9.4 Construction noise and vibration

An assessment of the noise and vibration impacts associated with the construction of the M2 Upgrade project has been undertaken and is presented below. This assessment is supported by *Technical Paper 2 – Noise and Vibration* (Volume 2).

Director-General's Requirements	Where addressed
General Construction Impacts – the environmental assessment must consider the potential impacts associated with the construction of the project, and present a management framework for construction works to ensure that impacts are mitigated, monitored and managed. The environmental assessment must include consideration of, and a management framework for:	
• *Construction noise and vibration, including a considered approach to scheduling construction works having regard to the nature of construction activities (including transport, blasting and tonal or impulsive noise-generating works, as relevant), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially-affected human receivers and structures, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management). The environmental assessment must also present a strategy for monitoring and mitigating construction noise and vibration, with a particular focus placed on those activities identified as having the greatest potential for adverse noise or vibration impacts, and a broader, more generic approach developed for lower-risk activities.*	*Section 9.4, Technical Paper 2*

9.4.1 Construction noise assessment criteria

A review of guidelines and current practices for the assessment and subsequent mitigation of construction noise was conducted. The assessment approach was undertaken in accordance with the DECCW *Interim Construction Noise Guideline* (2009) (ICNG).

The ICNG recommends that a quantitative assessment be carried out for *"major construction projects that are typically subject to the EIA process"*. A quantitative assessment, based on a likely 'worst case' construction scenario, has been carried out for the M2 Upgrade project.

The ICNG requires the determination of Noise Management Levels (NMLs) for noise affected receivers consistent with current practices to deal with construction noise in a transparent and consistent way. Table 69 sets out management levels for noise at residences and how they are to be applied. Table 69 presents noise management levels for sensitive land uses other than residential.

Ground-borne noise criteria as applicable to the works proposed for the Norfolk Tunnel are discussed in Section 9.4.5.

Table 69 Noise at residences using quantitative assessment

Time of day	Management level LAeq (15min)[1]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (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 75 dB(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-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 + 5 dB	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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements refer to section 7.2.2 of the ICNG

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

Table 70 Construction noise management levels – non-residential sensitive land uses

Land use	Management level, $L_{Aeq\ (15\ min)}$ (applies when properties are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas(characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS/NZS 2107:2000 for specific uses.

Souorce: DECCW, 2009

Sleep disturbance criteria

The most recent guidelines in relation to sleep disturbance are those contained in the DECCW *Application Notes - NSW Industrial Noise Policy*. The Application Notes recommends that sleep disturbance be assessed based on the emergence of the $L_{A1\ (1\ minute)}$ noise level over the corresponding $L_{A90\ (15\ minute)}$ noise level. The following screening criterion for sleep disturbance is recommended in the Application Notes:

LA1(1 minute) < LA90(15 minute) + 15 dB(A).

Construction traffic criteria

The ECRTN provides relevant criteria applicable to assess the impact arising from traffic movements generated during the construction phase of the M2 Upgrade project.

The criteria for arterial, collector and local roads are set out in Table 71.

Table 71 DECCW road traffic noise criteria

Development	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Land use development with potential to create additional traffic on existing freeways/arterials	LAeq(15 hour) 60 dB(A)	LAeq(9 hour) 55 dB(A)
Land use development with potential to create additional traffic on collector roads	LAeq(1 hour) 60 dB(A)	LAeq(1 hour) 55 dB(A)
Land use development with potential to create additional traffic on local roads	LAeq(1 hour) 55 dB(A)	LAeq(1 hour) 50 dB(A)

Where L_{Aeq} noise levels already exceed the above targets, a 2 dB(A) increase in the overall traffic noise levels is normally regarded as an alternative target in order to maintain the general acoustic amenity of the area. In order to achieve this, it is necessary for the noise contribution from the additional traffic to be at least 2 dB(A) below the existing traffic noise level.

9.4.2 Existing noise environment

In order to characterise the existing noise environment adjacent to the M2 Motorway and to establish the noise levels upon which to base the construction noise emission objectives, environmental noise monitoring was performed at a number of representative locations along the length of M2 corridor.

The monitoring was completed over two separate surveys. The first of these surveys was completed in March and April 2008 at 24 receptor locations along the M2 Motorway, and the second survey completed in December 2008 at a further 13 locations (refer to Appendix B of Technical Paper 2 for noise monitoring locations).

The results of the ambient noise surveys are presented in Table 57. Representative L_{A90} noise levels (background) during the DECCW's standard daytime construction hours (7.00 am to 6.00 pm), the evening period (6.00 pm to 10.00 pm) and the night-time period (10.00 pm to 7.00am) are provided in Table 72. These noise levels are used to set noise management levels in relation to the construction phase of the M2 Upgrade project.

Table 72 Summary of unattended noise logging – construction noise indices

Receiver ID	Address		Construction noise indices (RBL)		
			Daytime period[1]	Evening period[2]	Night-time period[3]
S1-1	13 Sierra Place	Baulkham Hills	44	45	38.5
S1-2	89 Baulkham Hills Road	Baulkham Hills	50	47	38
S1-3	24 Lambert Crescent	Baulkham Hills	52	47	39.5
S1-4	15 Leatherwood Court	Baulkham Hills	48.5	49	47
S1-5	108 Junction Road	Baulkham Hills	51.5	47.5	37.5
S1-6	17 Livingstone Avenue	Baulkham Hills	47.5	44	36.5
S1-7	10 Murrills Crescent	Baulkham Hills	46	43.5	38.5
S1-8	13 Leatherwood Court	Baulkham Hills	51	48	36
S1-9	4 Craig Avenue	Baulkham Hills	57.5	54	38
S1-10	10 Petrina Close	Baulkham Hills	59.5	56.5	41.5
S2-1	12 Mill Drive	North Rocks	37	38	34
S2-2	10 Virginia Place	West Pennant Hills	52	48	39.5
S2-3	11 Wilshire Avenue	Carlingford	56.5	52.5	42
S2-4	70 Westmore Drive	West Pennant Hills	53.5	50	38
S2-5	3 Mundon Place	West Pennant Hills	47	46	35.5
S2-6	25 Coral Tree	Drive Carlingford	46	49	41.5
S2-7	5 Orchard Road	Beecroft	51.5	47	36
S2-8	24A Castle Howard	Road Cheltenham	53.5	48.5	33
S2-9	13 Williams Road	North Rocks	57.5	53	38.5
S2-10	8 Rajola Place	North Rocks	58	52.5	41.5

Receiver ID	Address		Construction noise indices (RBL)		
			Daytime period[1]	Evening period[2]	Night-time period[3]
S2-11	33 Carmen Avenue	Carlingford	57.5	54.5	37.5
S2-12	30 Austral Avenue	Beecroft	57	52.5	39
S3-1	30 Dunmore Road	Epping	58	52	46
S3-2	4 Somerset Street	Epping	52	48	35
S3-3	56 Somerset Street	Epping	49	44.5	32.5
S3-4	19 Woodvale Avenue	North Epping	54.5	50	33
S3-5	6/8 Nile Close	Marsfield	44.5	42	36.5
S3-6	40 Ashburton Avenue	South Turramurra	45.5	47	38.5
S3-7	45/147 Talavera Road	Marsfield	50	46	35
S3-8	3/3 Tasman Place	North Ryde	51	48.5	41.5
S3-9	21 Epping Road	North Ryde	53.5	51.5	41
S3-10	13 Stewart Close	Cheltenham	54	50.5	33.5
S3-11	140 Crimea Road	Marsfield	53	49	36.5
S3-12	150 Crimea Road	Marsfield	49	45	31
S3-13	2/4 Nile Close	Marsfield	47	44.5	31.5
S3-14	1A Busaco Road	Marsfield	48.5	47.5	37
S3-15	1 Fontenoy Road	Macquarie Park	54	51.5	42

Note 1: DECCW's standard construction hours: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Note 2: Evening hours: 6.00 pm to 10.00 pm.

Note 3: Night-time hours: 10.00 pm to 7.00 am Sunday to Friday, 10.00 pm Saturday to 8.00 am Sunday.

9.4.3 Construction noise impact assessment

The following sections contain an assessment of the construction noise and vibration impacts associated with the M2 Upgrade project. Construction noise and vibration goals have been established based on the relevant government guidelines and industry standards. Noise and vibration emission levels have been determined based on expected activities. Where exceedances are predicted, impact mitigation measures would be implemented where reasonable and feasible as per relevant government and industry guidelines. The M2 Upgrade project represents a major infrastructure development project, constructed over two years, and as such there would be periods when impacts on the surrounding areas associated with construction noise would be expected. As it would be necessary for the M2 Motorway to, at least partly, remain open during the daytime, certain works would be required to be conducted during the less busy evening and night-time periods.

