Appendix H

Noise and vibration report

Roads and Maritime Services

New England Highway Upgrade - Belford to Golden Highway

Operational Traffic and Construction Noise and Vibration Assessment Report

R01

Rev A | 17 January 2017

Job number 244597-00

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Contents

Appendix C

20% Constructability Construction Program

Appendix D

Noise Contours

1 Introduction

Roads and Maritime Services (Roads and Maritime) proposes to upgrade the New England Highway between Belford and the Golden Highway. The road upgrade would improve traffic flow, travel times and safety for motorists along a busy section of the New England Highway.

Key features of the proposal include:

- Widening the New England Highway for around 3.2 km to provide a divided road with two travel lanes in each direction between Belford and the Golden Highway
- Replacing the existing right turn movement from the Golden Highway to the New England Highway with a right turn flyover
- Establishing a road corridor for future development of the New England Highway towards Singleton.

Arup has carried out an environmental noise and vibration assessment as part of the Review of Environmental Factors (REF) for the proposal. This report presents the potential construction and operational noise impacts for the proposal and the recommended management measures.

A glossary of acoustic terminology used is provided in Appendix A.

2 Project description

2.1 Site description

The existing junction between the Golden Highway and the New England Highway is located at a key link in the regional infrastructure of the Hunter Region / Lower Hunter region, connecting the Golden Highway corridor, with the New England Highway corridor. Both corridors are locally and regionally important, with the New England Highway forming the inland route from Sydney to Brisbane and the Golden Highway accessing and servicing industries including agriculture and mining, and commuter needs.

The project extends from the existing junction of the Golden Highway and the New England Highway to approximately 300 m west of Bell Road, Belford. The surrounding environment is primarily rural, with rural residential properties sparsely located and at least 200 m from the nearest carriageway.

2.2 Noise sensitive receivers

In accordance with Roads and Maritime guidelines, all receivers within 600 m from the centre line of the outermost traffic lane on each side of the subject roads have been identified for the noise assessment, and are identified in Table 1 and shown in Figure 1.

Table 1: Receiver locations

ID	Address	Lot	Distance from Project[1]
Residential			
R1	98 Mitchell Line Road	351//DP1053417	410 m
R2	96 Mitchell Line Road	27//DP1128978	260 m
R3	3193 New England Highway, Belford	10//DP703050	450 m
R4	3193 New England Highway, Belford	42//DP1128981	470 m
R5	3193 New England Highway, Belford	106//DP1141521	220 m
R6	3193 New England Highway, Belford	107//DP1141521	485 m
R7	3193 New England Highway, Belford	108//DP1141521	325 m
R8	3193 New England Highway, Belford	3/4/DP758078	550 m
R9	2 Lindsay Street, Belford	A//DP400750	430 m
R10	2 Lindsay Street, Belford	11//DP1125000	460 m
R11	10 Lovell Street, Belford	3/14/DP758078	575 m
R12	Lindsay Street, Belford	69//DP755209	585 m
Other Receivers			
C1	United Service Station - New England Highway, Whittingham	21//DP1014307	180 m

[1] – Approximate distance from centre line of outermost carriageway to façade of receiver building.

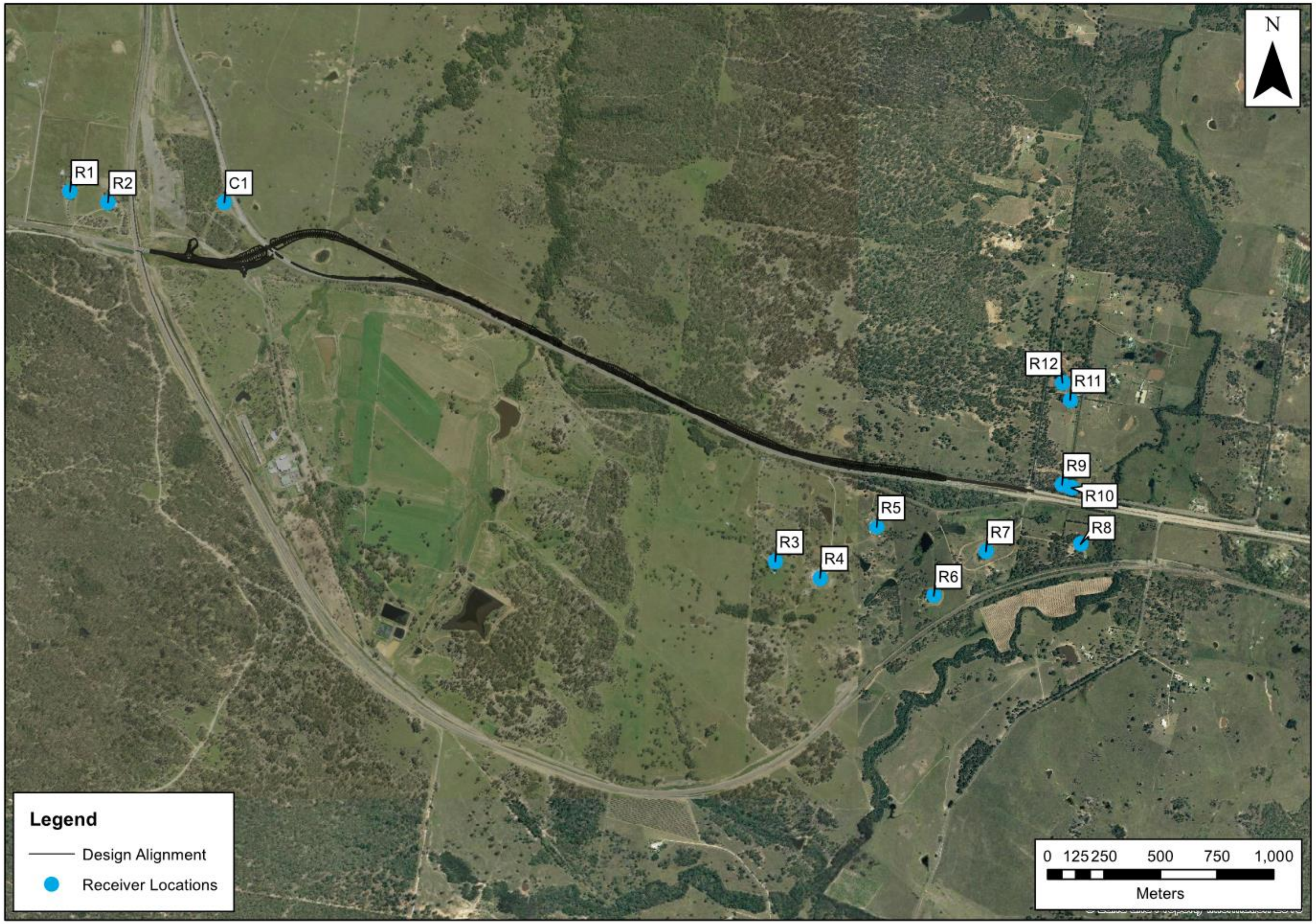


Figure 1: Project site and noise and vibration receiver locations.

2.3 Existing road features

At the intersection with the New England Highway, the Golden Highway is a two-lane unseparated road with one lane in each direction. The New England Highway is currently a three lane unseparated carriageway with one eastbound and two westbound lanes between the Golden Highway intersection and the eastern project extent. East of the project extent the New England Highway becomes a separated carriageway with two lanes in each direction.

2.4 Assessment objectives

Arup's assessment has been carried out in accordance with:

- NSW Road Noise Policy [1]
- Roads and Maritime Noise Criteria Guideline [2]
- Roads and Maritime Noise Mitigation Guideline [3]
- Roads and Traffic Authority Environmental Noise Management Manual [4]
- Roads and Maritime Construction Noise and Vibration Guideline [5]
- NSW Interim Construction Noise Guideline [6]
- Assessing Vibration: A Technical Guideline [7]
- NSW Industrial Noise Policy [8]

3 Existing ambient noise environment

Noise measurements of the existing acoustic environment have been carried out for the purpose of validating the road traffic noise model, as well as to establish background noise levels for the derivation of construction noise management levels.

3.1 Measurement locations

An ambient noise survey was carried out for seven consecutive days from Friday, 4 December 2015 to Friday, 11 December 2015. Noise loggers were set up in the vicinity of the residential dwellings located at the lots listed in Section 2.2.

The noise loggers measured L_1, L_{10}, L_{eq} and L_{90} parameters over 15-minute intervals. The results of the unattended noise measurements are presented in Appendix B.

The unattended noise measurements were supplemented by a 15-minute attended noise level measurement at each noise logger location at commencement and completion of the logging period for the purposes of verification.

The distance of each measurement location to the nearest road and nearest residential receiver is summarised in Table 2 and measurement locations are shown in Figure 2.

Table 2: Noise monitoring locations with indicative distance to the nearest road and nearest residential receiver.

ID	Noise logger location	Approx distance to nearest road kerb	Description
L1	R4 - Lot 42, DP1128981	458 m	Logger located in the free-field on the northern side of the property. Ambient L_{Aeq} noise levels influenced by freight rail noise.
L2	R5 - Lot 106, DP1141521	185 m	Logger located in the free-field on the northern side of the property. Ambient L_{Aeq} noise levels dominated by road traffic along the New England Highway.
L3	R10 - Lot 11, DP1125000	30 m	Logger located in the free-field on the southern side of the property. Ambient L_{Aeq} noise levels dominated by road traffic along the New England Highway.

Figure 2: Noise logging locations

3.2 Equipment

Table 3 outlines the measurement and calibration equipment used. All measurement and calibration equipment used in the noise survey holds current accredited laboratory calibration certification. All noise level measurement equipment was calibrated at the beginning and end of measurements, with no significant drift in calibration occurring over the duration of measurements.

Table 3: Measurement and calibration equipment details.

Type	Model	Serial number
Noise logger	ARL Ngara with Type 1 Microphone	878107
Noise logger	ARL Ngara with Type 1 Microphone	878061
Noise logger	ARL Ngara with Type 1 Microphone	8780D0
Sound level meter	Brüel & Kjaer Type 2270, Type 4189 Microphone	2754328
Calibrator	Brüel & Kjaer Type 4231 Sound Calibrator	2445716

3.3 Measured noise levels

The noise environment around the proposal area is mainly characterized by road traffic noise, including heavy vehicles, along the New England Highway, rail movements along the Hunter Rail Line, rural industry and machinery and local insect and animal noise.

A summary of existing ambient and road traffic noise levels is provided in Table 4.

Table 4: Existing ambient and road traffic noise levels

ID	Location	Rating background noise levels (RBL)[1]			L_{Aeq} road traffic noise levels[2] (dB)	
		Day	Evening	Night	$L_{Aeq,(15 hr)}$	$L_{Aeq,(9 hr)}$
L1	R4 - Lot 42, DP1128981	43	42	35	52	n/a[3]
L2	R5 - Lot 106, DP1141521	46	47	43	54	53
L3	R10 - Lot 11, DP1125000	54	49	37	67	63

1 - Rating Background Level. See NSW Industrial Noise Policy (INP) [8] for a detailed description.

Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays

Evening: 18:00-22:00 Monday to Sunday & Public Holidays

Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

2 - Traffic results as measured in the free field.

3 – Due to distance from the carriageway and relative low traffic flows during the night-time period, road traffic noise was not considered the dominant noise source measured at this location.

4 Operational noise assessment

4.1 Study Area

The following definitions are provided in Section 6 of the NCG:

> *The RNP defines the study area width as '600 metres from the centre line of the outermost traffic lane on each side of the subject road'. This distance is based on the limit of accuracy of currently approved road traffic noise models.*
>
> *Under some circumstances, such as in rural areas, criteria may still be exceeded at 600 metres. Where it can be demonstrated that criteria may be exceeded beyond 600 metres then each residence will be need to be assessed on a case by case basis.*
>
> *The extent of the study area is the chainage in which physical works associated with the road project occur and may be extended to close-by landmarks to provide a logical endpoint.*

The receiver locations that fall within the study area for this project are therefore R3 through R7.

C1 is not considered as part of the operational noise assessment as it is not classified as a noise sensitive receiver.

4.2 Operational noise criteria

The noise criteria for residences is established using the NSW Government's Road Noise Policy [1] (RNP) and Roads and Maritime Noise Criteria Guideline [2] (NCG).

