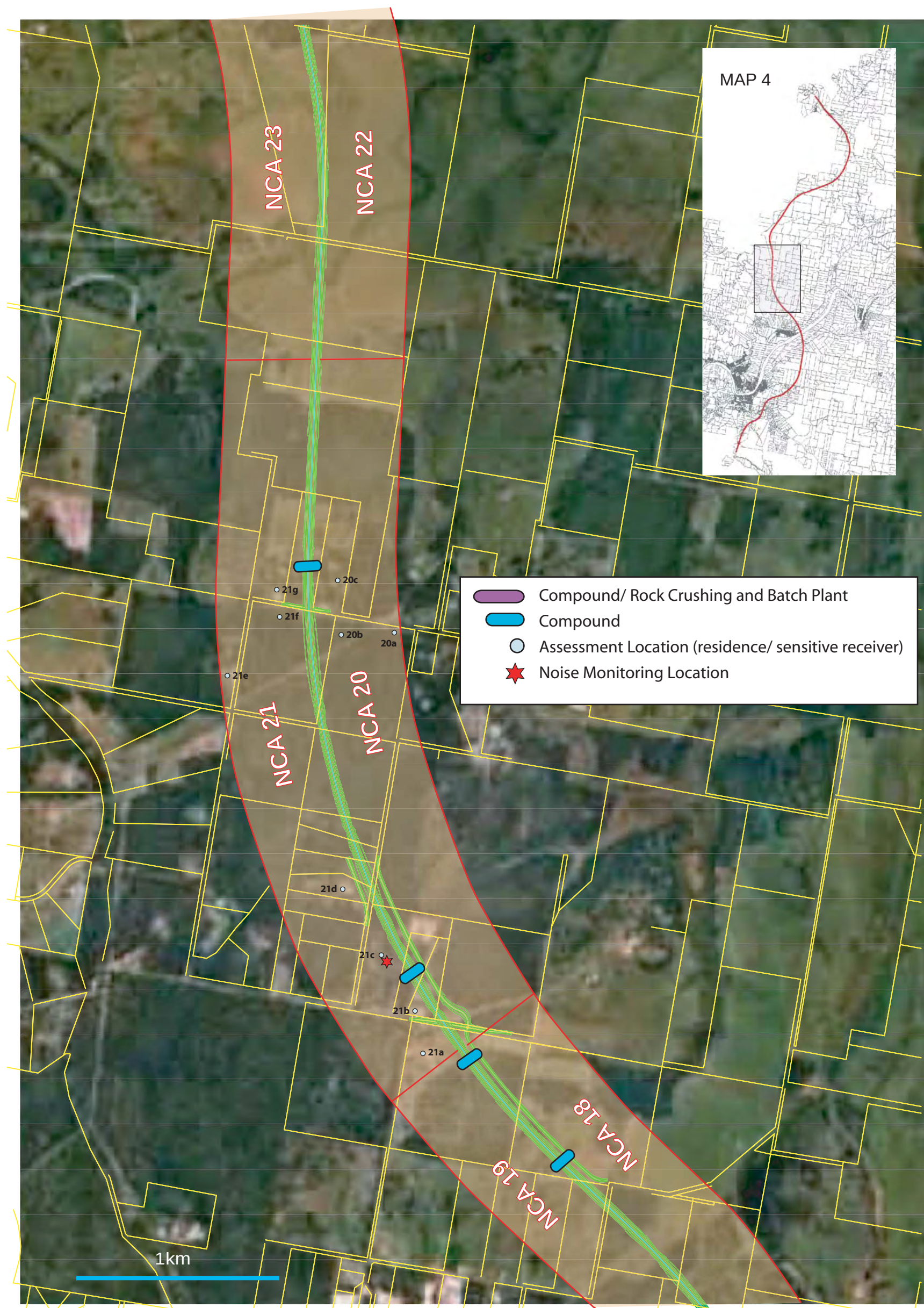


Figure 2d : Aerial Photograph and NCA 19 - 23

Date : 23/12/05

Scale: 1:20000

Project : Pacific Highway Upgrade - Kemsey to Eungai

Ref : TA546-07P05 (rev 1)

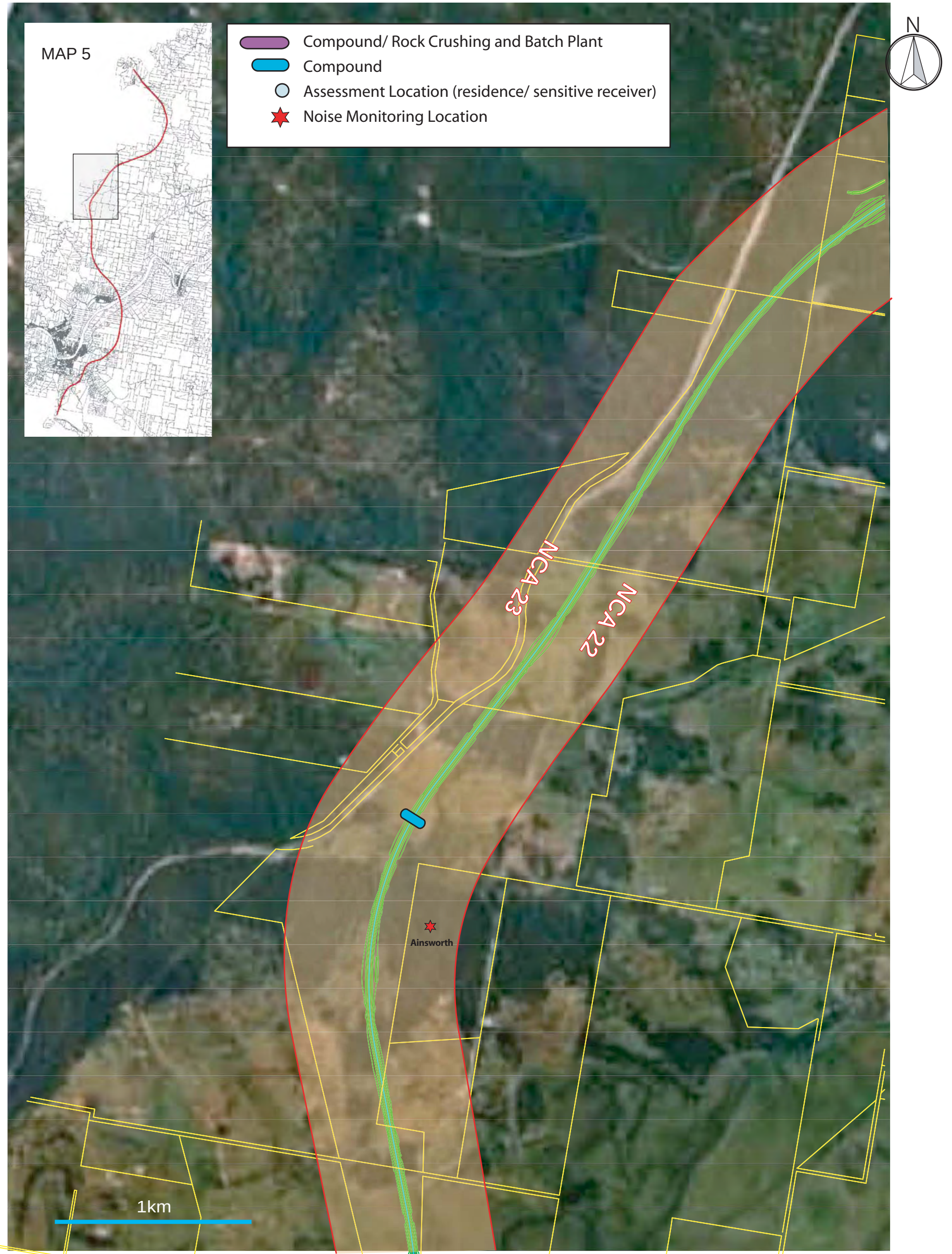


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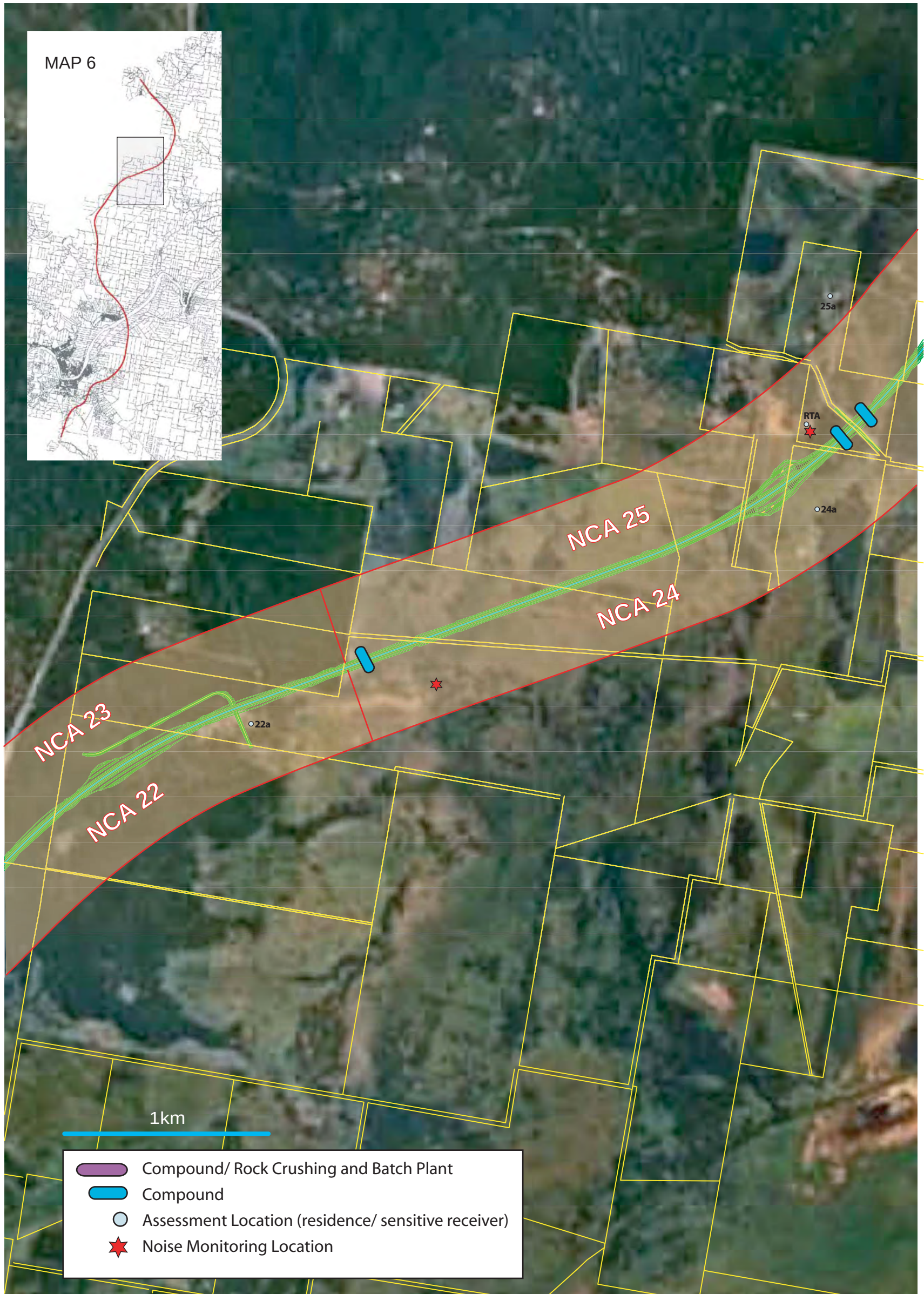
Figure 2e : Aerial Photograph and NCA 22 - 23

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 23/12/05

Scale: 1:20000

Ref : TA546-07P06 (rev 1)



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Figure 2f : Aerial Photograph and NCA 22 - 25

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 23/12/05

Scale: 1:20000

Ref : TA546-07P07 (rev 1)

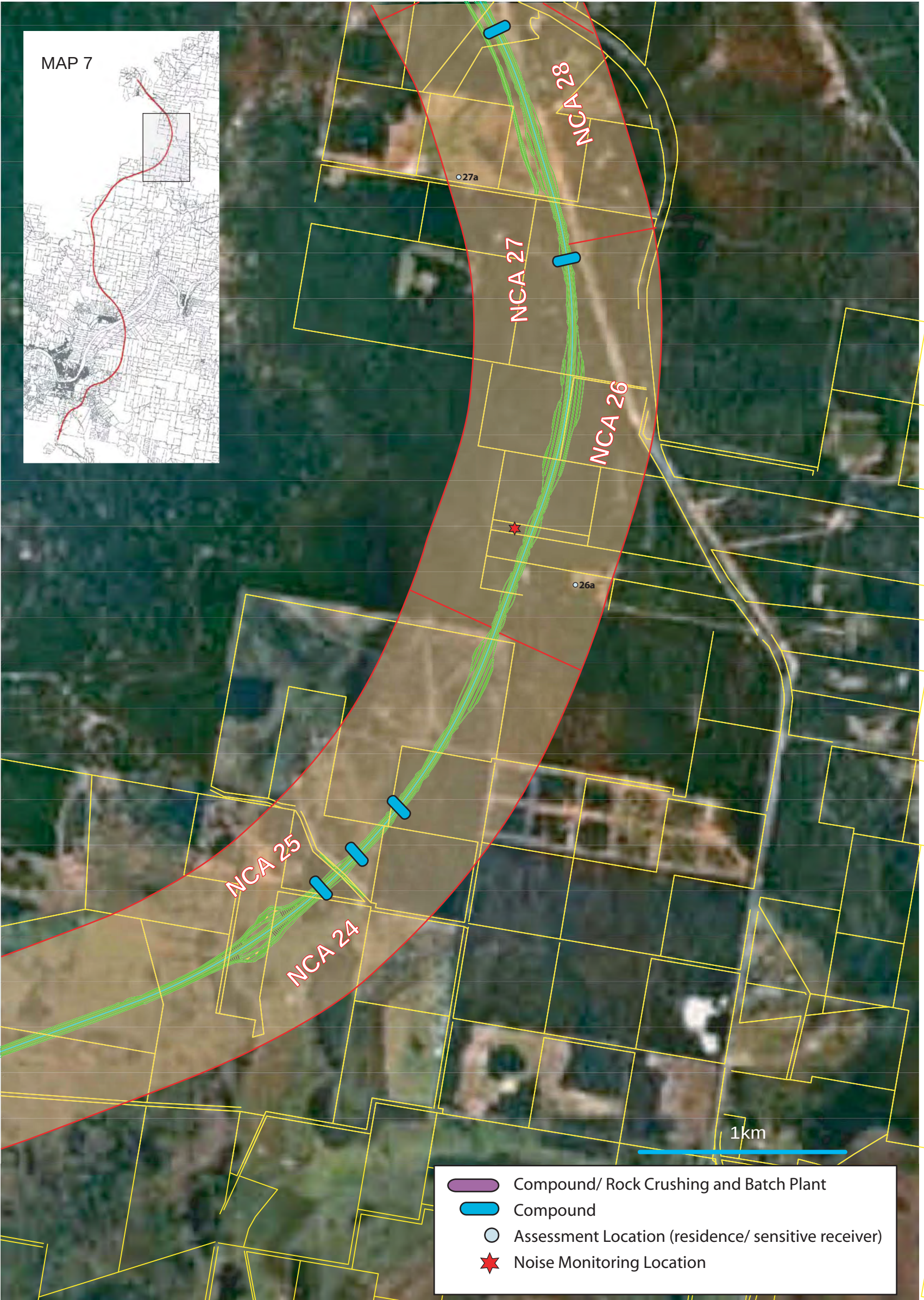


Figure 2g : Aerial Photograph and NCA 24 - 28

Date : 23/12/05

Scale: 1:20000

Project : Pacific Highway Upgrade - Kemsey to Eungai

Ref : TA546-07P08 (rev 1)



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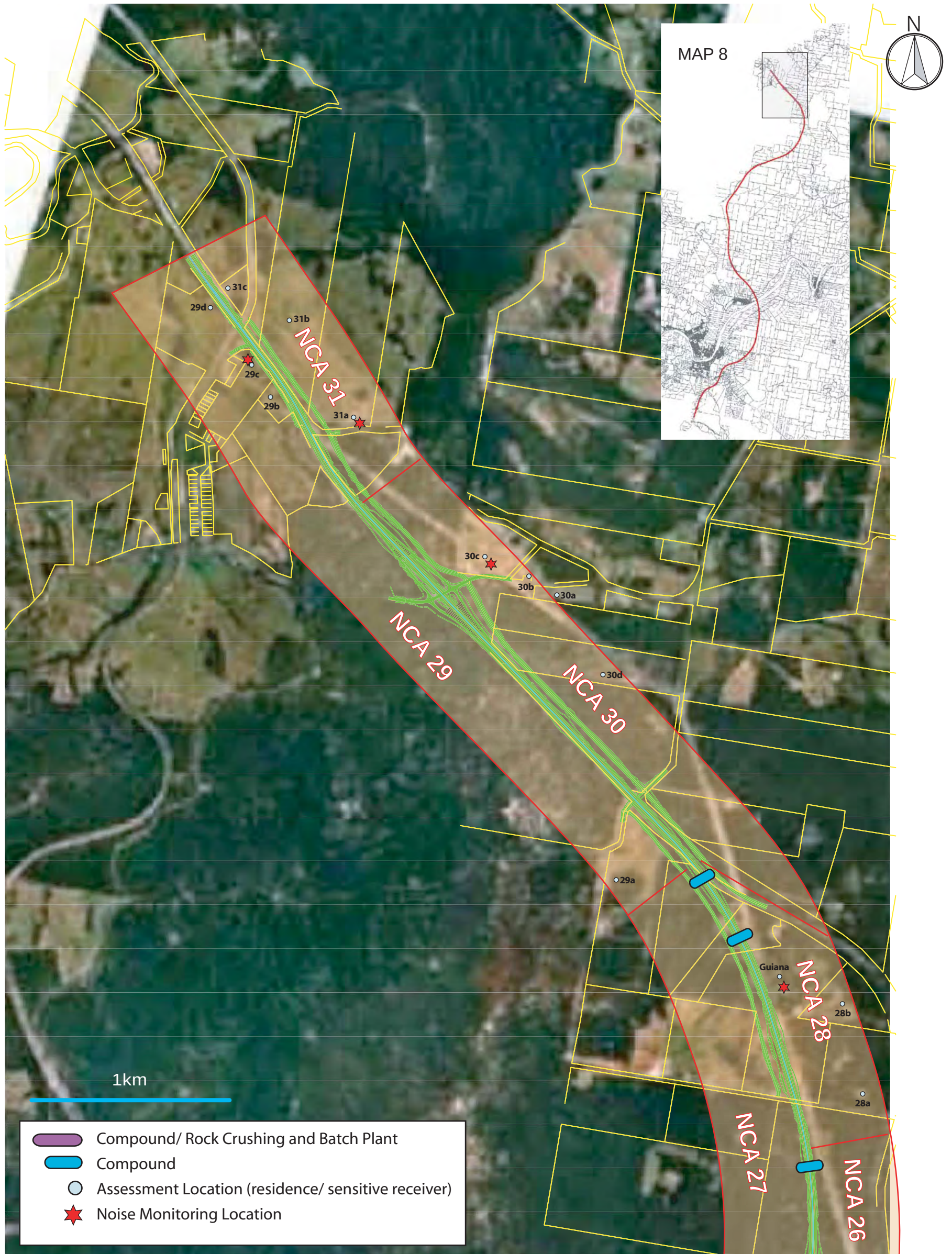


Figure 2h : Aerial Photograph and NCA 28 - 31

Date : 23/12/05

Scale: 1:20000

Project : Pacific Highway Upgrade - Kemsey to Eungai

Ref : TA546-07P09 (rev 1)



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2.4 NOISE MONITORING PROCEDURES AND INSTRUMENTATION

Long term, unattended noise monitoring was undertaken using RTA Technology noise monitors installed on site to monitor the existing acoustic environment at each selected location. The noise monitoring equipment used complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as a Type 2 instrument suitable for field use.

A noise monitor consists of a sound level meter and a computer housed in a weather resistant enclosure. Ambient noise levels were recorded at a rate of 10 samples per second. Every 15 minutes, the data is processed statistically and stored in memory. The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 calibrator. No significant drift in calibration was observed.

The noise monitor is set-up at the identified representative locations, preferably 1 metre from the facade that is most exposed to traffic noise (or future traffic noise) and at a height of 1.5 metre above ground level. Noise monitoring is conducted continuously over a minimum of 7 days. The minimum noise parameters recorded are L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period. Explanation of these noise parameters is provided in the Glossary in Appendix A.

Monitoring was conducted over a minimum 7 day period for each location during December 2004 and February 2005. Weather information was obtained from the Bureau of Meteorology for the area over this period and any data adversely affected by rain, wind or extraneous noise was discarded.

Short term, attended measurements supplemented long term noise measurements to assist in verifying noise sources over the monitoring period.

The graphical recorded outputs of the noise monitors are presented in Appendix C.

2.5 L_{eq} TRAFFIC NOISE LEVELS

The measured L_{eq} traffic noise levels at the monitoring locations are shown below. The descriptors relevant to traffic noise studies according to the NSW Government's current policy for traffic noise are the $L_{Aeq(15hr)}$ daytime and $L_{Aeq(9hr)}$ night time descriptors. Daytime represents the period 7am to 10pm and night represents the period 10pm to 7am. Furthermore, $L_{Aeq,24hr}$ noise levels are also reported, in accordance with the ENMM and the RTA brief.

Table 2.2 – Results of L_{eq} Traffic Noise Monitoring

NCA	Monitoring Location	Representative Noise Level, dB(A)		
		$L_{Aeq,15hr}^1$	$L_{Aeq,9hr}^1$	$L_{Aeq,24hr}$
1	702 Pacific Highway South Kempsey	62	61	61
2	511 Pacific Highway, South Kempsey	55	56	54
3	479 Pacific Highway, South Kempsey	50	49	50
4 (&5)	28 Shannon Close, South Kempsey	49 ²	50 ²	49 ²
13 (&12)	575 South West Rocks Road, Gladstone	62 ²	55 ²	60 ²
15 (&14)	2/DP623487, Lawson Street, Frederickton	59	56	58
16	921 Pacific Highway, Frederickton	63	64	63
17	KSC Fredrickton Golf Club, Frederickton	55 ²	49 ²	53 ²
26 (&27)	80 Hills Lane, Barraganyatti	46 ²	47 ²	47 ²

NCA	Monitoring Location	Representative Noise Level, dB(A)		
		$L_{Aeq,15hr}^1$	$L_{Aeq,9hr}^1$	$L_{Aeq,24hr}$
28	2925 Pacific Highway, Barraganyatti	58 ²	64 ²	61 ²
29	3381 Pacific Highway, Eungai Rail	62	61	62
30	21 Stuarts Point Road, Eungai Rail	53	51	52
31	29 Brushbox Rd, Eungai Rail	50	50	50

Note: 1. Daytime ($L_{Aeq,15hr}$) represents the period 7am to 10pm and night ($L_{Aeq,9hr}$) represents the period 10pm to 7am.
2. Traffic noise audible, but not necessarily dominant.