Ground-borne noise impacts from the works associated with widening of the Norfolk Tunnel are discussed in Section 9.4.5.

Construction activities, equipment and sound power levels

For the M2 Upgrade project, a series of construction scenarios have been developed which represent the various construction phases of the upgrade process. Table 73 details the critical work activities for each scenario which are of relevance to construction impacts, together with the equipment required during each activity and the corresponding sound power levels for each item of plant. The expected location and duration of each of the key construction activities is presented in Table 13 of the Technical Paper 2 together with the period of the day in which the activity would be undertaken. It is noted that not all activities are required at all locations along the M2 Motorway.

Table 73 Construction activities and typical equipment involved

Scenario	Activity	Equipment used	Sound Power Level dB(A) [2]	
			LAeq	LAmax
1a + 1b	Road widening (Scenario 1b includes the additional equipment associated with Rocksawing/breaking)	Excavator 30t	109	115
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Mobile Crane	105	113
		Vibratory Roller	106	114
		Plus at selected locations – Scenario 1b		
		Rocksaw	114	118
		Rockbreaker	117	124
		Compressor	106	107
		Generator	100	103
2	Cross-stitching and temporary median works	Excavator 30t with Hammer	109	115
		Jack Hammer	115	117
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Mobile Crane	105	113
		Vibratory Roller	106	114
3	Intelligent Transport System (ITS) works	Excavator 30t	109	115
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Reinforcement Cutting	109	118
		Mobile Crane	105	113
		Generator	100	103
		Lighting Tower	87	88
4	Re-surfacing asphalt works	Asphalt Paver	108	110
		Vibratory Roller	106	114
		Tip Trucks	93	97

Scenario	Activity	Equipment used	Sound Power Level dB(A) [2]	
			LAeq	LAmax
5	Traffic management, set-up and line marking	Truck (delivery / removal)	93	97
		Generator	100	103
		Lighting Tower	87	88
6	Hydroblasting	Drilling Rig	104	104
		Truck (delivery / removal)	93	97
		Compressor	106	107
		Generator	100	103
		Jackhammer	115	117
		Mobile Crane	105	113
		Lightning Tower	87	88
7a	Bridgeworks (daytime bored piling, abutments and piers, deck and finishing)	Piling Rig (bored)	107	110
		Rockbreaker	117	124
		Excavator 30t	109	115
		Backhoe	106	111
		Truck (delivery / removal)	93	97
		Generator	100	103
		Compressor	106	107
		Jackhammer	115	117
		Crane (up to 70t)	109	113
		Concrete Pump	108	112
		Vibratory Roller	106	114
		Lighting Tower	87	88
7b	Bridgeworks (evening and night-time works)	Generator	100	103
		Compressor	106	107
		Concrete Truck	109	113
		Concrete Pump	108	112
		Concrete Vibrator	105	112
		Truck (deliver/removal)	93	97
		Mobile Crane	105	113
		Boom Lift	102	108

The majority of the proposed road widening construction works associated with the M2 Upgrade project would be undertaken during the standard (daytime) construction hours. Evening and night-time works would be required for certain activities where it is not appropriate to undertake these activities during live traffic conditions. This would be determined for safety reasons or to set up construction areas to facilitate day time construction activities. Furthermore, where evening and night-time works are required, such works would not necessarily be continuous at any one location for the full duration of the activities. Certain construction activities are proposed outside of the normal working hours (including on Sundays and Public holidays) to help reduce potential disruption to traffic and to maintain the safety

of construction personnel and other road users. Construction activities undertaken outside of standard construction hours would be subject to approval from DECCW. Appropriate communication with affected community members would be undertaken prior to the commencement of out of hours activities.

Construction noise predictions

Using the sound power levels in Table 73, construction noise levels have been predicted at the nearest receiver locations to the various Noise Catchment Areas for each of the construction scenarios detailed in Table 13 of the Technical Paper 2 (noting that not every scenario is apparent of each assessment location).

The resultant daytime, evening and night-time $L_{Aeq(15minute)}$ noise levels are presented in Table 74, Table 75, and Table 76 respectively (where appropriate) and compared with the relevant NMLs.

The predicted construction noise levels would inevitably depend upon the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. A receiver would therefore experience a range of values, representing the variation in construction noise depending upon the location of the particular construction activity and the likelihood of the equipment of interest operating simultaneously. Where a range of values are apparent, the values presented in the assessment tables represent the predicted noise levels at several receivers within that Noise Catchment Area at various offset distances from the construction works. It is noted that the following predictions are representative of typical construction works situated on the carriageway of M2 in the vicinity of each of the assessment locations, and that for extended periods of time, noise levels would potentially be lower than the calculated levels as predicted for the construction scenarios evaluated.

In each construction scenario, all of the equipment belonging to a particular activity is assumed to be operating concurrently for the full 15 minute period. The following predictions relate to when the particular plant is approximately adjacent to the residences of interest and that as plant and equipment moves along the road of concern, noise levels would reduce.

Noise impacts associated with noise wall relocations

There are locations along the motorway corridor where the construction of new noise walls would not be possible prior to the removal of the existing noise walls. These scenarios are mostly associated with locations where the widening of the motorway would require the construction of new retaining walls and the widening of bridge decks. At these locations, the existing noise walls would have to be removed to facilitate widening of the road. In these situations it is not physically possible to construct the new noise wall until after the road has been widened and the physical structure on which the new noise wall would be constructed (such as retaining wall or bridge deck) has been created. This is illustrated for a retaining wall in Figure 28.

For retaining walls, where access is available at the base of the wall it may be possible to commence construction at ground level, with the existing noise wall in place. However, at some point as the wall is increased in height, where access to the base of the wall is not physically possible or where the construction of new access to the base of the wall would cause undue environmental impact, construction of the wall would have to occur from the M2 Motorway itself at road level. In these instances sections of existing noise walls would need to be removed to provide access to carry out the work and to lower in equipment and/or materials where required. The new noise wall could not be constructed until the new road pavement is complete.

For bridge widening, other than column construction and the installation of new bridge girders, the majority of work required to widen the bridge deck road pavement would occur from the road way.

The existing noise wall would need to be removed to provide access and facilitate the pavement construction. The new noise wall could not be constructed until the widened bridge deck is complete.

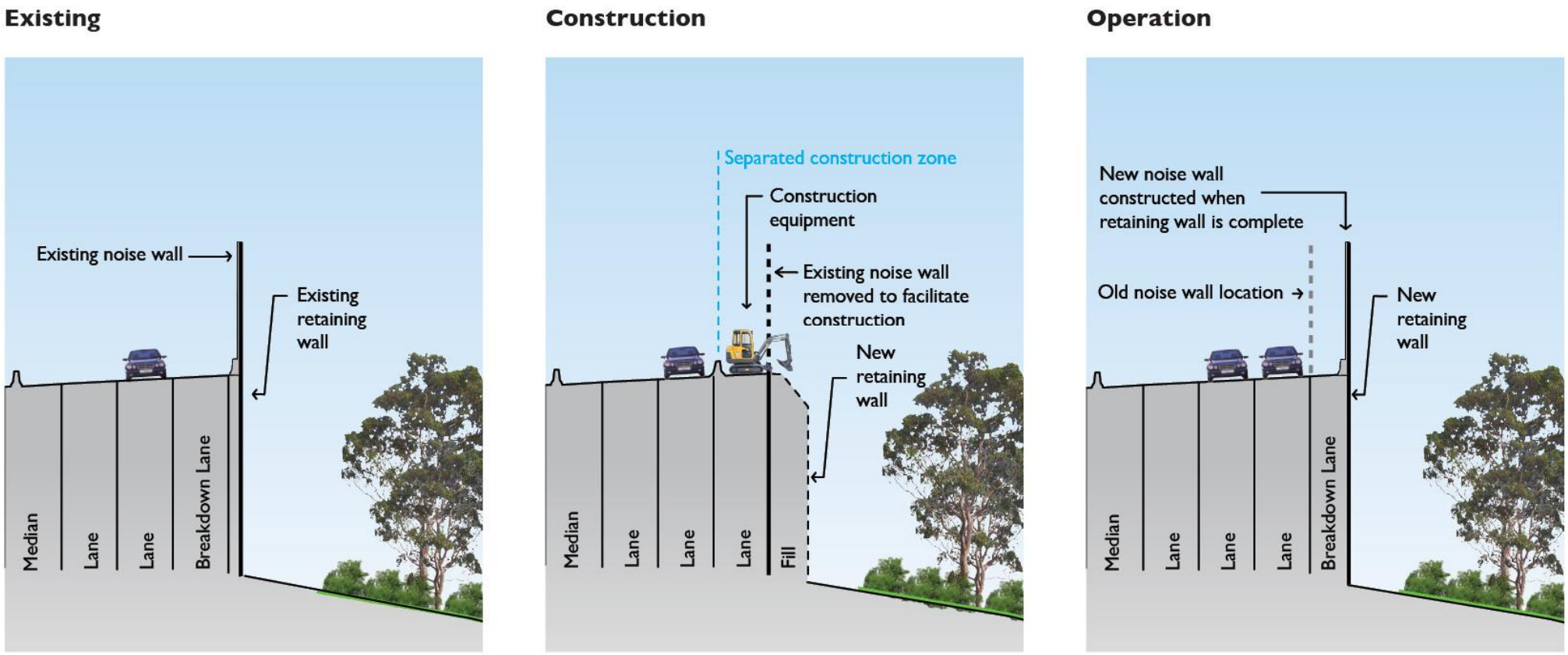
When this situation occurs, elevated noise levels from the operation of the M2 Motorway could be experienced at adjacent receivers. The relevant construction and operational noise guidelines do not provide specific advice in these circumstances. These guidelines are the DECCW *Interim Construction Noise Guideline* (2009) (ICNG), the DECCW (formerly EPA) *Environmental Criteria for Road Traffic Noise* (ECRTN) (1999) and the RTA *Environmental Noise Management Manual* (ENMM), (2001).

