14 METEOROLOGICAL EFFECTS

The ENMM discuss assessment of traffic noise under changing meteorological conditions. It has been suggested that the *NSW Industrial Noise Policy (INP)* of the DECC be used to undertake the qualitative assessment of meteorological effects.

The *INP* discusses the effect of temperature inversions and wind. Both the temperature inversions and wind can enhance noise propagation from a source to receiver. The *INP* discusses procedures for this assessment. For the best confidence in the assessment it is required to have meteorological data for the area under consideration. In this case, meteorological data for Woomargama is unavailable. In such cases, the default conditions of the *INP* can be applied. The default conditions are temperature inversions of 3° per 100 metres in combination with a drainage wind of 2 metres per second from source to receiver where the receiver is below the noise source. In this case, the receivers are typically above the height of the bypass, hence the drainage wind has not been considered.

The prediction of traffic noise under different meteorological conditions is not well understood. The *CoRTN* algorithms used for prediction in this study do not include any methodology for different meteorological conditions. The following procedure was used to estimate the effect of these conditions:

- Noise propagation from the bypass was predicted using the Environmental Noise Model (ENM) from RTA Technology.
- A line source (to simulate the flow of traffic) representing the bypass was used and noise was predicted at all receivers under various meteorological conditions. We then have the noise at any receiver from the bypass under isothermal still conditions and under a temperature inversion of 3° per 100 metres. The difference in these two levels is typically 1 to 4dBA, depending on the location of the receiver with respect to the highway. This difference was then added to the predicted traffic noise level calculated from the *CoRTN* algorithms. In this way, the traffic noise level under various meteorological conditions was estimated.

The analysis shows that the temperature inversion increases noise levels by up to 3dBA at any residence. This increase in noise level exists only for the time of the temperature inversion.

The *INP* suggests that temperature inversions most likely occur for the hour immediately before and after sunrise. So while there may be an increase in noise level during those periods of between 1 to 3 dB, the effect over the entire 9 hour period of night time is an increase in $L_{Aeq,\,9\,hour}$ by less than 1dBA at most residences.

With respect to wind, there would be a similar increase in noise level if there were a continuous low velocity wind blowing toward a receiver.

As a result of this study of traffic noise increases under meteorological conditions; it is considered that possible increase in traffic noise levels due to meteorological conditions for Woomargama are within standard confidence levels of the *CoRTN* prediction procedure.

15 MAXIMUM NOISE LEVEL EVENTS

15.1 Guidelines

For road redevelopments the *ECRTN* and *ENMM* provide guidance as to the likelihood of sleep disturbance. The *ECRTN* points out the following:

- There are no universally accepted criteria governing the likelihood of sleep disturbance. In other words, at the current level of understanding, it is not possible to establish absolute noise level goals that would correlate to levels of sleep disturbance (for all or even a majority of people).

- The *ECRTN* suggests that :

  Maximum internal noise levels below 50dBA to 55dBA are unlikely to cause awakening reactions.

  One or two events per night, with maximum internal noise levels of 65dBA to 70dBA, are not likely to affect health and wellbeing significantly.

  At locations where road traffic is continuous rather than intermittent, the $L_{Aeq,9hour}$ target noise level should sufficiently account for sleep disturbance impacts.

  However, where the emergence of L_{Amax} noise levels over the L_{Aeq} noise level is greater than 15dBA, the $L_{Aeq,9hour}$ criteria may not sufficiently account for sleep disturbance impacts.

Thus, the *ECRTN* recommends that the assessment of sleep disturbance should include a consideration of the maximum noise level exceedances occurring during the night time period and the emergence of these exceedances above the ambient noise level.

The issue of sleep disturbance is addressed within the RTA's *ENMM* in a similar fashion.

- It is suggested that the assessment of sleep disturbance should include an examination of "maximum noise events": A "maximum noise event" is defined as any single event where the L_{Amax} noise level exceeds 65dBA and the L_{Amax} noise level exceeds the $L_{Aeq,1hour}$ noise level by more than 15dBA.

- "Maximum noise event" characteristics to be assessed at nearest residential receivers include their occurrence throughout the 10.00pm to 7.00am night time period and their magnitudes.

Due to the absence of definitive qualitative correlation between sleep disturbance and noise level, the *ENMM* suggests that the above nominated noise levels and guidelines should not be taken to be criteria, but should be taken into consideration when determining noise mitigation measures to address general road traffic noise.

The quoted noise levels are not intended as specific noise criteria for the purpose of implementing mitigation measures but to highlight the potential for awakening reactions and the consideration of this in the design of noise mitigation, where this is considered to be necessary to reduce overall noise levels.

15.2 Maximum Noise Level Assessment

Table 15-1 shows estimated maximum levels from the existing Hume Highway. The Table also shows that the levels exceed the threshold at residences in Woomargama and rural residences. As the Hume Highway will continue to be used after the opening of the bypass, the analysis will change only by the number of vehicles using the highway. Heavy vehicles passing along the Hume Highway might still cause awakening events in 2021, but there will be many fewer such events than in 2011. This relative change is shown by the numbers in the last two columns of the table.

Table 15-1 Maximum Noise Level Events – Existing Hume Highway

Location	$L_{Aeq,1hour}$ Noise Level (dBA) - Typical Night Time	Estimated L_{Amax} Noise Level (dBA)	By how much is L_{Amax} above the 65dBA Noise Threshold (dBA)	By how much is L_{Amax} above the $L_{Aeq,1hour}$ Noise Level (dBA)	No. of Vehicle Movements per hour - 2011	No. of Vehicle Movements per hour - 2021 with Bypass
Woomargama near Highway	65-68	70-74	5-9	5-6	200-220	10-20
Woomargama 50m from Highway	52-55	60-66	1	6-11	200-220	10-20
107, 108, 109	57	63-68	3	5-9	200-220	10-20
58	58	63-68	3	5-10	200-220	10-20
117	57	63-68	3	5-10	200-220	10-20

Table 15-2 shows the maximum noise levels for the bypass. In general, the maximum noise levels will be much less in Woomargama village, but will increase for the rural residences in close proximity to the bypass.

Table 15-2 Maximum Noise Level Events – Bypass

Location	$L_{Aeq,1hour}$ Noise Level (dBA) - Typical Night Time	Estimated L_{Amax} Noise Level (dBA)	By how much is L_{Amax} above the 65dBA Noise Threshold (dBA)	By how much is L_{Amax} above the $L_{Aeq,1hour}$ Noise Level (dBA)	No. of Vehicle Movements per hour - 2011	No. of Vehicle Movements per hour - 2021 with Bypass
Woomargama near Highway	<50	<50	-	-	-	-
Woomargama 50m from Highway	<50	<50	-	-	-	-
107, 108, 109	58	63-68	3	5-9	-	190-210
58	59	60-67	2	1-8	-	190-210
117	60	66-71	6	6-11	-	190-210

16 CONSTRUCTION NOISE

16.1 Construction Noise Criteria for Residences

Guidelines for the assessment of construction noise in New South Wales (NSW) are specified in the *Environmental Noise Control Manual (ENCM)*, Chapter 171 (NSW EPA, 1994).