2.6 BACKGROUND L_{90} NOISE LEVELS

The measured L_{90} background noise levels are shown below. Day represents the period 7am to 6pm, evening 6pm to 10pm and night 10pm to 7am.

Table 2.3 – Results of Background L_{90} Noise Monitoring, dB(A)

NCA	Monitoring Location	Representative Background Level, dB(A)		
		Day L_{A90}	Evening L_{A90}	Night L_{A90}
1	702 Pacific Highway South Kempsey	48	45	40
2	511 Pacific Highway, South Kempsey	43	44	47
3	479 Pacific Highway, South Kempsey	42	43	42
4 (&5)	28 Shannon Close, South Kempsey	39	39	37
6 (&7)	7 Bruces Lane, Kempsey	37	38	38
8 (&9)	63 Bruces Lane, Kempsey	36	37	38
10 (&11)	80 Inches Road, Kempsey	32	33	32
13 (&12)	575 South West Rocks Road, Gladstone	39	40	34
15 (&14)	2/DP623487, Lawson Street, Fredrickton	44	43	37
16	921 Pacific Highway, Frederickton	40	37	32
17	KSC Fredrickton Golf Club, Frederickton	38	39	36
21 (18-20)	26 Seashore Lane, Frederickton	31	37	35
22 (&23)	Seven Hills Road, Tambar	27	24	23
25 (&24)	269 Cooks Lane, Tambar	34	37	35
26 (&27)	80 Hills Lane, Barraganyatti	32	32	31
28	2925 Pacific Highway, Barraganyatti	39	40	40
29	3381 Pacific Highway, Eungai Rail	48	44	40
30	21 Stuarts Point Road, Eungai Rail	41	42	39
31	29 Brushbox Rd, Eungai Rail	40	41	40

Note: 1. Day represents the period 7am to 6pm, Eve (evening) 6pm to 10pm and Night 10pm to 7am.

3. ROAD TRAFFIC NOISE ASSESSMENT

3.1 ROAD CLASSIFICATION

The Pacific Highway between Kempsey and Eungai is classed as a freeway / arterial road in that it handles through traffic bound for another locality and has characteristically heavy and continuous traffic flows.

The bulk of the proposal will constitute a 'new' road as defined in the NSW *Environmental Criteria for Road Traffic Noise* (the "ECRTN", Environment Protection Authority, 1999) and the RTA's *Environmental Noise Management Manual* (the "ENMM", Roads & Traffic Authority 2001), as it will be a road on a corridor that has not previously been a freeway / arterial road.

At the connection points of the road in South Kempsey and to the north in Barraganyatti, the proposal will be a road 'redevelopment' as defined in the ECRTN as the works will increase the traffic carrying capacity and the road alignment of the existing highway. Further definition in the ENMM supports this redevelopment classification since at these locations:

- The upgrading has been proposed in order to increase traffic-carrying capacity;
- There is an existing road traffic noise exposure of equal to or greater than 55dB(A) $L_{Aeq}(15hr)$ (day) and 50dB(A) $L_{Aeq}(9hr)$ (night), at sensitive receivers along the route;
- The existing traffic noise level is equal to or greater than the criteria applying to 'redeveloped roads' (when allowances are taken into account, these are effectively 58dB(A) $L_{Aeq}(15hr)$ (day) and 53dB(A) $L_{Aeq}(9hr)$ (night)); and

The upgrading does not involve a new road traffic noise source.

3.2 TRAFFIC NOISE CRITERIA

Road traffic noise impacts addressed in this report are assessed in accordance with the NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW Environment Protection Authority 1999) and the RTA's *Environmental Noise Management Manual* (ENMM, 2001).

The Pacific Highway is classed as a freeway / arterial road in that it carries through traffic bound for another locality and has characteristically heavy and continuous traffic flows. The proposed Upgrade primarily involves the construction of a new Pacific Highway route outside the existing highway carriageway. Along most of the proposed Upgrade, traffic noise generated by its operation will expose residences previously unexposed to traffic noise. In accordance with the ENMM, this constitutes a 'new road traffic noise source'. In some locations along the proposed Upgrade, traffic may produce noise at an existing receptor from a direction different to that of the existing highway. According to the ENMM, this also constitutes a 'new road traffic noise source'. Therefore, the ECRTN 'new arterial road' criterion (see Item 1 in Table 3.1 below) applies.

In South Kempsey and Eungai Rail, where the proposed Upgrade occurs within the existing road corridor, the proposed Upgrade does not constitute a 'new road traffic noise source' because the road is not a new road and does not produce noise to receptors from a different direction. At these locations, the proposed Upgrade is essentially an expansion of an existing arterial road to increase traffic carrying capacity. Therefore, the "redeveloped road" criteria as set out in the ECRTN apply. The noise criteria for redevelopment of an existing arterial road are as follows (see item 3 in Table 3.1 below).

Table 3.1 – NSW Environmental Criteria for Road Traffic Noise

Type of Development	Criteria, dB(A)		Where Criteria are Already Exceeded*
	Day	Night	
1. New freeway or arterial road corridor	L _{Aeq(15hr)} 55	L _{Aeq(9hr)} 50	The new road should be designed so as not to increase existing noise levels by more than 0.5dB.
3. Redevelopment of existing freeway/ arterial road	L _{Aeq(15hr)} 60	L _{Aeq(9hr)} 55	The redevelopment should be designed so as not to increase existing noise levels by more than 2dB.

Note: * Only applicable where all reasonable and feasible noise mitigation measures have been considered.

It is noted that when the criteria in the above table are already exceeded and where all reasonable and feasible noise mitigation measures have been used and considered, an 'allowance' criteria would be applicable. The allowance criteria for a new freeway or arterial road corridor and the redevelopment of an existing freeway / arterial road will be the existing noise levels plus 0.5dB(A) and 2dB(A), respectively.

Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

In accordance with Practice Note I of the ENMM (pp79-83), the 'new freeway' criteria apply where the proposal is wholly or partly outside an existing road corridor, where there is no existing road traffic noise exposure; and/ or where the new road constitutes a new noise source. The 'redeveloped freeway' criteria apply where the proposal involves a road duplication or upgrade, or for a road upgrade outside the existing road corridor where there is existing road traffic noise exposure. A site is defined as having existing road traffic noise exposure where the prevailing noise from the existing road alignment under consideration is equal to or greater than L_{Aeq(15h)} (day) 55 dB(A) or L_{Aeq(9h)} (night) 50 dB(A).

Table 3.2 following summarises the applicable road traffic noise criteria for each NCA.

Table 3.2 – Road Traffic Noise Criteria for Each NCA

NCA	New Noise Source?	Existing Noise Exposure?		Applicable Criteria, dB(A)		
		L _{Aeq(15hr)} >55	L _{Aeq(9hr)} >50	Classification	L _{Aeq(15hr)}	L _{Aeq(9hr)}
1	No	62	61	Redevelopment	64 ¹	63 ¹
2	Yes	55	56	New freeway	55	50
3	Yes	-	-	New freeway	55	50
4	Yes	49	50	New freeway	55	50
5-28	Yes	-	-	New freeway	55	50
29	No	62	61	Redevelopment	64 ¹	63 ¹
30	No	53	51	Redevelopment	60	55
31	No	50	50	Redevelopment	60	55

Note: 1. Only applicable where all reasonable and feasible noise mitigation measures have been considered.

It is noted that bushfires were experienced around Barraganyatti and Eungai Rail in late 2004, prior to the monitoring of existing traffic noise at residences in this area. Traffic noise levels were

perceived by residents to be louder at nearby residences after the bushland was destroyed by the fires. Noise catchments potentially affected by this include NCAs 24 to 28.

NCAs 24 to 28 are assessed to the 'new road' criteria. Existing traffic noise levels at the residences in these catchments were measured to be low, or the proposed Upgrade will affect a new facade of the residence, therefore existing traffic noise is not considered in the assessment of impact at these residences. Therefore, the effect of the bushfire on existing traffic noise for these catchments is irrelevant.

Sensitive Land Use Developments

The ECRTN also sets guidelines for the assessment of traffic noise on sensitive land uses such as schools, hospitals, places of worship and recreation areas. Kempsey Seventh Day Adventist Church and School are located within the study area, on Crescent Head Road, to the west of the new alignment. In addition, Frederickton Golf Club is located to the west of the proposed Upgrade, on Yarrabinndinni Road, north of Frederickton. The relevant noise criteria, reproduced from the ECRTN (p10), are summarised in Table 3.3 below.

Table 3.3 – Road Traffic Noise Criteria for Sensitive Land Use Developments

Type of Development	Criteria, dB(A)	
	Day	Night
Existing school classroom	$L_{eq(1hr)} 45^1$	-
Places of worship	$L_{eq(1hr)} 40^1$	$L_{eq(1hr)} 40^1$
Active recreation (eg golf courses)	$L_{eq(15hr)} 60^2$	-
Passive recreation and school playgrounds	$L_{eq(15hr)} 55^2$	-

Notes: 1. Internal noise criteria
2. External noise criteria

To achieve internal noise criteria in the short-term, the most practicable mitigation measures are often related to building or facade treatments.

In the medium to longer term, strategies such as regulation of exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access to sensitive areas or during sensitive times to low-noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium to long-term strategies apply equally to mitigating internal and external noise levels.

Where existing levels of traffic noise exposure exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise exposure levels by more than 0.5dB(A) for new roads and 2dB(A) for redeveloped roads.

3.3 TRAFFIC FLOW AND COMPOSITION SUMMARY

Traffic volumes and heavy vehicle proportion data have been provided by Parsons Brinckerhoff Australia Pty Ltd. In accordance with the RTA's ENMM and the NSW ECRTN, traffic volumes were provided for the following scenarios:

1. Existing traffic volumes – these were input to the model along the existing Pacific Highway so that modelled existing noise levels could be compared with measured existing noise levels

(summarised in Table 2.2). This process allowed the noise model to be verified and validated for the local conditions.

2. Future existing traffic volumes – these are traffic volumes along the existing Pacific Highway in the year the proposed Upgrade would have opened (2011), if the proposed Upgrade were not to go ahead.
3. Future traffic volumes – these are traffic volumes for the year of the proposed Upgrade opening (2011) and ten years after opening (2021).

Traffic volumes are summarised in the sections below.

3.3.1 Existing and Future Existing Traffic Volumes

Traffic classification counts were undertaken along the existing Pacific Highway and Crescent Head Road in order to determine existing traffic volumes and compositions. This survey was conducted by Parsons Brinckerhoff, during the same period as traffic noise measurements were undertaken near the existing Pacific Highway. Future traffic volumes on the existing Pacific Highway have been forecast by Parsons Brinckerhoff for the year of proposed Upgrade opening (2011) if the construction of the proposed Upgrade does not take place.

Table 3.4 following shows existing and future existing traffic volumes and compositions in terms of daytime (15hr) and night-time (9hr) data.

Table 3.4 – Existing (2004/05) and Future Existing (2011) Traffic volumes

Road/ Traffic Count Location	Period ¹	Speed, km/h	Existing 2004/05		Future Existing 2011	
			Volume	%Heavy	Volume	%Heavy
Pacific Highway south of South Street, South Kempsey	Day	80	8880	15	13168	15
	Night	80	3458	24	2130	54
Pacific Highway North of Frederickton	Day	100	8582	14	10394	13
	Night	100	3375	23	1647	51
Pacific Highway at Eungai Rail	Day	100	7238	15	10477	18
	Night	100	3245	23	1899	62

Notes: 1. Day is the period between 7:00am and 10:00pm, night is the period between 10:00pm and 7:00am

3.3.2 Future Traffic Volumes

Future traffic volumes on the proposed Upgrade following its completion have been forecast by Parsons Brinckerhoff should an un-staged approach be adopted and construction of the entire proposed Upgrade is completed in 2011. Traffic volume forecasts have been provided for the year of the proposed Upgrade opening (2011) and ten years after the proposed Upgrade opening (2021). The traffic volume forecasts are summarised in Table 3.5 below.

Table 3.5 – Forecast Traffic Volumes for 2011 and 2021

Road/ Traffic Count Location	Period ¹	Speed, km/h	2011		2021	
			Volume	%Heavy	Volume	%Heavy
Upgrade Main Line-South of Pacific Highway	Day	110	13168	15	19155	15
	Night	110	2130	54	3092	54
Upgrade Main Line- North of Pacific Highway	Day	110	5153	12	9521	13
	Night	110	754	46	1411	48
Upgrade Ramps-South of Pacific Highway	Day	80	8562	18	11281	19
	Night	80	1490	58	2014	60
Upgrade Ramps-North of Pacific Highway	Day	80	548	24	1647	23
	Night	80	113	67	333	66
Upgrade Main Line-North of Frederickton Road	Day	110	10889	14	16209	14
	Night	110	1714	53	2527	52
Upgrade Ramps-North of Frederickton Rd	Day	60	7065	13	10466	13
	Night	60	1089	52	1611	52
Upgrade Ramps-South of Frederickton	Day	60	1305	10	3750	12
	Night	60	176	41	558	48
Upgrade Main Line-North of Joneses Road	Day	110	10477	18	15714	18
	Night	110	1899	62	2811	61
Upgrade Ramps-North of Joneses Road	Day	80	1688	37	2619	36
	Night	80	468	81	709	80
Upgrade Ramps-South of Joneses Road	Day	80	2100	9	3114	9
	Night	80	283	45	425	41
Pacific Highway- South of South Street	Day	60	9080	18	12864	19
	Night	60	1596	59	2330	61
Pacific Highway-North of Frederickton	Day	60	9531	12	14282	12
	Night	60	1457	49	2192	50
Pacific Highway-Eungai Rail	Day	100	10477	18	15714	18
	Night	100	1894	61	2811	61

Notes: 1. Day is the period between 7:00am and 10:00pm, night is the period between 10:00pm and 7:00am

3.4 NOISE PREDICTION MODELLING

3.4.1 Noise Prediction Model

The traffic noise prediction model used to model the proposed Upgrade is based on a method developed by the United Kingdom Department of Environment entitled “Calculation of Road Traffic Noise (1988)” known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board. The model

predicts noise levels for free flowing traffic and a modified method has been developed which enables an accurate prediction of noise from high truck exhausts to be taken into account.

The method predicts the $L_{10(1\text{hour})}$ noise levels within the daytime 15 hour (7am to 10pm) and night-time 9 hour (10pm to 7am) periods and a correction of -3dB(A) is applied to obtain the $L_{eq(1\text{hour})}$ noise levels for each period. The $L_{eq(1\text{hour})}$ noise level for the time period 7am to 10pm is then equated to the daily $L_{eq(15\text{hour})}$ noise level. Similarly, the $L_{eq(1\text{hour})}$ noise level for the time period 10pm to 7am is then equated to the night time $L_{eq(9\text{hour})}$ noise level.

Distances between vehicles and critical receivers and relative road heights were obtained from concept design drawings supplied by Parsons Brinckerhoff, and from aerial photographs of the proposed route. A digital terrain model providing topographic contours at 1m intervals was also provided for 500m either side of the proposed route. This was incorporated into the noise model to enable evaluation of receiver heights and shielding provided by the topography between the proposed Upgrade and receivers. Other factors that potentially influence traffic noise levels such as the gradient of the road and angles of view have also been considered in the model.

Table 3.6 below summarises the noise prediction model inputs taken into account:

Table 3.6 – Summary of Modelling Inputs

Input Parameters	Data Acquired From
Traffic volumes and mix	Traffic counts data provided by Parsons Brinckerhoff, collected in December 2004 and February 2005
Vehicle speed	Vehicle speed is summarised in Section 3.3 above
Gradient of roadway	From Concept Design drawings
Source height	0.5m for car exhaust, 1.5m for car and truck engines and 3.5m for truck exhaust and detailed within CoRTN
Ground topography at receiver & road	From digital terrain model and Concept Design drawings
Angles of view from receiver	Determined during site inspections and from aerial photos
Reflections from existing barriers, structures and cuttings on opposite side of road	Determined from digital terrain model and Concept Design drawings which have been incorporated into the model.
Air and ground absorption	Detailed within CoRTN, ground absorption varied along route. Numeric values varied between 0 (hard surface) to 1 (soft surface)
Receiver Heights	1.5m above ground level for ground floor and 4.5m above ground level for 1 st floor
Facade correction	+2.5dB(A)
Acoustic properties of road surfaces	- Existing (validation) model uses dense graded asphalt - Future (prediction) model uses concrete with course hessian drag & tining
Roadside barriers	Prediction model assumes no existing barriers.
Traffic noise levels (L_{Aeq})	Based on long term monitoring results

Table 3.7 below provides a comparison of the noise characteristics of varying pavement surface types relative to Dense Graded Asphaltic Concrete (DGAC) and used for noise modelling purposes.

Table 3.7 – Road Pavement Surface Type Noise Corrections Relative to DGAC

Surface Type	Relative difference to DGAC, dB(A)
Dense Graded Asphaltic Concrete (DGAC)	0
Concrete with coarse hessian drag & tining	+2
Concrete with light hessian drag & tining	+0.5
Low-Noise Pavement	-2.0

3.4.2 Model Verification

The model was verified and calibrated using the long-term noise monitoring results obtained for the proposed Upgrade. Table 3.8 summarises the results of the traffic noise model verification, providing a comparison of the modelled traffic noise levels for existing conditions compared to the measured traffic noise levels.

Table 3.8 – Noise Model Verification Results

NCA	L _{Aeq(15hr)} Noise Level ¹			L _{Aeq(9hr)} Noise Level ¹		
	Measured	Modelled	Variation	Measured	Modelled	Variation
1	62	63	1	61	62	1
2	55	54	-1	56	53	-3
3	50	53	-3	49	53	-4 ²
16	63	65	2	64	65	1
29	62	64	2	61	63	2
31	50	51	1	50	52	2

Note: 1. Daytime (L_{Aeq(15hr)}) represents the period 7am to 10pm and night (L_{Aeq(9hr)}) represents the period 10pm to 7am.

2. Traffic noise audible, but not necessarily dominant at night due to insect noise, therefore not considered representative for model validation at night

The noise model verification tests presented in Table 3.8 above, generally show the model to predict results that fall within ± 3 dB(A) of the measured noise levels during the day and night. The accuracy of the CoRTN noise algorithms is generally expected to predict noise levels that are within 2.7dB(A) of the true noise levels in practice with an 85% confidence interval [RTA's Interim Traffic Noise Policy (ITNP), Appendix B, Section 3]. Therefore, the results presented above provide a reasonable level of confidence in the accuracy of the noise model used for predicting future traffic noise levels for the proposed Upgrade.

3.5 ROAD TRAFFIC NOISE ASSESSMENT

3.5.1 Predicted Traffic Noise Levels

Road traffic noise levels are predicted for all residences within the NCAs using noise contour maps. In addition, further noise modelling was completed at 116 residential premises identified along the route, and shown in Figure 2, and the following noise sensitive receivers (daytime assessment only):

- Kempsey Seventh Day Adventist Church, 108 Crescent Head Road, Kempsey;
- Kempsey Adventist Primary School, 108 Crescent Head Road, Kempsey;
- Frederickton Public School, Great North Road, Frederickton; and

- Frederickton Golf Course, Yarrabinndinni Road, Frederickton.

Noise levels have been predicted for the completed road project for the following years:

- 2011, the year the completed project will open.
- 2021, 10 years after the opening year.

Residential Receivers

Predicted project noise levels at each identified receiver location are summarised in Appendix D, based on concrete with coarse hessian drag and tining pavement surface. Table 3.9 below summarises the number of residential premises where the traffic noise criteria, summarised in Table 3.2 are exceeded.

Table 3.9 – Summary of Number of Residential Exceeding Traffic Noise Criteria for Various Road Pavement Surface Types

Scenario	Day $L_{Aeq(15h)}$		Night $L_{Aeq(9h)}$	
	2011	2021	2011	2021
Dense Graded Asphaltic Concrete	25	48	41	61
Concrete with light hessian drag & tining	32	50	42	65
Concrete with coarse hessian drag & tining	41	66	52	85
Low-Noise Pavement	15	33	27	46

Note: Daytime receivers include noise sensitive receivers

The results presented in the table above show that in the absence of further noise mitigation treatment, there will be a number of residences exposed to road traffic noise levels in excess of the noise criteria. With a dense graded asphaltic concrete surface 40% of the total 116 noise receivers during the day and 60% of 116 residences at night will be exposed to traffic noise levels in excess of the criteria ten years after the completion of the proposed Upgrade. A concrete with light hessian drag and tining surface will provide similar results. More receivers (nearly 60% during the day and 80% at night) are affected if concrete with coarse hessian drag & tining were to be used as a pavement surface. A low-noise pavement surface would reduce the number of residences exceeding the base criteria to approximately 30% of receivers during the day and 40% at night.

Figure 3 to Figure 6 in Appendix E present the day and night-time noise contours representing road traffic noise generated by the proposed Upgrade for the years 2011 and 2021. The modelling assumed a concrete with coarse hessian drag and tining pavement surface and that no noise control measures have been incorporated into the road development. The noise contours were interpolated from a series of calculations to specific points within a regularly spaced grid, 1.5m above ground level. It is noted that the noise contours are estimates of the predicted noise levels, and that contour values may differ slightly from equivalent spot calculations. Further, traffic noise levels presented in the noise contour maps are for ground floor level only.

The predicted traffic noise levels presented Appendices D and E indicate that residential receivers in the study area are exposed to traffic noise levels that exceed the ECRTN requirements for noise. Therefore, further investigation of all reasonable and feasible noise control options is required. All reasonable and feasible noise mitigation treatments should be

considered as part of the road development to reduce traffic noise levels at residences to within the ECRTN base noise criteria. Where all reasonable and feasible mitigation options have been exhausted, the proposed Upgrade should, as a minimum, be designed so as not to increase existing traffic noise levels by more than:

- 0.5dB(A), where the 'New Freeway' criteria apply (see Section 3.1); and
- 2dB(A), where the 'Redeveloped Road' criteria apply (see Section 3.1).

Furthermore, noise mitigation measures should be considered to reduce traffic noise levels at residences identified as having 'acute' noise levels, where such levels have occurred as a result of the proposed Upgrade. Acute noise levels are defined as traffic noise levels during the day of $L_{Aeq(15h)}$ 65dB(A) or above, or at night $L_{Aeq(9h)}$ 60dB(A) or above.