The extent of the noise impact would depend on many factors, including:

- The length of wall removed.
- The duration for which no noise wall is in place.
- The characteristics of the local area that would affect the propagation of noise from the motorway.

The length of noise wall that requires removal would be dependent on the final detailed design, but would be the minimum necessary for construction access. The duration for the period where there is no noise wall in place would be dependent on the construction methodology adopted. The construction methodology cannot be finalised until the detailed design is known. As such, it is not possible to accurately predict noise impacts associated with the removal and relocation of noise walls at this time. Further assessment would be undertaken as more details become known as per the methodology described in Section 9.4.6.

Figure 28 Typical noise wall relocation phasing



Daytime construction noise

The assessment of the impacts of construction noise during the daytime period, for each of the construction scenarios, is provided in Table 74. Note that DECCW's governing periods for standard construction hours are: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Table 74 Construction noise predictions – daytime

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
	North	62	-	-	-	57-63	49-52	-	-	-
1	South	62	-	-	-	54	45	-	-	-
2	North	62	-	-	-	59	52-54	-	-	-
	North	61	-	-	-	51-54	44-48	-	-	-
3	South	61	-	-	-	56	49	-	-	-
	North	61.5	-	-	-	57	53	-	-	-
4	South	61.5	-	-	-	55	49	-	-	-
	North	57.5	51-67	53-68	-	-	44-54	-	-	49-63
5[2]	South	56	54-66	52-67	-	-	49-53	-	-	50-63
6	South	69.5	54	56-60	-	-	46-48	-	-	-
	North	67.5	52-54	57-59	-	-	48	-	-	-
7	South	67.5	56	59-60	-	-	49	-	-	-
	North	68	50	55	-	-	45	-	-	-
8	South	68	51	53	-	-	42	-	-	-
9	South	68	53	57	-	-	47	-	-	-
	North	62	51	55	-	-	44	-	-	-
10	South	66.5	43	48	-	-	38	-	-	-
	North	63.5	47	51	-	-	42	-	-	-
11	South	67.5	58-62	67	-	-	56	-	-	-
12	South	61.5	-	-	-	61	-	-	-	-
	North	67	59-61	61-64	-	-	50-53	-	-	-
13	South	61.5	52	59	-	-	49	-	-	-
14	South	61.5	48-54	53-57	-	-	43-47	-	-	-
	North	63.5	55-60	60-63	-	-	49-52	-	-	59
15	South	68	49-53	54-59	-	-	44-47	-	-	54-59
	North	63.5	53-55	59	-	-	47	-	-	-
16	South	68	56-60	60-61	-	-	49-51	-	-	-

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
	North	62	57-62	61-64	-	57-59	52	-	-	-
	South	62	57	59	-	55	48	-	-	-
17	Tunnel	66	54	59	-	56	49	-	-	-
	North	59	50-54	57	-	51-54	44-47	-	-	54-60
18	South	59	52-55	54-58	-	51-55	44-49	-	-	48-55
	North	55.5	47	51	-	-	41	-	-	-
19	South	57	57	60	-	-	51	-	-	-
	North	58.5	46-51	52-55	-	-	39-45	-	-	50-63
20	South	60	42-51	53-55	-	-	37-45	-	-	56-61
21	North	64	49-53	63	-	59	52	-	-	-

Note 1: Refer to Appendix B of the Technical Paper 2

Note 2: Location 5 presents the worst-case noise levels apparent when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Construction noise during the daytime period is generally predicted to be in line with the NMLs at most of the assessment locations detailed in Table 74. Construction noise does not appear to be significant in most cases due to the high background noise levels which are apparent from existing traffic movements on the M2 Motorway.

A number of small exceedances (less than 5 dB(A)) of the NMLs are predicted for the scenarios associated with Road Widening and Bridgeworks. The largest exceedance is predicted at Noise Catchment Area 5 in the vicinity of the proposed new Windsor Road access ramps. This exceedance, however, represents the worst-case noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

Evening construction noise

The assessment of the impacts of construction noise during the evening period, for each of the construction scenarios, is provided in Table 75. Evening construction periods are from 6.00 pm to 10.00 pm Monday to Friday, as recognised by DECCW.

During the evening period exceedances are apparent for most of the construction scenarios assessed. Exceedance of the project NMLs in these scenarios typically range from zero (compliance) to around 15 dB(A).

The largest exceedance (of about 20 dB(A)) is predicted at Noise Catchment Area 5 in the vicinity of the proposed new Windsor Road access ramps. This exceedance represents the worst-case noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

The proposed out of hours construction activities that are likely to cause substantial exceedances of noise management levels in the evening period are works associated with widening the Norfolk Tunnel, as well as cross stitching around the Winston Hills Mall and ITS works near the Windsor Road ramps.

It is noted that evening construction works would not be expected to be continuous at any one location for the full duration of the works within that section.

Table 75 Construction noise predictions – evening

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
1	North	52	-	-	59-65	-	49-52	50-55	-	-
	South	52	-	-	54	-	45	45	-	-
2	North	52	-	-	62	-	52-54	49-51	-	-
3	North	53	-	-	56	-	44-48	43-46	-	-
	South	53	-	-	59	-	49	48	-	-
4	North	52.5	-	-	61	-	53	50-52	-	-
	South	52.5	-	-	59	-	49	46-48	-	-
5[2]	North	49	-	-	53-67	49-68	-	44-53	50-63	38-56
	South	48.5	-	-	52-67	49-67	-	46-54	51-63	57-66
6	South	61.5	-	-	55-57	51-57	-	46	-	44-63
7	North	58	-	-	55-57	52-54	-	45-47	-	44-69
	South	58	-	-	58	55	-	47	-	45-51
8	North	57.5	-	-	52	49-51	-	43	-	-
	South	57.5	-	-	56	48	-	42	-	-
9	South	57.5	-	-	55	54	-	43-45	-	44-51
10	North	53	-	-	53	51	-	42	-	-
	South	57.5	-	-	46	43	-	36	-	-
11	North	55	-	-	49	47	-	39	-	-
	South	59.5	-	-	62-64	59-63	-	50-52	-	-
12	South	52	-	-	-	-	-	-	-	-
13	North	57.5	-	-	60-62	59-61	-	49-51	-	52-58
	South	52	-	-	58	53	-	47	-	40-41
14	South	52	-	-	52-56	49-54	-	39-44	-	60-69
15	North	53.5	-	-	58-61	56-59	-	47-50	-	-
	South	57	-	-	52-56	49-54	-	42-44	-	-
16	North	53.5	-	-	56	55	-	45	-	46-50
	South	57	-	-	58-60	56	-	47-50	-	51-57

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
17	North	53	57-62	61-64	59-63	-	52	50	-	-
	South	53	57	59	57	-	48	45	-	-
	Tunnel	57	54	59	58	-	49	47	-	-
18	North	49.5	50-54	57	53-56	-	44-47	43-46	-	40-45
	South	49.5	52-55	54-58	53-57	-	44-49	43-47	-	39-53
19	North	52	-	-	50	47	-	40	-	-
	South	49.5	-	-	60	57	-	49	-	-
20	North	52.5	-	-	50-54	45-50	-	40-44	-	-
	South	51	-	-	50-53	50	-	35-44	-	-
21	North	56.5	-	-	61	-	52	50	-	41-48

Note 1: Refer to Appendix B of the Technical Paper 2

Note 2: Location 5 presents the worst-case noise levels apparent when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Night time construction noise

The assessment of the impacts of construction noise during the night time period, for each of the construction scenarios, is provided in Table 76. Note that DECCW governing periods for night construction are 10.00 pm to 7.00 am Sunday to Friday and10.00 pm Saturday to 8.00 am Sunday.