The construction noise objectives presented in the *ENCM*, Chapter 171 are as follows:

- For periods of four weeks or less, the L_{A10} level should not exceed the background (L_{A10}) level by more than 20dBA;
- For periods greater than four weeks and less than 26 weeks, the L_{A10} level should not exceed the background (L_{A10}) level by more than 10dBA.

Although not clearly stated by the DECC, it is considered that for construction periods longer than 26 weeks, as is the case with the Woomargama Bypass, the L_{A10} noise level should not exceed the background (L_{A10}) level by more than 5 dBA.

In addition, the DECC suggests the following time restriction for the construction activities where the noise is audible at residential premises:

- Monday to Friday 7.00am - 6.00pm
- Saturday 8.00am - 1.00pm (if audible on residential premises, otherwise 7.00am to 1.00pm)
- No construction work is to take place on Sundays or Public Holidays.

However, if night time construction is required for the project, it recommended that the L_{A10} should not exceed the existing night background (L_{A10}) by more than 5dBA.

Additionally, peak noise levels have the potential to cause sleep disturbance. The DECC's current sleep disturbance criterion is the $L_{A1,\ 1minute}$ should not exceed the background L_{A90} by more than 15dBA.

The DECC also recommends generally that all possible steps should be taken to reduce noise levels of construction site equipment so as to minimise the impact of construction noise.

16.2 Construction Working Hours

The majority of construction activities would take place from 6am to 7pm, Monday to Friday, and 7am to 4pm Saturday (the daytime period), with no work on Sunday or public holidays. However, certain activities would be required to take place during the evening and night-time periods due to:

- Technical considerations (such as the need to meet particular quality specifications for placement of concrete pavement).
- The climatic environment (cold winters and hot summers).
- An accelerated construction program.

The proposed working hours and associated activities are outlined in Table 16-1.

Table 16-1 Construction working hours and associated activities

Day	Time	Activity
Monday to Friday	Daytime (6am to 7pm)	▪ Compound operation. ▪ Earthworks. ▪ Structures. ▪ Drainage. ▪ Ancillary/ finishing works. ▪ Paving. ▪ Concrete saw cutting. ▪ Concrete batch plant operation. ▪ Maintenance activities. ▪ Blasting activities (would only occur between 9am and 5pm and be limited to two blasts per day).
	Evening (7pm to 10 pm) and Night-time (10pm to 6am)	▪ Compound operation. ▪ Paving. ▪ Concrete saw cutting. ▪ Concrete batch plant deliveries. ▪ Concrete batch plant operation. ▪ Commissioning of services.
Saturday	Daytime (7am to 4pm)	▪ Compound operation. ▪ Deliveries. ▪ Earthworks. ▪ Structures. ▪ Drainage. ▪ Ancillary/finishing works. ▪ Paving. ▪ Concrete saw cutting. ▪ Concrete batch plant deliveries. ▪ Batch plant operation. ▪ Maintenance activities.
Sunday and public holiday	No scheduled work	

Construction activities not identified above would be undertaken during the daytime or, if in the evening and night-time periods, only if:

- Works do not cause construction noise to be audible at any sensitive receiver; or
- Delivery of materials is required by the Police or other authorities for safety reasons; or
- Work is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm; or
- On a case-by-case or activity specific basis, which would be subject to consultation with the Department of Planning, the Department of Environment and Climate Change (DECC) and affected sensitive receivers.

16.2.1 Justification for activities in the evening and night-time periods

Concrete paving

The RTA has specifications for placement of concrete pavement that relate to temperature and rainfall. For jointed concrete base, the specifications prohibit the placement of concrete during rain or when the ambient air temperature is below 5°C or above 32°C. As hot weather affects the quality of concrete pavement, paving in the early evening and into the night is recommended as it takes advantage of night-time cooling. For cold weather concreting, early morning paving is recommended, to take advantage of daytime solar radiation and heat generation to promote concrete strength.

It is highly likely that concrete paving would need to be carried out during summer. Due to the climatic conditions experienced in the region during summer months, where daytime ambient temperatures often exceed the maximum temperature threshold of 32°C, concrete paving would need to occur during the day, evening and night-time periods as indicated in Table 16-1.

Concrete saw cutting

The project would most likely use plain concrete pavement, which is an unreinforced pavement. To manage cracking associated with drying shrinkage, saw cutters would be used to cut the pavement (usually in 4.2 metre long sections). The timing of concrete cutting is governed by the hydration rate of the pavement, and may require cutting at any time within four and 24 hours after paving, with a ‘cutting window’ as short as 30 minutes. As the timing of cutting is critical to the quality of the pavement and acceptance of the finished product, concrete saw cutting may need to be undertaken at any time, including outside normal construction hours. Concrete saw cutting is a construction activity that is transient in nature, and each ‘saw cut’ would be of a short duration.

As mentioned above, concrete paving is highly likely to be carried out during summer months. Following concrete paving, concrete saw cutting would take place within a four and 24 hour period, during the day, evening and night-time periods as indicated in Table 16-1.

Concrete batch plant operation and deliveries

Wet and dry concrete batch plants are proposed as part of the project. The wet concrete batch plant would need to operate approximately one month prior to and in conjunction with concrete paving works, including during the evening and night-time periods as indicated in Table 16-1.

A dry concrete batch plant would be operational for the entire construction period to supply concrete to a number of other project components, including during the evening and night-time periods.

To keep up with materials demand during the peak periods of concrete production, the batch plants would likely require materials deliveries outside of normal working hours. Due to the regional location of the project, the timing of deliveries may be determined by the pattern of supplier fleet movements (ie at night).

The number of deliveries would be dependent on the size of the batch plant and its storage capabilities. There is potential for up to eight deliveries per night during peak production periods.

Concrete batch plant deliveries may be undertaken during the evening and night-time periods during the following hours:

- 12am to 6am and 7pm to 12pm Monday to Friday.

Maintenance activities and site compound operation

Maintenance and operation of the site compound would be required to support the activities described above.

16.3 Project Specific Criteria

The criteria specific to this project are shown in Table 16-2, based on the measured RBLs. For the village the criteria are based on the levels measured in Woomargama (Location E).

For rural properties, criteria have been based on the lowest levels measured at any property.

For this project daytime construction hours are 6.00am to 7.00pm. As the hour from 6.00am to 7.00am is normally considered night time, it has been considered separately and denoted "early morning". The hour from 6.00pm to 7.00pm is normally considered evening, but as the RBLs for this period were similar to the RBLs for daytime, it was included in the assessed daytime period.

The background noise changes throughout the day as traffic flow changes on the Hume Highway. The early morning background (6am-7am) is therefore higher than the background for the remainder of the daytime period.

Table 16-2 L_{A10} Construction Noise Criteria

Receiver	L_{A10} Construction Noise Criteria (dBA)				Sleep Disturbance L_{A1}, dBA	
	Early Morning (6am-7am)	Daytime (7am- 7pm) *	Evening (7pm- 10pm)	Night (10pm-6am)	Early Morning (6am-7am)	Night (10pm-6am)
Village	45	43	49	38	55	48
Isolated Residences	45	41	47	36	55	46

* including DECC Early Evening (6.00pm to 7.00pm)

16.4 Assessment of Noise from Mobile Plant

The construction stages proposed by the Hume Highway Woomargama Alliance are shown in Table 16-3.