Other Sensitive Receivers

A number of schools, a church and Frederickton Golf Course are potentially affected by the completed Upgrade. Daytime noise levels in the outdoor areas (eg. school playgrounds) and inside buildings, assuming a 10dB(A) noise reduction from outside to inside through an open window, have been predicted assuming concrete with coarse hessian drag and tining pavement surface. The results are presented in Table 3.10 below.

Table 3.10 – Predicted Noise Levels at Other Sensitive Receivers – Unstaged (2021)

Sensitive Receiver	NCA	Recreation Areas / Playgrounds $L_{Aeq(15h)}$	Inside Worst Affected Building $L_{Aeq(1h)}$
Kempsey Seventh Day Adventist Church	5	-	44
Frederickton Public School	17	57	43
Kempsey Adventist Primary School	5	54	44
Frederickton Golf Course	17	59	-

Note: Numbers highlighted in **bold** exceed the noise criteria identified in Table 3.3

The table above identifies that traffic noise levels will comply at Kempsey Adventist Primary School and Frederickton Golf Course in 2021, ten years after the opening of the un-staged project. Noise levels at Frederickton Public School for the playground areas and the Kempsey Seventh Day Adventist Church will marginally exceed the noise criteria by 2dB(A) and 4dB(A), respectively. Further investigation of noise mitigation of these premises will be required to reduce noise impacts to within compliant levels.

3.5.2 Increase in Existing Ambient Noise Levels

The noise criteria set out in the ECRTN are intended to preserve amenity appropriate to the land use. The confidence for such an outcome occurring for the specified noise levels is based on well-documented social surveys defining a dose–response relationship between noise level and annoyance. The noise criteria set out in the ECRTN are well supported by the comparison with overseas criteria, as set out in Appendix B1 of the ECRTN.

As reported in Appendix B2 of the ECRTN, based on research findings, the practice has developed that environmental objective for transportation-related noise sources be set approximately at the point at which 10% of residents are highly annoyed by the noise. This would indicate that, for road traffic noise, such objectives should be set at approximately 55dB(A) L_{eq} for daytime noise exposure. However, other factors also influence the choice of a criterion, including the practicality of achieving the criterion in high-noise areas and the additional impact of the introduction of a new noise source to a relatively quiet environment.

On the issue of introducing a new noise source to a relatively quiet environment, the level of reaction to a newly introduced noise may not be directly predictable. In simple terms, while people may express a certain level of acceptance of their existing noise environment, they may feel strongly about any increase in noise. There is evidence to suggest that reaction to a newly introduced noise source is considerably higher than reaction to a source that has been present for some time. The results of studies referred to in the ECRTN indicate that where noise exposure is suddenly and substantially increased, reaction is higher than would be predicted from studies of steady noise conditions.

For this project, since the majority of the proposed Upgrade is through 'greenfield' areas where receivers are not currently affected by traffic noise and the existing ambient noise levels are generally very low, complaints may arise once the proposed Upgrade is completed and in operation. Although future ambient noise levels due to traffic noise from the Upgrade may comply with the ECRTN noise criteria, the increase in the ambient noise levels may be significant and initial complaints may occur as a result of residents suddenly being exposed to a significant increase in ambient noise levels.

3.5.3 Option to Stage Construction

Due to the significant length of the proposed Upgrade, there may be an option to allow it to be constructed over two stages. Stage 1 would likely be the section South of the Macleay River, opened prior to the completion of the full Upgrade. Stage 2 would be the section north of the Macleay River to Eungai Rail. If staging were to occur, the second stage would be expected to be completed within 10 years of Stage 1 of the proposed Upgrade opening.

If a staged approach is adopted then at the completion of Stage 1 traffic will be diverted off the proposed Upgrade route at Frederickton and directed back onto the existing Pacific Highway between Frederickton and Eungai Rail. There is potential for traffic noise levels to increase along the existing Pacific Highway as a result of increased traffic volumes after the completion of Stage 1 and up to the completion of Stage 2.

The traffic conditions on the proposed Upgrade are not anticipated to change significantly as a result of staging the construction. The table below summarises the predicted traffic volumes along the existing Pacific Highway in the event of staging the construction phase.

Table 3.11 – Forecast Traffic Volumes on Existing Pacific Highway for 2011 and 2021 (Staged Option)

Road/ Traffic Count Location	Period ¹	Speed, km/h	2011		2021	
			Volume	%Heavy	Volume	%Heavy
Pacific Highway, North of Frederickton	Day	100	9025	13	10999	13
	Night	100	1383	48	1735	51
Pacific Highway, Eungai Rail	Day	100	10477	18	15714	18
	Night	100	1899	61	2811	61

An assessment of the potential increase in traffic noise levels as a result of staging the proposed Upgrade has been completed. The results are summarised in Table 3.12 below.

Table 3.12 – Predicted Changes in Traffic Noise Levels on the Pacific Highway from Staged Upgrade Construction

Section of Pacific Highway	Period	Change in Noise Level from Staged Approach, dB(A)		
		2011 Future Existing	2011 Stage 1 Complete	2021 Stage 1 Complete
North of Frederickton	Day	-	-1	0
	Night	-	-1	0
Eungai Rail	Day	-	0	2
	Night	-	0	2

Notes: 2011 Future Existing refers to traffic noise level in 2011, if the road project were not to go ahead
2011 S1 refers to change in traffic noise level in 2011, following completion of Stage 1 only
2021 S1 refers to change in traffic noise level from 2011, Stage 1 only complete

The predicted change in noise levels as a result of staging the proposed Upgrade indicate that there will be an insignificant [2dB(A) or less] increase in traffic noise on the existing Pacific Highway as a result of staging the proposed Upgrade and redirecting traffic back onto the Pacific Highway at Frederickton.

3.6 MAXIMUM NOISE LEVEL ASSESSMENT

The NSW ECRTN does not specify a night-time L_{max} noise limit or noise goal. This is primarily because research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined. According to the policy however, the likely maximum or peak noise levels are to be broadly assessed and reported for the night-time period, which is considered by the DEC as being 10pm to 7am.

The RTA's 'Environmental Noise Management Manual' (ENMM) provides guidance for assessing maximum noise levels. Guidelines for assessing maximum noise levels are provided in Practice Note III of the ENMM. The guidelines are to be used as a tool to help prioritise and rank mitigation strategies, but should not be used as a decisive criterion in itself.

The ENMM defines a "maximum noise event" as any pass-by for which

$$L_{max} - L_{eq} \geq 15\text{dB(A)}, \text{ where the } L_{max} \text{ noise level is greater than } 65\text{dB(A)}.$$

Noise monitoring carried out at the three noise monitoring locations identified in Table 2.1 determined the average $L_{Aeq(1h)}$ and the average L_{Amax} traffic noise levels at each of the measurement locations along the existing Pacific Highway over one night. The monitoring also identified the number of 'maximum noise events' that occurred over the night. The results are shown in Table 3.13.

Table 3.13 – Analysis of Maximum Noise Events Along Existing Pacific Highway

L_{Amax} Measurement Location	Average $L_{Aeq(1h)}$ dB(A)	Average L_{Amax} dB(A)	Nº Maximum Noise Events	Nº Heavy Vehicles
702 Pacific Highway South Kempsey	60	76	4	949
921 Pacific Highway, Frederickton	71	87	29	824
3381 Pacific Highway, Eungai Rail	67	82	18	854

Maximum noise levels at night have been predicted using the measured existing L_{max} noise level data and taking into consideration the proposed road design and distance between the road and residential receivers along the proposed Upgrade route.

Table 3.14 – Analysis of Maximum Noise Events Along Proposed Upgrade (Year 2021)

Nearest Affected Receiver Location for each NCA	Average $L_{Aeq(1h)}$ dB(A)	Average L_{Amax} dB(A)	N° Heavy Vehicles
NCA1a	54	81 - 87	2969
NCA2a	49	62 - 68	2969
NCA3b	58	73 - 78	2969
NCA4a	61	78 - 84	2969
NCA5a	62	82 - 87	2969
NCA6e	61	78 - 84	2969
NCA7I	57	75 - 81	2969
NCA8n	63	76 - 82	2969
NCA9c	60	77 - 83	2969
NCA10g	53	67 - 72	2969
NCA11a	51	83 - 88	2969
NCA12a	54	69 - 75	2969
NCA13b	56	69 - 74	2969
NCA19b	64	81 - 87	3936
NCA20c	55	67 - 73	3936
NCA21d	57	73 - 78	3936
NCA22a	55	86 - 92	3936
NCA24a	60	67 - 73	3936
NCA26a	49	65 - 70	3936
NCA27A	48	60 - 66	4182
NCA28a	52	62 - 68	4182
NCA29b	63	84 - 90	4182
NCA30c	53	69 - 74	4182
NCA31c	59	81 - 87	4182

Maximum noise levels along the existing Pacific Highway route will be significantly reduced by the proposed Upgrade as vehicles will bypass the denser residential areas. Nonetheless, most residences along the proposed Upgrade have not previously been exposed to traffic noise.

The proposed Upgrade route has been design to minimise changes in grade and to smooth curves/ corners in the road alignment, to make a safer route for road travel. It is therefore expected that on the proposed Upgrade route, the need for heavy vehicles to utilise engine brakes is greatly reduced from the current usage on the Pacific Highway, therefore minimising maximum noise events. It should be noted however that the use of truck exhaust brakes is at the driver's discretion. Therefore the assessment reported above is based on a conservative

approach assuming that the maximum noise level event is generated at the closest point on the road to the nearest affected receiver.

3.7 NOISE MITIGATION OPTIONS

As discussed in Section 3.5, the ECRTN noise criteria are exceeded at residential receiver locations within the study area. Therefore, an assessment of feasible and reasonable noise mitigation options is required. At NCAs 1, 29 and 30, where future-existing traffic noise levels already exceed the base traffic noise criteria, an allowance of 2dB(A) above existing traffic noise levels might be applied, where all reasonable and feasible mitigation measures have been exhausted. Furthermore, noise mitigation measures should be considered for residences identified as having 'acute' noise levels, where such levels have occurred as a result of the proposed Upgrade.

The following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. This information is presented for the purpose of the approvals process and cost planning and should not be used for construction unless otherwise approved in writing by the acoustic engineers. Further investigation through the assistance of an acoustic engineer would be sought during the detailed design stage of the project.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of urban design and visual impacts, structural design, buildability, fire ratings, fitness for purpose and the like.

3.7.1 Quieter Pavements

The RTA's 'Environmental Noise Management Manual' (ENMM) gives guidance on appropriate treatment of sensitive receivers affected by road traffic noise. 'Quiet' road pavement surfaces such as Open Graded Asphaltic Concrete (OGAC) or Stone Mastic Asphalt (SMA) could be laid along sections of the proposed Upgrade affecting residential and other sensitive receivers. At speeds of greater than 80km/hr, quiet road pavement can provide a 2-4dB(A) noise reduction at the source compared to standard pavements, although noise reductions are less for speeds less than 80km/hr.

The intended posted speed limit for the proposed Upgrade is 110km/hr. With this in mind, using a quieter pavement may be feasible, however, the application is not a reasonable one for certain areas of the Upgrade route. The high costs associated with the application of a quieter pavement in these areas are not considered a cost effective option in regards to the low-noise reductions achieved compared to the noise reduction required to comply with the ECRTN criteria. Additionally, given the low density of sensitive receivers along these areas of the route, and the level of noise reduction required at some receivers, provision of low-noise pavement would reduce traffic noise levels to compliant levels at less than 20% of receivers located in these areas.

However, for areas where the density of sensitive receivers is high (groups of three receivers or more), the use of low-noise pavement is considered reasonable. Areas of the Upgrade route where this is applicable are NCA 3, 6, 7, 8 and 9 located in the township of Kempsey.

Furthermore, it should be noted that pavement selection may also be influenced by external factors, such as geotechnical considerations. For example, along the southern section of the route (south of the Macleay River) in which NCA 3, 6, 7, 8 and 9 are located, the pavement selection will be influenced by the soft soil types identified in this area to avoid settlement issues post construction. A composite pavement such as OGAC or SMA may be cost effective in this area as it would satisfy the geotechnical requirements for the road construction, as well as providing noise reduction to residential receivers.

3.7.2 Noise Barriers

Noise barriers are most feasible where residences are closely grouped, where the barriers do not cause access difficulties to properties, and where they are visually acceptable.

Practice Note IV of the RTA's ENMM provides guidance on selecting reasonable and feasible noise mitigation measures. The ENMM notes that architectural treatment of residences is preferred over roadside barriers where residences are clumped in groups of 3 or less. It also notes that noise barriers in excess of 8 metres are generally considered visually unacceptable.

To derive the most appropriate height for noise barriers (walls and mounds) for each NCA, a cost-effectiveness analysis was undertaken in accordance with Practice Note IV of the RTA's ENMM. According to the ENMM, the "*assessed barrier*" option is defined as the most cost-effective barrier height on the basis of 'providing the greatest marginal noise reduction benefit and the greatest benefit per unit of barrier area'. The "*target barrier*" option is defined as 'the barrier height required to meet the target noise levels in Columns 2 and 3 of Table 1 in the ECRTN at the most affected residence, if it is feasible to meet these targets'.

Due to the sparse density of residential premises along the route, it was generally found that residences were singular or gathered in groups of 3 or less, making noise barrier construction unreasonable. The exception to this was at NCA 3 (between stations 900 and 1700) and NCAs 6, 7, 8 and 9 (between stations 3500 and 5700).

Noise predictions with noise barriers positioned along the road-edge were performed using the traffic noise model for noise catchment areas where there are more than three residences grouped together (within 50m of each other) and where traffic noise levels are predicted to exceed traffic noise criteria. The noise prediction model inputs outlined in Table 3.6 were used in the noise model together with a low-noise pavement surface for the areas indicated in Table 3.15, where noise barriers may be used. Noise predictions were conducted to the ground floor of residences that were found to exceed the traffic noise criteria, and the required nominal heights of noise barriers were determined to achieve compliant noise levels. The model assumes that:

- Barriers are located along the edge of the carriageway.
- The base of the barrier is at the highest point on the edge of the formation.
- Low-noise pavement is used in the areas where noise barriers are assessed.

**Table 3.15 – Noise Barrier Locations and Nominal Heights
Based on Cost-Effectiveness Analysis**

Noise Catchment Area	Road Side	Approx. Start Station	Approx. Length	Target Barrier Height	Noise Criteria Achieved?	Assessed Barrier Height	Cost-Effective Barrier Height
NCA 3	West	800	900m	>8m	No	None	None
NCA 6	East	3500	600m	6.5m	Yes	4.5m	6.5m
NCA 7	West	3500	600m	3.5m	Yes	1.5m	3.5m
NCA 8a	East	4100	600m	3m	Yes	2.5m	3m
NCA 8b	East	5100	600m	6m	Yes	2.5m	6m
NCA 9	West	4200	600m	5.5m	Yes	2.5m	5.5m

From Table 3.15 it can be seen that the cost-effective barrier height for all NCAs (except NCA 3) is the target barrier height. For NCA 3, the barrier height of more than 8m would be required to

reduce noise to acceptable levels. This is not considered cost effective, visually acceptable and feasible.

Aerated concrete or timber is generally the least expensive barrier construction materials. Metal or polycarbonate tends to be more expensive. Using transparent panels, absorptive facing or patterned aesthetic finishes also increases costs.

NCA's 3, 6, 8b and 9 will require noise barriers in excess of 5m in height in order to achieve the base criteria at all sensitive receivers within the catchment areas. Noise barriers higher than 5m above ground level are often considered unacceptable in terms of visual amenity, particularly when located on the boundary of residential properties. While it may be feasible to construct a 5.5m to 6.5m noise barrier to reduce noise levels, the subsequent aesthetic impacts may deem it unreasonable.

Therefore, final barrier heights and pavement types should be reviewed and optimised at the detailed design phase of the proposed Upgrade. Furthermore, as part of the design phase height or barriers will also need to be subjected to community preferences through consultations and the DEC will be consulted on any changes to the configuration of barriers as part of the design process.

3.7.3 Architectural Treatment

At-house or building treatment should only be considered for dwellings where the traffic noise criteria is exceeded and other noise mitigation measures are either exhausted or are not feasible or cost-effective.

The ECRTN's target noise levels are external noise goals, but building treatment only reduces noise levels inside a dwelling. Therefore, any building treatment should be designed to achieve the internal noise levels that would have been achieved had noise from the proposed Upgrade complied with the ECRTN criteria externally.

It is generally accepted that most buildings provide a noise reduction of at least 10dB(A) when windows are left 20% open, without providing additional treatment (EPA ECRTN p14). This equates to internal traffic noise criteria of $L_{Aeq(15hr)}$ 45-50dB(A) and $L_{Aeq(9hr)}$ 40-45dB(A) for the proposed Upgrade, depending on whether the criteria are for a 'new' or 'redeveloped' road. Therefore, the goal of architecturally treating residences is to reduce future traffic noise levels to 45dB(A) $L_{Aeq(15hr)}$ and 40dB(A) $L_{Aeq(9hr)}$ internally for 'new' road criteria sections of the project (ie NCAs 2 to 28 and 31) and 50dB(A) $L_{Aeq(15hr)}$ and 45dB(A) $L_{Aeq(9hr)}$ internally for 'redeveloped' road criteria sections of the project (ie NCAs 1, 29 and 30).

Traffic noise predictions have been used to determine the additional noise reductions required to achieve the internal noise goals for residential receivers that are modelled to fall between the road and the night $L_{Aeq,9h}$ 55dB(A) external noise contour (ie exposed to traffic noise greater than $L_{Aeq,9h}$ 55dB(A) at night) for NCAs 1, 29 and 31, and between the road and the night $L_{Aeq,9h}$ 50dB(A) external noise contour for NCAs 2 to 28 and NCA 31. It is assumed that the pavement surface is concrete with coarse hessian drag and tining for most of the Upgrade route and low-noise pavement in NCA's 6, 7, 8 and 9 (as per Table 3.15). The cost-effective noise barrier heights presented in Table 3.15 have also been assumed in determining the number of residences requiring architectural treatment. Results are presented in Table 3.16 below.

Table 3.16 – Additional Noise Reduction to Achieve Night Time Internal Noise Goals

NCA	Roadside Noise Treatment Option	Noise Reduction Required (year 2021), dB(A)	N° Residences Exceeding Traffic Noise Criteria (year 2021)
1	None	4	1
2	None	2	1
3	None	1-16	9
4	None	1-15	2
5	None	12	1
6 ¹	Low-Noise Pavement & 6.5m Noise Wall	0	0
7 ¹	Low-Noise Pavement & 3.5m Noise Wall	0	0
(8a) ¹	Low-Noise Pavement & 3m Noise Wall	0	0
(8b) ¹	Low-Noise Pavement & 6m Noise Wall	0	0
9 ¹	Low-Noise Pavement & 5.5m Noise Wall	0	0
10	None	1-6	5
11	None	1-7	5
12	None	8	1
13	None	4-9	2
19	None	4-15	2
20	None	2-6	3
21	None	4-14	6
22	None	7	1
24	None	15	1
26	None	1	1
28	None	1-3	2
29	None	9-11	3
31	None	2-7	3

Note: 1. Noise treatment option based on cost-effectiveness analysis results presented in Table 3.15
2. House counts based on information provided by Parsons Brinckerhoff, as shown in Figure 2.
3. Assumes all dwellings are single storey.

As a guide, the tabulated information regarding the level of noise reduction required can be cross-referenced with the noise control options below.

Option 1 Mechanical ventilation only

**<5dB(A)
reduction**

Where external noise levels are less than 5dB(A) above the ECRTN 'base' criteria, the internal 'base' criteria may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the ECRTN internal 'base' criteria can only be achieved with windows closed, then mechanical ventilation or air conditioning must be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

Option 2 Mechanical ventilation and sealing of wall vents

*5-10 dB(A)
reduction*

Where external noise levels are less than 10dB(A) above the ECRTN 'base' criteria, the internal 'base' criteria may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (RTA Noise Management Manual p20) when windows are closed and wall vents are sealed. If the ECRTN internal 'base' criteria can only be achieved with windows closed, then mechanical ventilation or air conditioning must be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.

Option 3 Upgraded windows, glazing and doors

*>10 dB(A)
reduction*

Where the predicted external noise level exceeds the ECRTN 'base' criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors will be required on the facades exposed to the proposed Upgrade, in addition to the mechanical ventilation described in Option 1. Note that these upgrades are only suitable for masonry buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.

3.7.4 Sensitive Receivers

Predicted noise levels at sensitive receivers in 2021 generally comply with the noise criteria, with the exception of the Kempsey Adventist Church. Noise levels inside the Kempsey Adventist Church have been modelled to exceed the internal noise criterion by 2dB(A). This is considered to be a minor non-compliance that can be rectified by closing the church windows during its use and providing mechanical ventilation to meet the ventilation requirements of the Building Code of Australia. Further analysis of the church building construction would be carried out at the detailed design stage to confirm whether the provision of architectural treatment is reasonable and feasible.

3.8 METEOROLOGICAL EFFECTS

Certain meteorological conditions may increase noise levels by focusing sound-wave propagation paths at a single point. Such sound refraction (or bending of) sound waves will occur during:

- temperature inversions (atmospheric conditions where air temperatures increase with height above ground level), and
- gradient winds (that is, wind velocities that increase with height) where the wind direction is from the source to receiver location.

These conditions tend to have a negligible effect on noise levels at relatively short distances (up to 200-300m) and have a greater effect at larger distances (eg greater than 200-300m) to receivers from a noise source.

There is no requirement to assess meteorological effects such as temperature inversions and wind effects under the ECRTN. This is largely because the most affected receivers from road traffic noise impacts typically occur within 200-300 metres of the road. Thus, including assessment of the impacts of meteorological effects on road traffic noise is not considered necessary.

The impacts of meteorology on road traffic noise was raised in the Northern Pacific Highway Taskforce Report prepared by the RTA in consultation with the Far North Coast community (August 2003). The Taskforce Report reiterates that *“for roads the worst affected residences are typically closer than 200-300 metres and thus including weather effects in assessing noise levels is not needed”*. However, the Taskforce Report also states that *“in situations where the worst affected residences are distant from the road, weather effects may, depending on circumstances (eg prevailing winds, presence of inversions, etc) influence noise levels”*. Therefore, in response to the Taskforce Report, meteorological conditions should be reviewed as part of the detailed design process.

4. CONSTRUCTION NOISE & VIBRATION ASSESSMENT

4.1 CONSTRUCTION METHODOLOGY

Detailed information about the timing and programming of construction works is unknown at this stage of the proposed Upgrade. This assessment is based on a general understanding of road construction and of the works that may be required for the construction of the proposed Upgrade.