Table 76 Construction noise predictions – night time

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
	North	44.5	-	-	59-65	-	49-52	50-55	-	-
1	South	44.5	-	-	54	-	45	45	-	-
2	North	44.5	-	-	62	-	52-54	49-51	-	-
	North	41	-	-	56	-	44-48	43-46	-	-
3	South	41	-	-	59	-	49	48	-	-
	North	42.5	-	-	61	-	53	50-52	-	-
4	South	42.5	-	-	59	-	49	46-48	-	-
	North	41.5	-	-	53-67	49-68	-	44-53	50-63	38-56
5[2]	South	43.5	-	-	52-67	49-67	-	46-54	51-63	57-66
6	South	46.5	-	-	55-57	51-57	-	46	-	44-63
	North	43.5	-	-	55-57	52-54	-	45-47	-	44-69
7	South	43.5	-	-	58/	55	-	47	-	45-51
	North	46.5	-	-	52	49-51	-	43	-	-
8	South	46.5	-	-	56	48	-	42	-	-
9	South	46.5	-	-	55	54	-	43-45	-	44-51
	North	44.5	-	-	53	51	-	42	-	-
10	South	47	-	-	46	43	-	36	-	-
	North	43	-	-	49	47	-	39	-	-
11	South	42.5	-	-	62-64	59-63	-	50-52	-	-
12	South	41	-	-	-	-	-	-	-	-
	North	44	-	-	60-62	59-61	-	49-51	-	52-58
13	South	41	-	-	58	53	-	47	-	40-41
14	South	41	-	-	52-56	49-54	-	39-44	-	60-69
	North	38	-	-	58-61	56-59	-	47-50	-	-
15	South	51	-	-	52-56	49-54	-	42-44	-	-
	North	39	-	-	56	55	-	45	-	46-50
16	South	51	-	-	58-60	56	-	47-50	-	51-57
	North	40	57-62	61-64	59-63	-	52	50	-	-
	South	40	57	59	57	-	48	45	-	-
17	Tunnel	44	54	59	58	-	49	47	-	-

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
	North	37.5	50-54	57	53-56	-	44-47	43-46	-	40-45
18	South	37.5	52-55	54-58	53-57	-	44-49	43-47	-	39-53
	North	43.5	-	-	50	47	-	40	-	-
19	South	36.5	-	-	60	57	-	49	-	-
	North	42	-	-	50-54	45-50	-	40-44	-	-
20	South	40	-	-	50-53	50	-	35-44	-	-
21	North	47	-	-	61	-	52	50	-	41-48

Note 1: Refer to Appendix B of the Technical Paper 2

Note 2: Location 5 presents the worst-case noise levels apparent when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Discussion on exceedances

In the above assessment of the daytime, evening and night-time periods, the higher exceedances are generally related to the use of the following items of plant:

- Concrete saws (and reinforcement cutting).
- Rockbreakers.
- Jackhammers.

The proposed out of hours construction activities that are likely to cause substantial exceedances of noise management levels in the night time period are works associated with:

- Widening the Norfolk tunnel.
- Cross stitching along the length of the M2 Motorway.
- ITS works from Windsor Road to Lane Cove Road.
- Resurfacing works at a few locations.
- Some traffic management activities at certain locations.
- Hydroblasting west of Windsor Road.

Certain proposed night-time works have the potential to result in noise levels well above background noise levels. As such they have the potential to impact upon adjacent sensitive receivers causing possible disturbance and nuisance. Evening and night time works are only proposed for specific works on the M2 Motorway or on the major roads that intersect with the motorway. Undertaking these works during the daytime would have the potential to cause significant traffic disruption both directly at the works location and also extending out widely into the surrounding road networks. Due to the large number of people potentially affected by such works, it is therefore considered that night time works are appropriate in these instances.

Working on busy roads can pose safety risks to both construction personnel and the users of the roads if appropriate measures are not put in place. Most construction works associated with roads often require temporary modification to existing lane alignments and other traffic control measures which are different to the usual conditions experienced by road users at these locations. This increases the potential for traffic incidents that may affect the safety of construction personnel and other the road users. As such, certain activities are proposed at night-time to address these safety concerns. Some of these works involve short term activities such as making appropriate changes to the lane alignment and other intersection features to create safer daytime working environments for both construction personnel and road users.

In summary, whilst the noise associated with the proposed night time work activities may have the potential to impact upon the amenity of adjacent sensitive receivers, their justification is based on vital safety considerations and the potential for widespread traffic disruption.

Although the above assessment predicts the potential for significant exceedances, at times, the sensitive receiver noise levels presented above are all predicted during a worst-case scenario when all of the equipment within a particular scenario is operating concurrently, for the full 15 minute assessment period, in a location immediately adjacent to the residences of interest. Higher exceedances of the Noise Management Level associated with night-time works may therefore only be apparent at a particular receiver for a relatively short period of time. As the plant and equipment moves along the road of concern, the noise levels would be expected to reduce accordingly.

On the basis of the above, the following approach would be undertaken, in accordance with the ICNG:

- All reasonable and feasible work practices need to be applied to meet the noise goals.
- Where NMLs are likely to be exceeded (especially during the more sensitive evening and night-time periods), community liaison must be undertaken and negotiation take place to arrive at the final mitigation strategy.

Suitable methods for mitigating the impact of construction noise (and vibration) are discussed in more detail in Section 9.4.6.

Sleep disturbance

The assessment of the predicted sensitive receiver L_{Amax} noise levels during the night-time period is presented in Table 77, along with the corresponding Sleep Disturbance Screening Criterion (RBL +15 dB(A)) for each assessment location.

Many of the proposed noise generating construction activities are expected to exceed the project Sleep Disturbance Screening Criteria. These exceedances range from zero (compliance) to around 20 dB(A).

The largest exceedance is predicted at Assessment Location 5 which is in the vicinity of the proposed new Windsor Road access ramps. This exceedance represents the noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

Again, the higher exceedances of the Sleep Disturbance Screening Criteria are generally related to the use of the following items of plant:

- Concrete saws (and reinforcement cutting).
- Rockbreakers.
- Jackhammers.

These highly-noise intensive activities would be closely managed in accordance with the ICNG to minimise night-time impacts.

Table 77 Construction noise predictions – sleep disturbance

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
1	North	54.5	-	-	60-65	-	54-57	54-62	-	-
	South	54.5	-	-	57	-	51	50	-	-
2	North	54.5	-	-	64	-	56-59	56-58	-	-
3	North	51	-	-	56-58	-	50-52	48-51	-	-
	South	51	-	-	61	-	55	53	-	-
4	North	52.5	-	-	63-66	-	58	58	-	-
	South	52.5	-	-	61	-	55	52-54	-	-
5[2]	North	51.5	-	-	57-68	56-71	-	50-62	52-59	45-61
	South	53.5	-	-	63-72	63-75	-	58-61	55-67	64-71
6	South	56.5	-	-	58-61	58-62	-	50-52	-	50-67
7	North	53.5	-	-	58-60	58-60	-	53	-	51-73
	South	53.5	-	-	60	61	-	52	-	52-57
8	North	56.5	-	-	57	57	-	48	-	
	South	56.5	-	-	56	58	-	49	-	-
9	South	56.5	-	-	56-59	59	-	47-50	-	50-55-
10	North	54.5	-	-	57	57	-	48	-	-
	South	57	-	-	49	50	-	43	-	-
11	North	53	-	-	53	53	-	44	-	-
	South	52.5	-	-	63-67	69	-	57-59	-	-
12	South	51	-	-	66	-	-	-	-	-
13	North	54	-	-	60-63	68	-	52-55	-	58-63
	South	51	-	-	59-61	65-67	-	55	-	45-47
14	South	51	-	-	52-57	58-60	-	45-49	-	65-72
15	North	48	-	-	62	54-58	-	52-54	-	-
	South	61	-	-	56-61	62-65	-	48-50	-	-
16	North	48	-	-	58	56-61	-	49	-	50-54
	South	61	-	-	61-64	59	-	53-55	-	55-61
17	North	50	64-68	69	64-67	-	57	55-58	-	-
	South	50	63	65	63	-	54	53-54	-	-
	Tunnel	54	60	65	60	-	54	52	-	-
18	North	47.5	57-60	63	57-59	-	49-52	51	-	47-50
	South	47.5	58-61	60-64	56-61	-	49-54	49-52	-	45-57