The objective of the project is to improve the safety, reduce congestion, and increase throughput of the intersection. As advised by Roads and Maritime, for the purposes of the noise assessment the project is considered 'minor works' as it is not expected the noise environment will vary significantly at the noise sensitive receivers. It is also noted that there are not many sensitive receivers near the flyover and residential receivers near the widened section of the road are unlikely to trigger noise mitigation due to exceeding the cumulative limit. Therefore, assessment as Minor Works or a project with transition zones would result in the same outcome.

Roads and Maritime applies existing road criteria (RNP Table 8) where the minor works increase noise levels by more than 2.0dBA relative to the existing noise levels at the worst affected receiver.

Existing road criteria are shown in Table 5 for reference.

Table 5: Road traffic noise assessment criteria for residential land uses

Existing road category	**Target noise level – dB(A)**	
	Day (7am-10pm)	**Night (10pm-7am)**
Freeway/arterial/sub-arterial road	$L_{Aeq, (15 hour)}$ 60 (external)	$L_{Aeq, (9 hour)}$ 55 (external)

For minor works Roads and Maritime applies the criteria from the NCG if noise levels increase by more than 2.0dBA at the worst affected receiver.

When this is demonstrated, all sensitive receivers must be assessed where the noise levels exceed the controlling criterion within the minor works study area (NCG). Where the total noise level for the ‘build’ year exceeds the criterion and there is an increase of more than 2.0dBA (ie 2.1dBA), relative to the ‘no-build’ year, then the receiver qualifies for consideration of noise mitigation. This includes the situation where the ‘no-build’ noise level is below the criterion value(s).

4.3 Traffic modelling parameters

Traffic data was obtained from The 'New England Highway Duplication – Belford to Golden Highway Traffic Modelling Report' (Hyder Consulting, 2014). Included with the report were tube counts undertaken in 2014 along the New England Highway and the Golden Highway. The tube counts were used to obtain daily average and nightly average traffic volumes. Turning proportions were then extracted from the report and were applied to the daily and nightly averages. A 2 per cent annual linear growth rate (as in modelling undertaken by Hyder) was applied across the study to obtain the 2015, 2019 and 2029 modelling scenarios.

A summary of traffic volumes used for operational noise modelling of the various scenarios are provided in Table 6.

Table 6: Traffic volume summary for noise modelling

Road Section	Direction	Time period	Vehicle class	Existing conditions (2015)	Year of opening (2019)		Design year (2029)	
					'No Build' scenario	'Build' scenario	'No Build' scenario	'Build' scenario
New England Highway - East of Golden Highway	Westbound	Daytime 7am-10pm	Light	7836	8482	8482	10339	10339
			Heavy	399	431	431	526	526
			Total	8234	8913	8913	10865	10865
		Night-time 10pm-7am	Light	2962	3206	3206	3908	3908
			Heavy	139	151	151	184	184
			Total	3101	3357	3357	4092	4092
	Eastbound	Daytime 7am-10pm	Light	6476	7009	7009	8544	8544
			Heavy	404	438	438	534	534
			Total	6880	7447	7447	9078	9078
		Night-time	Light	464	502	502	612	612

Road Section	Direction	Time period	Vehicle class	Existing conditions (2015)	Year of opening (2019)		Design year (2029)	
					'No Build' scenario	'Build' scenario	'No Build' scenario	'Build' scenario
		10pm-7am	Heavy	93	101	101	123	123
			Total	557	603	603	735	735
	Eastbound On-Ramp	Daytime 7am-10pm	Light	NA	NA	1665	NA	2029
			Heavy	NA	NA	169	NA	206
			Total	NA	NA	1833	NA	2235
		Night-time 10pm-7am	Light	NA	NA	115	NA	140
			Heavy	NA	NA	33	NA	41
			Total	NA	NA	148	NA	181
New England Highway - North of Golden Highway	Northbound	Daytime 7am-10pm	Light	6564	7105	7105	8661	8661
			Heavy	451	488	488	595	595
			Total	7015	7593	7593	9256	9256
		Night-time 10pm-7am	Light	2348	2542	2542	3099	3099
			Heavy	193	209	209	255	255
			Total	2542	2751	2751	3354	3354
	Southbound	Daytime 7am-10pm	Light	7832	8477	8477	10334	10334
			Heavy	316	342	342	417	417
			Total	8148	8819	8819	10751	10751
		Night-time 10pm-7am	Light	671	726	726	885	885
			Heavy	75	81	81	99	99

Road Section	Direction	Time period	Vehicle class	Existing conditions (2015)	Year of opening (2019)		Design year (2029)	
					'No Build' scenario	'Build' scenario	'No Build' scenario	'Build' scenario
			Total	745	807	807	984	984
Golden Highway	Westbound	Daytime 7am-10pm	Light	4529	4902	4902	5975	5975
			Heavy	620	671	671	817	817
			Total	5148	5573	5573	6793	6793
		Night-time 10pm-7am	Light	1044	1130	1130	1377	1377
			Heavy	105	114	114	139	139
			Total	1149	1244	1244	1516	1516
	Eastbound	Daytime 7am-10pm	Light	2501	2707	2707	3300	3300
			Heavy	160	173	173	211	211
			Total	2661	2880	2880	3511	3511
		Night-time 10pm-7am	Light	368	398	398	485	485
			Heavy	34	36	36	44	44
			Total	401	434	434	530	530

4.4 Modelling methodology

The noise model is based upon the Concept Design alignment for the proposed bridge and road system, and may be updated and refined during the detailed design process.

Acoustic modelling has been undertaken in accordance with Roads and Maritime guidelines as well as international best practice. Predictions have been made using the Calculation of Road Traffic Noise [9] (CoRTN) model within the SoundPLAN 7.4 software suite. Guidance on acoustic modelling best practice has been obtained from the WG-AEN [10] position paper as appropriate.

A summary of the modelling parameters is included below in Table 7.

Table 7: Operational traffic noise modelling parameters

Item	Details
Traffic volumes	See Table 6
Traffic speeds	Validation: 85th percentile Design: Posted speeds
Noise modelling algorithms	CoRTN [9] as implemented by SoundPLAN V7.4 $L_{Aeq,}$ = CoRTN $L_{10,}$ - 3 dB
Split height corrections	Cars (0.5m) – 0dB Trucks (1.5m) – -0.6dB Truck Exhaust – -8.6dB
Road surface corrections	0 dB (Dense Grade Asphalt) +3 dB (Concrete)
Australian conditions correction (ARRB)	-1.7 dB for façade locations -0.7 dB for free-field locations
Ground absorption	0.75
Receiver locations	1 m from building facades 1.5 m above ground level for ground floor 4.5 m above ground level for 1st floor
Façade correction	+2.5 dB for assessment location 1m from building facades.

The noise model was validated using the measured results outlined in Table 4 and existing traffic volumes presented in Table 6. The results of the model validation are presented in Table 8.

4.5 Modelling validation

Table 8: Model validation results

Site ID	Location	Day, $L_{Aeq,15hr}$, dB(A), 7am-10pm			Night, $L_{Aeq,9hr}$, dB(A), 10pm-7am		
		Measured	Modelled	Difference, dB(A)	Measured	Modelled	Difference, dB(A)
L1	R4 - Lot 42, DP1128981	51.8	50.2	-1.6	-	-	-
L2	R5 - Lot 106, DP1141521	54.4	55.6	1.2	53.0	52.0	-1.0
L3	R10 - Lot 11, DP1125000	66.5	66.9	0.4	62.8	62.3	-0.5

Predicted levels at L1 are within 2 dB for the daytime period and L2 and L3 are within 1.5 dB of measured levels. The acoustic model is therefore considered to be validated.

4.6 Predicted noise levels

Using the calibrated noise model, predicted noise levels for the year of opening and design year are presented in Table 9.

Table 9: Predicted road traffic noise levels on the Year of Opening and Design Year

Receiver ID	Opening year, dB(A)				Design year, dB(A)				NCG criteria, dB(A)		Are the -NCG criteria exceeded?		Change in noise level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening year		Design year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R3	51.5	47.9	51.1	47.5	52.4	48.7	51.9	48.4	60	55	NO	NO	-0.4	-0.4	-0.4	-0.4
R4	52.0	48.4	51.7	48.1	52.9	49.3	52.5	48.9	60	55	NO	NO	-0.3	-0.3	-0.3	-0.3
R5	56.9	53.3	56.5	53.0	57.7	54.2	57.3	53.8	60	55	NO	NO	-0.4	-0.3	-0.4	-0.3

Receiver ID	Opening year, dB(A)				Design year, dB(A)				NCG criteria, dB(A)		Are the -NCG criteria exceeded?		Change in noise level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening year		Design year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R6	53.8	50.1	53.6	50.0	54.6	51.0	54.5	50.9	60	55	NO	NO	-0.1	-0.1	-0.1	-0.1
R7	55.9	52.4	55.7	52.2	56.8	53.2	56.6	53.1	60	55	NO	NO	-0.2	-0.2	-0.2	-0.1

* Receiver locations outside project study area

Predicted operational 'Build' road traffic noise levels are within 0.5 dB of 'No-Build' levels for all residential receivers. Road traffic noise levels at all receiver locations within the study area are predicted to be below the NCG criteria.

Predicted road traffic noise increases are below 2.0 dBA for all receiver locations and therefore do not qualify for mitigation.

5 Construction noise and vibration

Construction noise and vibration has been assessed in accordance with the NSW Roads and Maritime Services '*Construction noise and vibration guideline*' (CNVG) [5], which superseded Section 5 and Practice Note (vii) of the '*Environmental Noise Management Manual*' (ENMM) [4]. The CNVG is to be considered for all Roads and Maritime projects including minor works and maintenance projects, but excluding emergency works. It is noted that construction vehicle traffic and traffic diversions are to be assessed and mitigated using standard road traffic noise processes.

5.1 Construction noise criteria

In accordance with the CNVG, construction noise management levels are to be established in accordance with the NSW *Interim Construction Noise Guideline* [6]. The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses, above which all feasible and reasonable work practices should be applied to minimise the construction noise impact.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 10 and other sensitive receivers in Table 11 following.

Table 10: Construction noise management levels at residential receivers

Time of day	**Management level** [1] **$L_{Aeq\ (15\ min)}$**	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
		morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 *of the ICNG.*

[1] - Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 11: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the ‘maximum’ internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

[1] - Noise management levels apply when receiver areas are in use only.

For work within standard construction hours, if after implementing all ‘feasible and reasonable’ noise levels still exceed the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community. While there is no ‘highly-noise affected level’ outlined in the ICNG for out-of-hours work, this report adopts the terminology where the construction noise level is 5 dB above the noise affected level

With regard to standard hours, the CNVG recommends construction activities (including the delivery of plant and equipment) should be limited to within the hours described in Table 12 below wherever feasible and reasonable.

Table 12: CNVG recommended construction hours

Construction hours	Monday to Friday	Saturday	Sunday / Public holiday
Standard construction hours	7:00 am to 6:00 pm	8:00 am to 1:00 pm	No work
Construction activities with impulsive or tonal noise emissions	8:00 am to 5:00 pm[1]	9:00 am to 1:00 pm[1]	No work
Blasting	9:00 am to 5:00 pm	9:00 am to 1:00 pm	No blasting

[1]. Works may be carried out in continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block. 'Continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work the subject of this condition.

5.1.1 Construction noise management levels

Construction noise management levels for residential receivers are established from the prevailing background noise level. Measured noise data obtained at the logger location most representative of each residential location has been used to derive appropriate noise management levels for the project, and are presented in Table 13. It is noted that the results from logger Location 2 has been conservatively excluded due to the higher measured background noise levels.

Table 13: Project construction noise management levels (NMLs)

Receiver location(s)	Logger ID	Noise management levels (NMLs)			
		Standard hours[1]	OSH – Day[2]	OSH – Evening[3]	OSH – Night[4]
R1-R8 & R11-R12	L1	53	48	47	40
R9 & R10	L3	64	49	54	42
C1 - United Service Station	N/A	75 (when in use)			

[1] - 07:00-18:00 Monday to Friday, 08:00-13:00 Saturday

[2] - Outside Standard hours – Day 13:00-18:00 Saturday, 08:00-18:00 Sunday

[3] - Outside Standard hours – Evening: 18:00-22:00 Monday to Sunday

[4] - Outside Standard hours – Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

5.2 Construction vibration criteria

5.2.1 Human comfort and amenity

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW DEC '*Assessing Vibration; a technical guideline*' [7]. The criteria outlined in the guideline is based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent', as described in Table 14.

Table 14: Types of vibration – Definition

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	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	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Table 15 reproduces the 'Preferred' and 'Maximum' values for continuous and impulsive vibration from Table 2.2 of the Guideline.