The total duration of the construction phase will be 3 years.

Site clearing will be one of the first major activities to occur and is expected to take approximately 2 months to complete.

Bulk earthworks (24-30 months) and drainage works (18 months) are likely to be of the longest total duration, and potentially the loudest. South of the Macleay River there is a considerable amount of hard rock, and it is unlikely that scrapers would be used. Ripping, rock hammering and/or blasting will be required in the cuttings at STN 1300, STN 3000 and STN 7000 to remove hard rock material. It is expected that a crushing operation will be used to produce concrete aggregate or road base material. Blasting is not likely to be required north of the Macleay River, where it is expected that ripping will be sufficient to remove cut material.

Bridgeworks are also significant in terms of duration and potential noise generated, particularly the construction of the Macleay River Bridge. This is expected to take approximately 18 months to construct. Unlike other construction activities, the bridge is in a fixed location, with potential to cause impact for the full duration of bridgeworks. Works at some specific bridge sites will involve the lifting and setting of bridge girders over roads currently in use. These works will need to be carried out at night for safety reasons, and to minimise disturbance caused to existing road traffic flows. These bridge locations include:

- Southern Interchange;
- Crescent Head Road;
- Old Station Road;
- South West Rocks Road;
- Existing Pacific Highway at Frederickton; and
- Existing Pacific Highway at Eungai.

All practical measures should be undertaken to limit noise generated by these night works.

The surface preparation and paving works would be of shorter duration than the works described above, approximately 12 months total duration starting about 12 to 18 months into the proposed Upgrade, and are likely to generate less noise. Vibratory rollers would be used for compaction during surface preparation. Since a concrete pavement would be used, a concrete batch plant will also be established along the route, although the exact location for this has not been determined. A large number of concrete pours would be required. Concrete sawing would likely be required at night.

Ancillary infrastructure will consist of:

- Site compounds will include the main compound and other minor compounds at bridge sites or remote areas of the proposed Upgrade. 25 potential sites have been identified for site compounds, at stations 700, 900, 1900, 2500, 4200, 5200, 6400, 6700, 7400, 7800, 12800,

13700, 15300, 15800, 16400, 18400, 22900, 28100, 30500, 30800, 31100, 34000, 35200 and 35400.

- Crushing operations - four sites identified along the route – at Station 700, 2500, 5200 and the Churchill Quarry.
- Concrete/ Asphalt batching plants - for assessment purposes, four sites have been adopted, based on the crushing locations.
- Stockpile areas.

The following table summarises the major construction activities expected to be undertaken on the proposed Upgrade.

Table 4.1 – Expected Construction Activities

Noise Generating Activity	Description	Hours of Use	Timing of Activity
Corridor Clearing	Removal of vegetation by chainsaw and chipping by tub grinder wood chipper. Tree & stump removal. Topsoil stripping. Loading.	10 hrs per day	2 months
Bulk Earthworks – south of river	Excavation of soil and rock. Hammering/rock breaking, ripping, blasting (2 locations), loading, and haulage.	10 hrs per day	12-15 months
Bulk Earthworks – north of river	Excavation of soil and rock. Scraping, ripping, loading, and haulage.	10 hrs per day	12-15 months
Drainage	Excavation of trenches and pits; delivery and placement of pre-cast pipes and pits; filling and compacting.	10 hrs per day	18 months
Bridges	Casting; concrete pours; placement of pre-cast elements; bored and/ or driven piling.	10 hrs per day	18 months Start 6 months into construction
Pavement	Concrete batching. Delivery of raw materials; placement of surface material; saw cutting.	10 hrs per day – concrete saw may work at night	12 months Start 12 months into construction
Construction Compounds	Light vehicles accessing site; deliveries to compound; maintenance; office areas & storage	10 hrs per day	36 months (project duration)
Crushing Plants	Rock crushing and stockpiling of material	10 hrs per day	12-15 months
Batching Sites	Concrete/ asphalt batching plants	10 hrs per day	12 months Start 12 months into construction

4.2 CONSTRUCTION CRITERIA

4.2.1 Construction Noise

The NSW *Environmental Noise Control Manual* (ENCM, Environment Protection Authority 1994) provides guidelines for assessing noise generated during the construction phase. Specifically, Chapter 171 of the ENCM provides noise goals for the construction period.

Noise Level Restrictions

- i) *Construction period of 4 weeks and under.*
The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 20 dB(A)**.
- ii) *Construction period greater than 4 weeks and not exceeding 26 weeks.*
The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 10 dB(A)**.

Chapter 171 of the ENCM provides no specific guidelines where the construction period will be greater than 26 weeks. It is however generally accepted that where the construction period will be greater than 26 weeks, noise levels should aim to achieve the following goal:

- iii) The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 5 dB(A)**.

It is noted that although the progress of works along a linear project such as a road upgrade is such that the acoustic centre will change as the work progresses, the total duration of the proposed Upgrade as a whole is in excess of 26 weeks. For a conservative assessment, construction activities are expected to occur for more than 26 weeks, and therefore would be subjected to criterion iii) above.

Time Restrictions

The ENCM also states that construction works should be limited to the following times:

- Monday to Friday, 7am to 6pm.
- Saturday, 7am to 1pm if audible on residential premises, otherwise: 8am to 1pm.
- No construction work to take place on Sundays or Public Holidays.

It may be necessary for construction activities to be carried out at times other than those specified above for safety and operational reasons.

The noise monitoring results from Section 2.6 have been used to set construction noise criteria. The noise monitoring at each monitoring location was considered to be representative of the lowest background noise levels in each noise catchment area (NCA). Therefore, measured noise levels are suitable for setting construction noise criteria, consistent with a conservative assessment. Based on the background noise levels measured at each NCA and the duration of construction activities being greater than 26 weeks, the construction noise criteria are summarised below.

Table 4.2 – Summary of Construction Noise Criteria

NCA	L_{A90} Noise Level, dB(A)	Construction Noise Criteria, dB(A) [More than 26 weeks = ($L_{A90} + 5$)]
1	48	53
2	43	48
3	42	47
4 & 5	39	44
6 & 7	37	42
8 & 9	36	41

NCA	L _{A90} Noise Level, dB(A)	Construction Noise Criteria, dB(A) [More than 26 weeks = (L _{A90} + 5)]
10 & 11	32	37
13 & 12	39	44
15 & 14	44	49
16	40	45
17	38	43
18-21	31	36
22 & 23	27	32
25 & 24	34	39
26 & 27	32	37
28	39	44
29	48	53
30	41	46
31	40	45

The Department of Environment and Conservation are currently reviewing criteria for construction noise. If applicable, revised criteria may need to be considered by the construction contractor.

4.2.2 Construction Vibration

The effects of ground vibration on buildings near construction sites may be broadly defined by the following three categories:

1. Disturbance to building occupants - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,
2. Effects on building contents - Vibration where the building contents may be affected, and,
3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

In many cases, it is the residents' concerns about building damage that increases the potential annoyance caused by vibration generating construction activities.

Vibration criteria for human disturbance (1) are generally more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would ensure that compliance is also achieved for the other two categories.

Category 1 – Human Comfort

Table 3.2 gives an indication of typical human perception of vibration. The table indicates that vibration is perceived at very low magnitude.

Table 4.3 – Vibration and human perception of motion

Approximate vibration (mm/s) ¹	Degree of perception
0.10	Not felt
0.15	Threshold of perception
0.35	Barely noticeable
1.0	Noticeable
2.2	Easily noticeable
6	Strongly noticeable
14	Very strongly noticeable

Note: 1. Approximate vibration (in floors of buildings) having a frequency in the range of 8 Hz to 80 Hz

For disturbance to human occupants of buildings, we refer to the NSW Department of Conservation's 'Assessing Vibration; a technical guideline', published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, 'Evaluation of human exposure to vibration in buildings (1-80Hz)'.

Vibration sources are defined as *Continuous*, *Impulsive* or *Intermittent*. Section 2 of the technical guideline defines each type of vibration as follows:

Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time).

Impulsive vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.

Intermittent vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude.

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'

Preferred and maximum values for continuous and impulsive vibration are defined in table 2.2 of the guideline and are reproduced below.

Table 4.4 – Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s²) 1-80Hz

Location	Assessment period ¹	Preferred values		Maximum values	
		z-axis	x & y axes	z-axis	x & y axes
Continuous vibration					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

Table 4.5 – Acceptable vibration dose values for intermittent vibration ($\text{m/s}^{1.75}$)

Location	Daytime ¹		Night-time ¹	
	Preferred	Maximum	Preferred	Maximum
Critical areas ²	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992

Category 2 – Effects on building contents

The typical frequency range of road and bridge construction induced ground vibration is approximately 8 Hz to 100 Hz. Over this range the threshold of visible movement of building contents such as plants, pictures, blinds etc is approximately 0.5 mm/s. At vibration levels higher than 0.9 mm/s, audible rattling of loose objects such as crockery can be expected.

Category 3 – Structural Damage to Buildings

Currently there exists no Australian Standard for assessment of building damage caused by vibrational energy. The British Standard 7385: Part 2 "Evaluation and measurement of vibration in buildings", can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur. Further to this, the German standard *DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures"*, provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration.

The vibration limits are presented in Table 4.6 below.

Table 4.6 – Structural Damage Criteria - Safe Limits for Building Vibration

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation At Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

The values presented in Table 4.6 are generally recognised to be conservative. Vibration higher than these minimum figures for low frequencies may be quite safe, depending on the frequency of the vibration. The values provided in the table are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

DIN 4150 also states that when vibration at higher than the "safe limits" is present, it does not necessarily follow that damage will occur.

4.2.3 Blasting

Blasting produces ground-borne vibration and air blast overpressure, both of which can cause discomfort and at higher levels, damage to property.

The *ANZECC Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* have been adopted by DEC and establish ground vibration and airblast overpressure criteria for potentially effected locations.

The guidelines state that:

"Blasting operations should in most cases be confined to the periods Mondays to Saturdays, 9am to 3pm. Blasting outside of those times should be approved only where blasting during the preferred times is clearly impracticable, and should then be limited in number. Blasting at night should be avoided unless it is absolutely necessary."

The following table shows the limiting blast overpressure and ground vibration for the control of blasting impact on residential premises.

Table 4.7 – Limiting Criteria for the Control of Blasting Impact at Residences

Day	Time of Blasting	Blast Overpressure Level, dB (linear)	Peak Ground Vibration, mm/sec
Monday to Saturday	9am-3pm	115	5
Monday to Saturday	6am-9am, 3pm-8pm	105	2
Sunday, Public Holiday	6am-8pm	95	1
Any day	8pm-6am	95	1

In addition, any exceedence above a blast overpressure of 115dB (linear) should be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 120dB (linear) should not be exceeded at any time.

Ground vibrations above 5 mm/sec should also be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 10 mm/sec should not be exceeded at any time.

4.3 NOISE AND VIBRATION PREDICTION MODELLING

4.3.1 Construction Noise Sources

The following table lists construction plant and equipment likely to be used by the contractor to carry out the necessary construction work for the proposed Upgrade.

Table 4.8 – Typical Construction Equipment & Sound Power Levels, dB(A)

Activity	Plant Description	No. Plant	L _{WA} dB(A) ¹	Activity	Plant Description	No. Plant	L _{WA} dB(A) ¹
Corridor Clearing	Bulldozer	2	116	Drainage	Backhoe	3	104
	Excavator	2	108		Excavator	2	108
	4-5hp Chainsaw	5	114		Compactor	2	113
	Tub grinder/ mulcher	1	116		Dump Truck	4	108
	Dump trucks	10	108	Pavement	Batch Plant	1	111
Bulk Earthworks (sth/nth)	Bulldozer	4/4	116		Paver	2	114
	Scraper	1/6	110		Road truck	15	108
	Rock Crusher	1/0	113		Concrete saw	2	103
	Excavator	10/8	108		Asphalt truck/ sprayer	10	106
	Rock breaker	5/0	120		Agitator	5	103
	Dump truck	20	108		Roller	2	118
	Road truck	10	108				
	Compactor	4	113				
	Water cart	5	107	Compound /s	Front End Loader	2	113
Bridges	Mobile Crane	1	113		Dump Truck	10	108
	Pile Driving Rig	1	137		Compressor	1	98
	Bored piling rig	1	114		Welding equipment	2	105
	Generator	2	103		Light vehicles	30	103
	Concrete pump	2	105		Heavy vehicles	10	106
	Agitator	4	103		Generator	2	104
	Concrete truck	2	109	Blasting	Air track drill	1	124
	Compressor	2	98	Rock Crushing	Rock Crusher	1	113
	Jackhammer	5	113		Bulldozer	1	116
	Welding equipment	5	105		Tracked Excavator	1	108

Note: 1. L_{WA} refers to the sound power level (referenced to 1pW)

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table D2 of Australian Standard 2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", information from past projects and information held in our library files.

4.3.2 Construction Vibration Sources

Construction equipment most likely to cause significant vibration are pile drivers, hydraulic rock breakers, jackhammers, bulldozers, vibratory rollers and trucks. Typical vibration levels from these items are summarised below. The information was sourced from a variety of reference materials available in the Renzo Tonin & Associates library.

Table 4.9 – Typical Ground Vibration Generated by Construction Plant

Activity	Typical ground vibration
Driven piling	20-40mm/s at a distance of 10m, dependent on the blow energy used (20-60 kilojoules); 7-12mm/s at 20m; and 2-3.5mm/s at 100m.
Bored piling	4mm/s to 5mm/s at a distance of approximately 5m, and 1.5mm/s at 10m. At distances greater than 25m, vibration are usually below 0.6mm/s, and at 50m or more vibration are usually below 0.1mm/s
Bulldozers	Typical ground vibration from bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s.
Hydraulic rock breakers	A large rock-breaker operating in hard sandstone is likely to generate 4.5mm/s at a distance of 5m, and 0.4mm/s-0.1mm/s at distances of 20m to 50m. A small rock-breaker operating in hard sandstone is likely to generate 1mm/s at a distance of 5m, and 0.1mm/s-0.01mm/s at distances of 20m to 40m.
Compactor	Compactors typically generate 20mm/s at distances of approximately 5m, 2mm/s at distances of 15m. At distances greater than 30m, vibration are usually below 0.3mm/s.
Jackhammers	Typical ground vibration from jackhammers range from 1mm/s to 2mm/s at distances of approximately 5m. At distances greater than 20m, vibration levels are usually below 0.2mm/s.
Vibratory rollers	Ground vibration caused by vibratory rollers can range up to 1.5mm/s at distances of 25m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, especially dwellings. Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller).
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 - 0.2mm/s at the footings of buildings located 10 - 20m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher. In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded.

4.4 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

4.4.1 Construction Noise

Residential, commercial and rural/industrial buildings are scattered along the proposed Upgrade and varying distances from construction activities. There are a higher number of residences within 100m of the road works south of the Macleay River. In South Kempsey, some factory buildings are 10 to 20m from the alignment. There are a number of residences around the Old Station Road and Bruces Lane areas that are typically 20m to 50m from the alignment. Other residences are 100m or more from the alignment.

North of the Macleay River residences are sparsely scattered, typically 100m to 500m from the alignment. Residences are as close as 50m to the alignment around Barranganyatti, and within 20m to 30m of the alignment at Eungai Rail, where the proposed Upgrade rejoins the existing alignment.

Noise levels at any receptors resulting from construction would depend on the location of the receptor with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of operation being undertaken. Furthermore, noise levels at receivers will vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used. A range of noise levels has been calculated, including the quietest plant items operating alone, and a typical configuration of plant items operating concurrently for each activity, based on typical distances from road activities to receiver locations. Table 4.10 summarises the predicted levels.

Table 4.10 – Predicted Construction Noise Level Range at Receivers

NCA	Typical Distance from work, m	Criteria, dB(A)		Noise level from Construction Activity, dB(A)				
		< 4 weeks	4-26 weeks	Corridor Clearing	Bulk Earthworks	Drainage	Bridges	Pavement
1	50	68	58	-	64-80	62-72	36-60	61-74
2	50	63	53	-	64-80	62-72	56-75	61-74
3	100	62	52	60-69	58-72	56-66	36-60	55-68
4	50 & 150	59	49	56-65 66-75	54-71 64-80	52-63 62-72	36-60 36-60	51-64 61-74
5	150	59	49	56-65	54-71	52-63	50-69	51-64
6	100	57	47	60-69	58-72	56-66	50-69	55-68
7	100	57	47	60-69	58-72	56-66	36-60	55-68
8	100	56	46	60-69	58-72	56-66	32-51	55-68
9	50	56	46	66-75	64-80	62-72	46-65	61-74
10	150	52	42	56-65	54-71	52-63	41-60	51-64
11	150	52	42	56-65	54-71	52-63	36-60	51-64
12	150	59	49	56-65	54-71	52-63	39-58	51-64
13	150	59	49	56-65	54-71	52-63	32-51	51-64
14	480	64	54	46-55	32-53	39-49	42-61	38-50
15	270	64	54	52-61	50-62	48-58	46-65	47-60
16	150	60	50	56-65	54-67	52-63	36-55	51-64
17	500	58	48	46-55	36-56	42-52	-	41-54
18	-	51	41	-	-	-	-	-
19	30 350	51	41	70-79 49-58	68-81 47-60	66-77 45-55	- 32-51	65-78 44-57
20	150	51	41	56-65	54-67	52-63	36-55	51-64
21	120	51	41	58-67	56-69	54-65	-	53-66
22	300	47	37	50-59	48-61	46-57	-	45-58
23	750	47	37	42-51	40-53	39-49	40-59	38-50

NCA	Typical Distance from work, m	Criteria, dB(A)		Noise level from Construction Activity, dB(A)				
		< 4 weeks	4-26 weeks	Corridor Clearing	Bulk Earthworks	Drainage	Bridges	Pavement
24	70	54	44	63-72	61-73	59-69	36-55	58-71
25	250	54	44	52-61	50-62	48-58	32-51	47-60
26	250	52	42	52-61	50-62	48-58	50-69	47-60
27	100	52	42	60-69	58-70	56-66	40-59	55-68
	300			50-59	48-61	46-57	36-55	45-58
28	70	59	49	63-72	61-73	59-69	32-51	58-71
	300			50-59	48-61	46-57	43-63	45-58
29	30	68	58	-	68-81	66-77	53-72	65-78
	(350)			49-58	47-60	45-55		44-57
30	70	61	51	63-72	61-73	59-69	40-59	58-71
31	200	60	50	53-63	51-64	50-60	36-60	49-62

Based on the construction noise levels predicted above, there is potential for the construction noise criteria to be exceeded at the nearest residences in each NCA. A reasonable and feasible approach towards noise management measures will be required to reduce noise levels as much as possible to help achieve compliance. The level of impact will depend on the type of activity, as described below:

- **Corridor Clearing** Noise levels generated during corridor clearing will be of relatively short duration, about 2 to 3 weeks, in each noise catchment, depending on the level of clearing required. This will generally be followed by a respite period before bulk earthworks commence, thus the short term ($L_{A90} + 20\text{dB(A)}$) criterion applies. Most of the clearing is required in remote areas, away from residences and other sensitive receivers.

The noisiest plant on site will be the tub grinder/ mulcher, which may generate levels of 78-74 dB(A) at receivers 30 to 50m away from the alignment. It is recommended that where possible, this plant is located 500m or more from sensitive receivers.

Typical activities are likely to include a bulldozer, dump truck and chainsaw operating concurrently. This is likely to produce noise levels of 79-75dB(A) at the nearest receivers 30 to 50m away from the alignment, where there is no shielding provided. Noise levels between 56-70dB(A) may occur at most residences 100 to 500m from the alignment. Exceedance of the short term criteria during clearing is possible in most NCAs and management measures should be implemented to limit potential impact (see Section 4.5.1).

- **Bulk Earthworks & Drainage** Bulk earthworks will be the longest duration activity and are likely to produce the highest noise levels. The duration of works in each catchment will vary from 2 to 3 months to 6 months, depending on the extent of work required. The medium term criteria ($L_{A90} + 10\text{dB(A)}$) is likely to apply to these works, depending on the final staging of construction activities.

South of the Macleay River, the noisiest activities will be those associated with removing hard rock from the cuttings at STN 1300, STN 3000 and STN 7000 – rock breaking, blasting (which is assessed separately), ripping and

rock crushing. The nearest residences are typically 150m from the centre of the cuttings, and will be shielded from noisy activity by the cutting itself. There will be limited shielding (that provided by topography only) from works carried out at-grade or fill.

North of the Macleay River there is less hard rock, and it is expected that ripping will be adequate to excavate material.

Noise generated by earthworks and drainage are likely to exceed the construction noise goals. Noise control measures to be incorporated into the construction operations are discussed in Section 4.5.1.

- Bridges

There are 24 bridges to be built as part of the road upgrade works. Each bridge will differ in terms of length of time to construct, depending on its size and the degree of difficulty involved. The duration of construction of bridges across the floodplain south of the Macleay River will be longer due to the significant lengths of the bridges. Impacts from bridgeworks in general are expected to be less than from other project works, as residences are generally further removed from the bridge sites. The most significant bridgeworks will be at the Macleay River crossing, south of Frederickton, and is likely to take about 18 months to complete.

Night work will be unavoidable for several bridges identified in Section 4.1 as they cross existing roads. Measures will need to be undertaken to reduce noise impact from all bridge works (see Section 4.5.1).

Driven and bored piling is likely to be the noisiest activity to occur during bridgeworks. Impact sound resulting from lifting and setting of bridge girders at night may potentially cause sleep disturbance where residences are within 100m of the bridge.

Management and mitigation measures recommended in Section 4.5.1 should be incorporated into construction methods to reduce impacts, particularly at night.

- Pavement

The paving process will be relatively short term, and is only likely to affect receivers in each catchment for 2 to 4 weeks, thus the short term criteria will apply. However some plant, particularly the pavement laying machine, are quite noisy and may cause exceedance of the short term criteria when operating in close proximity to residences, particularly around South Kempsey, near Crescent Head Road and Old Station Road, and at Eungai Rail where the proposed Upgrade rejoins the existing alignment.

Noise management measures will be required to reduce noise levels as much as possible to help achieve compliance.

Site construction compounds may be located at stations 700, 900, 1900, 2500, 4200, 5200, 6400, 6700, 7400, 7800, 12800, 13700, 15300, 15800, 16400, 18400, 22900, 28100, 30500, 30800, 31100, 34000, 35200 and 35400. Noise impact from typical compound activity has been predicted from each potential compound location to the nearest affected receivers. The results are summarised in Table 4.11 following.