Noise Catchment Area[1]	Side of Motorway	Daytime NML (dB(A)) (RBL +10 dB(A)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario dB(A) (Refer to Table 73 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
19	North	53.5	-	-	52	54	-	46-49	-	-
	South	46.5	-	-	61-63	64	-	54	-	-
20	North	52	-	-	54-57	52-58	-	48-50	-	-
	South	50	-	-	55-57	52-56	-	48	-	-
21	North	57	-	-	64	-	-	55	-	48-52

Note 1: Refer to Appendix B of the Technical Paper 2

Note 2: Location 5 presents the worst-case noise levels apparent when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Construction noise impact – sensitive land uses

Educational facilities

The above assessment concludes that at the existing educational facilities, the majority of the predicted construction noise levels are below the NMLs. The only exception is at Epping Heights Public School, where exceedances of around 9 dB(A) are predicted for a number of the scenarios. Noise mitigation measures in accordance with the ICNG would be adopted. The duration of works in the vicinity of the Epping Heights Public School are expected to last approximately three months. These works are mostly in association with minor works in the median of the M2 Motorway.

Places of worship

Exceedances of the Noise Management Level at Our Lady of Lourdes Church are predicted when the widening works are in proximity to the church. Elevated construction noise levels would likely only be an issue during periods when the church was actively being used. Consultation with the church and works scheduling (where practicable) may be adopted to lessen potential impacts to the church from construction noise. Noise mitigation measures in accordance with the ICNG would be adopted. The duration of works in the vicinity of Our Lady of Lourdes Church are expected to last approximately 15 months. These works are mostly in association with the construction of the Windsor Road ramps.

Construction compound sites

The M2 Upgrade project would require several temporary construction compound sites to be constructed along the length of the route. These compounds would be used for a variety of purposes including laydown areas, stockpiling, stores, team offices, and car parking.

The proposed locations of the construction compounds are immediately adjacent to the M2 Motorway (refer to Table 13 for location of construction compounds), and as such, are already subject to reasonably high levels of ambient (road traffic) noise.

It is noted that the smaller compound sites are intended to be used during the daytime periods, with only the major compounds intended to be used 24 hours a day.

Exceedances of the NMLs are predicted where sensitive receivers are situated in proximity to the compound sites. As such, it would be necessary to provide some form of noise mitigation to minimise the impact of noise generated by the compounds.

The following subsections describe potential impacts arising from key compound sites that are proposed to be used during night time hours (refer to Section 7.8.1 for description of compounds).

TIDC main compound

The main compound is surrounded by a commercial complex on one side and the motorway on the other, limiting the potential for disturbance due to works outside standard construction hours. Some residents are present on the opposite side of Epping Road that might be subject to elevated noise levels during night time activities at the compound. However, the residents are located reasonable distances from this compound site and the compound would be set up so that loading and unloading areas and other activities likely to generate elevated noise levels would occur as far as practicable away from the residences. Supplementary noise controls, such as noise hoarding around the perimeter of the compound where sensitive receivers are located would be installed as required to minimise potential disturbance.

Windsor Road compound

The Windsor Road compound is located at north west corner of the M2 Motorway and Windsor Road intersection, the compound is bordered by Windsor Road to the east, M2 Motorway to the South, Torrs Street to the north, and six private homes to the west. Residents immediately to the west would experience elevated noise levels from use of this compound. Site specific procedural and physical controls to reduce noise generation and propagation from the proposed compound would be developed to ensure that any noise impacts to residents outside of standard construction hours are minimised. A noise hoarding would be installed immediately adjacent to neighbouring properties, and required floodlights would be directed away from close proximity sensitive receivers.

Beecroft Road (old bus ramp)

There are residences in close proximity to the west across Beecroft Road, which would be affected by elevated noise levels associated with the use of the Beecroft Road (old bus ramp) compound. Site specific procedural and physical controls to reduce noise generation and propagation from the proposed compound would be developed to ensure that any noise impacts to residents outside of standard construction hours are minimised.

Sutherland Road compound (tunnel compound)

The Sutherland Road compound (tunnel compound) is in close proximity to residences in the east, in Constance Close, and to the west in Sutherland Road, which may be affected by elevated noise levels associated with the use of the compound. Site specific procedural and physical controls to reduce noise generation and propagation from the proposed compound would be developed to ensure that any noise impacts to residents outside of standard construction hours are minimised. Such controls would include the installation of noise hoardings adjacent to neighbouring residents and a policy of strict education to all personnel engaged in nightwork activities in this location.

Toll Plaza

This proposed compound is not within the vicinity of any residences and forms part of the larger Toll Plaza, which currently operates on a 24 hour basis.

Christie Road

There are no residences in the vicinity of this compound, minimising the potential for noise impacts outside standard construction hours.

Macquarie Park

This proposed compound location is approximately 100 metres from residences to the east, which may be subject to elevated noise levels associated with the proposed use of this compound. Site specific procedural and physical controls to reduce noise generation and propagation from the proposed compound would be developed to ensure that any noise impacts to residents outside of standard construction hours are minimised.

Construction traffic impact

The majority of compound sites are proposed to be accessed from the M2 Motorway carriageway, and as such, the impact of light and heavy vehicle movements associated with these sites would be negligible over existing ambient noise levels. Where possible, construction traffic would utilise major roads, including the M2 Motorway, Epping Road, Lane Cove Road or Windsor Road. However to access some of the compound sites, it is likely that construction vehicles would, at times, need to travel short distances on local roads.

Local roads – light vehicles

The potential noise impact of construction related light vehicle movements on local roads at the smaller compound sites is considered to be negligible when considering the relatively small number of daily movements to these compounds. It is highly-likely that the noise from these vehicles would be perceived as part of the general road traffic. The TIDC compound contains large car parking facilities which are accessed from Lane Cove Road and Epping Road. As both of these roads are major arterial routes, which are already subject to high daily volumes of traffic, the additional construction traffic that the M2 Upgrade project would create is not expected to create additional noise impacts.

Local roads – heavy vehicles

Heavy vehicle movements on collector and arterial roads are likely to be perceived as part of the general road traffic. However, once heavy vehicles move onto the local roads immediately adjacent to the compound sites, the community is likely to associate these heavy vehicle movements with the M2 Upgrade project construction works. For the smaller compound sites it is anticipated that during the worst-case hour, four heavy vehicle movements would occur during the daytime in busy periods, with lower numbers during quieter periods. No night time movements to smaller compound sites are expected along local roads. Heavy vehicle movements associated with the main TIDC compounds would access local roads with no residential receivers on them, and as such, there are anticipated to be no adverse impacts from heavy vehicles travelling to these compound sites.

9.4.4 Construction vibration impact assessment

Vibration targets vary primarily according to whether the particular activities of interest are continuous in nature or intermittent and whether they occur during the day or night time. The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed (human disturbance).
- Those in which the integrity of the building or the structure itself may be prejudiced.
- Those where the building contents may be affected.

Criteria relevant to the response of building occupants to vibration are more stringent than those relevant to building damage.

Human comfort goals for continuous and impulsive vibration

The DECCW's *Assessing Vibration: a technical guideline* is applicable to the M2 Upgrade project and is based on the guidelines contained in British Standard BS 6472-1992 *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*. The DECCW guideline refers only to human comfort considerations and nominates preferred and maximum vibration goals for critical areas, residences and other vibration sensitive receivers. Whilst criteria in *Assessing Vibration: a technical guideline* are non-mandatory, the guideline states:

> *"they are goals that should be sought to be achieved through the application of all feasible and reasonable mitigation measures. Where all feasible and reasonable measures have been applied and vibration values are still beyond the maximum value, the operator would need to negotiate directly with the affected community".*

Vibration criteria – surface structures

Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure(British Standard 7385: Part 2 - 1993 Guidelines). In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* as they "*are applicable to Australian conditions*". The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95 percent probability of no effect.