Table 15: Preferred and maximum vibration acceleration levels for human comfort, m/s^2

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
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

Location	**Assessment period**[1]	**Preferred values**		**Maximum values**	
		z-axis	**x- and y-axes**	**z-axis**	**x- and y-axes**
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
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

[1] - Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

[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 specified above. Alternative criteria is outside the scope of the policy and other guidance documents should be referred to.

Table 16 reproduces the 'Preferred' and 'Maximum' values for intermittent vibration from Table 2.4 of the Guideline.

Table 16: Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	**Daytime**[1]		**Night-time**[1]	
	Preferred value	**Maximum value**	**Preferred value**	**Maximum value**
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

[1]- Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

[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 of impulsive criteria for critical areas.
Source: BS 6472-1992

5.2.2 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2-1993 and/or German Standard DIN4150-3. British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*

- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of British Standard 7385 Part 2 (1993) sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

5.2.2.1 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 17 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 (1993, p.5) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 17: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

[1] - Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

[2] - Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

5.2.2.2 German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure'* (DIN 4150-3) are generally recognised to be conservative. DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The criteria are presented in Table 18.

Table 18: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	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

5.2.3 Buried services

DIN 4150-2:1999 sets out guideline values for vibration effects on buried pipework and reproduced in Table 19 below.

Table 19: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	**Guideline values for vibration velocity measured on the pipe, mm/s**
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note: For gas and water supply pipes within 2m of buildings, the levels given in Table 18 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 meters of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/sec the ground vibration is required to be monitored.

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50mm/s and 100mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

5.3 Blasting Criteria

AS2187.2:2006 *"Explosives – Storage and use Part 2: Use of explosives"* (AS2187) provides recommended limits for ground vibration and airblast overpressure associated with blasting. The following sections summarise recommended limits for each.

5.3.1 Ground vibration limits

AS 2187 recommended limits for ground vibration associated with blasting are summarised in Table 20.

Table 20: AS 2187 recommended ground vibration limits for blasting

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Human comfort limits		
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely effect the equipment operation
Structural control limits		
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency-dependent damage limit criteria Tables J4.4.2.1 and J4.4.4.1 of the standard.
Unoccupied structures of reinforced concrete or steel construction	All blasting	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

*A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

5.3.2 Airblast overpressure limits

AS 2187 recommended limits for airblast overpressure associated with blasting are summarised in Table 21.

Table 21: AS 2187 recommended airblast overpressure limits for blasting

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Human comfort limits		
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	115 dBL for 95% blasts per year. 120 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	120 dBL mm/s for 95% blasts. 125 dBL maximum unless agreement is reached with occupier that a higher limit may apply

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	125 dBL maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely effect the equipment operation
Damage control limits		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All blasting	133 dBL maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

*A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

5.4 Construction noise assessment

The Construction noise assessment has been prepared with reference to details outlined in the 20 per cent Concept Design Constructability Assessment prepared for the project.

5.4.1 Construction works schedule

The proposed construction programme indicates an approximate construction duration of 47 weeks until the commissioning of the new MC20 Eastbound Entry Ramp (bridge) and MC10 HW9 New England Highway, with full project completion at 53 weeks.

These durations are dry-weather durations and are based upon the following assumptions:

- Construction Environmental Management Plan approvals (and any Environment Protection Authority licences) would be obtained five weeks from contract award
- Relocation of the high pressure gas main is sufficient to allow bulk earthworks (including blasting) by week 17
- A flexible pavement (asphalt on a Densely Graded Base)
- Minimal removal and replacement of existing pavements on the Golden Highway and the New England Highway, particularly at:
- The intersection of the Golden Highway and the New England Highway

- The Golden Highway close to the rail overbridge
- The tie in of the existing New England Highway and MC10
- The re-configuration of the New England Highway westbound lanes.

The 20% Concept Design shows a single span prestressed concrete Super-T bridge structure. However, during the constructability, risk and health and safety in design workshops, further examination of the preferred bridge design was discussed. Based on inherent risks associated with the high pressure gas main, drainage in the reinforced soil wall and benefits of improved site lines and reduction in imported soil fill, it was considered that the three span prestressed concrete Super-T bridge structure may be more appropriate as the construction cost difference was minimal. As a result, the proposed construction programme reflects the proposed change to a three span prestressed concrete Super-T bridge structure and has assumed that with development of the bridge design the high pressure gas main will not be required to be relocated to allow the bridge and abutment works to be undertaken.

The proposed construction programme is attached in Appendix C.

Based on the indicative project program, the following key construction activities will occur:

- Road widening and new paving for the Golden Highway
- Construction of the overpass, including piling
- Site clearing and excavation (cut/fill) for the New England Highway duplication
- Blasting and processing for the New England Highway duplication
- Pavement works for the New England Highway duplication
- Reconfigure the existing New England Highway to westbound only

5.4.2 Construction Compounds

One main construction compound and one auxiliary construction compound will be required for construction purposes.

There is unlikely to be a requirement for compound areas for storage of large quantities of construction materials such as culvert units, bridge reinforcement and pavement materials as these will be delivered to their point of use. Due to the proximity to permanent facilities and the relatively small heavy plant requirements it is unlikely that on-site heavy plant workshop or bulk fuel storage will be needed.

The main construction compound will be required for:

- Site offices and facilities
- Staff car-parking
- Work-tool containers and minor storage

As the intersection of Golden Highway and New England Highway is very congested the main construction compound would not be located off the Golden Highway (as was the main compound for the rail upgrade). The main construction compound would need to be located on the northern side of the New England Highway (same side as the construction works). The only suitable locations within the project boundary are:

1. The area between the existing New England Highway and the new MC20 Eastbound Entry Ramp
2. Within the future corridor, northwest of the new MC20 Eastbound Entry Ramp.

Location (1) above is preferred as:

- It is located nearby the proposed New England Highway site accesses
- It does not require driving through work zones or crossing the creek line at MC10 Ch. 32950.

Potential construction compounds for the project are provided in Figure 3 for reference.

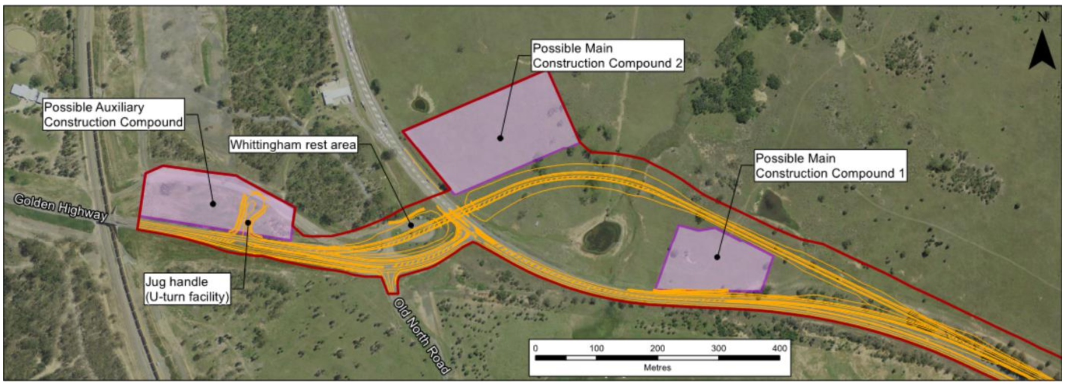


Figure 3: Potential construction compound locations

Given the likely location and proposed usage of site compounds, noise and vibration impacts are not expected to be significant and will not be discussed further in this report.

5.4.3 Traffic Staging

The traffic staging is heavily dependent upon the condition and re-use of the existing pavements. Further investigation will need to be undertaken to better quantify the condition of the existing pavements, particularly in the following locations:

- The intersection of the Golden Highway and the New England Highway
- The Golden Highway close to the rail overbridge
- The tie in of the existing New England Highway and MC10
- The re-configuration of the New England Highway westbound lanes.

Anecdotal discussions during the constructability workshop indicated that the pavements on the Golden Highway are of acceptable condition to merely tie into, and that the New England Highway westbound lanes should not need any rehabilitation. The biggest unknown is the make-up and condition of the existing New England Highway eastbound pavement and shoulder, where the new MC10 ties in.

The other major influence on the traffic staging is the pavement design to be adopted, which will need to combine the design of the new pavement and the condition of the existing to determine the jointing design and configuration.

All these matters need to be further investigated and detailed as the design is developed.

The proposed traffic staging is described below in Table 22.

Table 22 Proposed traffic staging

Location/ stage	**Construction**	**Intent**	**Traffic flow**
GH stage 1	Construct the eastern side of the new works on the Golden Highway. (Some temporary pavement may be required).	Construct sufficient width on the Golden Highway to allow all movements to be switched onto the east side to then allow construction of the new pavements on the west side.	Rest area no longer available. Rest area is currently utilised to provide access from local property and rail land to the Golden Highway. Local property and rail land access to the Golden Highway will need to be maintained throughout the construction phase. All other movements unchanged.
GH stage 2	Construct the western side of the new works on the Golden Highway, including the new jug-handle and MC20 Eastbound Entry Ramp pavements.	Complete all new pavement works on the Golden Highway.	Switch traffic onto the new “eastern side” pavements. The intersection of the Golden Highway and the New England Highway and the rail bridge area to be the same as current operation.
GH stage 3	Final configuration of the new intersection on the Golden Highway, largely line-marking and pavement tidy-up.	Complete the new intersection and tidy area.	Eastbound over the new MC20 Eastbound Entry Ramp (bridge).
NEH stage 1	Construct site accesses along the New England Highway.	Construction of safe site accesses off the New England Highway.	Westbound reduced to one lane. Ch. 30,500 – Ch. 32,600 (current “fast” lane used for right hand holding bay and acceleration/merge lane). Eastbound lane shoulder closures at access points during construction.

Location/ stage	Construction	Intent	Traffic flow
NEH stage 2	Construct MC10, MC20 and existing New England Highway tie-in.	Tie-in of new MC10, MC20 and existing New England Highway pavement.	Westbound reduced to one lane. Ch. 30,500 – Ch. 32,600 (current “fast” lane used for right hand holding bay and acceleration/merge lane). Eastbound shoulder closed Ch. 32,500 – Ch. 32,900.
NEH stage 3	Removal/ reshaping of the abandoned New England Highway eastbound	Complete new median along New England Highway.	Westbound returned to two lanes but with the right shoulder closed (or possible night works). Eastbound on the new carriageway.
NEH stage 4	New line marking and delineators on the New England Highway westbound.	Complete the new westbound lane configuration on the New England Highway	Westbound under traffic control (or probably night works). Eastbound on new carriageway.

Proposed traffic diversions are restricted to the existing and proposed road footprints. In addition, traffic management such as temporary speed limits will be enforced for safety. As such, no significant increase in noise level of is expected as a result of traffic staging during construction of the project.

Construction traffic associated with the development will be limited to site construction staff vehicles and truck deliveries. Given the significant number of heavy vehicles currently using the existing alignment, an increase of >2 dB is not expected due to construction traffic associated with the project.

5.4.4 Construction source noise levels

Detailed construction equipment will be determined by the contractor at a later stage of the project. For the purpose of this REF, indicative equipment listing and sound power levels for various work scenarios are listed in Table 23, which have been sourced from the Roads and Maritime Construction Noise Estimator which supplements the CNVG.