Table 16-3 Construction Stages

Construction phase	Activities	Plant and equipment	
Preconstruction			
Investigations	▪ Land acquisition. ▪ Survey of construction footprint. ▪ Geotechnical investigations.	▪ Survey equipment ▪ Backhoes ▪ Water carts	▪ Drilling equipment ▪ Excavators ▪ Explosives
Environmental management system (EMS)	▪ EMS. ▪ Environmental management plans. ▪ Statutory approvals and licensing.	-	
Property adjustments	▪ Fencing of construction site boundary. ▪ Relocation of farm fencing. ▪ Notify residents of commencement of work.	▪ Augers ▪ Backhoes/Excavators ▪ Light vehicles	
Site access	▪ Temporary sidetracks tie-in — north and south.	▪ Graders ▪ Dozers ▪ Loaders ▪ Compactors ▪ Excavators ▪ Light vehicles ▪ Cranes	▪ Scrapers ▪ Trucks and dogs ▪ Water carts ▪ Rollers ▪ Backhoes ▪ Concrete batch plants.
Site establishment and preparation	▪ Demarcation of environmentally sensitive areas. ▪ Establishment of site compounds and other construction support facilities (including crib facilities). ▪ Services/utilities provision and relocation.	▪ Graders ▪ Dozers ▪ Loaders ▪ Compactors	▪ Scrapers ▪ Trucks and trailers ▪ Water carts ▪ Rollers

Construction phase	Activities	Plant and equipment	
	▪ Installation of erosion and sediment control measures (temporary sediment control basins, silt fences and cross drainage). ▪ Establishment of turn in/turn out lanes. ▪ Minor access road ▪ Construction of temporary creek crossings. ▪ Minor clearing of non-threatened species ▪ Construction of temporary access for landowners and operators of equipment on Mount McKenzie.	▪ Excavators ▪ Light vehicles ▪ Cranes	▪ Backhoes ▪ Concrete batch plants.
Construction			
Earthworks	▪ Clearing and grubbing of vegetation. ▪ Mulching. ▪ Stripping and stockpiling of topsoil. ▪ Pavement drainage. ▪ Excavation of cuttings. ▪ Rock blasting (if required). ▪ Stockpiling of materials. ▪ Processing of excavated material (rock crushing and screening).	▪ Rollers ▪ Trenchers ▪ Primary and secondary screeners ▪ Loaders ▪ Drilling rigs ▪ Backhoes ▪ Trucks ▪ Dozers	▪ Scrapers ▪ Graders ▪ Excavators ▪ Water carts ▪ Trucks and trailers ▪ Compactors ▪ Explosives trucks
Bridgeworks	▪ Embankment construction. ▪ Structure construction. ▪ Finishing works.	▪ Jack hammers ▪ Cranes ▪ Boom lifts ▪ Concrete pumps ▪ Welders ▪ Pumps	▪ Excavators ▪ Trucks ▪ Pile rigs ▪ Drill rigs ▪ Trucks ▪ Concrete trucks

Construction phase	Activities	Plant and equipment	

Other works	▪ Property accesses.
	▪ Local road intersections.
	▪ Tie-ins.
	▪ Permanent sedimentation and erosion control:
	  ‣ Run-off collection pond and erosion protection downstream.
	  ‣ Vegetated medians and swales, cross drainage, diversion and drains (if required).
	▪ Removal of redundant Hume Highway sections (if required).
		▪ Texture curers
		▪ Water carts
		▪ Resin trailers
		▪ Jack hammers
		▪ Grinders
		▪ Saw cutters
			▪ Backhoes
			▪ Trucks
			▪ Concrete trucks
			▪ Pavers
			▪ Excavators
			▪ Rock hammers

Road base	▪ Placement and compaction of road base. ▪ Watering and further compaction.	▪ Rollers ▪ Multi-tyre rollers ▪ Excavators ▪ Suction trucks ▪ Graders	▪ Sprayers ▪ Trucks ▪ Tankers ▪ Front end loaders
Paving	▪ Operation of batching plants. ▪ Gravel base/sub-base layers and asphalt paving (flexible pavement). ▪ Placement of debonding layer. ▪ Concrete paving (rigid pavements).	▪ Backhoes ▪ Trucks ▪ Concrete trucks ▪ Pavers ▪ Texture curers ▪ Water carts ▪ Cranes	▪ Concrete batch plants ▪ Generators ▪ Hammers ▪ Grinders ▪ Resin trailers ▪ Saw cutters
Finishing works	▪ Safety barrier(s) ▪ Bridge drainage system (Mountain Creek) ▪ Lighting ▪ Line marking	▪ Side tippers ▪ Rollers ▪ Water carts ▪ Excavators	▪ Saw cutters ▪ Concrete trucks ▪ Jack hammers ▪ Trucks

Construction phase	Activities	Plant and equipment	
	▪ Signposting ▪ Signage ▪ Site clean up and restoration ▪ Landscaping and revegetation	▪ Trucks and trailers ▪ Graders ▪ Sweepers ▪ Rubber tyred excavators ▪ Pavers	▪ Tenders ▪ Cranes ▪ Auger/excavators ▪ Concrete pumps ▪ Line making trucks ▪ Sweepers ▪ High pressure cleaners

16.4.1 Mobile Plant Source Noise Levels

Sound levels of typical equipment are listed in Table 16-4.

The Table gives both Sound Power Level (SWL) and Sound Pressure Level (SPL) at 7 metres for the equipment. SWL is independent of measurement position. Verification of plant noise is typically done by measuring the SPL at 7 metres.

Table 16-4 Typical Construction Plant Sound Levels

Plant	Sound Power Level (dBA)	Sound Pressure Level at 7m (dBA)
Front End Loader	111	86
Grader	107	82
Smooth Drum Roller	107	82
Spoil, Materials or Concrete Truck	109	84
Tower Crane or Mobile Crane	105	80
Truck-mounted Shotcrete Pump	106	81
Excavator or Bobcat	107	82
Concrete Pump	105	80
Concrete Vibrator	103	78
Concrete Cutter	109	84
Large Bored Drilling Rig	112	87
Small Bored Drilling Rig	108	83
Powered Hand Tools	109	84
30t Excavator operating with hydraulic hammer	122	97
Rock Saw	116	91
Water Cart	110	85
Kerbing Machine	99	74
Chainsaw	106	81
Forklift	106	81
Mulcher	106	81
Articulated Dump Truck	113	88
Handheld Jackhammer	113	88
Air Compressor (Power Tools)	98	73
Asphalt Paving Plant	114	89

16.4.2 Typical Activity Noise Levels

Based on the above, noise from some example activities has been predicted. While noise has not been predicted from every activity shown in Table 16-5, the stages are considered representative of the majority of activities.