Construction vibration impacts

The major potential sources of construction vibration related to the M2 Upgrade project include the use of excavators, rockbreakers and vibratory rollers. In general, vibration produced by earthworks and road forming operations is expected to be less than structural damage criteria. Where vibration-intensive operations are being conducted in close proximity to the buildings nearest to the roadworks (for example, construction of the Windsor Road ramps), judicious selection of plant and equipment would be necessary as outlined above. Vibration may be perceptible for relatively short periods of time when construction activities are immediately adjacent to specific dwellings.

Given the distances of the nearest residences to the proposed construction works, a review of the construction plan would be required to confirm the extent of pre-construction building condition surveys.

9.4.5 Construction noise and vibration impact assessment of widening Norfolk Tunnel

During the widening of the Norfolk Tunnel, both airborne and ground-borne noise may potentially exceed the relevant criteria at certain times.

The construction activities associated with the widening of the Norfolk Road Tunnels and supporting works are proposed to occur continuously (24 hours a day, six days a week) over certain periods. This is required to enable the works within the tunnel to be completed within specified timeframes. Specific approval for these working hours is sought as part of the overall project approval.

Ground-borne noise criteria

Ground-borne (or regenerated) construction noise is usually present on tunnelling projects. Internal ground-borne NML of $L_{Aeq\ (15minute)}$ 40 dB(A) (evening) and $L_{Aeq\ (15minute)}$ 35 dB(A) (night-time) are specified within the ICNG. These goals are only applicable when the ground-borne noise levels are higher than the airborne noise levels inside residential dwellings. During daytime periods, only the human comfort vibration goals are applicable.

Ground-borne noise impact

The ground-borne noise impacts from tunnelling works would be greatest when a roadheader is situated immediately below the property in question. As the roadheader moves further along the tunnel, the impact from ground-borne noise would reduce for properties it has passed. It is anticipated that the roadheader would be underneath a particular receiver location for around 10 to 12 days.

The nearest affected receivers, with a slant distance of around 15 metres, the $L_{Aeq(15minute)}$ 35 dB(A) night-time noise goal would potentially be exceeded by around 5 dB(A). Properties that are less than 29 metres away from the widening works would potentially experience night-time exceedances, up to a maximum of around 5 dB(A), for a period of approximately two weeks (10-12 working nights).

Ground-borne noise from the operation of the roadheader at sensitive receivers would be neither impulsive nor intermittent, and, as a result, the potential for sleep disturbance at sensitive receivers in these locations during the night-time period is considered to be low.

Although potential exceedances of the night-time goals are predicted, the vibration levels associated with the use of roadheaders at the Norfolk Tunnel would be expected to be below the levels required to cause structural damage to the properties situated above.

Noise map predictions of ground-borne noise from tunnel works are shown in Figure 15 of Technical Paper 2. These illustrate that the following potential noise exceedances are likely from tunnel works:

- +1 to +2 dB(A) – two dwellings affected
- +3 to +4 dB(A) – six dwellings affected
- +5 to +6 dB(A) – ten dwellings affected

It should be noted that these results show the predicted worst-case ground-borne noise levels that may be experienced by nearby residences. These noise levels may occur when the roadheader is in the tunnel tube immediately below, or adjacent to, residences. As the tunnel widening works proceed, or

move to the other tunnel tube, the distance between the roadheader and the residences would increase and consequently the ground-borne noise levels would be noticeably reduce.

Airborne noise impact

The appropriate noise management levels and noise predictions for the proposed works outside the tunnel entrances, at the tunnel entrances and entirely within the tunnel with proposed mitigation measures in place are presented below in Table 78.

Table 78 Potential noise impacts arising from tunnel works

Activity	Equipment	Proposed Mitigation	Predicted Noise Level LAeq(15min) (dB(A))1	Noise Goals (dB(A))	
				Time Period Noise Management Level (Day/Eve/Night)	Sleep Disturbance LA1(60 sec)
A – Outside Portal Works	Excavator with hammer, rock drill	n/a	62	59 / 49.5 / 37.5	47.5
B – Widening Works at Tunnel Portal	Roadheader, rock drill, shotcrete rig	Acoustic Shed only	51		
C – Widening Works Entirely Within Tunnel	Roadheader, rock drill, shotcrete rig	Acoustic Shed and Acoustic Curtain	39		

Note 1: The predicted noise levels include a -5 dB(A) correction for the effect of the existing noise walls.

The airborne noise impacts from tunnelling works would be greatest when works are occurring near the tunnel portals. Works outside of the tunnel portals are predicted to be 62 dB(A) and would exceed the noise management levels for all time periods, which are 59, 49.5 and 37.5 dB(A) for daytime, evening and night time periods respectively, with the most substantial exceedance predicted during the night. The sleep disturbance criteria of 48 dB(A) would also be exceeded. Work at the tunnel entrances prior to the installation of an acoustic curtain is predicted to be 51 dB(A). This is just above the evening NMLs, but exceeds the night time and sleep disturbance noise goals.

For the majority of the construction period, works would occur entirely within the Norfolk Tunnel and as the proposed works move inside the tunnel portals mitigation measures such as the use of acoustic sheds and acoustic curtains would result in negligible or no noise impacts. This is evidenced by the prediction of 39 dB(A) $L_{Aeq(15minute)}$ from construction works occurring wholly within the Norfolk Tunnel. This is well below the noise goals for the daytime and evening periods and only just above the NML for the NML for the night time period. It would also be below the sleep disturbance noise goal of 48 dB(A).

It is also noted that there are only a few houses at each tunnel portal with a direct line of sight to the tunnel entrances and proposed work locations. The greatest exceedances of the NMLs are predicted at these locations. However, the works would occur within the deep existing excavations of the tunnel portals. This would provide noise attenuation for other properties in the vicinity that would have no line of sight to the proposed works. The potential for exceedance of the NMLs would decrease significantly with increasing distance from the tunnel portals.

Based on the above assessment, widening of the tunnel portals is proposed during the day period, works at the tunnel entrances are proposed in the day and evening periods and 24 hour per day works are proposed entirely within the tunnels and only after the installation of the proposed acoustic curtain. This

would substantially reduce the potential for exceedances of the NMLs associated with tunnel widening works. Slight exceedances only of the NMLs are likely at those properties with a direct line of vision to the proposed works locations.

Noise map predictions of airborne noise from tunnel works are shown in Figure 11 of Technical Paper 2. These illustrate that the following potential noise exceedances are likely from tunnel works:

- Activity A – Outside portal works: daytime only – no dwellings affected.
- Activity B – Widening works at Norfolk Tunnel portal: daytime and evening only – four dwellings affected.
- Activity C – Widening works entirely within Norfolk Tunnel: no restrictions. – two dwellings affected.

9.4.6 Construction noise and vibration mitigation measures

The construction scenario predictions have been examined to evaluate:

- Potential means for noise and/or vibration mitigation.
- Alternative methods to carry out specific construction activities.

In many instances, the options available for reducing noise emissions are limited, given the small range of plant and equipment able to carry out the tasks required. Furthermore, the mobility of much of the equipment limits the use of enclosures, which are otherwise effective in reducing noise emissions from fixed noise sources.

A considered approach to noise and vibration mitigation would be implemented through the CEMP, which is outlined in Appendix F, in the form of a Construction Environmental Management Framework.

Noise control with site planning

Certain 'baseline' mitigation strategies should be adopted along the route at sections where the noise goals are exceeded.

The construction contractor would, where reasonable and feasible, apply best practice noise mitigation measures including:

- Erecting temporary hoardings or other noise mitigation measures at site compounds, which are in proximity to residential receivers, where practicable as determined by detailed assessment of each location.
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- The coincidence of noisy plants working simultaneously close together and adjacent to sensitive receivers would be avoided, where practicable.
- Where possible, equipment with directional noise emissions would be orientated away from sensitive receivers.
- Where practical, the layout of plant and equipment at the site compounds would be developed so as to minimise noise exposure.
- Where practical, external and internal access at work sites and compounds would be designed to promote forward vehicular and plant movements, in order to minimise the need for reversing.
- Loading and unloading would be carried out away from sensitive receivers, where practicable.
- Loading, unloading and other activities that require repeated reversing would be restricted during evening, night and early morning periods where practical.

- The selection of site access points would take into account the proximity of noise sensitive receivers.
- Maintenance work on construction plants with the potential to generate noise impacts would be carried out away from noise sensitive receivers and confined to standard daytime construction hours, where possible.
- Minimising consecutive works in the same locality, where practicable.