Table 4.11 – Predicted Construction Compound Noise Level Range at Receivers

Compound Location (Station)	Nearest Receiver	NCA	Noise Criteria (L ₉₀ + 5 dB(A))	Predicted Compound L _{A10} Noise Level, dB(A)
700	1a	1	53	33-48
	2a	2	48	22-37
	RTA	2	48	46-61
	Barnes	3	47	40-55
	4a	4	44	20-35
900	1a	1	53	25-40
	2a	2	48	20-35
	RTA	2	48	50-65
	Barnes	3	47	50-65
	4a	4	44	22-37
1900	3f	3	47	42-57
	4a	4	44	46-61
	4b	4	44	36-51
	5a	5	44	43-58
	Adventist School	5	44	34-49
2500	4a	4	44	28-43
	4b	4	44	40-55
	5a	5	44	25-40
	Adventist School	5	44	42-57
4200	6e	6	42	37-52
	7l	7	42	36-51
	8g	8	41	46-61
	9a	9	41	42-57
5200	8h	8	41	32-47
	8l	8	41	46-61
	9c	9	41	32-47
6400	10b	10	37	36-51
	10e	10	37	31-46
	11a	11	37	39-54
	11b	11	37	28-43
6700	10b	10	37	36-51
	10e	10	37	34-49
	11a	11	37	50-65
	11b	11	37	32-47
7400	10g	10	37	42-57
	11f	11	37	39-54

Compound Location (Station)	Nearest Receiver	NCA	Noise Criteria (L ₉₀ + 5 dB(A))	Predicted Compound L _{A10} Noise Level, dB(A)
7800	10g	10	37	39-54
	10j	10	37	42-57
	11f	11	37	34-49
12800	12a	12	44	37-52
	13b	13	44	36-51
	Sergeant	13	44	40-55
13700	Frederickton Golf Club	17	43	30-45
15300	19a	19	36	28-43
	19b	19	36	50-65
15800	19b	19	36	34-49
	21a	21	36	40-55
	21b	21	36	31-46
16400	21b	1	36	46-61
	21c	2	36	43-58
18400	20b	20	36	42-57
	20c	20	36	43-58
	21f/g	21	36	43-58
22900	-	-	-	-
28100	22a	22	32	33-48
30500	RTA	25	39	53-68
	25a	25	39	33-48
	27a	27	37	43-58
30800	RTA	25	39	42-57
	25a	25	39	36-51
	27a	27	37	36-51
31100	-	-	-	-
34000	27a	27	37	23-38
	28a	28	44	37-52
	28b	28	44	32-47
	Guianna	28	44	25-40
35200	27a	27	44	32-47
	Guianna	228	44	39-54
	28b	28	44	33-48
	29b	29	53	23-38
35400	27a	27	44	25-40
	Guianna	228	44	35-50
	28b	28	44	30-45
	29b	29	53	29-44

The results indicate that there is potential for compound activities to exceed the noise criteria at the nearest affected receiver locations, particularly during site establishment, when the heavier machinery is likely to be in use. The compound locations with the least impact include those at stations 29900 and 31100, where there are no nearby residential receivers. At other potential locations, where there are nearby receiver locations, the site should be configured such that site sheds and other materials form a barrier to potentially noise generating activities. Further recommendations are provided in Section 4.5.1.

Crushing operations may be carried out at four sites identified along the route – Station 700, 2500, 5200 and the Churchill Quarry (east of station 3400). Noise impacts from crushing operations have been predicted to the nearest affected receivers to each potential locations.

Table 4.12 – Predicted Crushing Operations Noise Level at Receivers

Compound Location (Station)	Nearest Receiver	NCA	Noise Criteria (L ₉₀ + 5 dB(A))	Predicted Compound L _{A10} Noise Level, dB(A)
700	1a	1	53	49
	2a	2	48	38
	RTA	2	48	61
	Barnes	3	47	55
	4a	4	44	36
2500	4a	4	44	44
	4b	4	44	55
	5a	5	44	41
	Adventist School	5	44	57
3400 Churchill Quarry	6a	6	42	50
	6b	6	42	49
	6c	6	42	49
	7d	7	42	45
5200	8h	8	41	48
	8l	8	41	61
	9c	9	41	48

At station 700 noise emission from crushing would comply in NCAs 1 and 2, with the exception of the RTA property in NCA 2. There is potential for exceedance of the noise criteria in NCA 3. At station 2500 noise emission would comply at residences to the south of NCA 4 and 5, with potential exceedance at receivers to the north of these catchments, including the Adventist School. The nearest receivers to the Churchill Quarry and the location at station 5200 may be affected by noise levels in excess of the criteria during crushing operations. Adequate shielding of crushing plant would need to be incorporated into the site design. Further recommendations are provided in Section 4.5.1.

4.4.2 Construction Vibration

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing

interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of a vibration, are all important aspects in both the annoyances caused and the strains induced in structures.

As the pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific, below are some indicative minimum 'buffer' distances based on some recent projects used to avoid human discomfort during daytime:

Table 4.13 – Recommended Minimum Buffer Distances for Construction Plant

Plant Item	Recommended Minimum Buffer Distance (m)
Driven piling	>100m
Bored piling	40
Bulldozers	5
Hydraulic rock breakers - light	10
Hydraulic rock breakers – heavy	30
Compactor	30
Jackhammers	5
Vibratory rollers - light	5
Vibratory rollers - medium	12
Vibratory rollers - heavy	25
Truck movements	10

Based on the above table and distances of approximately 30m or more from the proposed road works to the nearest residences, it is unlikely that vibration generated by construction activity will exceed the set limits for human comfort. All bridgeworks will be more than 50m from residences, thus bored piling works are unlikely to generate vibration that exceeds the set limits for human comfort. Vibration from driven piles may however cause impact, depending on the frequency and energy of the blows. Vibration levels from other equipment are unlikely to exceed the set limits.

Since compliance with the more stringent human comfort criterion is achieved, the structural damage criteria will also be achieved. Most construction activities are therefore not likely to cause structural damage to dwellings within the vicinity of the proposed road works.

The potential for driven piling to cause structural damage will need to be confirmed once construction methods have been finalised. There is potential for structural damage from pile driving to occur at residences within 60 metres (20 kilojoule blow energy) to 80 metres (60 kilojoule blow energy) of pile driving works, depending on the blow energy used. Please note that these distances are only estimates, and should only be referred to for guidance at this preliminary stage. Measurement of vibration generated by pile driving at the nearest affected receivers is recommended during the construction phase to confirm there is no risk of structural damage.

4.4.3 Blasting

As blasting and seismic details are unknown at this stage, it will be necessary to carry out noise and vibration predictions once the proposed charge and blast configuration information becomes available. It is important that the buffer zone associated with each blast site be identified and

appropriate measures taken to limit overpressure and vibration to acceptable levels at critical locations. Blast charge and blast configurations must therefore be selected to ensure that ANZECC guidelines adopted by the DEC are not exceeded.

Blasting is likely to be required to remove hard rock material from two cuttings south of the Macleay River, at STN 1300 and STN 3000. At these locations, the nearest buildings are approximately 150m to 200m from the centres of the cuttings.

In view of the proximity of some buildings to the blast sites, it is important that blasting be monitored during the initial stages at critical locations surrounding the site to confirm predicted overpressure and vibration levels and to, in turn, modify the blast design and buffer zones around the site accordingly.

In the absence of specific blasting information and seismic details of the site, the following table provides general guidance for estimating the likely 'minimum distance limits' from blasting in terms of the vibration and overpressure criteria described above, for a range of blast Maximum Instantaneous Charge (MIC) quantities.

The distance limits relating to vibration are determined using Figure J3 of Australian Standard 2187.2-1993, applicable to free face blasting in 'average field conditions'. The distance limits relating to overpressure are determined from the results of a regression analysis of noise data obtained from a number of mine sites in the Hunter Valley. The distance limits per nominated MIC may vary significantly depending on the geological conditions, local shielding and meteorological factors at the site.

Table 4.14 – Minimum Distance Limits to Comply with Blast Vibration & Overpressure Limits

Maximum Instantaneous Charge (MIC), kg	Minimum Distance (metres) to comply with:	
	Vibration Limit	Overpressure Limit
0.12	6	100
0.50	12.5	150
1.39	21	200
3.06	31	250
35.50	106	500
412.46	361	1000

Therefore, it is seen that the 'minimum distance limits' or conversely the degree of impact is strongly dependent on the size of blasts. Also to comply with the overpressure limit a greater separation distance is required than for the vibration limit. Therefore, in terms of separation distance, the overpressure limit is more stringent than the vibration limit.

We reiterate, the above distances are only estimates, hence should only be referred to for guidance at this preliminary stage.

4.5 CONSTRUCTION NOISE AND VIBRATION MITIGATION

4.5.1 Construction Noise Mitigation

The following recommendations provide indicative noise control solutions to reduce noise impacts to residential receivers. Where actual construction activities differ from those assessed

in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Implementation of noise control measures, such as those suggested in Australian Standard 2436-1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-1981, Appendix E, Table E1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table E2 in Appendix E presents typical examples of noise reductions achievable after treatment of various noise sources. Table E3 in Appendix E presents the relative effectiveness of various forms of noise control treatment.

Table 4.15 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 4.15 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	7 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 30	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	15 to 25	15 to 25	60	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436, for this assessment.

To ensure efficient noise attenuation performance is achieved using any of the methods listed above, it is recommended acoustic engineers work closely with the construction contractors and carry out preliminary testing prior to commencement of works.

In addition to physical noise controls that may be adopted during construction, the following general noise management measures should be followed:

- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.

- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- Noise compliance monitoring for all major equipment and activities on site should be undertaken prior to their commencement of work on site.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the proposed Upgrade, as this is of paramount importance. Keeping people informed of progress and responding to complaints and enquiries quickly. The person selected to liaise with the community should be adequately trained and experienced in such matters.

Where noise level exceedances cannot be avoided, then consideration should be given to implementing time restrictions and/or providing periods of respite for residents, where reasonable and feasible.

4.5.2 Construction Vibration Mitigation

The following vibration control measures may be implemented to minimise vibration impact from construction activities to potentially affected receivers and to meet DEC's human comfort vibration limits:

1. The proper implementation of a construction noise and vibration management plan is required to avoid adverse vibration disturbance to potentially affected receivers. Consultation with property owners/residents is recommended and should be aimed at providing a communication path directly to the contractor.
2. A management procedure will be implemented to deal with vibration complaints. Each complaint will be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.
3. Carry out vibration testing of actual equipment on site to determine acceptable site-specific buffer distances to sensitive occupancies.
4. Carry out additional vibration monitoring when construction activities are at the nearest point to the potentially affected receivers. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies.
5. Carry out periodic monitoring at all critical or sensitive areas, and the vibration levels are to be tested for compliance with the set vibration limits. This monitoring should be undertaken in accordance with the noise and vibration monitoring program described in a construction noise and vibration management plan.
6. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller rock breakers, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions should be negotiated with affected receivers.

7. Where construction activities including blasting, pile driving, excavation by hammering or ripping, dynamic compaction or demolition of structures may cause damage through vibration or air blast to nearby public utilities, structures, buildings and their contents or if the items are located within the distance from the construction activity as noted in the table below, it is recommended that a Building Condition Inspection of these items be undertaken.

Table 4.16 – Distance from Construction Activity for Building Condition Inspection

Activity	Distance
Blasting Operations	500 metres
Pile Driving	200 metres
Vibration Compaction (> 7 tonne plant)	50 metres
Vibration Compaction (< 7 tonne plant)	25 metres
Demolition of structures	50 metres

Source: RTA Specification G36/ Appendix E

4.5.3 Blasting Management

For blasting it will be necessary to carry out noise and vibration predictions once the proposed charge and blast configuration information becomes available. The buffer zone associated with each blast site should be identified and appropriate measures taken to limit overpressure and vibration to acceptable levels at critical locations. Blast charge and blast configurations should therefore be selected to ensure the set DEC limits are not exceeded.

In view of the proximity of some buildings to the proposed Upgrade, blasting should be monitored at the initial stages at critical locations surrounding the site to confirm predicted overpressure and vibration levels and to in turn modify the blast design and buffer zones accordingly around the site.

To ensure blasting activities do not cause adverse impacts upon the surrounding community, the following measures should be followed:

- select blast charge and blast configurations to ensure that relevant vibration and overpressure limits are not exceeded,
- carry out noise and vibration measurements on a series of smaller test blasts in order to establish appropriate propagation characteristics for the site, which will in turn assist in accurately predicting noise and vibration levels once the proposed charge and blast configuration information is determined,
- from tests and calculations, establish a zone of affectation around the site, whilst taking into account adverse meteorological conditions,
- undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement and after completion of blasting activities at site,
- obtain appropriate weather data by taking measurements as soon as practicable prior to blasting, and from the data predict whether air blast overpressure levels are likely to be increased above the levels expected under adverse weather conditions,
- cease or restrict blasting if the predictions indicate that air blast overpressure levels are likely to be exceeded at neighbouring dwellings,

- monitor all blasts and record the overpressure and peak particle velocity vibration at noise sensitive sites (residences, schools, churches etc) selected in consultation with DEC, and
- ensure that air blast overpressure and vibration levels comply with the limits set in the ENCM.
- Contain all blasting activities to between the hours of:
 - 9:00 am to 3:00 pm, Mondays to Saturdays.

If safety or environmental conditions necessitate blasting outside these hours, the Principal should consult with DEC to gain the necessary approval. Any neighbours likely to be affected should also be contacted.

5. CONCLUSION

An assessment of traffic noise and construction noise emissions from the proposed Pacific Highway Upgrade: Kempsey to Eungai has been undertaken. The study found that the proposed Upgrade travels through predominantly rural land with scattered residential properties. For the majority of the route there is minimal existing road traffic noise.

Noise impacts have been investigated at sensitive receivers along the proposed Upgrade route. Overall noise impact from the proposed Upgrade was determined and traffic noise levels for identified residences and other sensitive receivers within the study area. Prediction of traffic noise levels were carried out based on the proposed Upgrade being completed in 2011.

The findings of this study are:

- Predicted traffic noise levels were found to exceed the NSW ECRTN at some residences. Up to 60% of the 120 identified noise receivers during the day and 80% of the 116 identified residences at night will be exposed to traffic noise levels in excess of the criteria ten years after the completion of the proposed Upgrade.
- Should the option for staged construction be selected there would be an insignificant increase in traffic noise levels along the existing Pacific Highway between 2011 and 2021. Stage 2 would be completed within 10 years of the completion of Stage 1.
- As per the RTA's ENMM, several methods of noise mitigation were considered. For the bulk of the route, use of low-noise pavement and noise barriers would not be reasonable due to the scattered nature of residences along the route. Areas where it may be reasonable and feasible to construct noise barriers and apply low-noise pavement are at NCAs 3, 6, 7, 8 and 9. Residences in these catchments are clumped together in groups of more than three, making the use of noise barriers and/or low-noise pavement more cost-effective.

Based on cost-effectiveness analysis (as per Practice Note IV(a) of the ENMM), noise barriers ranging from 3 metres to greater than 8 metres in height are required to achieve the ECRTN noise criteria in NCAs 3, 6, 7, 8 and 9.

- Due to the barrier heights generally being unacceptable following consideration of urban design issues, minimum barrier heights together with road pavement type are recommended for NCAs 3, 6, 7, 8 and 9.
- Noise impacts were also determined at the nearest affected sensitive receivers, including schools, churches and recreation areas along the proposed Upgrade route. Noise levels in excess of the ECRTN noise criteria were only identified at the Kempsey Adventist Church. It is recommended that the provision and form of architectural treatment of buildings to reduce noise impacts be further investigated at the detailed design phase to confirm feasibility and reasonableness.
- Construction noise is likely to impact residences located close to the proposed Upgrade route. As residential premises along the proposed Upgrade route are at distances of approximately 30m or more from the proposed road works to the nearest residences, it is unlikely that vibration generated by construction activity will exceed the set limits for human comfort. In-principle noise and vibration mitigation and management measures were provided to reduce construction noise and vibration impacts to acceptable levels.

- There is potential for blasting impact to occur, should this be required to remove hard rock material from two cuttings south of the Macleay River, at STN 1300 and STN 300. Recommendations have been provided for the management of blast impact. Further predictions of noise and vibration from blasting should be conducted once more details of blasting usage during the proposed Upgrade are known, so that buffer zones and blast charge limits can be set.

APPENDIX A – GLOSSARY OF ACOUSTIC TERMS

Glossary of Traffic Noise Terms

The following is a brief description of the technical terms used to describe traffic noise to assist in understanding the technical issues presented in this document.

<i>Adverse Weather</i>	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).																												
<i>Air-borne noise</i>	This refers to noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise and receiver.																												
<i>Ambient Noise</i>	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.																												
<i>Assessment Period</i>	The period in a day over which assessments are made.																												
<i>Assessment Point</i>	A point at which noise measurements are taken or estimated.																												
<i>Audible Range</i>	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.																												
<i>A-weighting</i>	An adjustment made to sound level measurement, by means of an electronic filter, to approximate the response of the human ear.																												
<i>Barrier - noise</i>	Any natural or artificial physical barrier to the propagation of noise (from a roadway), but generally referring to acoustically reflective or absorbent fences, walls or mounds (or combinations thereof) constructed beside a roadway.																												
<i>Buffer</i>	An area of land between a roadway and a noise-sensitive land use, used as open space or for some other noise-tolerant land use.																												
<i>Decibels [dB]</i>	10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound. The following are examples of the decibel readings of every day steady or quasi-steady sounds; <table><tr><td>0dB</td><td>the faintest sound we can hear</td></tr><tr><td>20dB</td><td>quiet bedroom at night or recording studio</td></tr><tr><td>30dB</td><td>quiet library or quiet location in the country</td></tr><tr><td>40dB</td><td>living room</td></tr><tr><td>50dB</td><td>typical office space or ambience in the city at night</td></tr><tr><td>60dB</td><td>normal conversational speech</td></tr><tr><td>70dB</td><td>a car passing by</td></tr><tr><td>80dB</td><td>kerbside of a busy road</td></tr><tr><td>90dB</td><td>truck passing by</td></tr><tr><td>100dB</td><td>nightclub</td></tr><tr><td>110dB</td><td>rock band or 2m from a jackhammer</td></tr><tr><td>120dB</td><td>70m from a jet aircraft</td></tr><tr><td>130dB</td><td>threshold of pain</td></tr><tr><td>140dB</td><td>25m from a jet aircraft</td></tr></table>	0dB	the faintest sound we can hear	20dB	quiet bedroom at night or recording studio	30dB	quiet library or quiet location in the country	40dB	living room	50dB	typical office space or ambience in the city at night	60dB	normal conversational speech	70dB	a car passing by	80dB	kerbside of a busy road	90dB	truck passing by	100dB	nightclub	110dB	rock band or 2m from a jackhammer	120dB	70m from a jet aircraft	130dB	threshold of pain	140dB	25m from a jet aircraft
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120dB	70m from a jet aircraft																												
130dB	threshold of pain																												
140dB	25m from a jet aircraft																												
<i>dB(A)</i>	Unit used to measure 'A-weighted' sound pressure levels.																												
<i>Diffraction</i>	The distortion around solid obstacles of waves travelling past.																												
<i>Fluctuating Noise</i>	Noise that varies continuously and to an appreciable extent over the period of observation.																												
<i>Free-field</i>	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.																												

<i>Frequency</i>	Of a periodic quantity: the time rate of repetition or the reciprocal of the period. It is also synonymous with <i>pitch</i> and is often used to describe the character of a sound. Frequency is measured in Hertz (Hz).
<i>Ground-borne noise</i>	Ground-borne noise propagating through the ground as vibration and then radiated by vibrating building elements such as wall and floor surfaces. This noise is normally noticeable only in areas that are well protected from airborne noise.
<i>Heavy Vehicle</i>	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
<i>Loudness</i>	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
$L_{10(1hr)}$	The L_{10} level measured over a 1 hour period.
$L_{10(18hr)}$	The arithmetic average of the $L_{10(1hr)}$ levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{Aeq}	Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq(1hr)}$	The L_{eq} noise level for a one-hour period. In the context of the EPA's Traffic Noise Policy it represents the highest tenth percentile hourly A-weighted L_{eq} during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
$L_{eq(8hr)}$	The continuous noise level during any one hour period between 10pm and 6am.
$L_{eq(9hr)}$	The L_{eq} noise level for the period 10pm to 7am.
$L_{eq(15hr)}$	The L_{eq} noise level for the period 7am to 10pm.
$L_{eq(24hr)}$	The equivalent continuous noise level during a 24 hour period, usually from midnight to midnight.
<i>Microphone</i>	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
<i>Noise</i>	Sound which a listener does not wish to hear.
<i>Reflection</i>	Sound wave changed in direction of propagation due to a solid object obscuring its path
<i>SEL</i>	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{eq} sound levels over any period of time and can be used for predicting noise at various locations.
<i>Sound</i>	An alteration in pressure, stress, particle displacement, or particle velocity which is propagated in an elastic material or the superposition of such propagated alterations.
<i>Sound Absorption</i>	The ability of a material to absorb sound energy through its conversion into thermal energy.

<i>Sound Level Meter</i>	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
<i>Sound Pressure Level</i>	The level of noise, usually expressed in dB(A), as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise
<i>Sound Power Level</i>	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
<i>Structure-borne noise</i>	Vibration propagating through solid structures in the form of compressional or bending waves, heard as sound.