Table 16-5 Calculation of Total Sound Power Level (SWL)

Activity	Typical Equipment Used	Total $L_{A10,15min}$ Sound Power Level (SWL) used for Calculations
Milling and repaving	Road Trucks, Compactor, multi tyred and vibratory Rollers, Asphalt paving plant, Backhoe, Profiler, Sweeper, Compressors, Generators	113
Site establishment	Excavators, Chainsaws, Mulching plant and Chipper, Cranes, Generators	111
Removal of corridor vegetation	25t Excavator, Mulcher, Chainsaw, Trucks, Grader, Combination Backhoe FEL	113
Earthworks	Road Trucks, Compactor, Grader, Steel, multi tyred and Vibratory Rollers, Concrete pour, including Trucks and Concrete Vibrator, Asphalt paving plant, Backhoe, Sweeper, Compressors, Generators, (Excavator with hammer)	114 (120)
Piling	Bored or driven piling rigs	115 (bored) – 120 (driven)
Bridge works	Piling rigs, cranes	115 – 120 (possible when piling)
Paving	Road Trucks, Compactor, (Jackhammers), Steel, multi tyred and vibratory Rollers, Concrete Pour, including Trucks & Concrete Vibrator, Asphalt paving plant, Backhoe, (Concrete saw), Profiler, Sweeper, Compressors, Generators	113 (116)
Landscaping of exposed areas	Excavator/Bobcat, Powered Hand Tools, Air Compressor, Spoil, Material or Concrete truck, Jackhammer (for concrete embedded parts)	111

Note: The Table shows the typical maximum sound power level predicted for each activity. The figures in brackets are for the occasional use of rock breakers, jackhammers and concrete saws.

16.4.3 Works Schedule and Proposed Working Hours

Table 16-6 shows the duration of construction activities, and an estimate of how long each activity would potentially cause noise impacts at any group of residences.

Table 16-6 Predicted Duration of Noise Impact of Construction Activities

Activity	Expected Duration of Impact at any Residence
Removal of corridor vegetation, fencing	2-3 weeks
Bulk earthworks	3 to 6 months
Bridges	6-8 months
Paving	2-4 weeks

16.4.4 Noise to Residences

The noise level experienced at any residence along the route will depend upon many factors, such as distance to the construction site, shielding between the site and the residence, and the activity occurring at the construction site. The quietest activities, such as site preparation, would be up to 20dBA quieter than the noisiest activities if earthworks, using rock breakers, are used. Further, noise levels would be quieter whenever the construction takes place in cut compared with that undertaken on fill. The construction site is also long – more than 5km. As activities move along the corridor noise will change at any residence.

As the construction site moves, residences are typically not exposed to line of sight view of paving equipment for an extended period of time (i.e. more than a few days or a week). Noise impact at some residences is therefore restricted to a limited time period.

Table 16-7 show the predicted noise levels of construction activities. For each residence (or group of residences) the table shows the daytime criterion, and a range of noise levels to be expected from each activity. The table gives a maximum level based on construction at the nearest point to the residence. The “typical” level in the table is an estimated noise level that would be audible for a significant time. Owing to the length of the project there will be times when construction activities will be inaudible.

Daytime road work noise satisfies the criterion at all village residences. Exceedances are predicted at the rural residences along the route, particularly during piling or when earthworks begin before 7.00am. From roadwork activities (such as earthworks along the alignment) the predicted exceedances are up to 16dBA at Location 117 when the road site construction is at the closest point.

To predict noise from piling and bridge structure construction, distances to creek crossings were estimated.

Noise from piling is predicted to exceed the daytime criterion at several of the rural houses. The worst case is again Location 117 where the exceedance could be up to 19dBA before 7.00am, and 23dBA after 7.00am. The extent of the noise impact will depend on the final requirements for impact piling. As with piling, noise from construction of bridge structures will depend on the final design of the bridges.

Table 16-8 and Table 16-9 show predicted levels from necessary evening and night time works. This is typically concrete cutting as part of pavement construction. Predicted noise levels are within 3dB of the evening criteria. Exceedances up to 20dBA are predicted at Location 117 during paving at night.

Table 16-9 also show the predicted maximum noise levels. The typical maximum sound level (measured as $L_{A1,1min}$ for assessing sleep disturbance) is estimated to be 118dBA for both paving and sawcutting. As the source level is the same for both sources, they have been combined in the table. The predicted levels are assessed against the sleep disturbance criteria for night time (10.00pm to 6.00am), and the early morning period (6.00am to 7.00am) which for this project is being considered as part of daytime.

The sleep disturbance criterion predicted to be exceeded at up to 10 residences during the night time period as shown in the table. During the early morning period the sleep disturbance criterion is exceeded at three residences.

Table 16-7 Predicted Construction Noise Levels - Daytime

Receiver	Criterion, $L_{A10,15min}$ dBA		Noise Levels, $L_{A10,15min}$ dBA									
	6am-7am	7am-7pm	Site Preparation		Earthworks		Piling		Bridge Structure		Paving	
			Typical	Max	Typical	Max	Typical	Max	Typical	Max	Typical	Max
102	45	41	39	**45**	**42**	**48**	**43**	**49**	38	**44**	41	**47**
103	45	41	37	**43**	40	**46**	41	**47**	36	**42**	39	**45**
105	45	41	34	40	37	**43**	38	**44**	33	39	36	**42**
109	45	41	41	**47**	**44**	**50**	**50**	**53**	**45**	**48**	**43**	**49**
113	45	41	10	16	13	19	19	25	14	20	12	18
116	45	41	42	**48**	**45**	**51**	**55**	**57**	**50**	**52**	**44**	**50**
117	45	41	**48**	**54**	**51**	**57**	**63**	**64**	**58**	**59**	**50**	**56**
125	45	41	**46**	**52**	**49**	**55**	**50**	**52**	**45**	**47**	**48**	**54**
168	45	41	**47**	**53**	**50**	**56**	**51**	**54**	**48**	**49**	**49**	**55**
126	45	41	**42**	**48**	**45**	**51**	**53**	**54**	**48**	**49**	**44**	**50**
127	45	41	38	**44**	41	**47**	**53**	**54**	**48**	**49**	40	**46**
121 Village Close	45	43	31	37	34	40	35	41	30	36	33	39
135 Village Far	45	43	29	35	32	38	33	39	28	34	31	37

Note: Bold text presents an exceedance of the criteria.

Table 16-8 Predicted Construction Noise Levels – Evening Time

Receiver	Noise Levels - $L_{A10,15min}$ Intrusiveness Assessment				
	Paving and Concreting			Sawcutting	
	Criterion, $L_{A10,15min}$ dBA	Typical	Max	Typical	Max
102	47	41	47	44	**50**
103	47	39	45	42	**48**
105	47	36	42	39	45
109	47	43	**49**	46	52
113	47	12	18	15	21
116	47	44	**50**	47	**53**
117	47	**50**	**56**	53	59
125	47	**48**	**54**	51	57
168	47	**49**	**55**	**52**	**58**
126	47	44	**50**	47	**53**
127	47	40	46	43	**49**
121 Village Close	49	33	39	36	42
135 Village Far	49	31	37	34	40

Note: Bold text presents an exceedance of the criteria.