Table 23: Construction noise sources

Activity	Description of activity	Plant/ equipment	L_{Aeq} SWL	Assumptions for quantitative assessment	
				No. Units	Activity total L_{eq} SWL
Mobilisation & Site Establishment	Installing construction boundary hoardings/ fences and traffic barriers	Truck (medium rigid)	103	4 per hour	115
		Road truck	108	4 per hour	
		Scissor Lift	98	1	
		Franna crane	98	1	

Activity	Description of activity	Plant/ equipment	L_{Aeq} SWL	Assumptions for quantitative assessment	
				No. Units	Activity total L_{eq} SWL
Utility, property, service adjustment	Adjustment of property boundaries (where required); relocation of services	Excavator (tracked) 35t	110	1	116
		Dump truck	110	4 per hour	
		Franna crane 20t	98	1	
		Pneumatic hammer	113	-	
		Concrete saw	118	1	
		Vacuum truck	109	-	
		Backhoe	111	-	
		Power generator	103	1	
Corridor Clearing	General land clearing, tree and stump removal, topsoil stripping, loading	Bulldozer D9	116	1	121
		Excavator (tracked) 35t	110	1	
		Chainsaw 4-5hp	114	2	
		Tub grinder/ mulcher 40-50hp	116	1	
		Dump truck	110	4 per hour	
Rock crushing	Crushing and screening of building waste/ rock material for re-use on site	Rock crusher	118	1	118
		Bulldozer D9	116	1	
		Excavator (tracked) 35t	110	1	
		Dump truck	110	4 per hour	
Bulk earthworks	Formation of road alignment. Excavation of soil and rock, hammering/rock breaking, drilling, loading, haulage, compaction of fill areas, grading	Bulldozer D9	116	1	123
		Scraper 651	110	1	
		Excavator (tracked) 35t	110	1	
		As above + hydraulic hammer	122	1	
		Grader	113	1	
		Dump truck	110	8 per hour	
		Compactor	106	1	
		Roller (large pad foot)	109	-	
		Water cart	107	-	
Drainage infrastructure	Excavation of trenches and pits;	Backhoe	110	-	115
		Franna crane 20t	98	1	

Activity	Description of activity	Plant/ equipment	L_{Aeq} SWL	Assumptions for quantitative assessment	
				No. Units	Activity total L_{eq} SWL
	Delivery and placement of precast pipes and pits; filling and compacting.	Excavator (tracked) 35t	110	1	
		Concrete truck	109	4 per hour	
		Truck compressor	75	1	
		Vibratory roller	109	1	
		Road truck	108	4 per hour	
Bridge works	Casting; concrete pours; Placement of pre-cast elements; Piling (mainly bored); and Demolition.	Franna crane 20t	98	1	120
		Piling rig - driven	116	-	
		Piling rig - bored	112	1	
		Power generator	100	1	
		Concrete pump	102	1	
		Concrete truck	109	4 per hour	
		Compressor	109	1	
		Pneumatic hammer	115	-	
		Welding equipment	105	-	
Paving/ asphalting (inc concrete sawing)	Delivery of raw materials. Placement of surface material. Saw cutting.	Pavement laying machine	114	1	118
		Dump truck	110	4 per hour	
		Asphalt truck & sprayer	103	1	
		Concrete truck	109	1	
		Smooth drum roller	107	1	
		Concrete saw	118	1	
Compounds	Deliveries. Plant and equipment. Maintenance. Office areas. Storage areas.	Front end loader	91	1	114
		Excavator (tracked) 35t	110	-	
		Road truck	108	4 per hour	
		Compressor	109	1	
		Welding equipment	105	1	
		Light vehicles	88	12 per hour	
		Power generator	103	1	
Construction Compound	Site Establishment	Chainsaw 4-5hp	114	2	119
		Pneumatic hammer	113	-	
		Fixed crane	113	1	

Activity	Description of activity	Plant/ equipment	L_{Aeq} SWL	Assumptions for quantitative assessment	
				No. Units	Activity total L_{eq} SWL
		Front end loader	112	1	
		Excavator (tracked) 35t	110	-	
		Grader	113	1	
		Vibratory roller	109	-	
		Concrete truck	109	4 per hour	
		Dump truck	110	4 per hour	
		Water cart	107	-	
		Concrete vibrator	113	1	
		Concrete pump	109	1	
		Power generator	103	1	
		Light vehicles (eg 4WD)	103	-	
Re-surfacing works	Milling the asphalt to expose the underlying concrete, then laying new asphalt	Daymakers	98	2	118
		Pavement profiler	117	1	
		Dump truck	110	4 per hour	
		Front end loader	112	1	
		Pavement laying machine	114	1	
		Asphalt truck & sprayer	106	1	
		Smooth drum roller	107	1	

5.4.4.1 Predicted construction noise levels

Construction noise predictions have been carried out for a selection of the worst case scenarios. As it is unclear at this stage whether out of hours work will be required, all criteria are presented for comparison.

Table 24: Construction noise predictions

ID	Address		Corridor clearing	Bulk earthworks	Paving
			Lw 121	Lw 123	Lw 118
R1	98 Mitchell Line Road	351//DP1053417	51	53	48
R2	96 Mitchell Line Road	27//DP1128978	57	59	54

ID	Address		Corridor clearing	Bulk earthworks	Paving
			Lw 121	Lw 123	Lw 118
R3	3193 New England Highway, Belford	10//DP703050	49	51	46
R4	3193 New England Highway, Belford	42//DP1128981	49	51	46
R5	3193 New England Highway, Belford	106//DP1141521	59	61	56
R6	3193 New England Highway, Belford	107//DP1141521	48	50	45
R7	3193 New England Highway, Belford	108//DP1141521	54	56	51
R8	3193 New England Highway, Belford	3/4/DP758078	47	49	44
R11	10 Lovell Street, Belford	3/14/DP758078	46	48	43
R12	Lindsay Street, Belford	69//DP755209	46	48	43
NMLs		**Standard hours**	**53**		
		Evening – OSH	**48**		
		Night – OSH	**35**		
R9	2 Lindsay Street, Belford	A//DP400750	50	52	47
R10	2 Lindsay Street, Belford	11//DP1125000	49	51	46
NMLs		**Standard hours**	**64**		
		Evening – OSH	**54**		
		Night – OSH	**42**		
C1	United Services Station		61	63	58
NML			**75**		

The assessment indicates that works have the potential to exceed the NMLs at locations R1 to R8 and R11 to R12, even when carried out during standard hours. At locations R9 and R10, works are predicted to exceed NMLs during the night time period only. The non-residential receiver (C1) is not predicted to exceed the noise management level.

5.4.5 Construction noise mitigation measures

The CNVG outlines a series of standard mitigation measures which it considers should be implemented on all construction projects where feasible and reasonable. For some measures, Roads and Maritime Communication and Stakeholder Engagement may be required to coordinate and delivery community consultation and notification. The recommended measures from the list of standard measures are provided in Table 25. It is recommended that these measures are reviewed once specific construction procedures for the project have been determined.

Table 25: Roads and Maritime CNVG Standard mitigation measures

Action required	Applies to	Details
Management measures		
Implement community consultation or notification measures (refer to Appendix C for further details of each measure)	Airborne noise Ground-borne noise & vibration	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night time period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of 7 calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required. Please contact Roads and Maritime Communication and Stakeholder Engagement for guidance. Website (If required) Contact telephone number for community Email distribution list (if required) Community drop in session (if required by approval conditions).

Action required	Applies to	Details
Site inductions	Airborne noise Ground-borne noise & vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Airborne noise Ground-borne noise & vibration	Where specified under Appendix C of the CNVG a noise verification program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Where required attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise Ground-borne noise & vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Source controls		
Construction hours and scheduling.	Airborne noise Ground-borne noise & vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out- of-hours work	Airborne noise Ground-borne noise & vibration	Please refer to Appendix C of CNVG for more details on the following respite measures: • Respite Offers (RO) • Respite Period 1 (R1) • Respite Period 2 (R2) • Duration Respite (DR)

Action required	Applies to	Details
Equipment selection.	Airborne noise Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits. Ensure plant including the silencer is well maintained.
Plant noise levels.	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix H of CNVG. Implement a noise monitoring audit program to ensure equipment remains within the more stringent of the manufacturers specifications or Appendix H of CNVG.
Rental plant and equipment.	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 2 of CNVG.
Use and siting of plant.	Airborne-noise	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers. Only have necessary equipment on site.

Action required	Applies to	Details
Plan worksites and activities to minimise noise and vibration.	Airborne noise Ground-borne noise & vibration	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. Very noise activities should be scheduled for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11:00pm. Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations such as before or during Higher School Certificate and at the end of higher education semesters. If programmed night work is postponed the work should be re-programmed and the approaches in CNVG apply again.
Reduced equipment power	Airborne noise Ground-borne noise & vibration	Use only the necessary size and power
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction sites.	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.

Action required	Applies to	Details
Blasting regime	Airborne noise Ground-borne noise & vibration	The noise and vibration impacts of blasting operations can be minimised by: • Choosing the appropriate blast charge configurations • Ensuring appropriate blast-hole preparation • Optimising blast design, location, orientation and spacing • Selecting appropriate blast times, and • Utilising knowledge of prevailing meteorological conditions. AS 2187.2 Explosives-Storage, transport and use, Part 2: Use of Explosives provides more detailed advice on ground vibration and airblast overpressure impact minimisation options.
Engine compression brakes	Construction vehicles	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans etc.	Airborne noise	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities.	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

After standard noise mitigation measures have been applied noise levels may still exceed noise management levels. Where exceedances remain consider implementing the following approaches where feasible and reasonable prior to undertaking the works.

While a detailed assessment may be warranted for each receiver once specific construction activities are known, Table 26 presents the additional measures recommended based on the worst case assessment at the nearest most potentially affected receiver.

Table 26: Roads and Maritime CNVG additional mitigation measures

Time	Additional Mitigation measure(s)
Standard Hours	None
Day (OOHW)	N, R1, DR
OOHW Period 1	N, R1, DR
OOHW Period 2	V, IB, N, PC, SN, R2, DR

Abbreviation	Measure
N	Notification (letterbox drop or equivalent
SN	Specific notifications
PC	Phone calls
IB	Individual briefings
RO	Respite offer
R1	Respite period 1
R2	Respite period 2
DR	Duration respite
AA	Alternative accommodation
V	Verification

5.5 Construction vibration assessment

The Roads and Maritime CNVG provides recommended safe working distances for vibration intensive plant. These are based on International Standards and guidance and have been reproduced in Table 27. Based on the identified nearest receiver locations, proposed construction works are not expected to occur within the safe working distances with respect to nearby sensitive receivers.

Table 27: Roads and Maritime recommended safe working distances for vibration intensive plant

Plant item	Rating / description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (NSW Assessing vibration)
Vibratory roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	2 m	7 m

Plant item	Rating / description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (NSW Assessing vibration)
Medium hydraulic hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

Note: More stringent conditions may apply to heritage or other sensitive structures

5.6 Blasting

Calculations have been undertaken based on methodologies provided in AS 2187.2 to determine potential groundborne vibration and airblast overpressure from proposed blasting. In lieu of detailed information, average conditions as recommended in the standard have been assumed.

5.6.1 Groundborne Vibration

Groundborne vibration levels from blasting have been calculated using the formula:

$$V = K_g \cdot \left(\frac{R}{Q^{1/2}}\right)^{-B}$$

Where:

V is the ground vibration as vector peak particle velocity, mm/s
R is the distance between charge and point of measurement, m|
Q is the maximum instantaneous charge (effective mass per delay), kg
Kg and B are constants related to site and rock properties for estimation purposes.

For the purposes of assessment, the following average conditions have been assumed:

$$Kg = 1140$$

$$B = 1.6$$

The following Maximum Instantaneous Charge (effective charge mass per delay) have been calculated to achieve the relevant assessment criteria at each of the 3 nearest vibration sensitive receiver locations. These limits are indicative only and will need to be confirmed by the successful contractor.

Table 28: Indicative maximum instantaneous charge limits for vibration

ID	Type	Distance (m)	PPV Criterion (mm/s)	Max MIC (kg)
-	Gas Main	25m	50	50
C1	Commercial	250m	25	540
R2	Residential	650m	5	535

5.6.2 Airblast Overpressure

Airblast overpressure levels have been calculated using the formula:

$$P = K_a \cdot (\frac{r}{Q^{1/3}})^a$$

Where:

P is the calculated pressure, kPa
Q is the mass of the explosive charge, kg
r is the distance from the explosive charge, m
Ka is the site constant
a is the site exponent

For the purposes of assessment, the following average conditions have been assumed:

$$A = -1.45$$

$$Ka = 100$$

The following Maximum Instantaneous Charge (effective charge mass per delay) have been calculated to achieve the relevant assessment criteria at each of the 2 nearest vibration sensitive receiver locations. These limits are indicative only and will need to be confirmed by the successful contractor.

Table 29: Indicative maximum instantaneous charge limits for airblast overpressure

ID	Type	Distance (m)	Overpressure Criterion (dBL)	Max MIC (kg)
C1	Commercial	250m	125	135
R2	Residential	650m	115	220

6 Conclusion

A noise and vibration assessment has been carried out for the proposed construction and operation of the New England Highway upgrade - Belford to the Golden Highway to inform the REF for the project. Potential noise and vibration impacts have been predicted based on the level of information available at the concept stage of the project.

The assessment found that no noise sensitive receivers within the study area are predicted to exceed NCG criteria for Minor Works due to the proposed project.