APPENDIX B – PROPERTY NUMBERS AND LOCATIONS

Table B.5.1 – Property Numbers and Locations

Identifier	Address	Identifier	Address
NCA 1a	702 Pacific Hwy South Kempsey	NCA 9a	Lot 1113 Lyall Ln, Sth Kempsey
NCA 2a	511 Pacific Hwy, South Kempsey	NCA 9b	6 Lois Ln, Sth Kempsey
NCA 3a	479 Pacific Hwy, South Kempsey	NCA 9c	18 Lyall Ln, Sth Kempsey
NCA 3b	487 Pacific Hwy, South Kempsey	NCA 9d	26 Lyall Ln, Sth Kempsey
NCA 3c	483 Pacific Hwy, South Kempsey	NCA 9e	Cnr Yablseys Ln & Lyall Ln
NCA 3d	477 Pacific Hwy, South Kempsey	NCA 10a	Inches Rd, Kempsey
NCA 3e	471 Pacific Hwy, South Kempsey	NCA 10b	Inches Rd, Kempsey
NCA 3f	27 Shannon Cl, South Kempsey	NCA 10c	Inches Rd, Kempsey
NCA 3g	Pacific Hwy, South Kempsey	NCA 10d	Inches Rd, Kempsey
NCA 3h	Pacific Hwy, South Kempsey	NCA 10e	Inches Rd, Kempsey
Ballroom/Gym	497 Pacific Hwy, South Kempsey	NCA 10f	Gorman Ln, Kempsey
Motel	465 Pacific Hwy, South Kempsey	NCA 10g	Old Station Rd, Sth Kempsey
NCA 4a	28 Shannon Cl, South Kempsey	NCA 10h	Old Station Rd, Sth Kempsey
NCA 4b	Lot 280 Rifle Range Rd	NCA 10i	Old Station Rd, Sth Kempsey
NCA 5a	47 Shannon Cl, South Kempsey	NCA 10j	247 Old Station Rd, Sth Kempsey
NCA 5b	South St, South Kempsey	NCA 11a	42 Inches Rd, Sth Kempsey
NCA 5c	South St, South Kempsey	NCA 11b	Bell Rio Cl, Sth Kempsey
NCA 6a	178 Crescent Head Rd	NCA 11c	28 Inches Rd, Sth Kempsey
NCA 6b	Crescent Head Rd, Sth Kempsey	NCA 11d	18 Inches Rd, Sth Kempsey
NCA 6c	Crescent Head Rd, Sth Kempsey	NCA 11e	Bell Rio Cl, Sth Kempsey
NCA 6d	Crescent Head Rd, Sth Kempsey	NCA 11f	Cnr Inches Rd & Old Station Rd
NCA 6e	1 Bruces Ln, Sth Kempsey	NCA 11g	Cnr Bell Rio Cl & Old Station Rd
NCA 6f	7 Bruces Ln, Sth Kempsey	NCA 11h	183 Old Station Rd, Sth Kempsey
NCA 6g	Bruces Ln, Sth Kempsey	NCA 11i	215 Old Station Rd, Sth Kempsey
NCA 6h	Bruces Ln, Sth Kempsey	NCA 12a	595 Sth West Rocks Rd, Gladstone
NCA 6i	Bruces Ln, Sth Kempsey	NCA 13a	541 Sth West Rocks Rd, Gladstone
NCA 6j	Bruces Ln, Sth Kempsey	NCA 13b	575 Sth West Rocks Rd, Gladstone
NCA 6k	Bruces Ln, Sth Kempsey	NCA 15a	Lawson St, Fredrickton
NCA 6l	Bruces Ln, Sth Kempsey	NCA 16a	921 Pacific Highway, Frederickton
NCA 6m	Bruces Ln, Sth Kempsey	NCA 17a	KSC Fredrickton Golf Club
NCA 6n	Bruces Ln, Sth Kempsey	NCA 19a	107 Raymonds Lane, Frederickton
NCA 6o	Kingfisher Ln, Sth Kempsey	NCA 19b	167 Raymonds Lane, Frederickton
NCA 7a	Crescent Head Rd, Sth Kempsey	NCA 20a	Kemps Access Rd
NCA 7b	Crescent Head Rd, Sth Kempsey	NCA 20b	Kemps Access Rd
NCA 7c	Crescent Head Rd, Sth Kempsey	NCA 20c	279 Kemps Access Rd
NCA 7d	Crescent Head Rd, Sth Kempsey	NCA 21a	232 Quarry Rd, Frederickton

Identifier	Address	Identifier	Address
NCA 7e	Yablseys Ln, Sth Kempsey	NCA 21b	258 Quarry Rd, Frederickton
NCA 7f	Yablseys Ln, Sth Kempsey	NCA 21c	26 Seashore Ln, Frederickton
NCA 7g	Yablseys Ln, Sth Kempsey	NCA 21d	53 Seashore Ln, Frederickton
NCA 7h	Yablseys Ln, Sth Kempsey	NCA 21e	Kemps Access Rd
NCA 7i	Crescent Head Rd, Sth Kempsey	NCA 21f	Kemps Access Rd
NCA 7j	Crescent Head Rd, Sth Kempsey	NCA 21g	243 Kemps Access Rd
NCA 7k	Crescent Head Rd, Sth Kempsey	NCA 22a	Seven Hills Rd, Tamban
NCA 7l	165 Crescent Head Rd	NCA 24a	269 Cooks Ln, Tamban
NCA 7m	Yablseys Ln, Sth Kempsey	NCA 25a	Cooks Ln, Pacific Hwy
NCA 7n	Crescent Head Rd, Sth Kempsey	NCA 26a	80 Hills Ln, Barraganyatti
NCA 8a	Cooper	NCA 27a	Nirvana Way, Barraganyatti
NCA 8b	55 Bruces Ln, Sth Kempsey	NCA 28a	6 Nirvana Way, Barraganyatti
NCA 8c	Bruces Ln, Sth Kempsey	NCA 28b	2925 Pacific Hwy, Barraganyatti
NCA 8d	59 Bruces Ln, Sth Kempsey	NCA 29a	3381 Pacific Hwy, Eungai Rail
NCA 8e	Bruces Ln, Sth Kempsey	NCA 29b	33 Barraganyatti Hut Rd
NCA 8f	67 Bruces Ln, Sth Kempsey	NCA 29b	Pacific Highway, Eungai Rail
NCA 8g	63 Bruces Ln, Sth Kempsey	NCA 29c	3381 Pacific Highway, Eungai Rail
NCA 8h	Bruces Ln, Sth Kempsey	NCA 29d	Pacific Highway, Eungai Rail
NCA 8i	Blairs Ln, Sth Kempsey	NCA 30a	Stuarts Point Rd, Eungai Rail
NCA 8j	Blairs Ln, Sth Kempsey	NCA 30b	Stuarts Point Rd, Eungai Rail
NCA 8k	129 Blairs Ln, Sth Kempsey	NCA 30c	21 Stuarts Point Rd, Eungai Rail
NCA 8l	129 Blairs Ln, Sth Kempsey	NCA 30d	Lot 2 Thurgood Ln, Eungai Rail
NCA 8m	144 Blairs Ln, Sth Kempsey	NCA 31a	29 Brushbox Rd, Eungai Rail
NCA 8n	141 Blairs Ln, Sth Kempsey	NCA 31a	29 Brushbox Rd, Eungai Rail

Note: Residences identified in **bold** are two storey.

APPENDIX C – LONG TERM NOISE MONITORING RESULTS

Long-term noise logs have not been printed, but are available in the electronic version and in hard copy on request.

APPENDIX D – PREDICTED NOISE LEVELS AT RECEIVER LOCATIONS

Table D.5.2 – Base Noise Criteria from NSW Environmental Criteria for Road Traffic Noise

Road Type	Base Traffic Noise Criteria (from ECRTN)	
	L _{Aeq} 15h Criteria	L _{Aeq} 9h Criteria
Redeveloped Road	60	55
New Road	55	50

Table D.5.3 – Summary of Impacts to Noise Sensitive Receivers

Receiver	Daytime L _{eq} , 15h			Night time L _{eq} , 9h			Applicable Criteria
	2011		2021	2011		2021	
	Future E ¹	Build ²	Build ²	Future E ¹	Build ²	Build ²	
NCA 1a	62	58	61	60	55	59	Redev Rd
NCA 2a	51	52	54	49	49	52	New Rd
NCA 3a	57	55	57	55	53	55	New Rd
NCA 3b	59	59	62	57	57	60	New Rd
NCA 3c	58	59	62	56	56	60	New Rd
NCA 3d	58	58	61	56	56	59	New Rd
NCA 3e	59	57	60	57	55	58	New Rd
NCA 3f	51	58	61	49	55	59	New Rd
NCA 3g	59	57	59	57	55	57	New Rd
NCA 3h	69	66	67	67	64	66	New Rd
NCA 3 Ballroom/ Gym	55	59	62	53	57	60	New Rd
NCA 3 Motel	56	50	54	54	47	51	New Rd
NCA 4a	46	63	68	44	60	65	New Rd
NCA 4b	-	51	55	-	48	52	New Rd
NCA 5 Adventist School	-	50	54	-	48	52	New Rd
NCA 5a	48	61	64	46	60	62	New Rd
NCA 5b	31	47	51	29	44	49	New Rd
NCA 5c	-	47	51	-	45	49	New Rd
NCA 6a	-	55	59	-	52	56	New Rd
NCA 6a (2 nd storey)	-	56	60	-	53	57	
NCA 6b	-	51	55	-	48	52	New Rd
NCA 6c	-	48	52	-	45	49	New Rd
NCA 6d	-	48	52	-	45	49	New Rd
NCA 6e	-	62	67	-	59	64	New Rd
NCA 6e (2 nd storey)	-	64	68	-	61	66	

Receiver	Daytime L _{eq, 15h}			Night time L _{eq, 9h}			Applicable Criteria
	2011		2021	2011		2021	
	Future E ¹	Build ²	Build ²	Future E ¹	Build ²	Build ²	
NCA 6f	-	57	61	-	54	59	New Rd
NCA 6g	-	55	59	-	52	57	New Rd
NCA 6h	-	54	58	-	52	56	New Rd
NCA 6i	-	53	57	-	51	55	New Rd
NCA 6j	-	52	56	-	49	54	New Rd
NCA 6k	-	52	56	-	49	53	New Rd
NCA 6l	-	51	55	-	48	52	New Rd
NCA 6m	-	51	55	-	48	52	New Rd
NCA 6n	-	50	54	-	47	51	New Rd
NCA 6o	-	47	51	-	44	48	New Rd
NCA 6p	-	47	52	-	44	49	New Rd
NCA 7a	-	46	50	-	43	48	New Rd
NCA 7b	-	47	51	-	44	48	New Rd
NCA 7c	-	49	53	-	46	50	New Rd
NCA 7d	-	50	54	-	47	51	New Rd
NCA 7e	-	47	51	-	44	48	New Rd
NCA 7f	-	47	51	-	44	48	New Rd
NCA 7g	-	46	51	-	43	48	New Rd
NCA 7h	-	47	52	-	45	49	New Rd
NCA 7i	-	53	57	-	50	54	New Rd
NCA 7j	-	55	59	-	52	56	New Rd
NCA 7k	-	56	60	-	53	57	New Rd
NCA 7l	-	58	62	-	56	60	New Rd
NCA 7l (2 nd storey)	-	60	63	-	57	61	
NCA 7m	-	39	43	-	36	40	New Rd
7n	-	49	53	-	46	50	New Rd
NCA 8a	-	52	57	-	49	54	New Rd
NCA 8b	-	49	53	-	46	51	New Rd
NCA 8c	-	51	55	-	48	52	New Rd
NCA 8d	-	53	57	-	50	55	New Rd
NCA 8e	-	51	55	-	48	52	New Rd
NCA 8f	-	55	59	-	52	56	New Rd
NCA 8g	-	55	59	-	52	56	New Rd
NCA 8h	-	53	57	-	50	54	New Rd
NCA 8i	-	49	54	-	46	51	New Rd

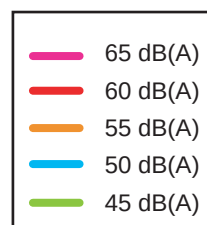
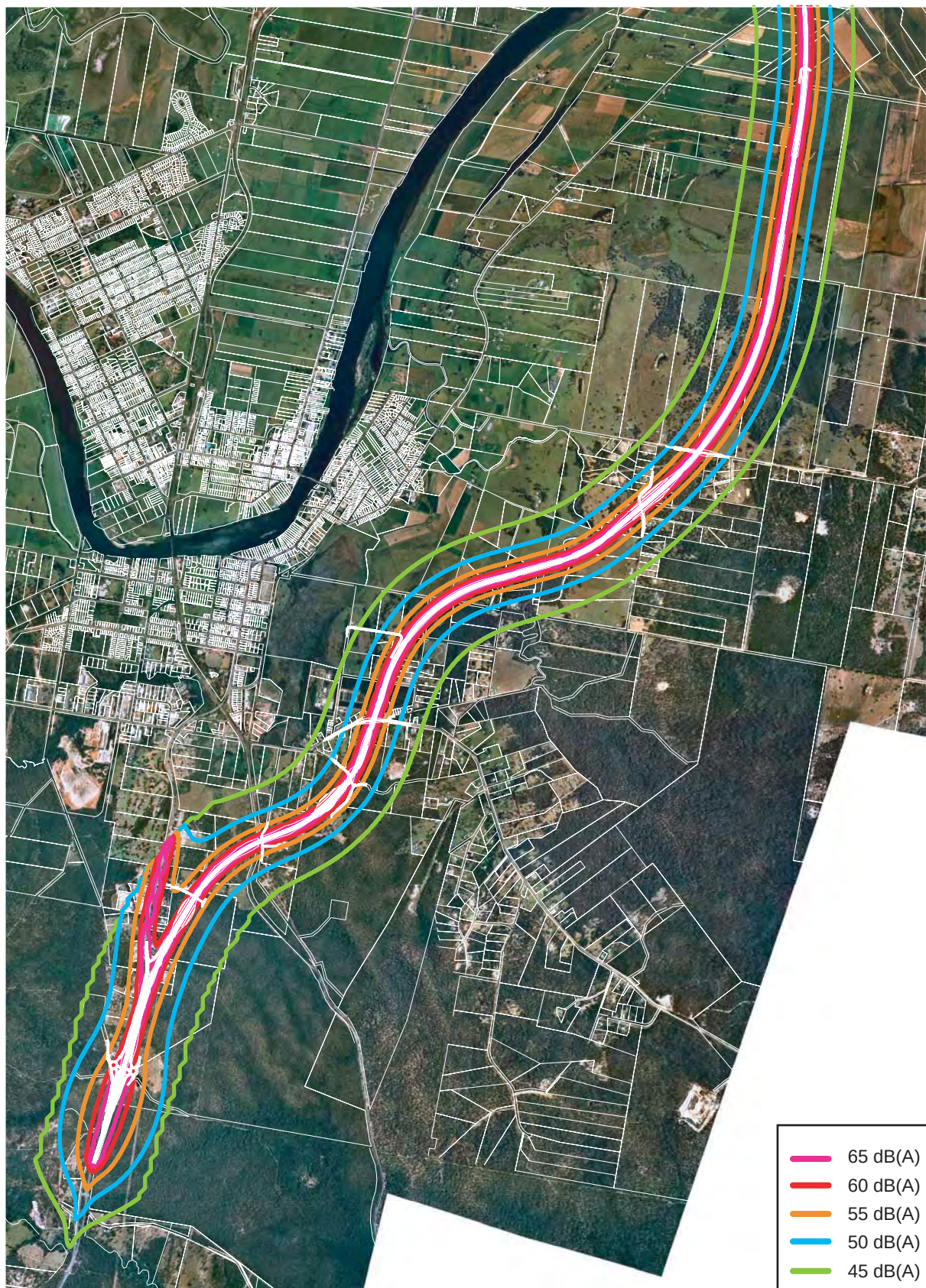
Receiver	Daytime $L_{eq, 15h}$			Night time $L_{eq, 9h}$			Applicable Criteria
	2011		2021	2011		2021	
	Future E ¹	Build ²	Build ²	Future E ¹	Build ²	Build ²	
NCA 8j	-	53	57	-	50	54	New Rd
NCA 8k	-	56	60	-	53	58	New Rd
NCA 8l	-	57	62	-	54	59	New Rd
NCA 8m	-	58	62	-	55	59	New Rd
NCA 8n	-	64	69	-	61	66	New Rd
NCA 9a	-	60	64	-	57	61	New Rd
NCA 9b	-	56	60	-	53	57	New Rd
NCA 9c	-	61	65	-	58	62	New Rd
NCA 9d	-	57	61	-	54	58	New Rd
NCA 9e	-	49	53	-	46	50	New Rd
NCA 10a	-	48	52	-	45	49	New Rd
NCA 10b	-	50	54	-	47	51	New Rd
NCA 10c	-	47	51	-	44	48	New Rd
NCA 10d	-	48	52	-	45	49	New Rd
NCA 10e	-	46	50	-	43	48	New Rd
NCA 10f	-	49	54	-	46	51	New Rd
NCA 10g	-	53	58	-	50	55	New Rd
NCA 10h	-	53	57	-	50	54	New Rd
NCA 10i	-	49	53	-	46	51	New Rd
NCA 10j	-	54	58	-	51	56	New Rd
NCA 11a	-	56	60	-	53	57	New Rd
NCA 11b	-	45	50	-	43	47	New Rd
NCA 11c	-	49	54	-	46	51	New Rd
NCA 11d	-	50	54	-	47	51	New Rd
NCA 11e	-	43	47	-	40	44	New Rd
NCA 11f	-	49	53	-	46	51	New Rd
NCA 11g	-	43	47	-	40	44	New Rd
NCA 11h	-	49	53	-	46	50	New Rd
NCA 11i	-	52	56	-	49	53	New Rd
NCA 12a	46	56	60	43	53	58	New Rd
NCA 13a	45	53	57	42	50	54	New Rd
NCA 13b	48	58	62	45	56	59	New Rd
NCA 15a	57	55	59	49	53	56	New Rd
NCA 15a (2 nd storey)	59	56	60	50	54	57	

Receiver	Daytime $L_{eq, 15h}$			Night time $L_{eq, 9h}$			Applicable Criteria
	2011		2021	2011		2021	
	Future E ¹	Build ²	Build ²	Future E ¹	Build ²	Build ²	
NCA 17 Primary School (outdoor)	56	55	57	54	54	55	New Rd
NCA 17 Primary School Building	53	51	53	51	50	51	New Rd
NCA 17 Golf Club	47	49	52	45	48	49	New Rd
NCA 17 Golf Club Building	46	57	59	44	55	56	New Rd
NCA 19a	-	55	56	-	53	54	New Rd
NCA 19b	-	67	68	-	64	65	New Rd
NCA 20a	-	54	54	-	51	52	New Rd
NCA 20b	-	55	56	-	53	54	New Rd
NCA 20c	-	58	59	-	56	56	New Rd
NCA 21a	-	59	59	-	56	57	New Rd
NCA 21a (2 nd storey)	-	60	61	-	58	59	
NCA 21b	-	66	67	-	63	64	New Rd
NCA 21c	-	58	59	-	56	57	New Rd
NCA 21d	-	60	61	-	58	59	New Rd
NCA 21e	-	48	49	-	46	47	New Rd
NCA 21f	-	55	56	-	53	54	New Rd
NCA 21g	-	57	58	-	55	56	New Rd
NCA 22a	-	59	59	-	56	57	New Rd
NCA 24a	-	67	67	-	65	65	New Rd
NCA 25a	-	47	48	-	45	45	New Rd
NCA 26a	36	53	54	34	51	51	New Rd
NCA 27a	42	50	51	40	48	49	New Rd
NCA 28a	49	54	56	47	52	53	New Rd
NCA 28b	47	53	54	45	50	51	New Rd
NCA 29a	48	52	53	46	49	50	New Rd
NCA 29b	63	66	68	62	64	66	Redev Rd
NCA 29c	62	64	66	60	62	64	Redev Rd
NCA 29d	63	66	68	61	64	66	Redev Rd
NCA 30a	52	55	55	50	52	53	Redev Rd
NCA 30b	49	52	54	47	50	51	Redev Rd
NCA 30c	51	55	57	49	53	55	Redev Rd
NCA 30d	50	53	54	48	51	51	Redev Rd

Receiver	Daytime $L_{eq, 15h}$			Night time $L_{eq, 9h}$			Applicable Criteria
	2011		2021	2011		2021	
	Future E ¹	Build ²	Build ²	Future E ¹	Build ²	Build ²	
NCA 31a	54	57	59	52	55	57	Redev Rd
NCA 31b	55	59	61	53	57	59	Redev Rd
NCA 31c	58	62	64	56	60	62	Redev Rd
Number of Residences Exceeding		41	66	-	52	85	-

Notes: 1. 'Future E' refers to future-existing noise level, the year of the proposed Upgrade opening if the proposed Upgrade were not to proceed.
2. 'Build' refers to the noise level with the proposed Upgrade constructed and operating

APPENDIX E – NOISE CONTOUR MAPS



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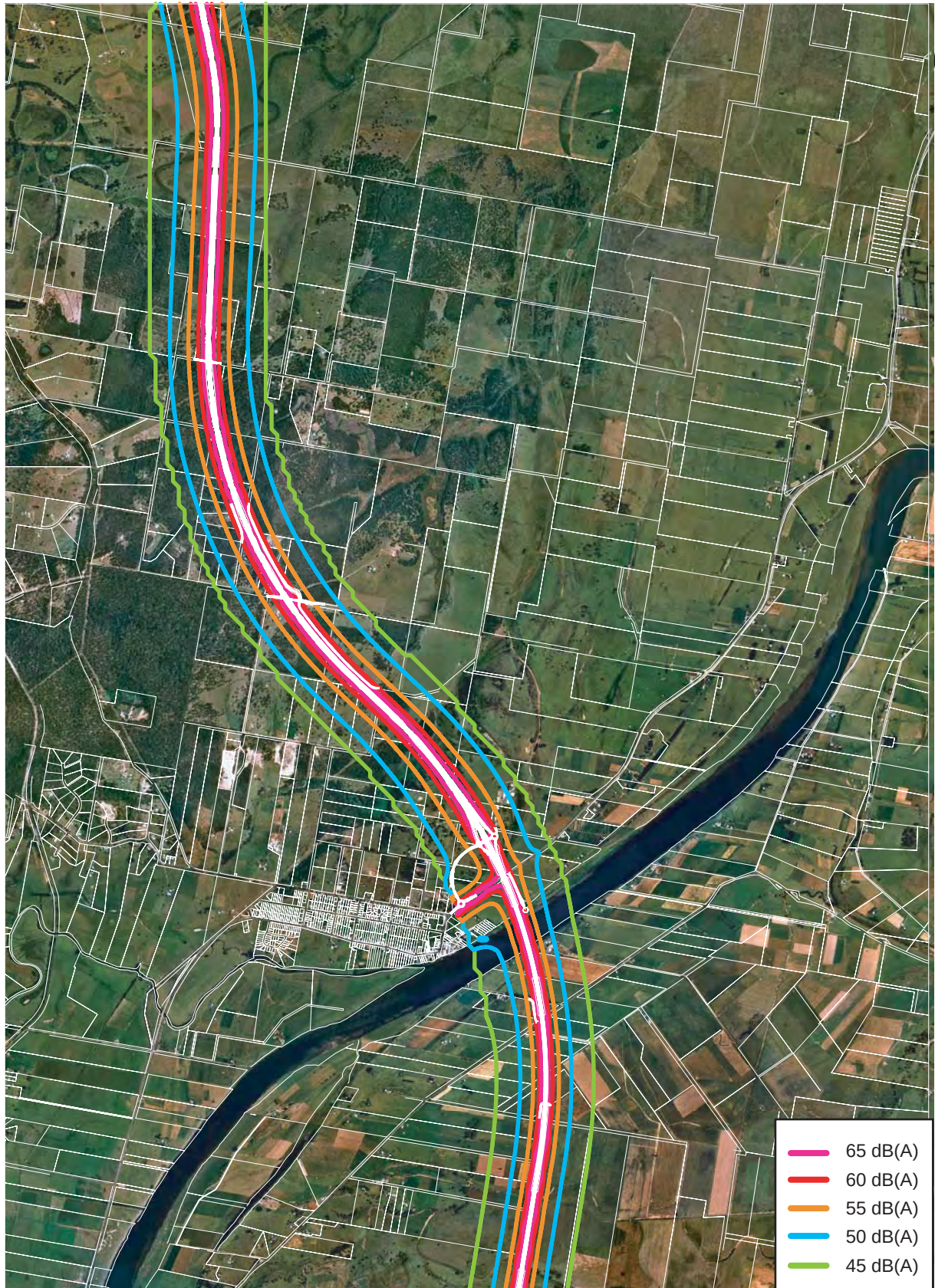
**Figure 3a : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2011 Project Completed - Section 1**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P10 (rev 0)