Table 16-9 Predicted Construction Noise Levels – Night Time

Receiver	RBL	Intrusiveness of Construction Noise, $L_{A10,15min}$ dBA					Sleep Disturbance Levels, $L_{A1,1min}$ dBA			
		Criterion 10.00pm to 7.00am	Noise Level, Paving		Noise Level, Sawcutting		Criterion 10.00pm to 6.00am	Criterion 6.00am to 7.00am	Noise Level, maximum event	
			Typical	Max	Typical	Max			Typical	Max
102	31	36	**41**	**47**	**44**	**50**	46	55	46	**52**
103	31	36	**39**	**45**	**42**	**48**	46	55	44	**50**
105	31	36	**36**	**42**	**39**	**45**	46	55	41	**47**
109	31	36	**43**	**49**	**46**	**52**	46	55	**48**	**54**
113	31	36	12	18	15	21	46	55	17	23
116	31	36	**44**	**50**	**47**	**53**	46	55	**49**	**55**
117	31	36	**50**	**56**	**53**	**59**	46	55	**55**	**61**
125	31	36	**48**	**54**	**51**	**57**	46	55	**53**	**59**
168	31	36	**49**	**55**	**52**	**58**	46	55	**54**	**60**
126	31	36	**44**	**50**	**47**	**53**	46	55	**49**	**55**
127	31	36	**40**	**46**	**43**	**49**	46	55	45	**51**
121 Village Close	33	38	33	**39**	36	**42**	48	55	38	44
135 Village Far	33	38	31	37	34	**40**	48	55	36	42

Note: Bold text presents an exceedance of the criteria.

16.5 Assessment of Noise from Concrete Batching Plant

Three batching plants have been proposed. Figure 16-1 shows the potential locations of the batching plants that will be spaced along the project.

Sinclair Knight Merz (SKM) has provided noise measurements of a batching plant used at Coolac which will be typical for this project. The dominant noise sources of the plant are described in Table 16-11.

Table 16-10 Dominant Noise Sources of Batching Plant

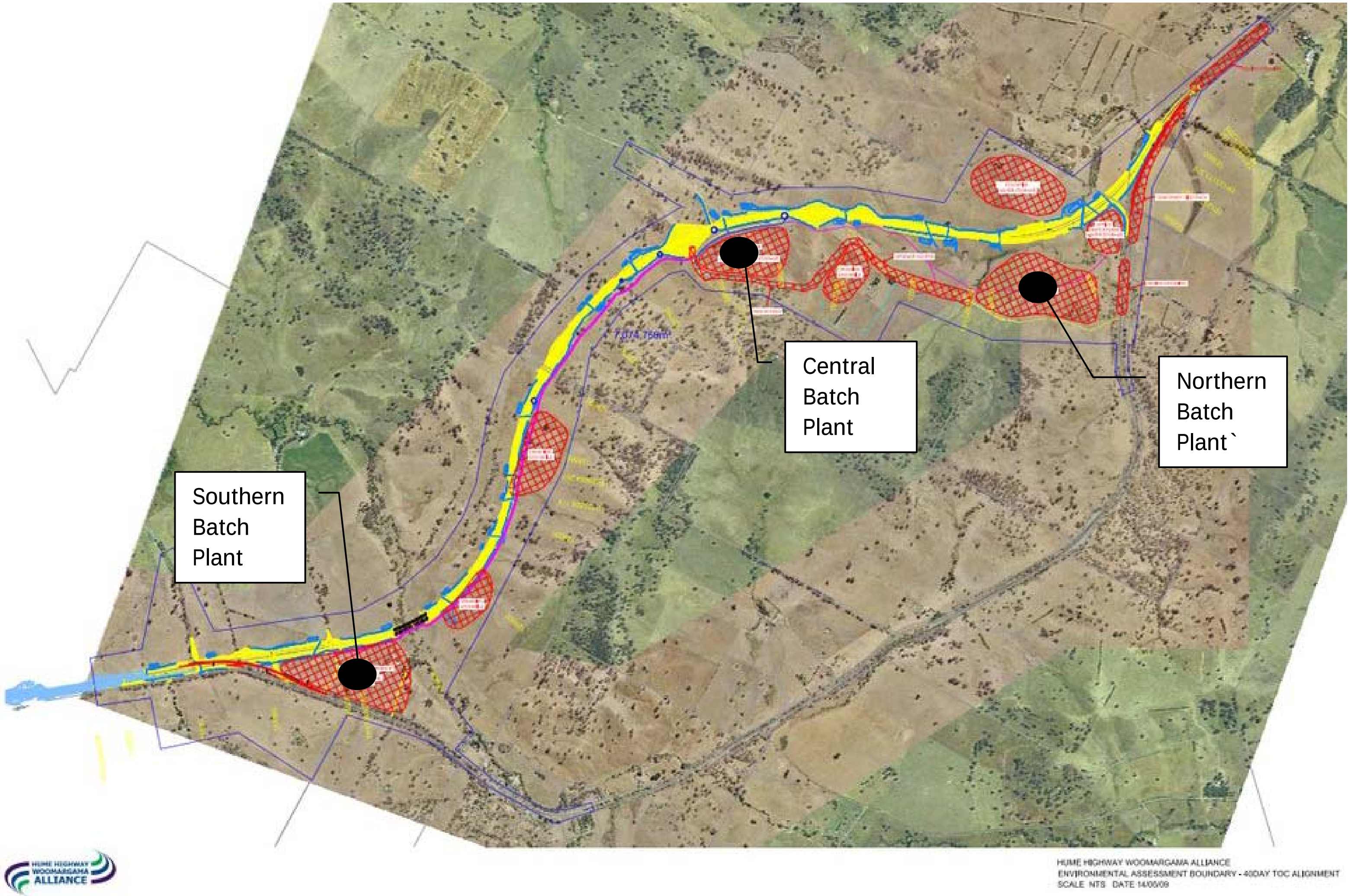
Noise Source	Description
Aggregate loading	A front end loader (FEL) is used to load aggregate and sand from the stockpiles into the hoppers (Two used on Hume Highway Southern Alliance project).
Aggregate hopper gates	The aggregate is loaded onto the conveyors via gates which are controlled by compressed-air power rams. There is a significant air release each time gates are opened.
Aggregate conveyor	The aggregate is loaded to the mixing drum via a conveyor. The conveyor is driven by an electric motor and runs on rollers, which squeal if not properly lubricated.
Dust extraction fan	The dust extractor fan is externally mounted.
Vibratory aggregate hopper cleaner	This cleaner is activated in each batch to ensure all product has been loaded and emits a mid-frequency hum.
Mixing drum	Rotation powered by an electric motor and tilts into the waiting truck.
Truck movements	Truck movements as in above table.
Compressor	Used to operate aggregate hopper gates, externally mounted
Generator	A diesel generator is required at both batching plants. Emergency use only if connect to the grid.
Cement loading	Cement is pneumatically loaded to the silo using a blower on the silo.
Reverse beepers	Trucks at the Coolac site were required to reverse into the loading bay. However, beepers were not a dominant noise source.
Light vehicles	Regular movements for worker transport and various site activities. Did not contribute significantly to overall plant noise.