The assessment found that, depending on proposed hours of construction, some residences may be exposed to noise impacts during construction work. A suite of mitigation measures to manage these impacts have been provided in accordance with the provisions of the Roads and Maritime Construction Noise and Vibration Guideline. Management of construction noise and vibration impacts should be revised during the following stages of the project.

References

[1] Department of Environment, Climate Change and Water NSW (DECCW), "NSW Road Noise Policy," DECCW, Sydney, 2011.

[2] NSW Roads and Maritime Services (RMS), "Noise Criteria Guideline," RMS, Sydney, 2015.

[3] NSW Roads and Maritime Services (RMS), "Noise Mitigation Guideline," RMS, Sydney, 2015.

[4] Roads and Traffic Authority NSW (RTA), "RTA Environmental Noise Management Manual v1.0 (ENMM)," RTA NSW, Sydney, 2001.

[5] NSW Roads and Maritime Service (RMS), "Construction Noise Guideline v1.0," NSW RMS, Sydney, April 2016.

[6] Department of Environment & Climate Change NSW (DECC), "Interim Construction Noise Guideline (ICNG)," NSW DECC, Sydney, July 2009.

[7] NSW Department of Environment and Conservation (DEC), "Assessing Vibration: A Technical Guideline," NSW DEC, Sydney, 2006.

[8] NSW Environment Protection Authority (EPA), "NSW Industrial Noise Policy," NSW EPA, Sydney, 2000.

[9] UK Department of Transport, "Calculation of Road Traffic Noise (CoRTN)," UK Department of Transport, London, 1988.

[10] European Commission Working Group Assessment of Exposure to Noise, "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure - Version 2," WG-AEN, Brussels, 2006.

Appendix A

Acoustic Terminology

A1 Acoustic terminology

Ambient noise level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background noise level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / $minL_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and $minL_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".

Peak Particle Velocity (PPV)

Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean* *squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

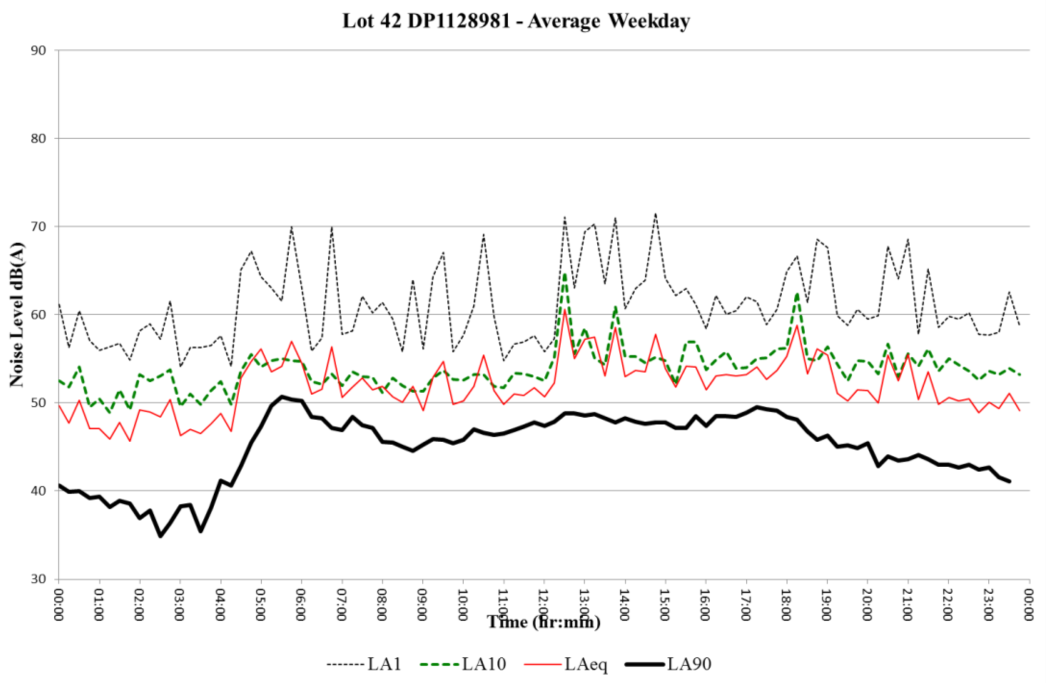
Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