— 65 dB(A)
 — 60 dB(A)
 — 55 dB(A)
 — 50 dB(A)
 — 45 dB(A)



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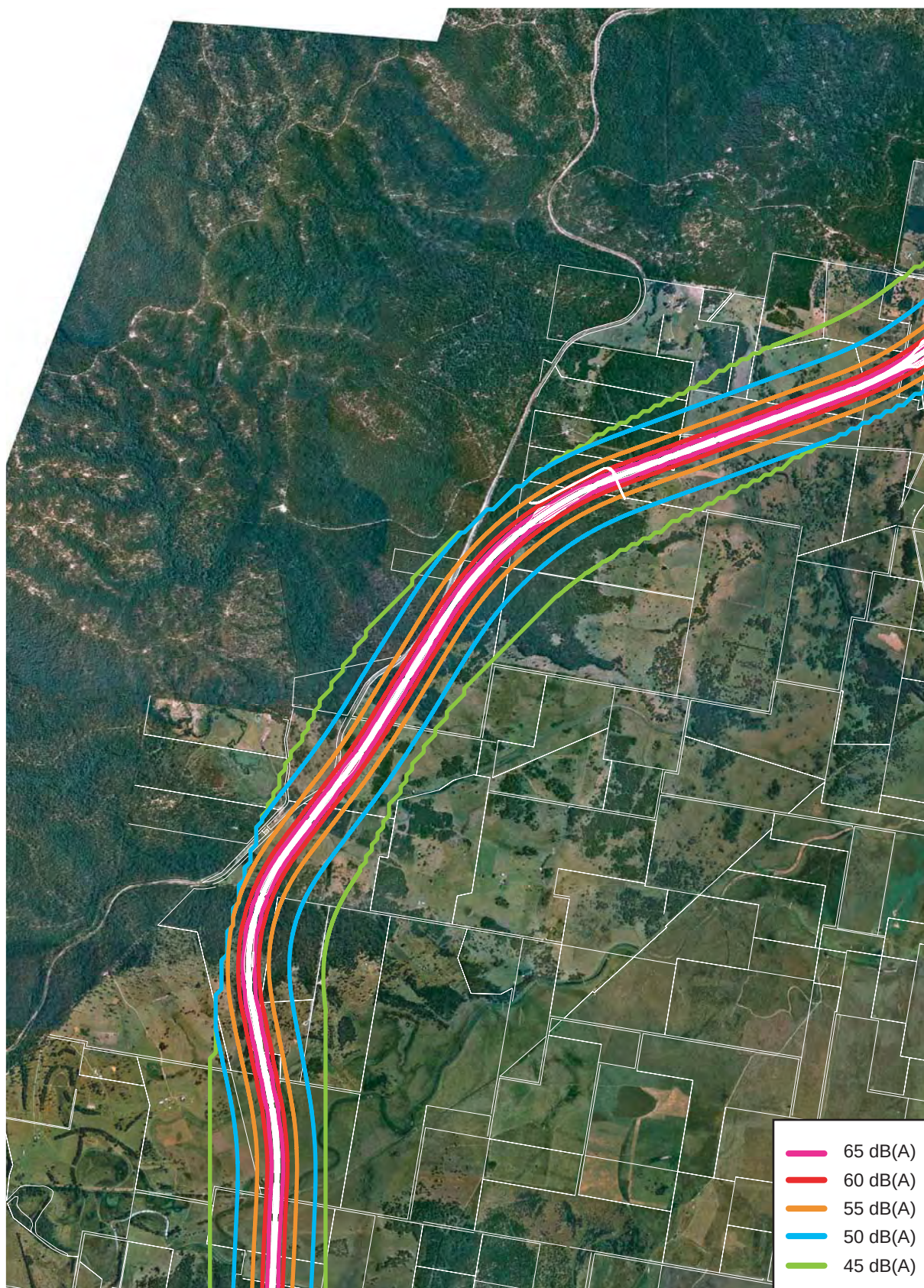
**Figure 3b : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2011 Project Completed - Section 2**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P11 (rev 0)



65 dB(A)
 60 dB(A)
 55 dB(A)
 50 dB(A)
 45 dB(A)



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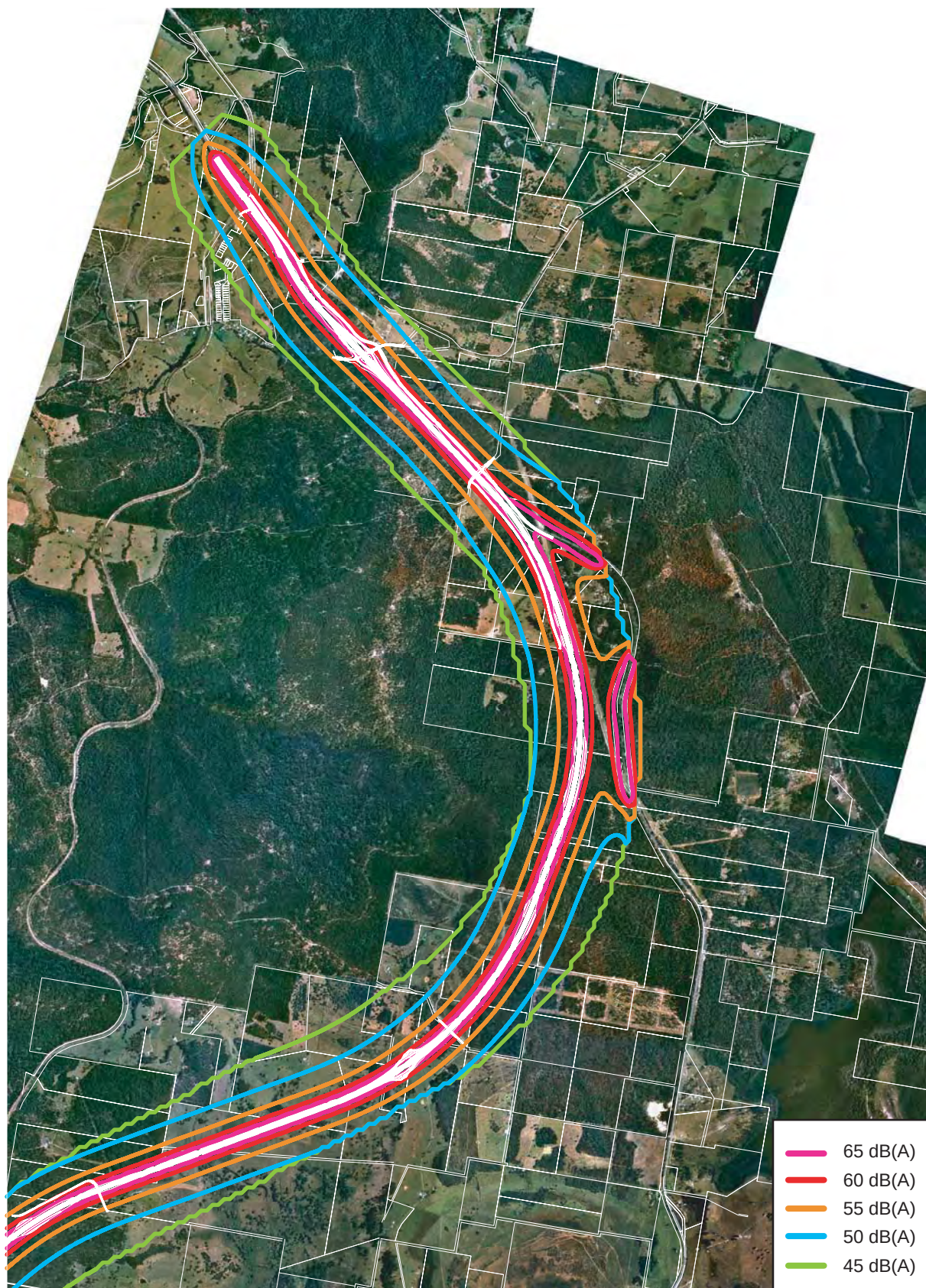
**Figure 3c : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2011 Project Completed - Section 3**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P12 (rev 0)



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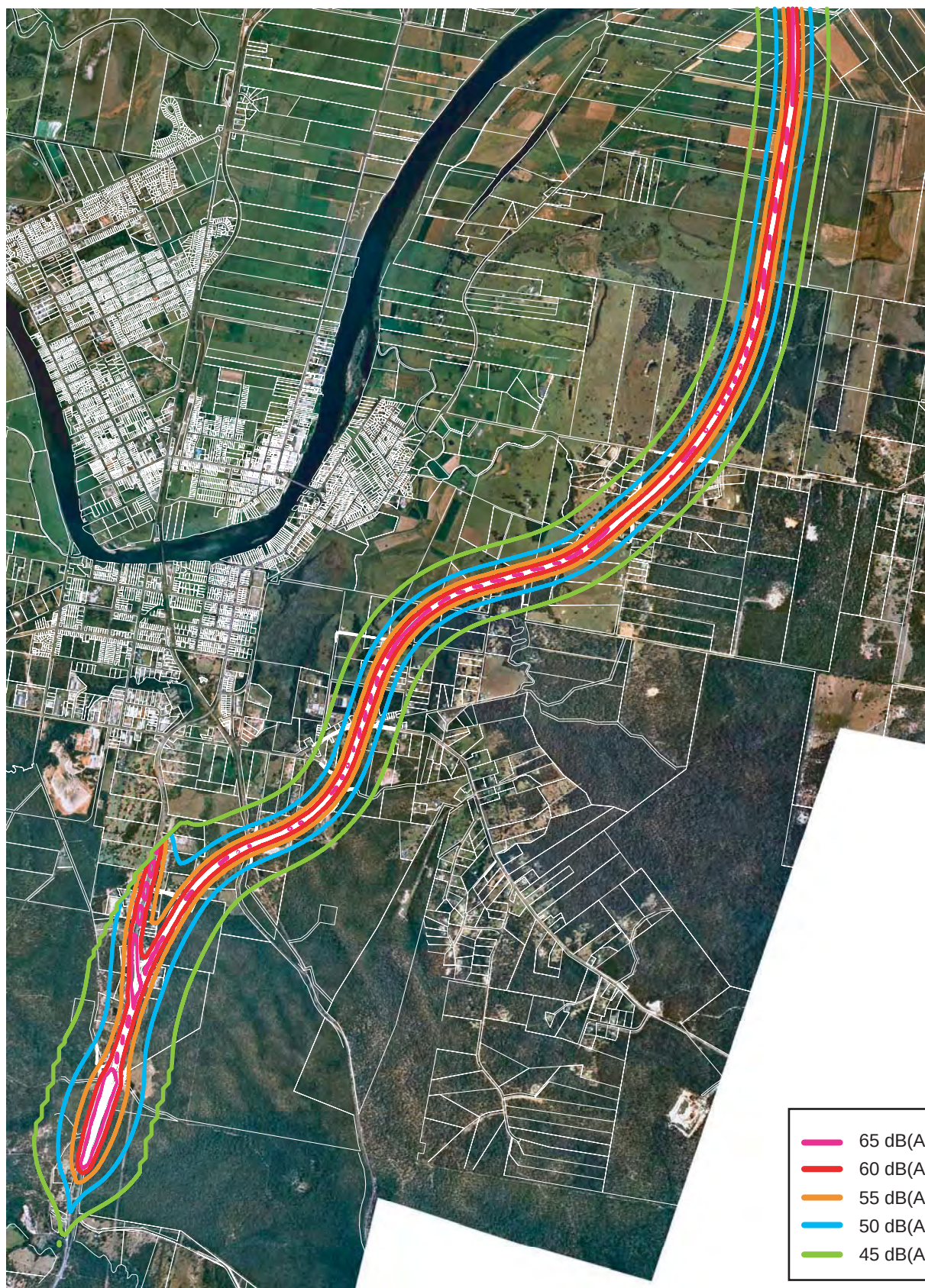
**Figure 3d : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2011 Project Completed - Section 4**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P13 (rev 0)



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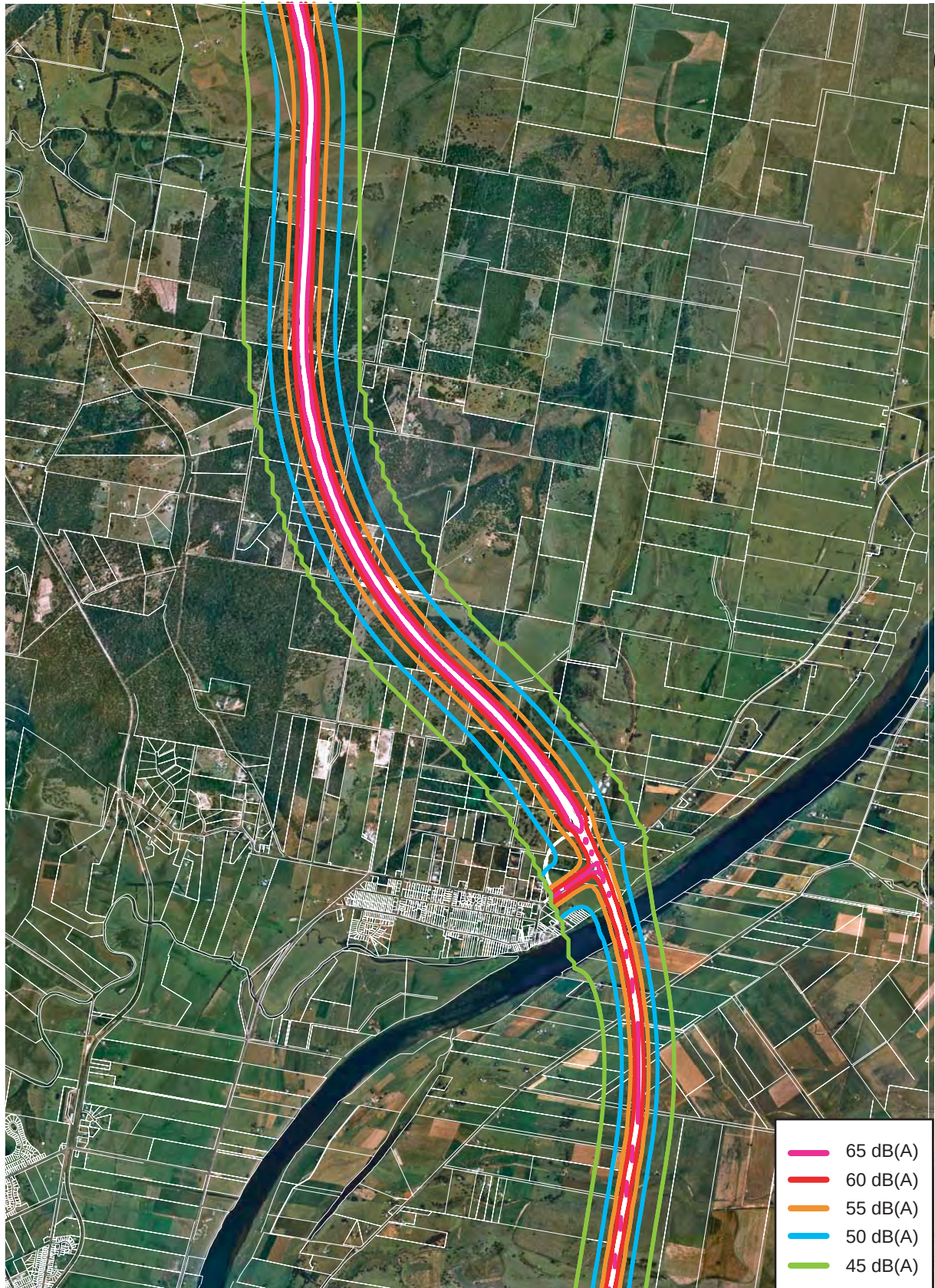
**Figure 4a : Aerial Photograph Showing Night Noise Contours
(9h - Ground Floor) 2011 Project Completed - Section 1**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P14 (rev 0)



— 65 dB(A)
 — 60 dB(A)
 — 55 dB(A)
 — 50 dB(A)
 — 45 dB(A)



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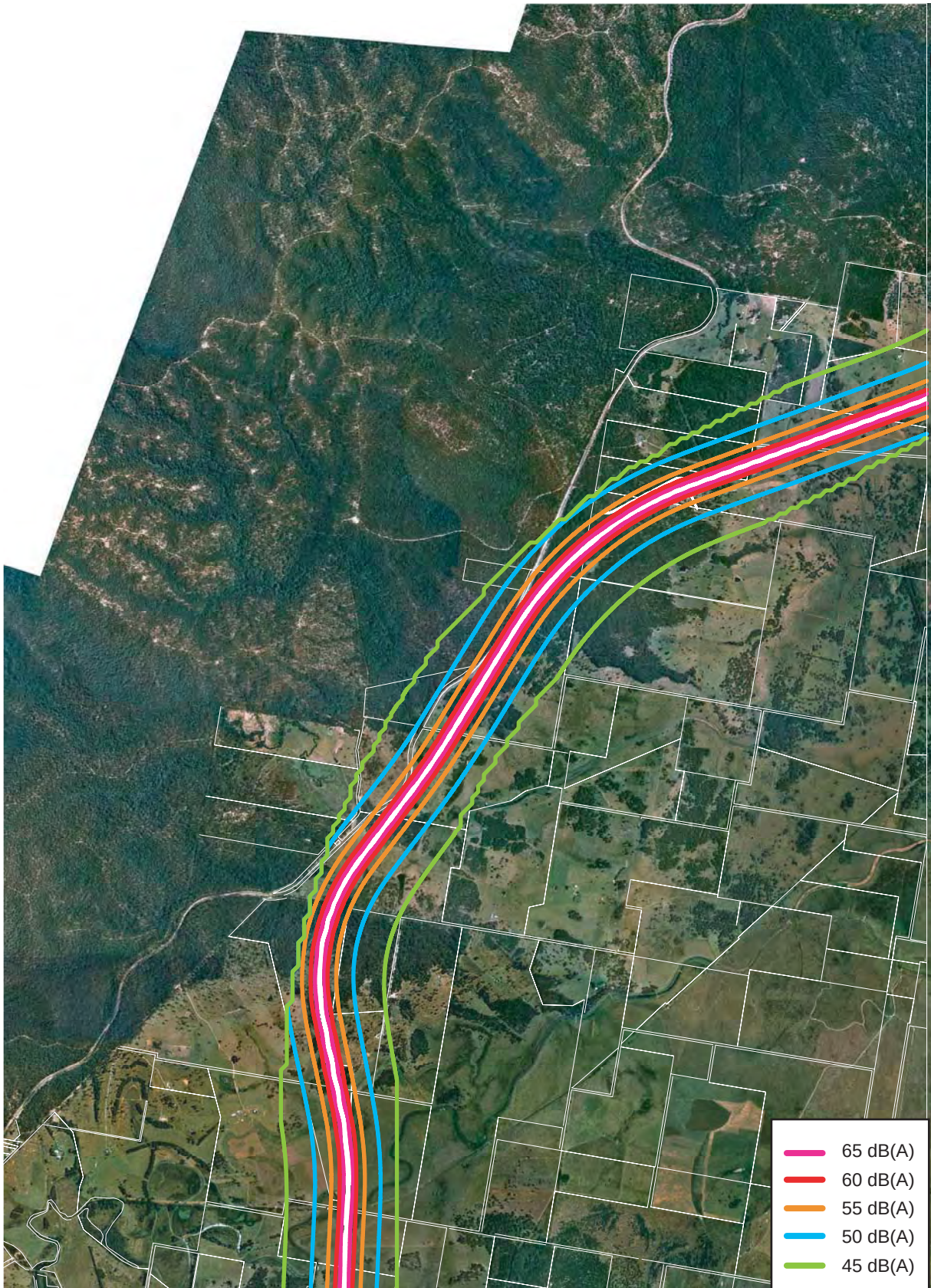
**Figure 4b : Aerial Photograph Showing Night Noise Contours
 (9h - Ground Floor) 2011 Project Completed - Section 2**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P15 (rev 0)



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**Figure 4c : Aerial Photograph Showing Night Noise Contours
(9h - Ground Floor) 2011 Project Completed - Section 3**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P16 (rev 0)



- 65 dB(A)
- 60 dB(A)
- 55 dB(A)
- 50 dB(A)
- 45 dB(A)