The total noise level of the plant is the combined noise of the plant (sound level 110dBA), two front end loaders (111dBA each), and two concrete trucks (109dBA each). The combined sound power level of 117dBA is similar to the levels measured by Wilkinson Murray at similar facilities.

For the possibility of after hours deliveries, the estimated source level is $L_{A10,15min}$ 115dBA – equivalent to one truck and one front end loader.

For sleep disturbance assessment a maximum level of L_{A1} 120 dBA is assumed.

Figure 16-1 Proposed Batch Plant Locations



16.5.1 Noise to Residences

Predicted noise levels from the batching plants and compounds are given in Table 16-11. As the final site of the batching plants is not yet fixed, a range of levels has been given based on the areas of disturbance shown in Figure 16-1. These levels are based on there being a direct line of sight from the houses to the batching plants. The final locations could be chosen to take advantage of local shielding by topography.

Exceedances of daytime criterion are predicted at Location C for the northern batching plant. After hours deliveries are predicted to exceed the night time criterion at Location 116, 107, 108 and 109. The amount of exceedance will depend on the final location of the plant.

The central batching plant is predicted to comply with noise criteria at all residences due to its distance. It will be approximately 2000m from the nearest residence.

For the southern batching plant exceedances of the daytime criterion are predicted at Location 117, Location 126 and Location 127. After hours deliveries will also exceed the night time criterion at these residences. There are also possible exceedances at Location 102, Location 103, and at the closer village residences during night time. The amount of exceedance, and number of residences impacted, will depend on the final location of the plant.

Table 16-12 show the predicted maximum noise levels. They are assessed against the sleep disturbance criteria for night time (10.00pm to 6.00am), and the early morning period (6.00am to 7.00am).

Table 16-11 Predicted Noise Levels from Batching Plants and Compounds

Receiver	Distance to Plant	Early Morning (6am-7am) Criterion $L_{A10,15min}$ dBA	Daytime (7am-7pm) Criterion $L_{A10,15min}$ dBA	Evening (7pm-10pm) Criterion $L_{A10,15min}$ dBA	Night Time Criterion $L_{A10,15min}$ dBA	Batching Plant $L_{A10,15min}$ dBA	After Hours Deliveries $L_{A10,15min}$ dBA
Northern Batching Plant							
109	800-1000m	45	41	47	36	42-45	38-41
116	100-400m	45	41	47	36	50-68	46-64
Central Batching Plant							
All Residences	>2000	45	41	47	<36	<35	<35
Southern Batching Plant							
117	100-500m	45	41	47	36	52-68	48-66
102, 103	>1000	45	41	47	36	<45	35-42
126	500-800	45	41	47	36	49-52	45-50
127	500-800	45	41	47	36	49-52	45-50
121 Village Close	800-1000	45	43	49	38	<45	<41
135 Village Far	>1300	45	43	49	38	<45	<36

Table 16-12 Predicted Construction Noise Levels – Sleep Disturbance - Batching Plants and Compounds

Receiver	Distance to Plant	Sleep Disturbance Night Time Criterion Criterion, $L_{A1,}$ dBA	Sleep Disturbance Early Morning (6am-7am) Criterion, $L_{A1,}$ dBA	Batching Plant $L_{A10,15min}$ dBA	After Hours Deliveries $L_{A10,15min}$ dBA
Northern Batching Plant					
109	800-1000m	48	55	45-48	42-46
116	100-400m	48	55	53-71	51-69
Central Batching Plant					
All Residences	>2000	48	55	<38	<38
Southern Batching Plant					
117	100-500m	48	55	55-71	52-71
102, 103	>1000	48	55	<48	40-47
126	500-800	48	55	52-55	50-55
127	500-800	48	55	52-55	50-55
121 Village Close	800-1000	46	55	<48	<46
135 Village Far	>1300	46	55	<48	<41

16.6 Mitigation of Construction Noise

Reduction of construction noise for night time road works is often impractical. For example if temporary screens are proposed a significant part of the shift might be used in setting up and taking down noise control, thereby extending the duration of the project. Often it is appropriate to mitigate impacts in consultation with residents most affected by the noise.

Best practice mitigation and management measures will be used to minimise construction noise and vibration at noise sensitive receivers and will be described in a construction noise management plan.

The plan would include procedures for:

- A notification and negotiation procedure will be developed for residences where noise impact cannot be mitigated to meet the criteria;
- An undertaking not to create audible noise at any sensitive receiver unless a negotiated agreement (as defined under the Industrial Noise Policy (EPA, 2000)) is in place;
- A procedure for dealing with and responding to complaints; and
- Noise monitoring and auditing procedures will be developed to verify compliance with the predicted noise impacts.

In general, management of noise and vibration requires attention to the following:

- Construction hours.
- Noise and vibration monitoring on site and at sensitive receivers.
- Training and awareness.
- Communication.
- Incident and emergency response.
- Non-conformance, preventative and corrective action.

Where appropriate the specific noise mitigation measures could include:

- Mitigation of specific noise sources may be possible by using portable temporary screens.
- For extended periods of driven piling and use of rock breakers, respite periods might be considered.
- Maximising the offset distance between noisy plant items and sensitive receivers.
- Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.
- Orienting equipment away from sensitive receivers.
- Carrying out loading and unloading away from sensitive receivers.
- Using dampened tips on rock breakers.
- Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks.
- Selecting plant and equipment based on noise emission levels.
- Using alternative construction methods to minimise noise levels.
- Providing alternative arrangements with affected residents such as temporary relocation.
- Selecting site access points and roads as far as possible away from sensitive receivers.
- Using spotters, closed circuit television monitors, “smart” reversing alarms, or “squawker” type reversing alarms in place of traditional reversing alarms.

Education and training of site staff is necessary for satisfactory implementation of noise mitigation measures. Education and training strategies should focus on:

- Site awareness training / environmental inductions that include a section on noise mitigation techniques / measures to be implemented throughout the project.
- Ensuring work occurs within approved hours.
- Locating noisy equipment away from sensitive receivers.
- Using noise screens for mobile plant and equipment.
- Ensuring plant and equipment is well maintained and not making excessive noise.
- Turning off machinery when not in use.

The potential noise mitigations that can be achieved by noise mitigation measures are shown in Table 16-13.