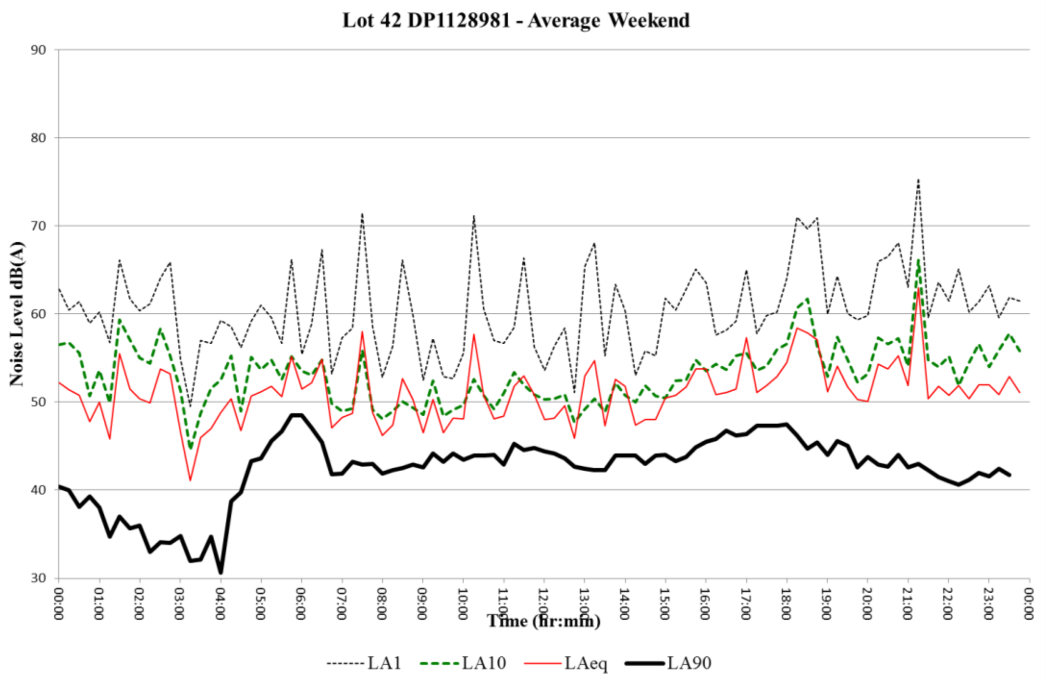
Environmental Noise Survey Results

B1 Location 1 – Lot 42 DP 1128981

B1.1 Average Weekday

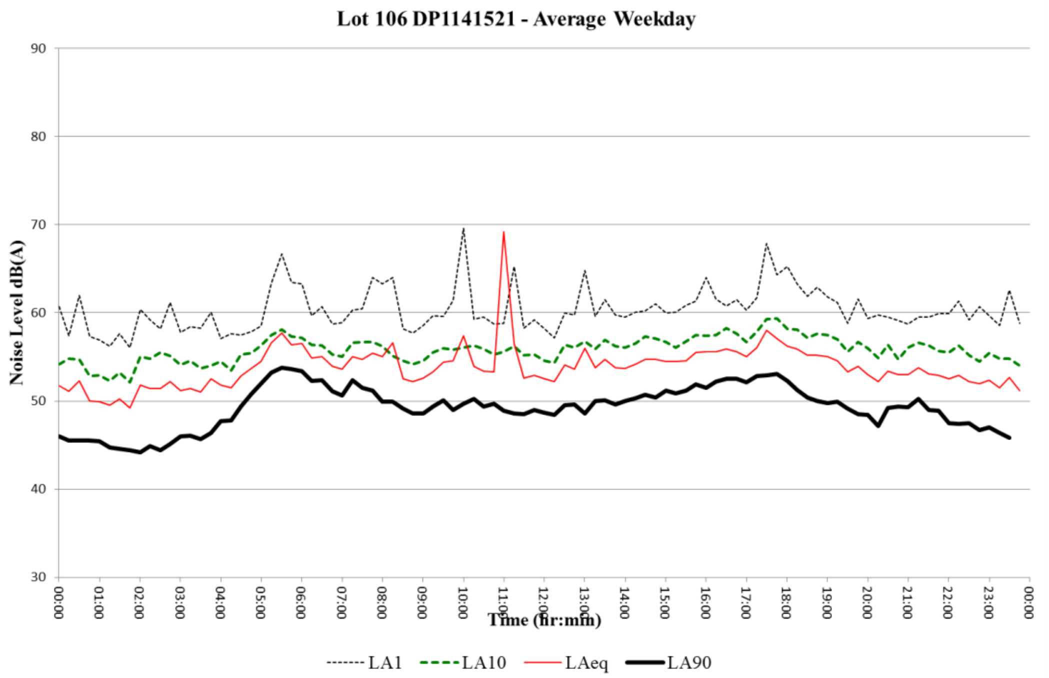


B1.2 Average Weekend

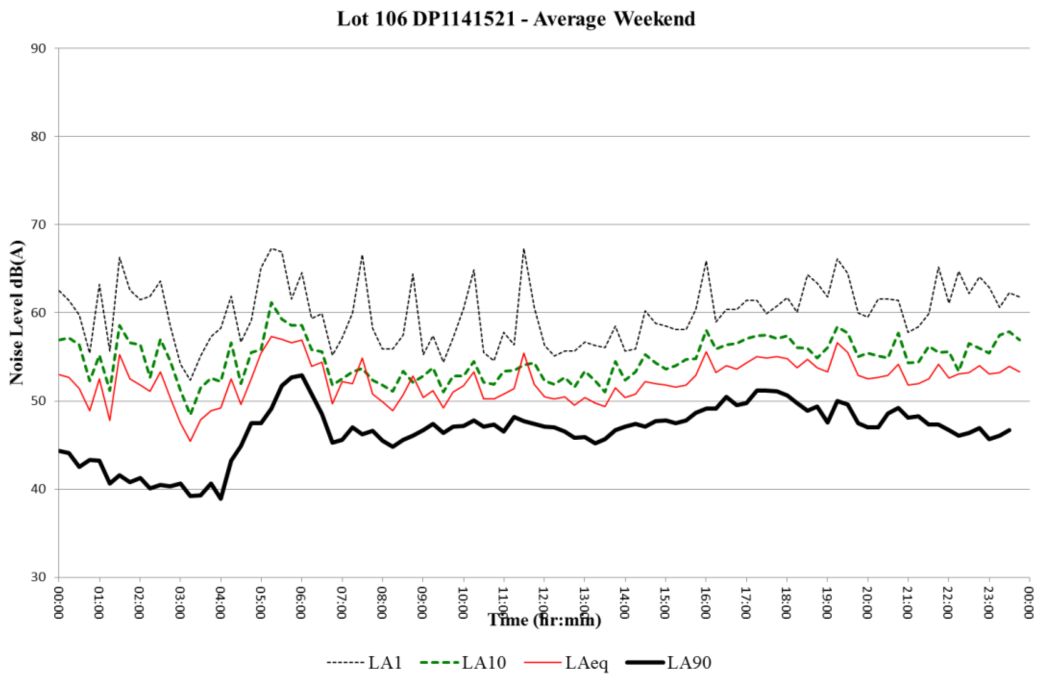


B2 Location 2 – Lot 106 DP 1141521

B2.1 Average Weekday

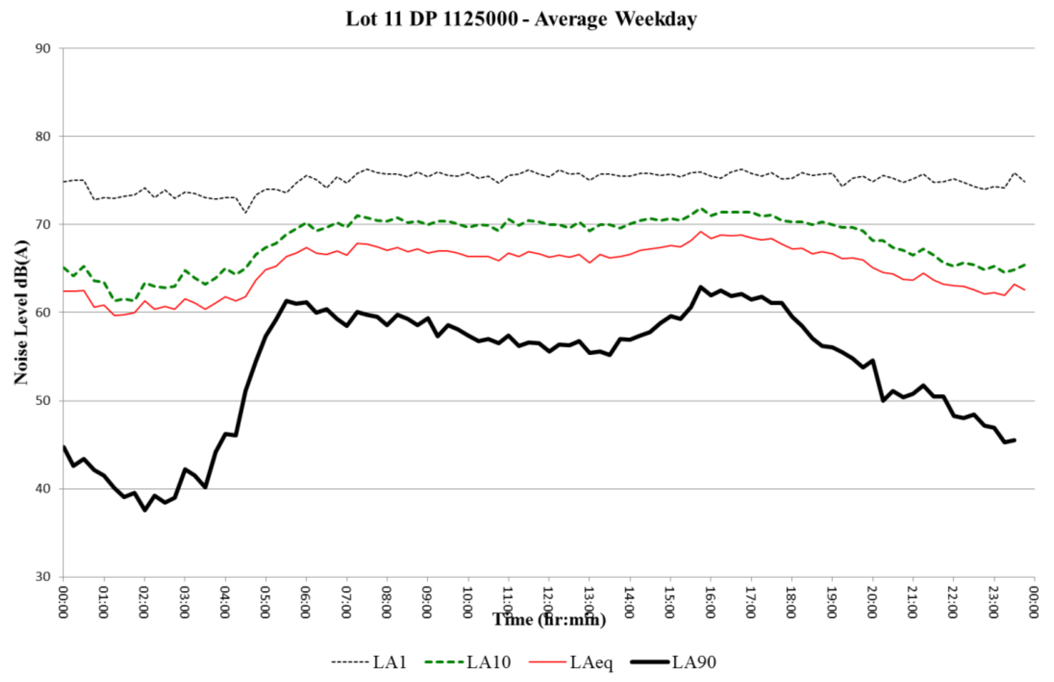


B2.2 Average Weekend

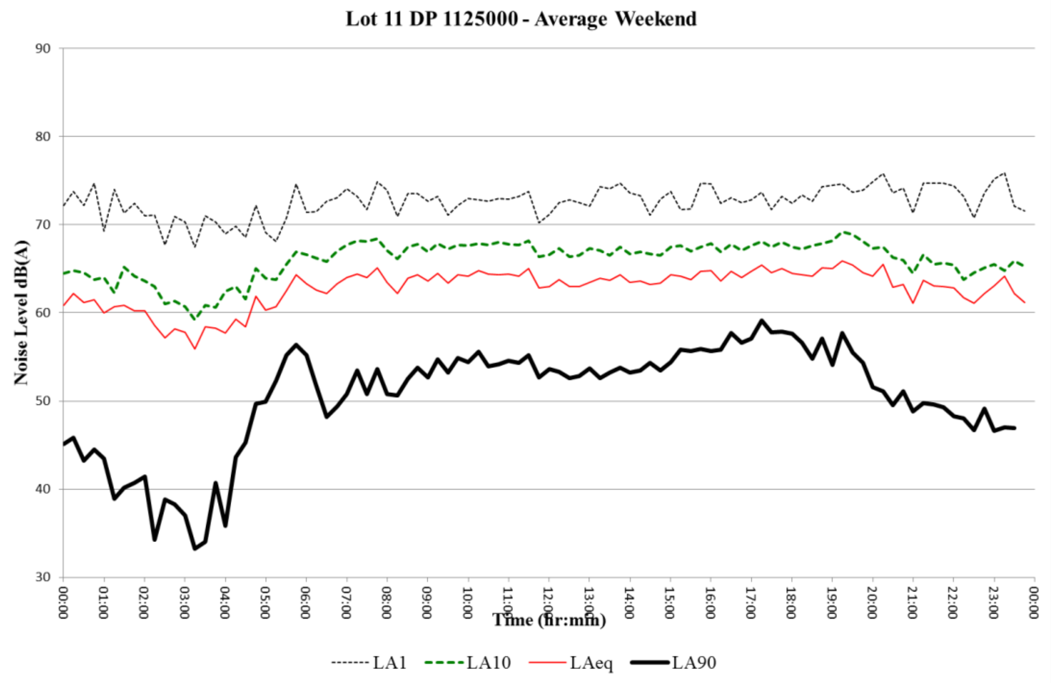


B3 Location 3 – Lot 11 DP1125000

B3.1 Average Weekday



B3.2 Average Weekend



Appendix C

20% Constructability
Construction Program

DRY-WEATHER PROGRAMME

HW9 - NEW ENGLAND HIGHWAY UPGRADE
BELFORD TO GOLDEN HIGHWAY

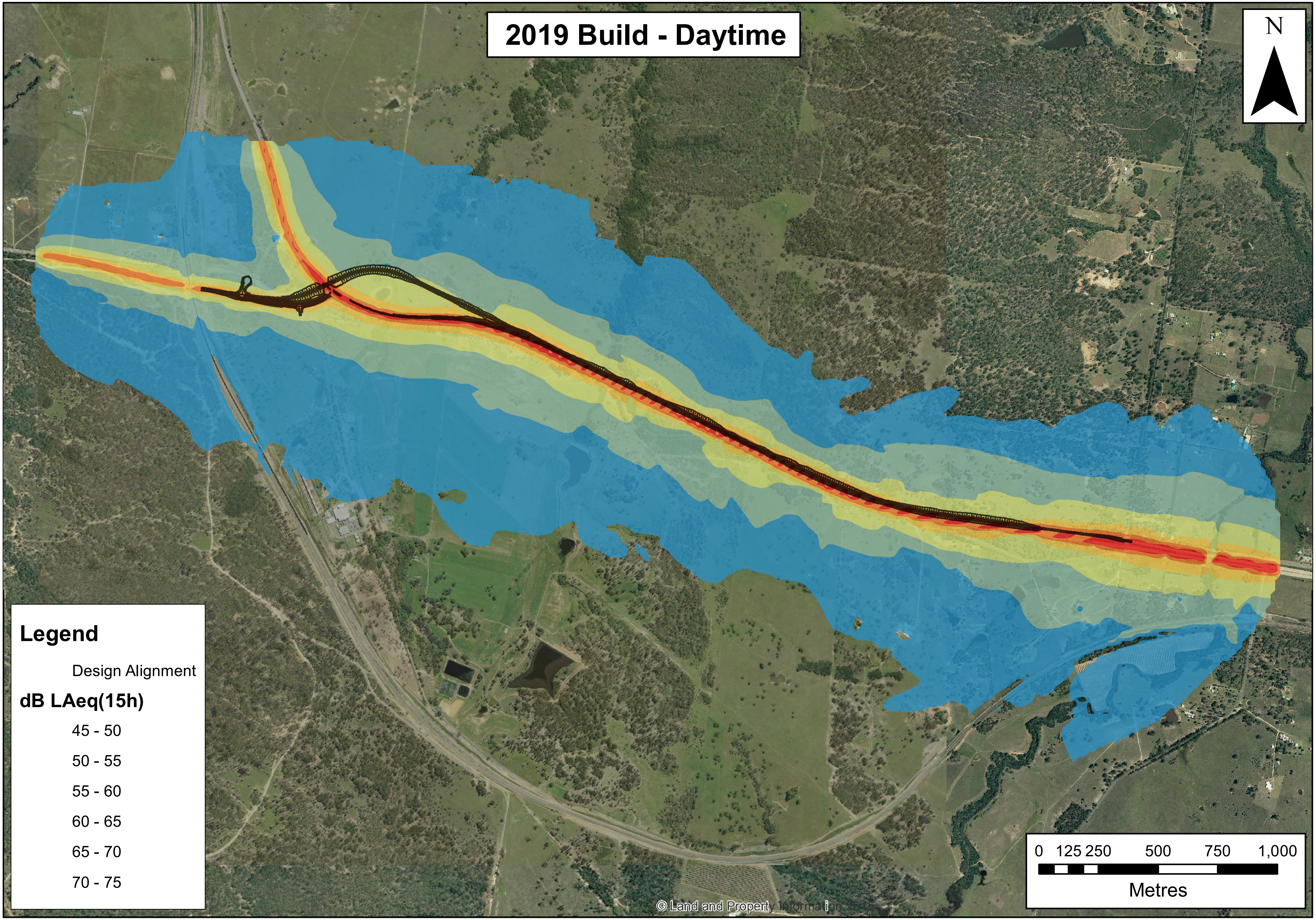
CONSTRUCTION PROGRAMME - CONCEPT DESIGN **(version date 12 Apr 2016)**

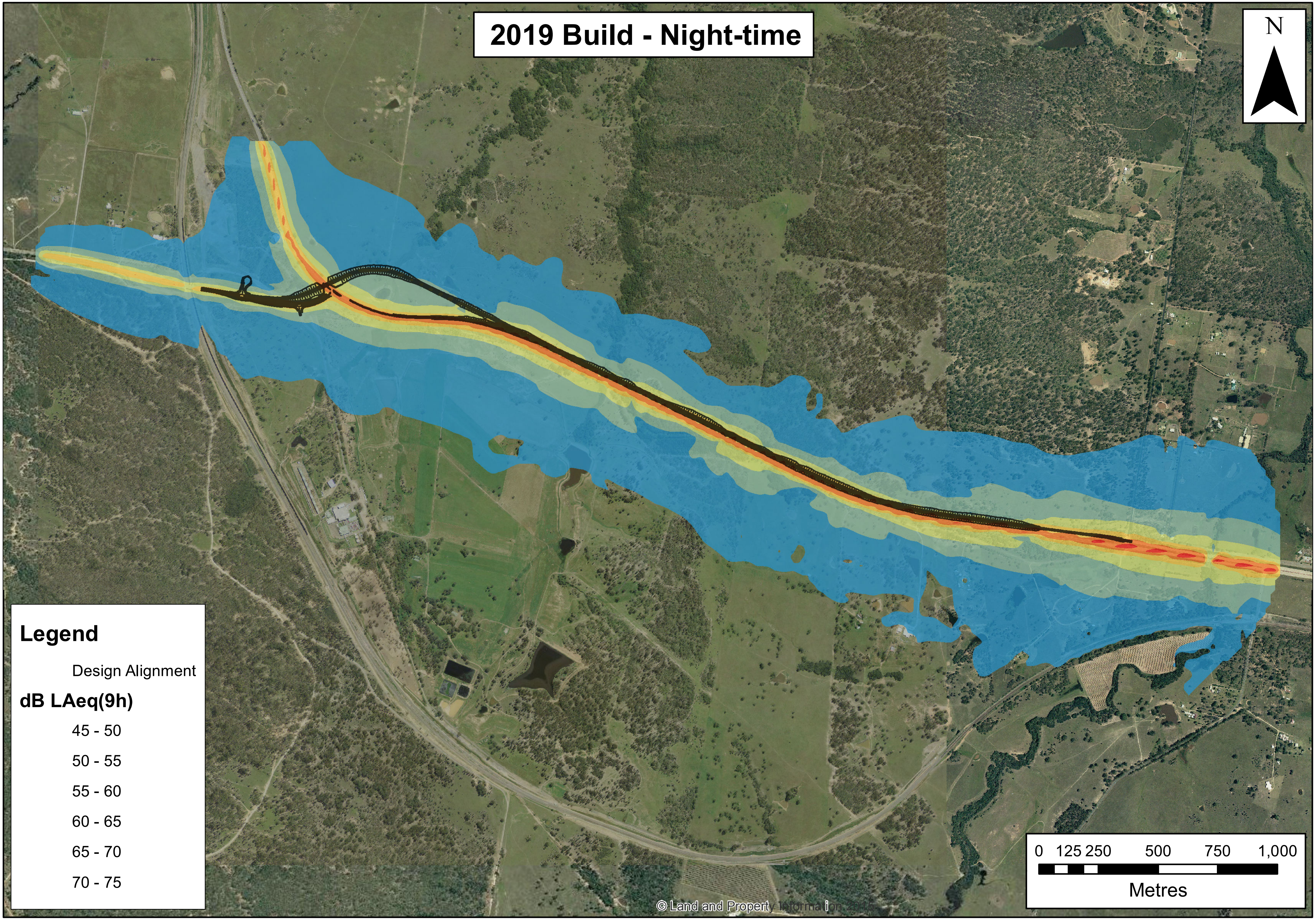
Construction Week: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54