Noise wall relocation planning

Each location where a new noise wall cannot be constructed prior to removing the existing noise wall would be assessed based on site specific conditions, final designs and proposed construction methodologies. The detailed design would be reviewed and amended as appropriate to minimise the removal of noise wall where possible, thereby reducing the exposure of receivers to operational road noise. The construction methodology would also be reviewed and amended to allow works to be staged so that time between removing the existing noise wall and constructing the new wall is minimised, thereby minimising the duration of the noise impacts associated with the project.

Specific noise controls and procedures would be developed for each location to minimise noise propagation from the motorway and to address any residual noise impacts at the adjacent properties. Suitable controls and procedures that would be considered include:

- Erection of temporary noise walls as close as possible to the edge of the trafficable lanes of the motorway to reduce the propagation of operational road noise.
- The progressive erection of temporary noise walls at the edge of the roadway as road widening occurs, prior to the construction of new permanent noise walls.
- Erection of temporary noise walls where practicable adjacent to sensitive receivers.
- Temporary hoarding around noisy plant.
- Limiting noise intensive construction activities to day-time construction periods wherever practicable.
- Traffic management strategies, including reduced speed limits during lane closures, to reduce potential road noise generation.
- Works staging programs and training programs for construction personnel to prevent the simultaneous operation of plant and/or operation of noise-intensive plant for extended lengths of time.

In addition, specific consultation would occur with residents in the vicinity of these locations during the public exhibition phase and extending into the construction phase.

Noise control with planning of construction activities

In order to minimise noise impacts during the works, the construction contractor would make use of reasonable and feasible measures to mitigate noise effects. The contractor would also take reasonable steps to control noise from plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers. Operators of construction equipment would be made aware of potential noise issues and of techniques to minimise noise emission through a continuous process of operator education. For example:

- Large waste material would be ‘placed’ into dump trucks as far as practical (rather than dropped in from a height).
- Where vehicle and equipment queuing is required close to sensitive receivers, engines would be shut down if queuing for extended periods, where practicable.
- Warming up of vehicles would be carried out as far away as possible from noise sensitive receivers.

- Reversing of equipment would be minimised so as to prevent nuisance caused by reversing alarms.
- Activities requiring repeated reversing, such and loading and unloading, would be restricted where practical during evening, night and early morning periods.
- Horn signals would be kept to as low a volume as possible, given appropriate Occupational Health and Safety (OH&S) considerations.
- Relocate any vibration generating plant and equipment away from noise sensitive receivers in order to lower any potential vibration impacts.
- Use lower vibration generating items of excavation plant and equipment, for example smaller capacity rockbreaker hammers, wherever possible.

Works scheduling

Works scheduling can often be adopted to effectively manage construction noise impacts and in particular to limit potential impacts during sensitive times of the day and night. However, given the constrained nature of the M2 Motorway corridor, the limited space available to establish work zones, and due to construction occurring during live traffic conditions, the options for works scheduling are limited.

Certain works are required outside of standard construction hours, to reduce potential safety risks to road users and construction personnel and to limit potential traffic disruption. These works potentially involve noise intensive activities and equipment during sensitive periods and it is not appropriate to undertake such works during live traffic conditions or periods of high traffic volumes. As such, there is limited scope to reschedule these activities during day time periods.

Works scheduling has been considered when developing proposed construction scenarios and methodologies associated with widening of the tunnel tubes and tunnel portals. For reasons of road user and construction personnel safety, it would be best to undertake these works at night. However, this would involve potentially significant exceedances of evening and night time noise management levels. The proposed methodology for the tunnel and portal widening outlined in Section 9.4.5 was developed to both limit number of houses affected and the potential noise exceedances of noise management levels in the evening and night time periods through the scheduling of the proposed work scenarios.

Scheduling of certain works could occur to ensure that the majority of noise intensive activities occur during standard construction hours. In particular, through the implementation of traffic management arrangements the construction contractor would set up work zones wherever practicable to facilitate general road widening and other works during the day, limiting the need for works outside of standard construction hours.

Other scheduling opportunities to limit noise impacts during sensitive periods include limiting concurrent activities and limiting work hours and implementing respite periods for key high noise impact activities. The options are discussed in the following sections.

Concurrent activities

There is some, albeit limited, scope for a proactive scheduling of equipment tasks to avoid ‘clustering’ of equipment close to sensitive receivers. This applies to the equipment within the individual construction crews.

Limiting of hours

The assessment of the potential impacts from construction noise for the M2 Upgrade project found that the higher exceedances of the NMLs were generally associated with use of:

- Concrete Saws (and reinforcement cutting).
- Rockbreakers.
- Jackhammers.

It is proposed to reduce the potential noise impacts during the more sensitive periods by restricting such activities, where sensitive receivers are likely to be adversely affected, to daytime and evening periods, where feasible and reasonable.

Respite periods

High impact noise activities, such as those likely to generate noise levels above LAeq 75 dB(A) and activities likely to generate noise with intermittent, impulsive, tonal or low-frequency characteristics have the potential to seriously affect the amenity of adjacent noise receivers. Examples of high noise impact activities proposed include saw and rock cutting, grinding, rock breaking, jack hammering, rock drilling and vibratory rolling. Notable construction scenarios where high impact noise activities are proposed would include widening of the existing cuttings through bedrock, widening of the tunnel portals, grinding works to widen the tunnel tubes, installation of rock bolts, saw cutting during pavement construction and excavation in rock for foundations for structures such as retaining walls and bridges.

When high noise impact activities are proposed that have the potential to affect the amenity of noise receivers in the vicinity of proposed work locations, appropriate respite periods would be implemented. Typically a minimum respite period of at least 30 minutes would be scheduled before the commencement of any high noise impact activity that would be undertaken for a continuous four hour period. Where high noise impact activities are proposed outside of standard construction hours with the potential to impact upon the amenity of adjacent sensitive receivers, specific consideration of appropriate respite periods would be considered and recommended as part of preparation of activity specific construction noise impact statements (see following subsection).

Construction noise and vibration management plan and impact statements

To ensure the adequacy of the noise and vibration mitigation measures for the actual design and construction method, detailed Construction Noise and Vibration Impact Statements (CNISs) would be prepared for major noise-intensive construction activities, prior to and for inclusion into the Construction Noise and Vibration Management Plan (CNVMP) for that stage/activity (inclusive of both construction staging and staged opening). Both the CNVMP and individual supporting CNISs would be revised as required.

In particular, CNISs would be prepared for areas where:

- Construction of new noise walls is not possible prior to the removal of existing noise walls.
- Noise intensive activities occur during standard construction hours with the potential to exceed appropriate noise management levels.
- Works are required outside of standard construction hours.

Source noise control strategies

Engines and exhausts, which are often the dominant noise sources on mobile plant, would be fitted with residential class mufflers. Wherever feasible, silenced air compressors, fitted with noise labels indicating a maximum (L_{Amax}) sound pressure level of not more than 75 dB(A) at seven metres would be used on site.

Compound sites – noise mitigation

In order to minimise potential impacts, it is likely that noise barriers would be required in locations where sensitive receivers are situated in close proximity to the proposed construction compounds. Noise barriers would be dedicated and/or temporary noise walls, temporary hoardings, site sheds or the like. Correctly designed and constructed barriers (of solid construction using appropriate materials) would be expected to result in the following reductions in noise levels:

- Minor barriers (hoarding of indicative height of three metres): 5 dB(A) to 10 dB(A) reduction.
- Major barriers (hoarding of indicative height of six metres): 10 dB(A) to 15 dB(A) reduction.

The key control strategies involved for mitigating noise from the compound sites would include:

- Noise walls (enclosures) surrounding continuously operating plant (generators).
- Truck management (for example, limiting of 'queuing' adjacent to residential areas).
- Temporary noise barriers (through temporary noise walls, hoardings and the like) wherever feasible protecting residents adjacent to the relevant sites, especially surrounding maintenance work areas.
- Where practical, developing site access arrangements that encourage forward vehicular and plant movements, in order to minimise the need for reversing.
- For compounds where 24 hours use is proposed, activities that require repeated reversing would be limited to less sensitive periods of the day.

Close liaison with the local community and a proactive information protocol (information on the duration and likely intensity of upcoming works) is proposed for the management of noise emissions at these locations.

More detailed assessment of the noise impacts from compound sites would be performed during the detailed design phase, when the specifics of each site would be known. Specific noise management strategies for each compound would be developed at that time.

Local roads – heavy vehicles noise mitigation

The following mitigation measures are proposed in order to minimise the impact of exceedances from heavy vehicles on local roads for the criteria at residential receiver locations:

- Trucks would be fitted with mufflers and any other noise control equipment in good working order.
- As far as practical, truck drivers would avoid:
  - heavy acceleration and braking.
  - compression braking.
  - high speeds.
- Truck movements are to be restricted to the daytime period to the furthest extent possible.