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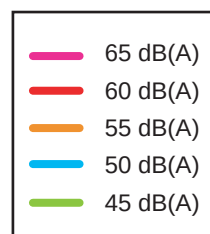
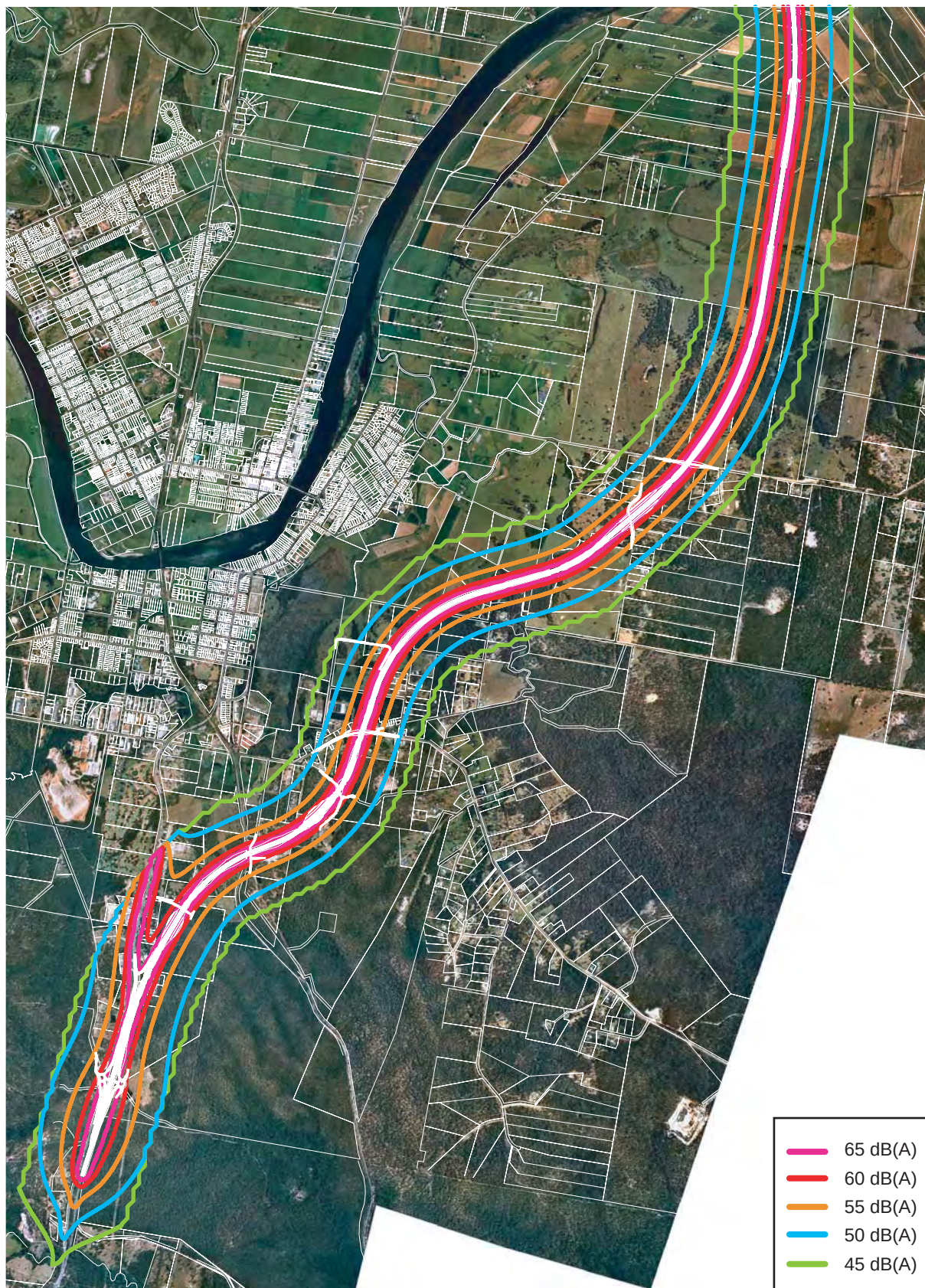
**Figure 4d : Aerial Photograph Showing Night Noise Contours
(9h - Ground Floor) 2011 Project Completed - Section 4**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 11/10/05

Scale: 1:50000

Ref : TA546-07P17 (rev 0)



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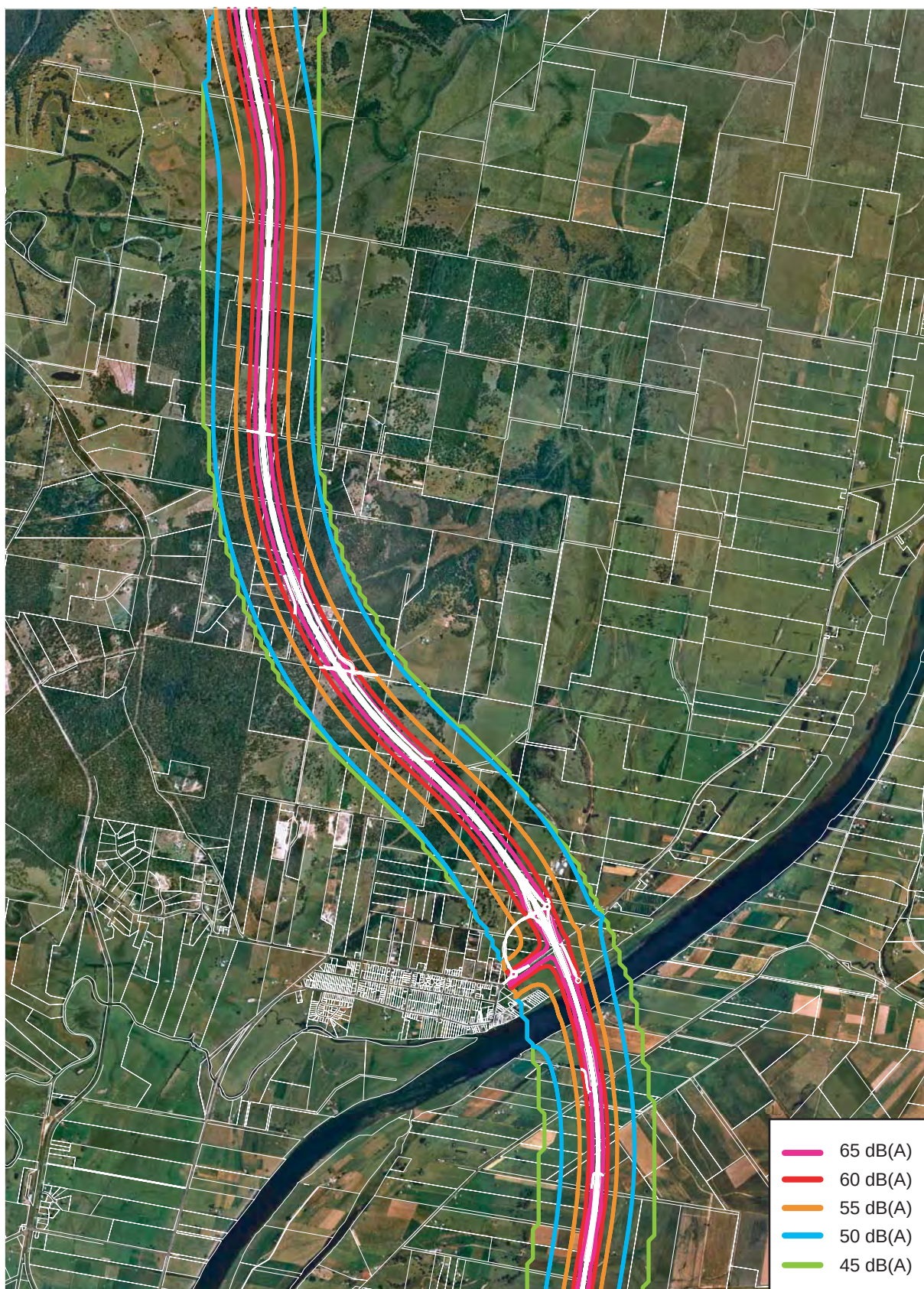
**Figure 5a : Aerial Photograph Showing Day Noise Contours
(15h - Ground Floor) 2021 Project Completed - Section 1**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P18 (rev 0)



65 dB(A)
 60 dB(A)
 55 dB(A)
 50 dB(A)
 45 dB(A)



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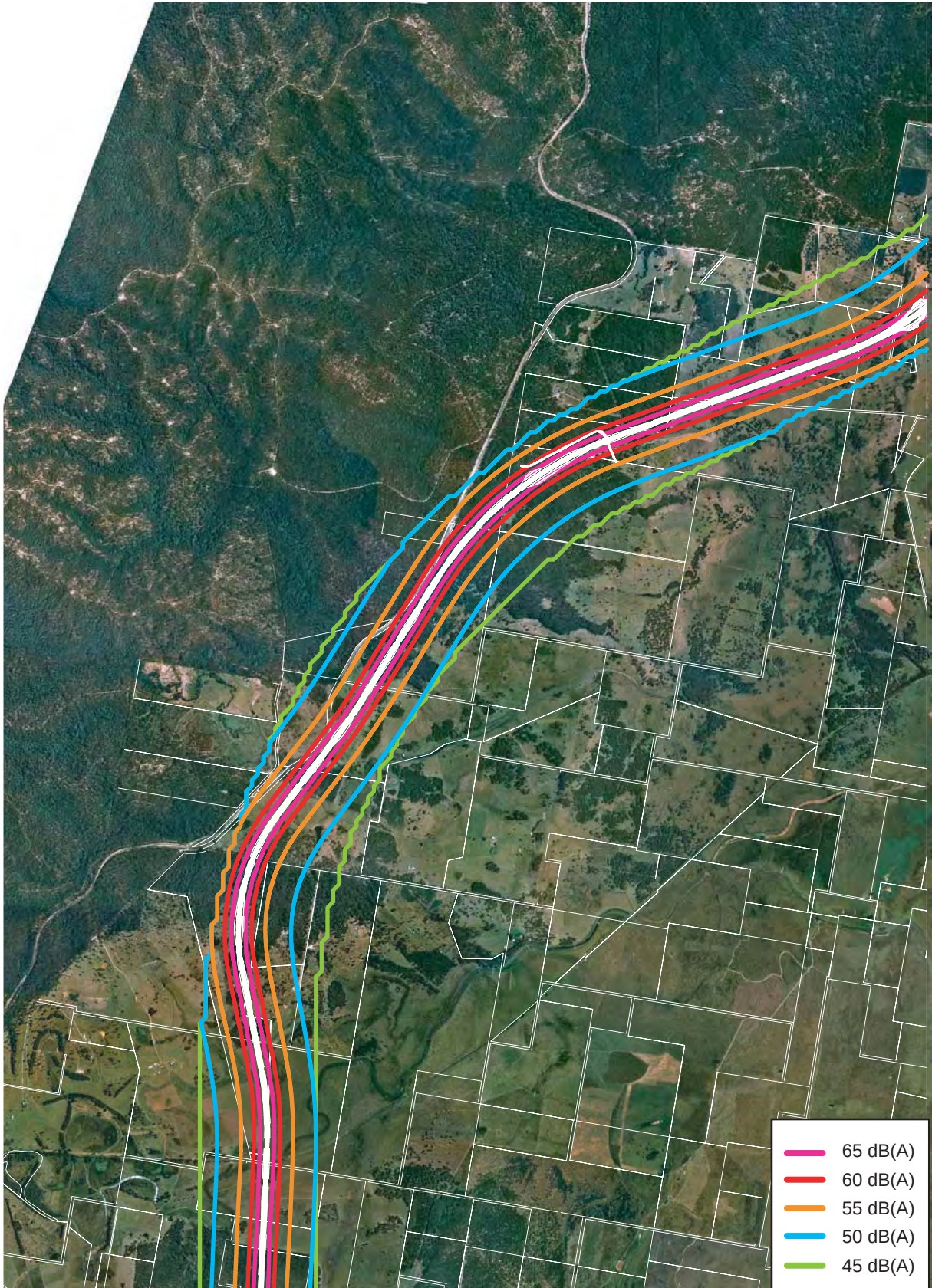
**Figure 5b : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2021 Project Completed - Section 2**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P19 (rev 0)



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**Figure 5c : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2021 Project Completed - Section 3**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P20 (rev 0)



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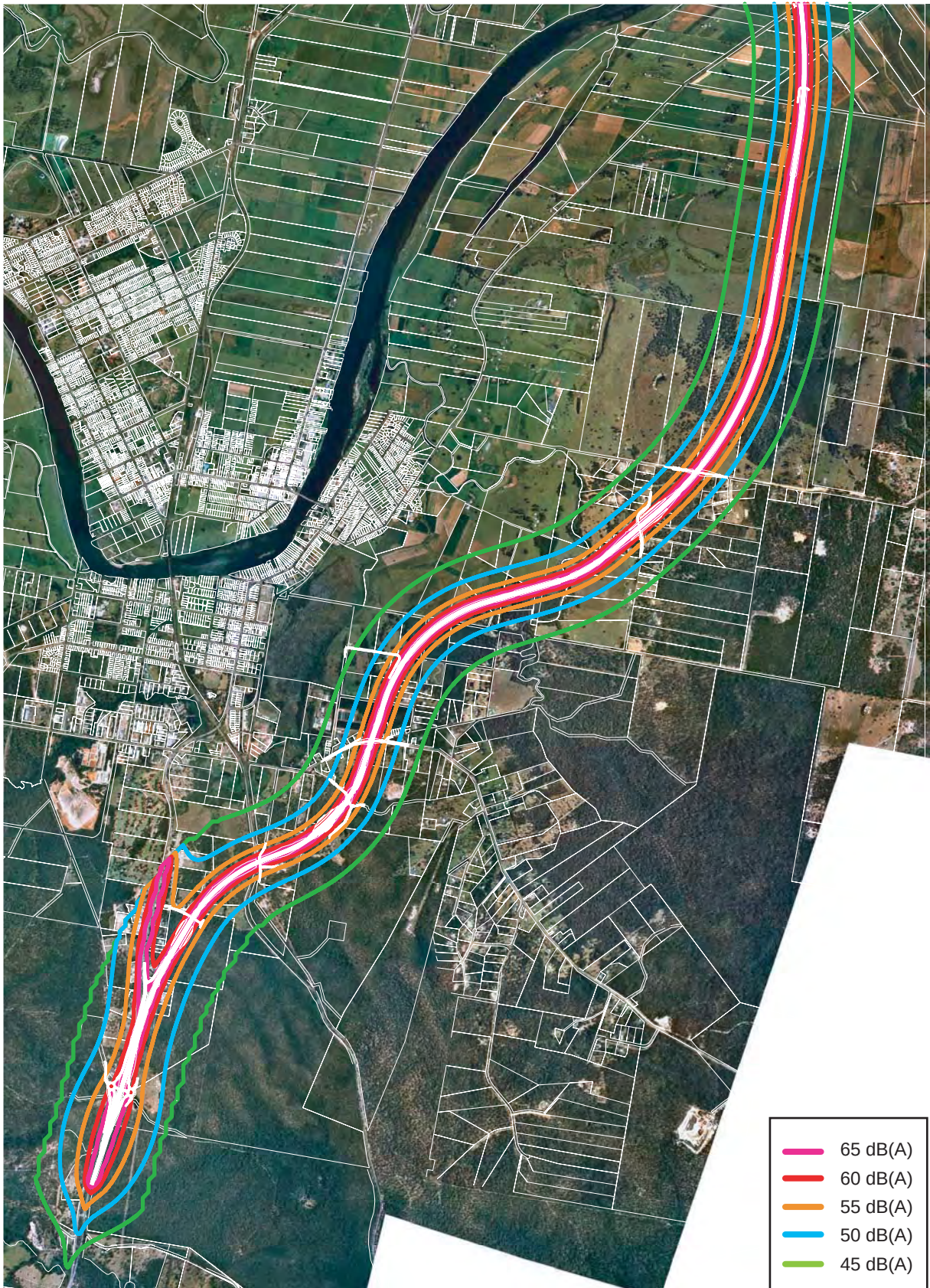
**Figure 5d : Aerial Photograph Showing Day Noise Contours
 (15h - Ground Floor) 2021 Project Completed - Section 4**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P21 (rev 0)



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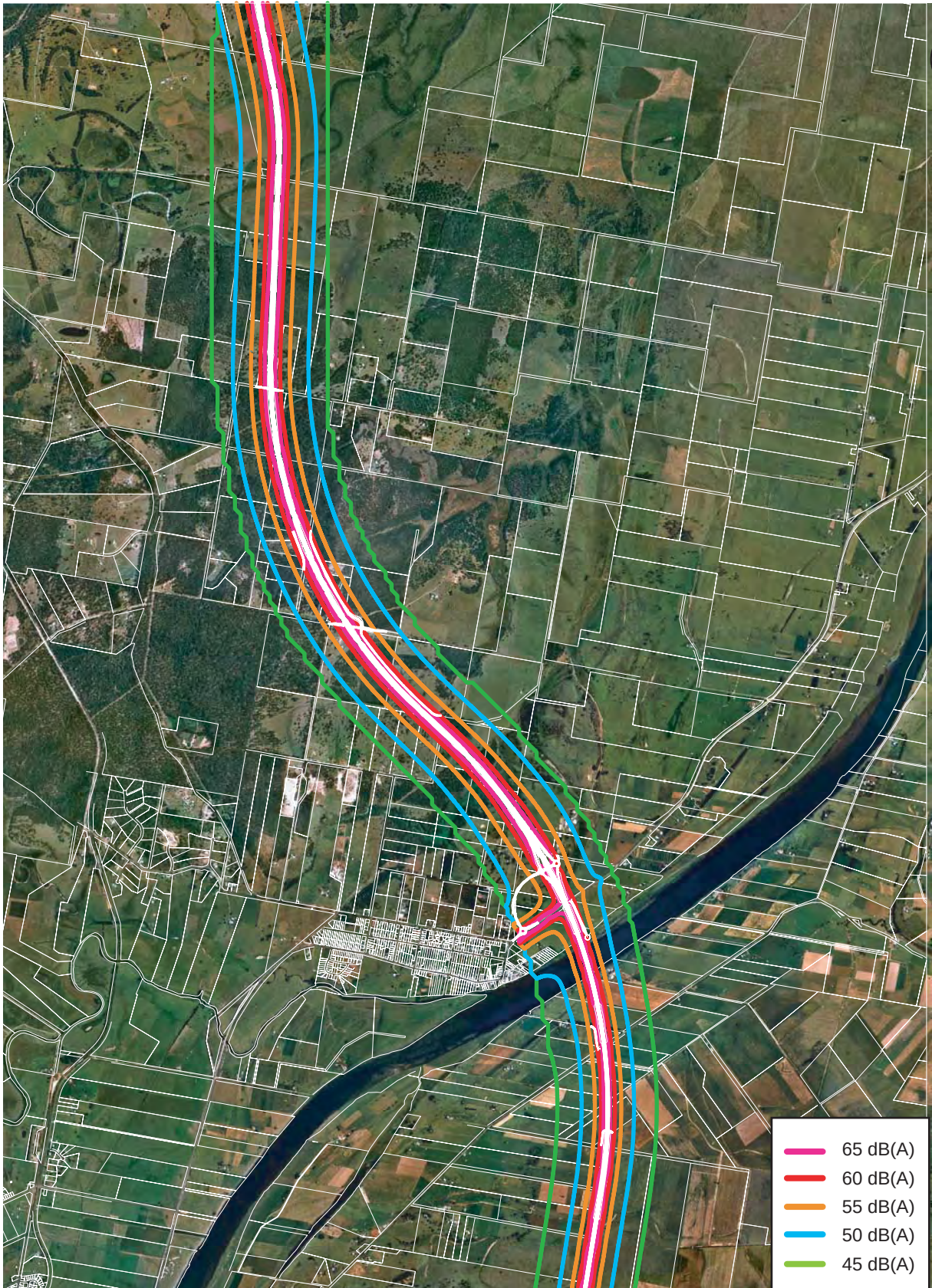
**Figure 6a : Aerial Photograph Showing Night Noise Contours
 (9h - Ground Floor) 2021 Project Completed - Section 1**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P22 (rev 0)



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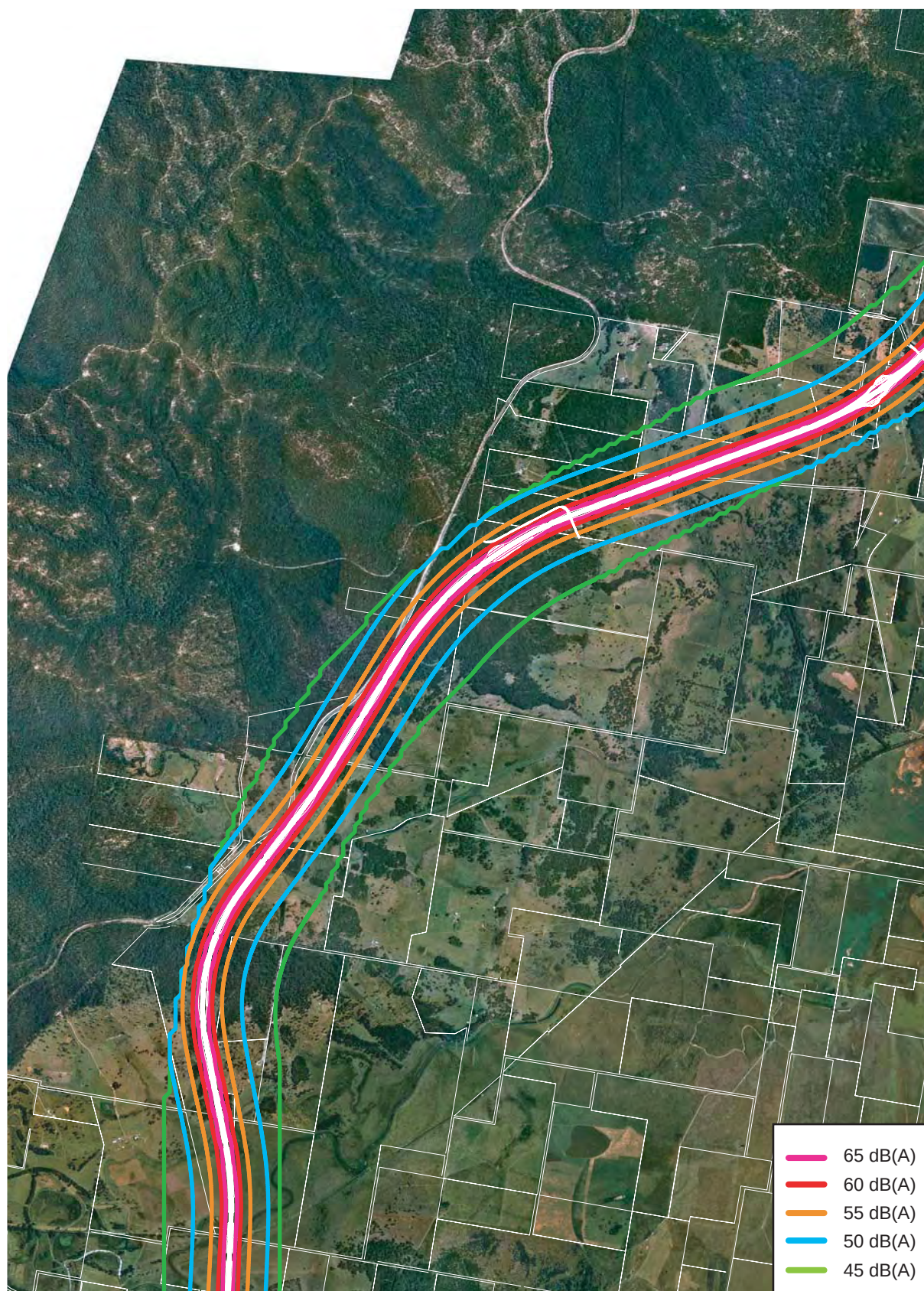
**Figure 6b : Aerial Photograph Showing Night Noise Contours
(9h - Ground Floor) 2021 Project Completed - Section 2**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P23 (rev 0)



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**Figure 6c : Aerial Photograph Showing Night Noise Contours
 (9h - Ground Floor) 2021 Project Completed - Section 3**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P24 (rev 0)



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**Figure 6d : Aerial Photograph Showing Night Noise Contours
(9h - Ground Floor) 2021 Project Completed - Section 4**

Project : Pacific Highway Upgrade - Kemsey to Eungai

Date : 12/10/05

Scale: 1:50000

Ref : TA546-07P25 (rev 0)