Table 16-13 Noise Mitigation Measures

Management Measure	Anticipated Noise Reduction, dBA
Administrative Controls	
Operate during approved hours	N/A
Undertake regular noise monitoring to determine the impact of operating plant on sensitive receivers	N/A
Appropriate training of onsite staff	N/A
Undertake community consultation and respond to complains in accordance with established project procedures	N/A
Turning off machinery when not in use	0-5
Respite periods for pile drivers and rock breakers	N/A
Engineering Controls	
Portable temporary screens	5-10
Screen or enclosure for stationary equipment	10-15
Maximising the offset distance between noisy plant items and sensitive receivers.	3-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.	2-3
Orienting equipment away from sensitive receivers.	3-5
Carrying out loading and unloading away from sensitive receivers.	3-5
Using dampened tips on rock breakers.	3-6
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks	5-10

Management Measure	Anticipated Noise Reduction, dBA
Selecting site access points and roads as far as possible away from sensitive receivers	3-6
Using spotters, closed circuit television monitors, “smart” reversing alarms, or “squawker” type reversing alarms in place of traditional reversing alarms	2-5
Employ non noise-generating structures such as site offices, storage sheds, stockpiles and tanks as noise barriers	5-10

17 ASSESSMENT OF CONSTRUCTION VIBRATION

17.1 Vibration (Excluding Blasting)

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

17.1.1 Human Comfort

The DECC's *Assessing Vibration: A Technical Guideline* provides acceptable values for continuous and impulsive vibration in the range 1-80Hz. Both preferred and maximum vibration limits are defined for various locations and are shown in Table 17-1.

Table 17-1 Preferred and Maximum Peak Particle Velocity (PPV) Values for Continuous and Impulsive Vibration

Location	Assessment Period (1)	Preferred Values	Maximum Values
Continuous Vibration			
Critical areas (2)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices, schools, educational institutions and places of worship	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2
Continuous Vibration			
Critical areas (2)	Day or night time	0.14	0.28
Residences	Daytime	8.6	17.0
	Night time	2.8	5.6
Offices, schools, educational institutions and places of worship	Day or night time	18.0	36.0
Workshops	Day or night time	18.0	36.0

Notes: 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 or impulsive criteria for critical areas. Source BS 6472-1992.

These limits relate to a long-term (16 hours for daytime), continuous exposure to vibration sources. Where vibration is intermittent, a vibration dose is calculated and acceptable values are shown in Table 17-2.

Table 17-2 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (1)		Night Time (1)	
	Preferred Value	Maximum Values	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

Notes: 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 or impulsive criteria for critical areas. Source BS 6472-1992.

17.1.2 Building Damage

In regard to potential building damage, German Standard DIN 4150 (Table 1) shows guideline values for short term vibration for commercial buildings, houses and heritage buildings which are dependent on the frequency of vibration. The recommended vibration level for sensitive heritage buildings ranges from 3 to 10mm/s, and 5 to 20mm/s for dwellings.

17.1.3 Source Levels of Vibration

Table 17-3 provides some estimated vibration levels at a range of distances from the various construction activities.

Table 17-3 Typical Vibration Emission Levels from Construction Plant

Activity	PPV Vibration Level (mm/s) at Distance		
	10m	20m	30m
Concrete Sawing	0.5	0.3	0.2
4-Tonne Vibratory Roller (High)	2.0-2.4	0.4-1.2	0.2-0.8
Hydraulic Hammer (30t)	3	1.5	1.0

17.1.4 Vibration Levels at Residences

As the minimum distance from any house to the construction site is more than 250m, no vibration impact is predicted.

18 BLASTING ASSESSMENT

18.1 Blasting Requirements

Blasting would be required in areas where major cuts are located. Blasting would be undertaken between 9am and 5pm – Monday to Friday. Up to two blasts per day would be undertaken. Generally the process for blasting would be:

- Drilling of holes into rock;
- Placement of explosives;
- Placement of stemming in drill holes;
- Clearance of area before blast;
- Explosion; and
- Removal of blasted rock to crushing and processing areas.

18.2 Blasting Assessment Criteria

18.2.1 Annoyance & Discomfort

For assessment of annoyance due to blasting, the DECC (and most similar authorities in Australia) has adopted guidelines produced by the Australian and New Zealand Environment and Conservation Council (ANZECC). The fundamental criteria are that at any residence or other sensitive location:

- The maximum overpressure due to blasting should not exceed 115dB for more than 5% of blasts in any year, and should not exceed 120dB for any blast; and
- The maximum peak particle ground velocity should not exceed 5mm/sec for more than 5% of blasts in any year, and should not exceed 10mm/sec for any blast.

18.2.2 Structural Damage

At sufficiently high levels, blast overpressure may in itself cause structural damage to some building elements such as windows. However, this occurs at peak overpressure levels of about 133dB and above, well in excess of criteria for annoyance.

For assessment of damage due to ground vibration, Australian Standard *AS2187.2-1993 Explosives – Storage, Transport and Use* contains an appendix specifying recommended levels for peak particle vibration velocity to protect typical buildings from damage.

These are:

- "Structures that may be particularly susceptible to ground vibration" – 5mm/sec;
- "Houses and low-rise residential buildings; commercial buildings not included below" – 10mm/sec; and
- "Commercial and industrial buildings or structures of reinforced concrete or steel construction" – 25mm/sec.