Noise from idling trucks near construction sites can also impact on amenity in some instances. To minimise impacts associate with idling trucks, it is proposed that queuing of trucks awaiting entry to the site outside normal construction hours be restricted to locations away from residences. If trucks are

required to queue in such locations during construction hours, engines would be shut down. The finalised construction traffic arrangements would be reviewed during the detailed design phase of the M2 Upgrade project.

Equipment selection and maintenance

The contractor carrying out the construction works would select equipment taking into account noise and vibration emissions, such as (but not limited to):

- Smaller equipment options or rubber-tracked equipment where equipment is fit-for-purpose and economically feasible.
- Equipment to be provided with residential grade mufflers.

Equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse noise impacts.

Reversing alarms

The potential noise impact of reversing alarms would be minimised via a combination of proactive driver/operator training and operational procedures. The following mitigation strategies would be undertaken, taking into account that WorkCover OH&S requirements would need to be satisfied with respect to safety surrounding construction vehicles.

- The primary means for minimising reversing alarm noise would be through a dedicated effort on the part of construction equipment drivers to minimise, wherever feasible, the amount of reversing of their vehicles.
- Wherever feasible, turning circles would be created at the end points of vehicle work legs, which would allow trucks, compactors, water carts and the like, to turn and avoid the need for reversing.
- Emphasis would be placed during driver training and site induction sessions on the potential adverse impact of reversing alarms and the need to minimise their use.
- Using non-tonal reversing alarms or alternative devices where practical.
- Where it is not feasible to use these alternative devices, the construction contractor should consider traffic management practices to minimise reversing as far as tractable and arrange for construction vehicles and mobile plant to reverse predominantly away from noise-sensitive properties.

Equipment noise compliance checks

Regular checks of equipment noise levels would be made to ensure that noise levels do not increase as a result of poor maintenance practice or say the replacement of individual items of equipment with alternatives which have higher noise emissions.

Noise (and vibration) monitoring

A well-planned, noise monitoring programme would assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities as the works progress. Mitigation measures, including changes in work sequences or selection of smaller items of equipment, would then be put in place before significant disturbance occurs. The programme would include:

- Initial (pre-construction background) noise monitoring, and dilapidation surveys of properties determined as likely to be affected by ground borne noise and vibration prior to tunnelling works commencing.
- Ongoing monitoring of emissions at residences and other sensitive receivers during critical phases of the work.
- Ongoing compliance checks of critical plant and equipment.
- Investigation of complaints and follow-up monitoring to assess the effectiveness of adopted control strategies.
- The options for mitigating ground-borne noise generated from tunnel works are very limited, as physical attenuation devices are not available and procedural management measures are not feasible. It is therefore recommended that where exceedances are indicated, suitable consultation with affected residents take place accompanied by monitoring to confirm the predicted levels.

A targeted noise (and vibration if necessary) monitoring plan at nearest residential and sensitive receivers based, at least initially, on the predictions provided in this report, would be implemented to guide mitigation controls during critical stages of work.

Temporary construction noise walls

Wherever practicable, the proposed new noise walls would be constructed prior to the existing walls being taken down. However, due to access restrictions and the limited availability of space required, in a number of areas the existing noise walls (or part of the existing wall) would be demolished before the new wall can be erected.

In such situations a detailed assessment would be undertaken to determine the reasonable and feasible noise mitigation measures. Options such as the use of temporary noise walls would be considered and implemented where appropriate. Where required, temporary noise walls would be erected as soon as practicable after the existing walls are removed to minimise potential impacts on receivers in the area.

Moveable (temporary) noise barriers

Many activities associated with the M2 Upgrade project would involve large-sized plant travelling along the M2 Motorway, such as milling and asphalt laying. Temporary barriers for these types of activities are not generally practical.

The most noise-intensive activities associated with the M2 Upgrade project, namely concrete sawing, rockbreaking and the use of jackhammers, would be highly localised. Based on the outcomes of detailed assessments of potential noise impacts at each work location and scenario, the use of temporary and moveable noise barriers (for example, loaded vinyl ‘curtains’), would be implemented where reasonable and feasible. Such barriers are likely to generate noticeable decreases in the associated noise emissions to sensitive receivers.

Ground-borne noise mitigation (Norfolk Tunnel)

The options for mitigating ground-borne noise, such as noise resulting from the operation of a road header, are limited, as physical attenuation devices are not available and procedural management measures are not feasible. It is therefore proposed that where exceedances are indicated, suitable consultation with affected residents take place accompanied by monitoring to confirm actual conditions against the predicted levels.

Noise management versus noise control

The mitigation of noise impacts can often involve noise management as distinct from noise control. For example, the scheduling of noise-intensive activities may be an effective noise management strategy in the present instance.

To minimise noise impacts associated with the M2 Upgrade project, time restrictions would be placed on the most noise-intensive activities, especially concrete sawing, rockbreaking and the use of jackhammers in the vicinity of sensitive receivers. Where there is a definite requirement for such activities to be completed out of the normal construction hours, such activities would be restricted to the evening period in preference to the night period, where reasonable and feasible.

Similarly, with respect to the activities located in the vicinity of sensitive receivers, advanced notice of high noise activities would be provided and respite periods employed. In addition, concrete saws would not be used on two consecutive evenings in the same area where reasonably and feasibly practicable.

An important component of the noise management of the proposed works is comprehensive community consultation, which would continue throughout the construction programme. The community would be kept informed as to the nature, timing and duration of pending construction works, the nearest sensitive receivers likely to be affected and the monitoring programme associated with construction works.

Community liaison

To keep the community informed of the progress of the construction programme, a combination of internet-based information, community meetings, local newsletters, leaflets, newspaper advertisements and community notice boards would be considered as part of the M2 Upgrade project consultation strategy. A contact person would be nominated within the CNVMP to directly address noise and/or vibration complaints that the community may have during the construction phase of the M2 Upgrade project.

Targeted community consultation with residents in the vicinity of the night works is proposed during the public exhibition period for the proposal and would continue for the duration of the night works should the proposal be approved. Refer to Chapter 5 for further description of community consultation.

The community liaison process would be progressively ‘fine-tuned’ to meet the specific requirements of the particular works under consideration. Equipment selections and work activities would be continuously coordinated and modified where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints and other issues of concern, should they arise.

Vibration control

The following 'baseline' vibration mitigation measures would be implemented by the construction contractor where reasonably and feasibly practicable:

- Relocate vibration generating plant and equipment to areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of excavation plant and equipment, for example, smaller capacity rockbreaker hammers.
- Minimise consecutive works in the same locality (if applicable).
- Schedule a minimum respite period of at least half an hour before activities commence, which are to be undertaken for a continuous four hour period.
- Use only dampened rockbreakers and/or 'city' rockbreakers to minimise the impacts associated with rockbreaking works.
- The use of a roller class 'II Light' when operating as close as five metres from the closest buildings.
- Consider providing temporary alternative accommodation for affected residents during tunnelling works.

Construction monitoring requirements

Noise monitoring would be undertaken as required for assessment against the adopted construction noise goals where, subsequent to project approval, detailed construction noise impact assessments indicate potential for significant exceedance at the nearest impacted noise sensitive receivers. It is also proposed that vibration monitoring be carried out for assessment against the transient vibration guidelines (BS 7385 and DIN 4150) when working within the safe working distances, and where the vibration levels are predicted to be greater than the maximum recommended values.

Widening the Norfolk Tunnel

The potential noise impacts from the widening works, which are proposed to be performed entirely within the tunnel, would be mitigated with the use of acoustic sheds during the widening of the tunnel, together with an acoustic curtain at either end of tunnel at other times. The acoustic shed would only be in place for the excavation phase of the widening. Other night-time works within the tunnels would utilise a noise curtain at the tunnel portals/entrances. These measures would contribute to reducing noise generated from tunnelling works to acceptable levels.

For the early widening works (adjustment to the portal transition areas and breaking out of existing concrete barriers) there are limited mitigation measures available, as the options for physical noise attenuation devices and procedural management measures (such as scheduling of activities) would either not be effective or are not considered feasible. As described in Section 9.4.5, the predicted impacts of ground-borne and airborne noise is not expected to be significant when construction works are occurring entirely within the Norfolk Tunnel portals. It is proposed that where exceedances are predicted (or measured), suitable consultation with the affected land owners would take place to determine the appropriate feasible and reasonable management strategies, together with on-going monitoring to confirm predicted levels.