Activity	Duration (wks)	Notes
PRELIMINARIES		
Management Pans / CEMP	5	
site compounds / accesses	4	can't start work until safe accesses off New England Hwy are constructed
Clearing / demolition	3	
Initial Environmental Controls	3	
Service relocations - power	3	could be done earlier
Service relocations - gas	5	after clearing (extent and duration subject to confirmation)
GOLDEN HIGHWAY		
MC30 - widen/new pavements -eastside	6	widen first and switch traffic to eastside to give safer separation for new MC20 works (may also require some temporary pavement)
MC30 - widen/new pavements -westside	4	
MC80 - construct Jug-handle	4	depending upon extent of existing HW27 pavement that can remain - commission early? (maintain property/rail land access)
MC20 -ch1000-1300 e/w (import)	5	
MC20 -ch1000-1300 pavement	3	after southern bridge abutment
MC20 -ch00-1000 e/w + culvert	27	imported fill @ approx 3000t /day
MC20 -ch00-1000 pavement	4	after bridgeworks nearly completed
MC20 guard rail/ furnishigs etc	3	
BRIDGEWORK (3 span spill thru)	20	piling after abutment fills up
NEW ENGLAND HW E/B - MC20		
culvert extensions	7	5 no
cut / fill	20	prep + approx 1500m3/day + rockfill? / UZ / SMZ zones
Blasting + processing	10	possible 60,000 t - needs geotech investigation to confirm
Longitudinal Culverts	5	
Pavement works	12	incl s/soils, kerbs, flex pavement, asphalt
SWITCH TRAFFIC (over bridge and new MC20)		
RECONFIGER HW9 - Westbound		including intersection at Golden Highway
Excavation, barriers , line marking	4	
Demobilisation	2	
PROJECT COMPLETE	2	

Appendix D

Noise Contours


2019 Build - Daytime
N
Legend
Design Alignment
dB LAeq(15h)
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres
© Land and Property Information



2019 Build - Night-time
N
Legend
Design Alignment
dB LAeq(9h)
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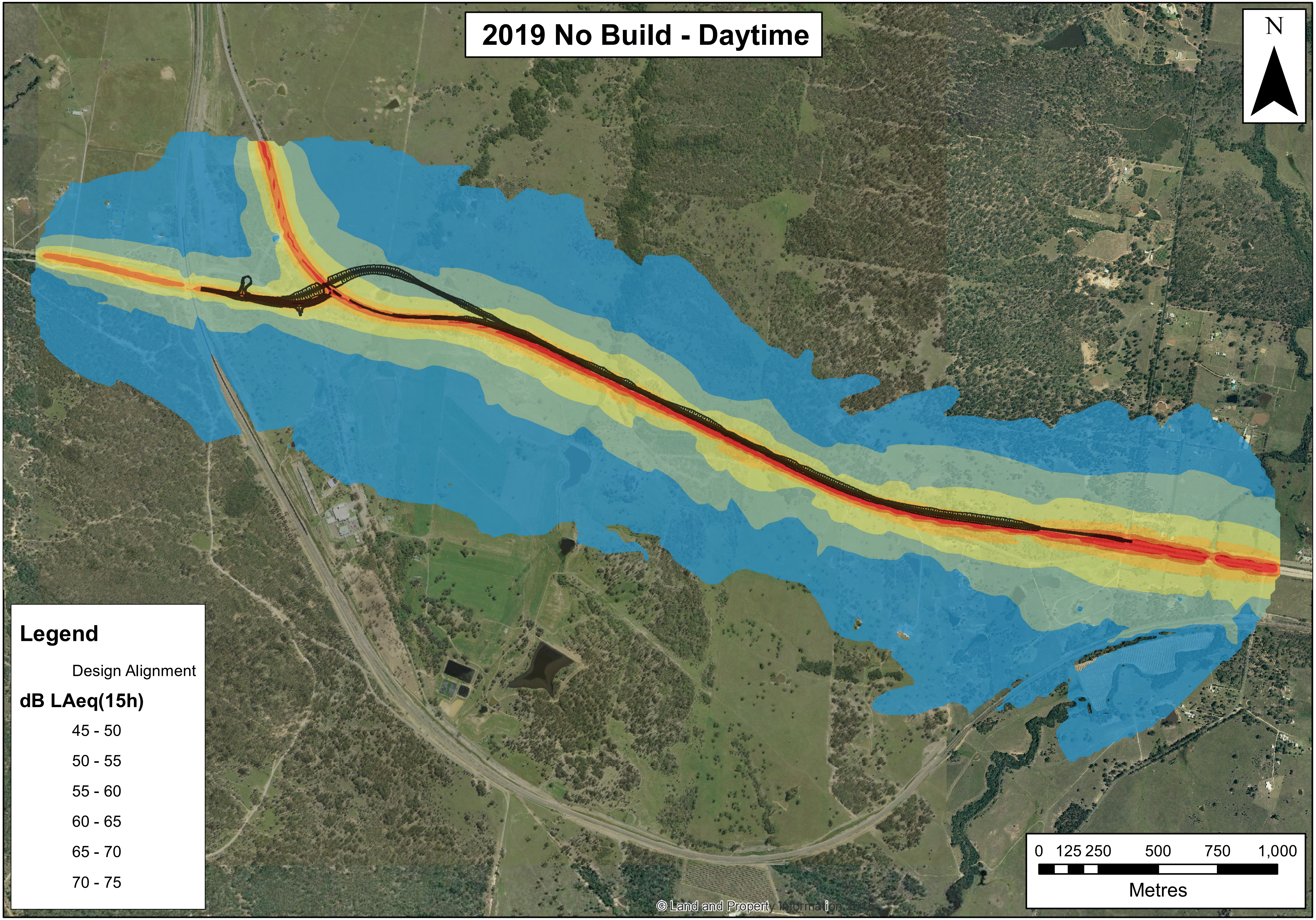
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres
© Land and Property Information



2019 No Build - Daytime
N
Legend
Design Alignment
dB LAeq(15h)
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50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
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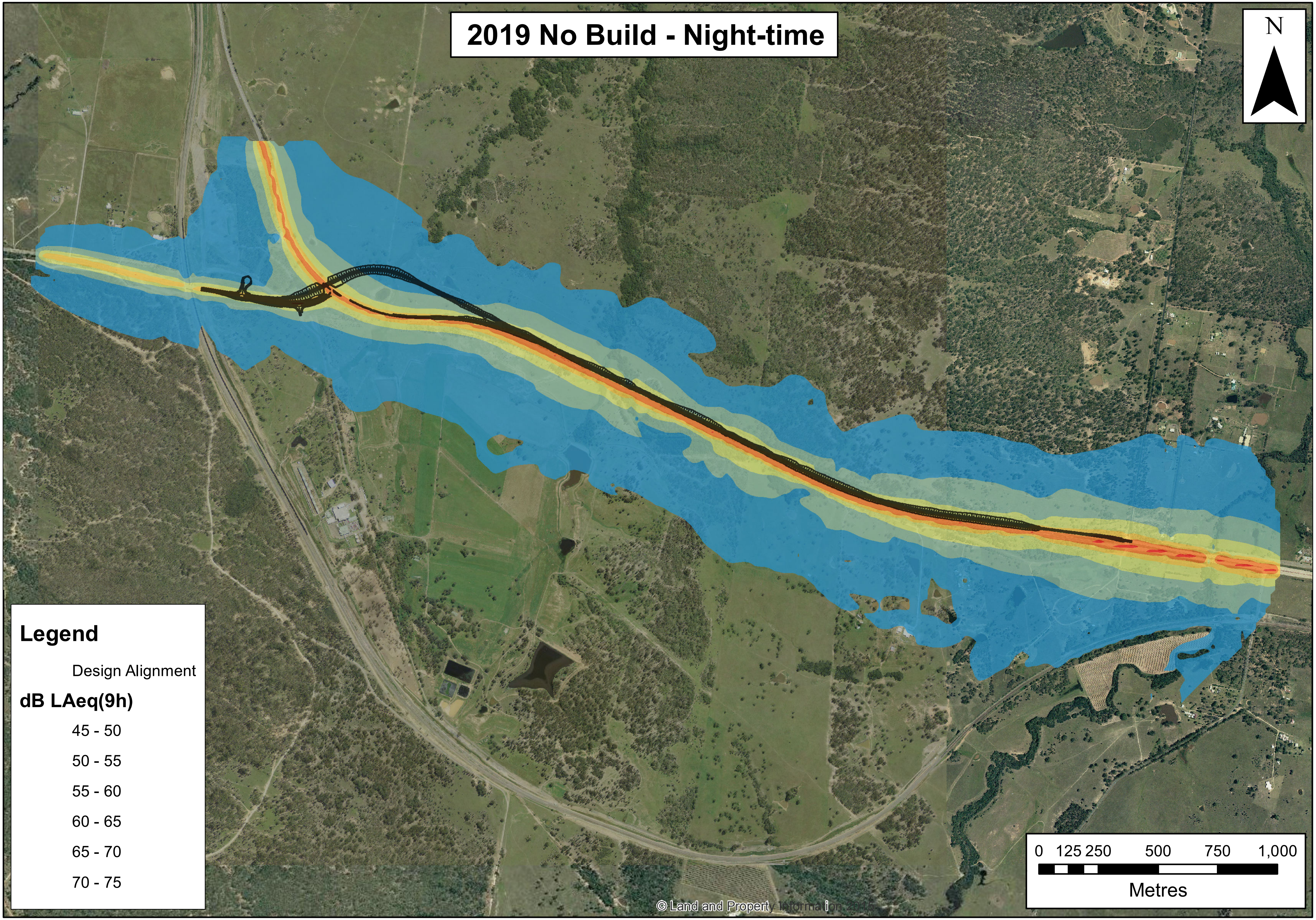
Metres
© Land and Property Information 2013



2019 No Build - Night-time
N
Legend
Design Alignment
dB LAeq(9h)
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50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
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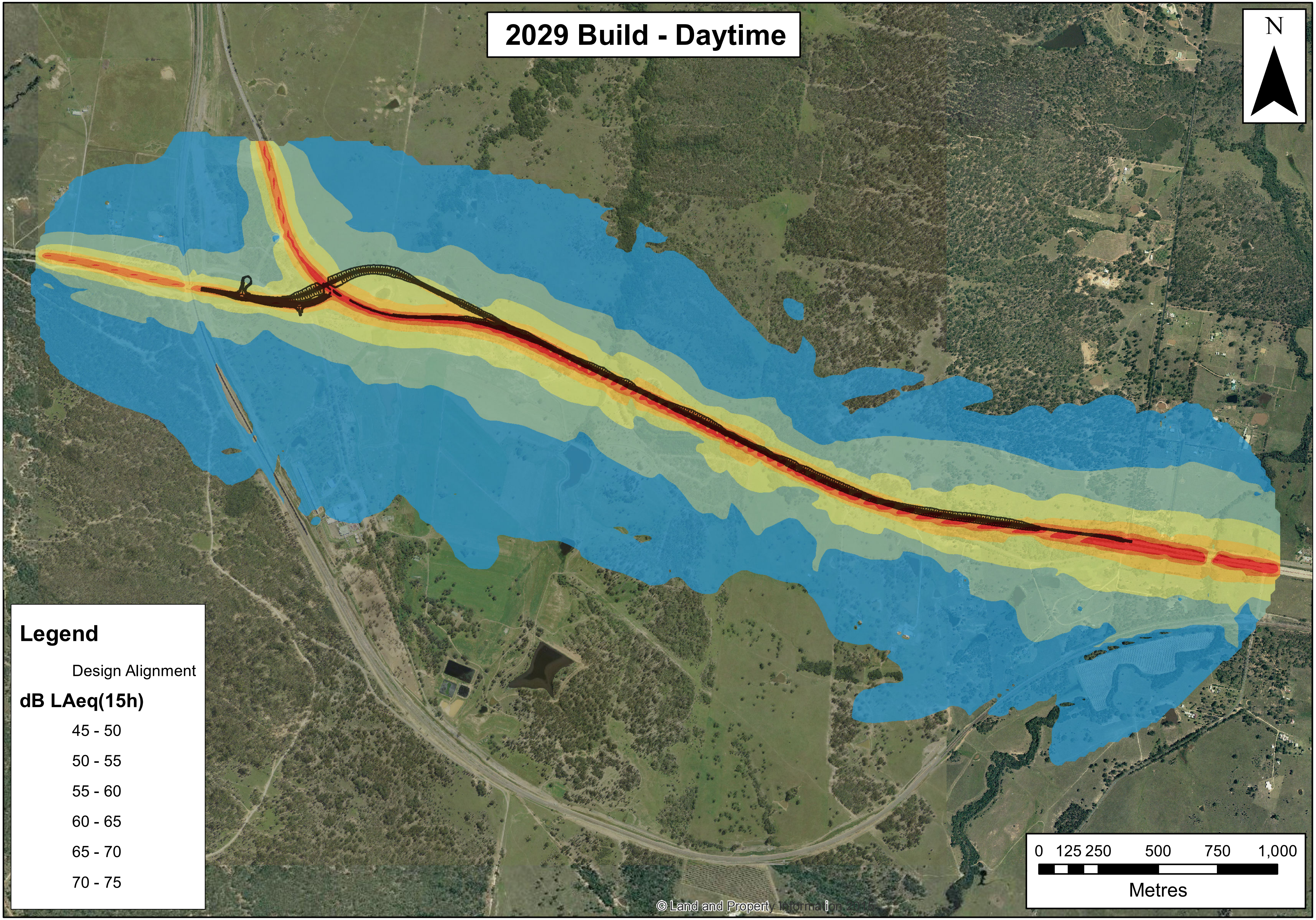
Metres
© Land and Property Information