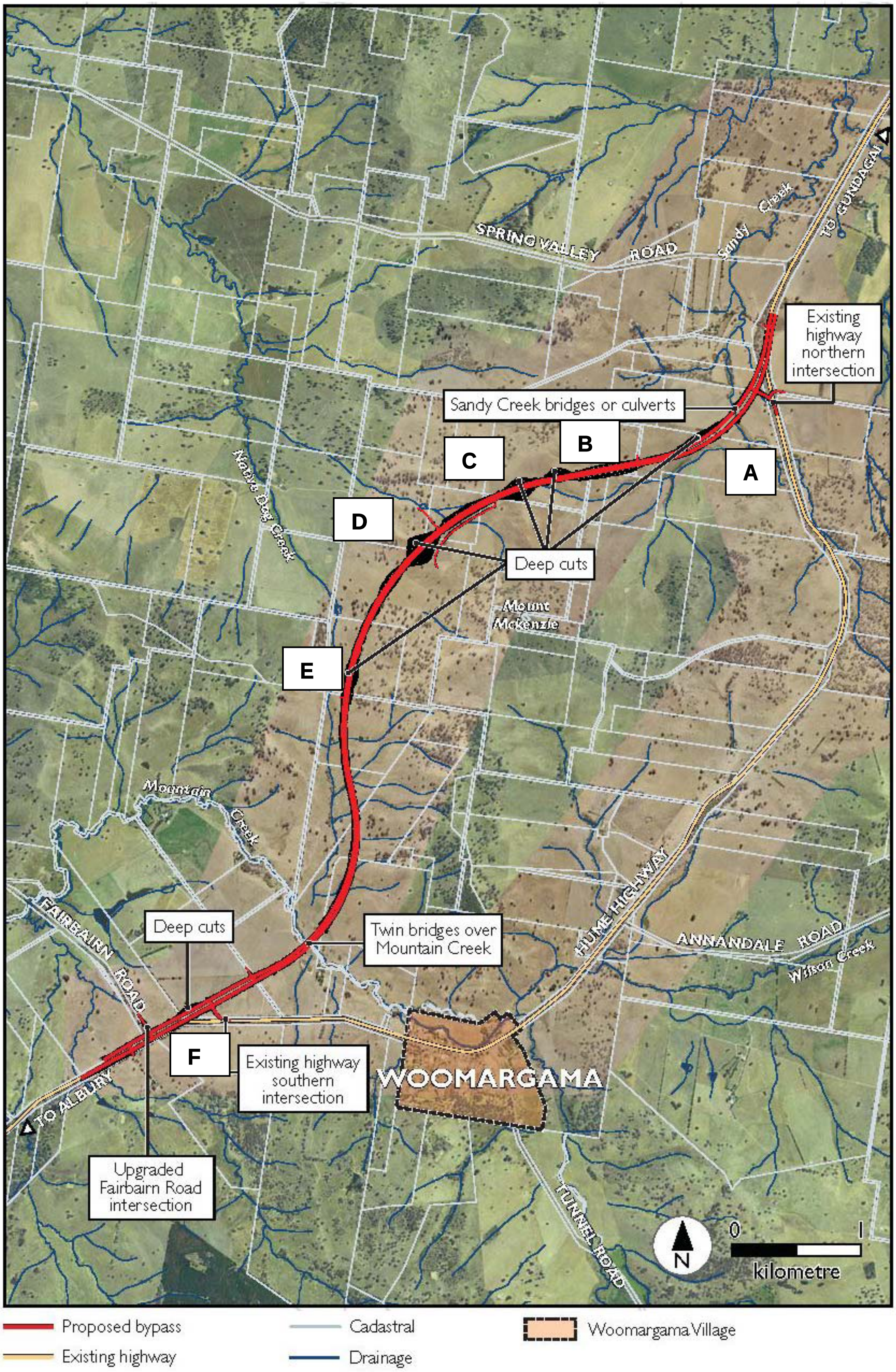
18.3 Locations of Blasting

Three receivers not previously discussed, as they are commercial farm structures and not residential, are shown on Figure 18-1. The locations, receivers 106, 111 and 112, have no criterion for overpressure.

Blasting would potentially be required at six locations, marked A to F on Figure 18-2.

Figure 18-1 Locations 106, 111 and 112.

Figure 18-2 Location of Cuts for Potential Blasting



18.4 Definition of "Scaled Distance"

Airblast overpressure and ground vibration levels from blasting are related to the "scaled distance" from the blast, which is defined as

Scaled distance = $D/W^{(1/3)}$ for airblast overpressure, and
Scaled distance = $D/W^{(1/2)}$ for ground vibration,

where D is the distance from the blast in metres and W is the maximum instantaneous charge of explosive, in kg Ammonium Nitrate Fuel Oil (ANFO) equivalent.

18.5 Prediction of Overpressure

Peak overpressure levels are predicted as

$$L = A - B \log(D/W^{1/3})$$

where B depends on the site characteristics and A depends on both site characteristics and blasting practice.

Wilkinson Murray have analysed blast monitoring from Prospect Quarry and Bayswater No 3 Mine. The "best fit" line has values of B = 22.4 and A = 158 in the above equation. However, to ensure that 95% of blasts are within a criterion, a value of A = 171 is required.

While mine blasts are typically much larger than those expected on the Woomargama Bypass, experience suggests that the overpressure values predicted by the "best fit" line can be achieved if best practice blasting procedures are adopted.

18.6 Prediction of Vibration Levels

The "scaled distance" from the a blast, which is defined as

$$\text{Scaled distance} = D/W^{(1/2)} \text{ for ground vibration.}$$

Peak particle velocity is predicted as

$$PPV = K \ (D/W^{1/2})^{-a}$$

where a depends on the ground characteristics and K depends on both site characteristics and blasting practice.

Australian Standard 2187.2 gives recommended values K and a for cases where site data are not available, the relevant values being:

Blasting to a free face, hard rock: K = 500, a = 1.6

Blasting to a free face, average rock: K = 1140, a = 1.6

18.7 Recommendations for Blasting

Table 18-1 shows the recommended Maximum Instantaneous Charge (MIC - Kg) for each cut based on the values for average rock. MIC is shown for estimated minimum and maximum distance from the cut to the residences.

Table 18-1 Recommended MIC to Achieve Criteria

Receiver	Distance to Cut, m		MIC to Meet Criteria from Nearest Point of Cut		MIC to Meet Criteria from Furthest Point of Cut	
	Minimum	Maximum	Vibration	Overpressure	Vibration	Overpressure
Cut A						
116	550	700	550 kg	290 kg	700 kg	598 kg
Cut B						
109	1,050	1,500	1,056 kg	2,017 kg	2,156 kg	5,880 kg
112	370	540	981 kg	N/A	2,089 kg	N/A
Cut C						
109	1,650	1,830	2,608 kg	7,826 kg	3208	10,676 kg
112	520	700	1,791 kg	N/A	3,510 kg	N/A
Cut D						
111	1,040	1,100	7,746 kg	N/A	8,666 kg	N/A
102	2,800	3,000	7,510 kg	38,000 kg	8,621 kg	47,000 kg
Cut E						
102	1,380	1,850	1,825 kg	4,578 kg	3,279 kg	11,030 kg
Cut F						
168	310	420	93 kg	52 kg	169 kg	129 kg

Due to the distance to residences, blasting would be feasible without exceeding relevant criteria. Site tests would be necessary to establish the characteristics of the rock and allow more accurate determination of the MIC values shown in the table.

19 CONCLUSION

Noise from the proposed Woomargama Bypass has been assessed. The following aspects were considered:

- Operational Noise;
- Construction Noise and Vibration; and
- Blasting Overpressure and Vibration.

19.1 Noise Monitoring

Noise monitoring was undertaken at six locations. The noise monitoring determined background noise and existing traffic noise.

19.2 Noise Modelling and Validation

Noise from both the existing highway and the proposed bypass was modelled. The model was validated using predicted noise from the highway and comparing it to noise measured while traffic was counted. Good correlation was found.

19.3 Recommendations for Operational Noise

The bypass is separated from the village by Mount McKenzie which acts as a noise barrier. Hence noise impact from the bypass is limited to isolated rural residences. Following this, noise mitigation by at-road features, such as noise barriers or low noise pavement, was not considered reasonable and feasible.

Five residences were identified where noise mitigation by architectural treatment would be considered. These are listed in Table 19-1.

Table 19-1 Predicted Night Time Noise Levels, $L_{Aeq,9hr}$ at Isolated Residences

Receiver Number	Future Existing Noise 2011 - $L_{Aeq,9hr}$	Combined Noise 2021 - $L_{Aeq,9hr}$	Base Criterion - $L_{Aeq,9hr}$	Architectural Treatment to be considered
107	52	**55**	50	Yes
108	50	**54**	50	Yes
109	49	**52**	50	Yes (increase by 3 at Bypass facade)
116	50	**53**	50	Yes
117	46	**56**	50	Yes

19.4 Acute Noise Levels

No residences are predicted to have acute noise levels after the bypass is constructed.

19.5 Construction Noise Assessment

Noise from construction will cause impact at some residences.

In general noise in Woomargama village will be below the noise goals except for some possible exceedances during night time hours from the southern batch plant. Noise impact assessment from batching plants was based on indicative locations.

Exceedances at rural properties are predicted both from road works and from batching plants. Noise management procedures for mitigating impacts from roadworks were discussed.

Noise mitigation from batching plants may be possible, depending on the final locations of the batching plants.

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