2029 Build - Daytime
N
Legend
Design Alignment
dB LAeq(15h)
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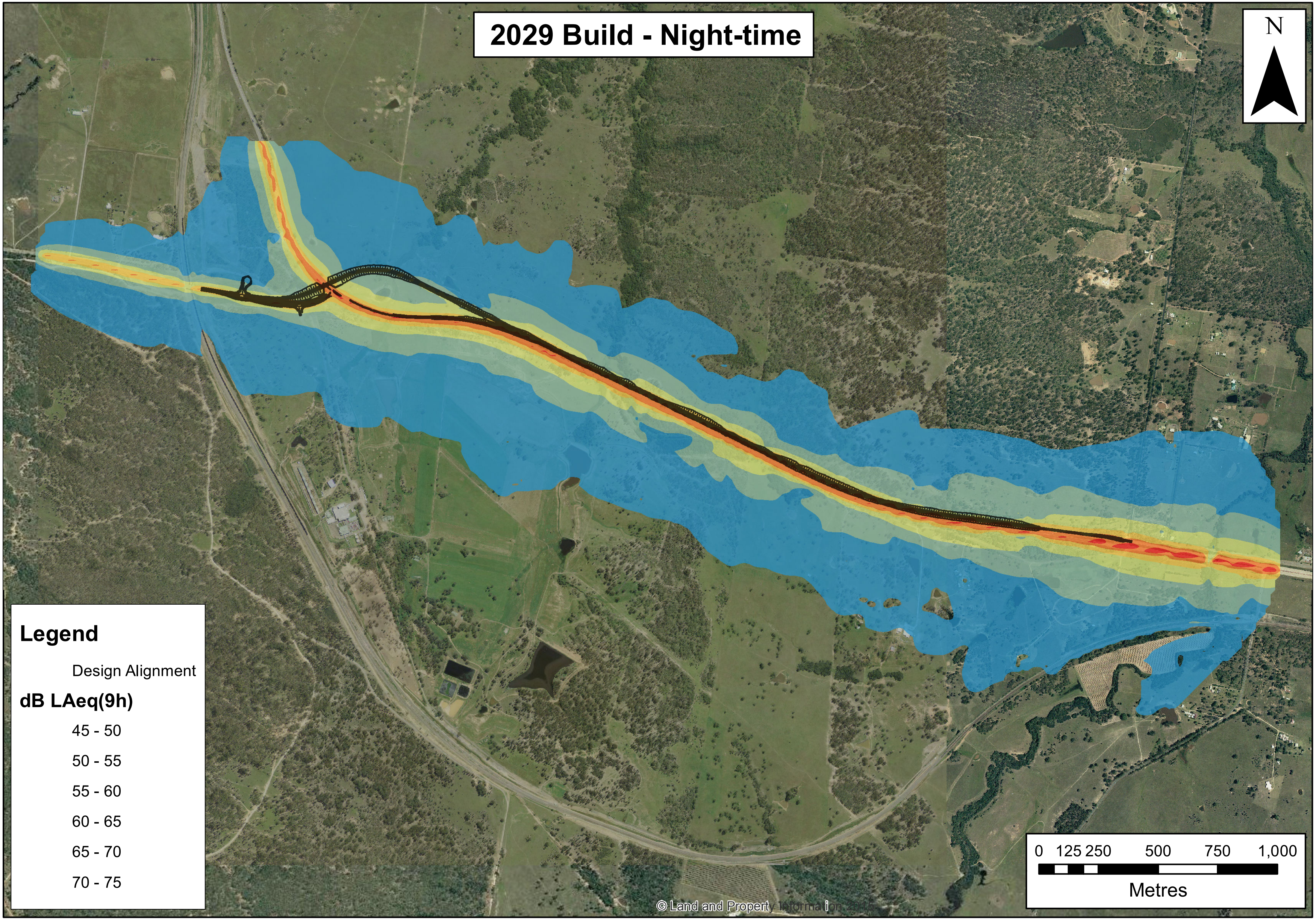
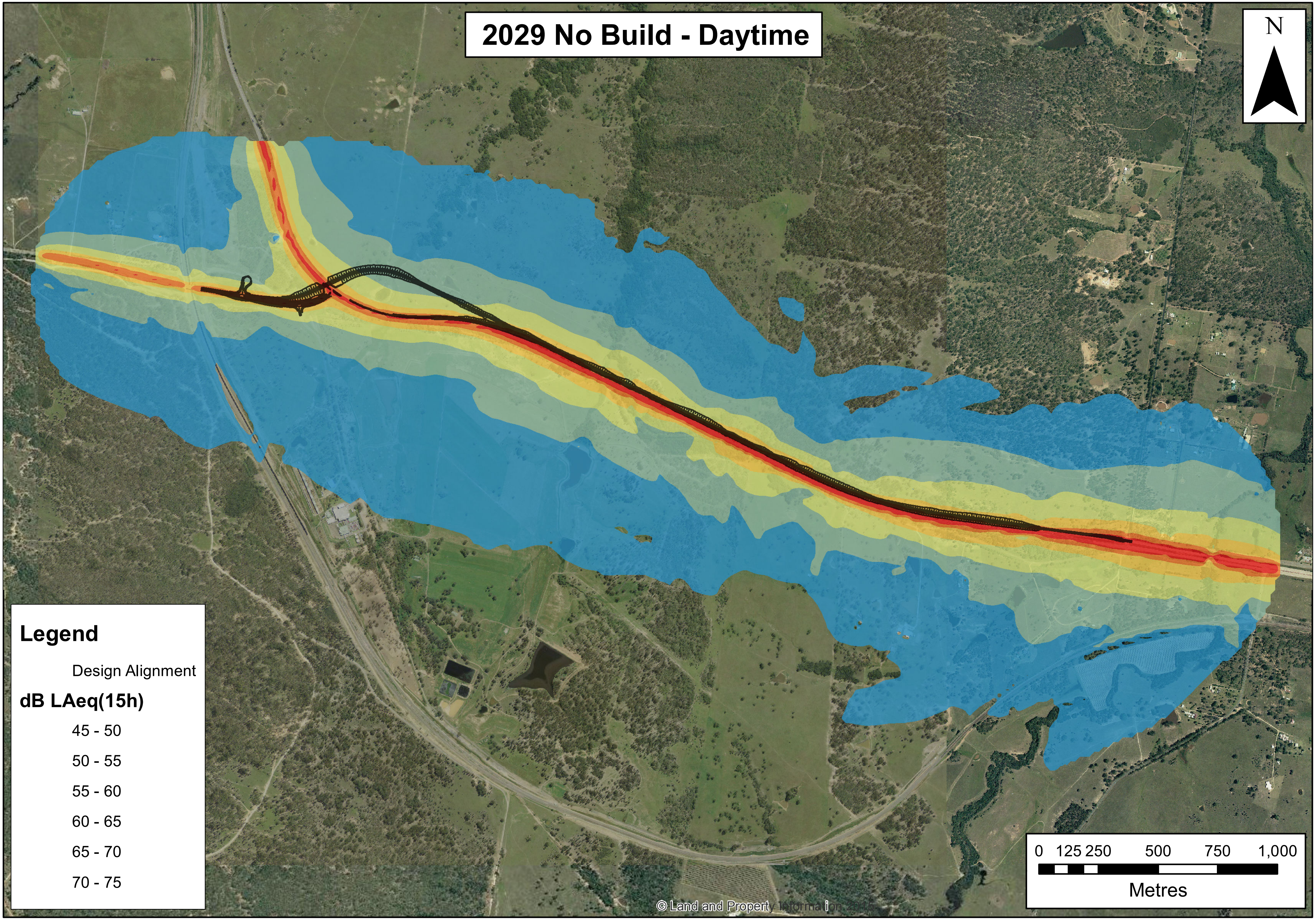
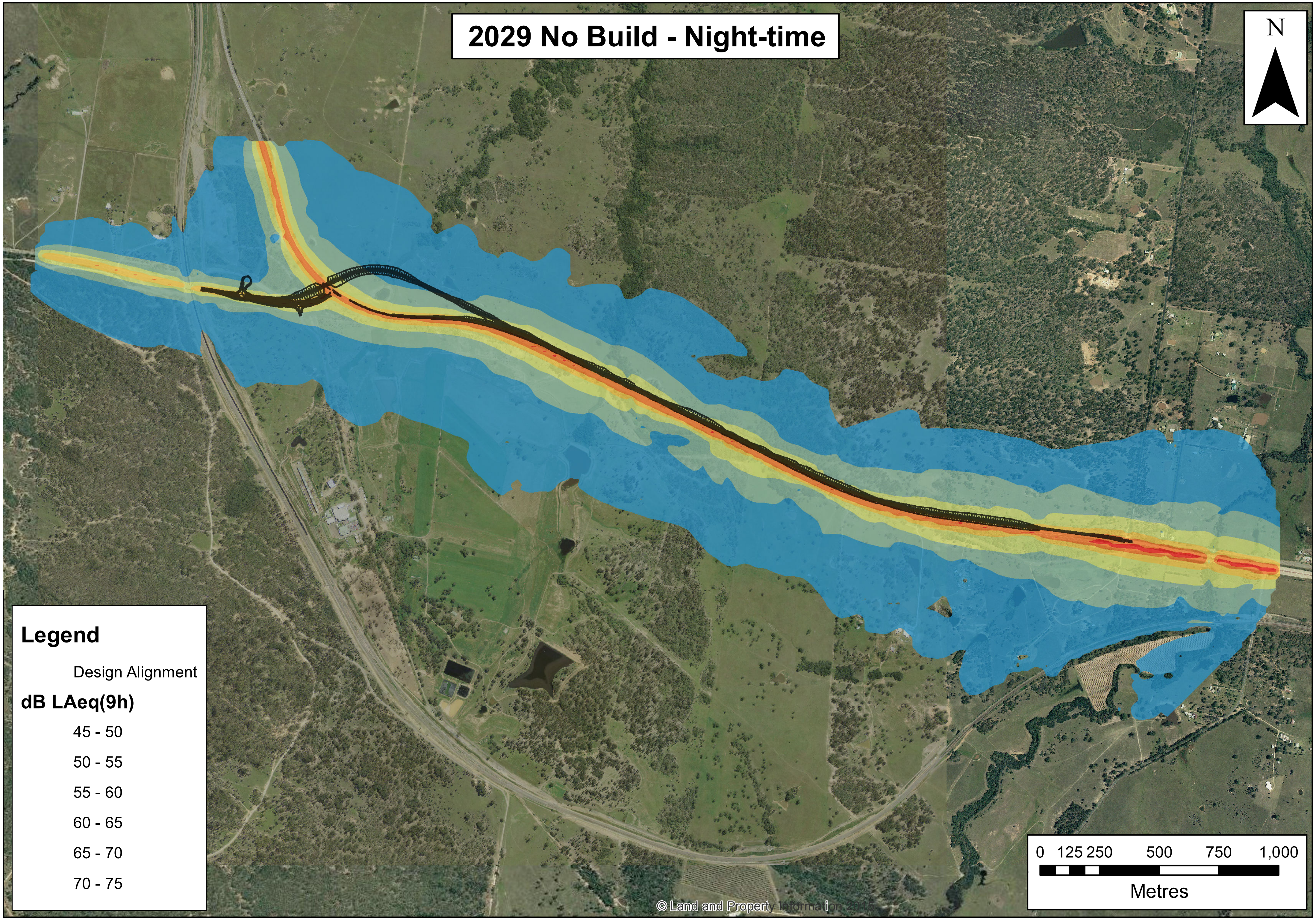
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres
© Land and Property Information



2029 Build - Night-time
N
Legend
Design Alignment
dB LAeq(9h)
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres



2029 No Build - Daytime
N
Legend
Design Alignment
dB LAeq(15h)
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres
© Land and Property Information


2029 No Build - Night-time
N
Legend
Design Alignment
dB LAeq(9h)
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
0 125 250 500 750 1,000
Metres
© Land and Property Information