

8.0 Air Quality

This chapter provides a summary of all matters relating to the Air Quality Impact Assessment (AQIA). The full AQIA report is provided in **Appendix E**. This assessment has been undertaken in consultation with DECCW and with reference to the DGRs and takes into consideration pollutants of concern associated with quarrying and brick making operations at the site.

8.1 Existing Environment

8.1.1 Existing Air Quality and Meteorological Environment

The existing air quality environment in the vicinity of the Project Site has been characterised using monitoring data from the DECCW air quality monitoring station located at Bringelly for the period 1 September 2006 to 31 August 2007. These data have been used in this assessment to estimate background pollutant concentrations. The DECCW air quality monitoring station is approximately 2 km south east of the Site.

The air pollutants relevant to the AQIA from the DECCW air quality monitoring station include:

- Fine particles (particulate matter less than 10µm in diameter (PM₁₀));
- Total suspended particulates (TSP);
- Sulfur Dioxide (SO₂); and
- Oxides of Nitrogen (NO, NO₂ & NO_x).

The background concentrations for each of these air pollutants are provided in **Table 17** below. The relevant impact assessment criteria specified in **Table 17** is the DECCW *Approved Methods (Department of Environment and Conservation (DEC), 2005)* for the AQIA pollutants of concern.

Table 17: Background Concentrations at the Bringelly DECCW Monitoring Station

Air Emission	Averaging Period	Background Concentration (µg/m ³)	Assessment Criteria (µg/m ³)
PM ₁₀	24 hours	38.5	50
	Annual	20.4	30
TSP ¹	Annual	45.5	90
Sulfur Dioxide (SO ₂)	1 hour	48.6	570
	24 hours	7.9	228
	Annual	1.1	60
Nitrogen Dioxide (NO ₂) for assessment of Nitrogen Oxides (NO _x) ²	1 hour	82	246
	Annual	11.6	62

¹ – TSP calculated by applying TSP to PM₁₀ ratio to PM₁₀ results as previously stated

² – NO₂ background data used to predict background concentrations using the ozone limiting method (OLM) method

The DECCW monitoring station results show relatively high background levels of PM₁₀ when compared to the assessment criteria. TSP background levels are also elevated, although are approximately half of the DECCW criterion of 90 µg/m³. All other measured pollutant background levels are considered to be low when compared to the assessment criteria.

Dust deposition has been monitored at four locations within the Site using dust deposition gauges from October 2007 to October 2008. Samples have been collected monthly and analysed for insoluble solids and ash residue. The average measured dust deposition results for each of the four locations were compared to the predicted dust deposition results in Section 7.0 of the *Air Quality Impact Assessment* located at **Appendix E**.

A review of meteorological data from the DECCW air quality monitoring station is provided in the AQIA (**Appendix E**). Wind patterns are generally dominated by winds from a south south-westerly direction, with minor winds in most other directions. Summer and spring showed the highest average wind speeds (more dispersion and hence higher dilution of pollutants) with winter having the most calm periods (wind speeds less than 0.5 m/s). These wind parameters suggest that impacts from the Project Site are likely to be highest to the north north-east of the Project Site (receptors 5, 6 and 7 as shown in **Figure 6**), with impacts potentially peaking in winter periods.

8.1.2 Sensitive Receptors

The DECCW considers sensitive receptors to be areas where people are likely to either live or work, or engage in recreational activities (DEC, 2005). Sensitive receptors have been identified at 11 locations surrounding the Project Site, which are considered to be representative of the local community for the purposes of the AQIA. The sensitive receptors are listed in **Table 18** below and are also shown on **Figure 6**.

Table 18: Sensitive Receptor Locations

Receptor Number	Sensitive Receptor Location	Distance from Nearest Site Boundary	Type
1	Badgerys Creek Rd	Approximately 670 m SW of site boundary	Industrial
2	Corner of Badgerys Creek Rd and Jagelman Rd	Approximately 480 m W of site boundary	Residential
3	Badgerys Creek Rd	Approximately 290m W of site boundary	Residential
4	Longleys Rd	Approximately 200m N of site boundary	Residential
5	Lawson Rd	Approximately 28m N of site boundary	Residential
6	Martin Rd	Approximately 15m N of site boundary	Residential
7	Braikfield Ave	Approximately 500m NE of site boundary	Residential
8	Western Rd,	Approximately 450m E of site boundary	Industrial
9	Victor Ave	Approximately 130m E of site boundary	Residential
10	Victor Ave	Approximately 215m E of site boundary	Residential
11	Ramsey Rd	Approximately 600m SE of site boundary	Residential

8.2 Assessment Methodology and Dispersion Modelling

In order to assess the potential air quality impacts of the project, an AQIA was undertaken which included the following scope of works:

- Identification of pollutants of concern and development of an emissions inventory containing air quality emissions information from current operations at the site;
- Preparation of an AUSPLUME atmospheric dispersion model in accordance with DECCW guidelines, using emissions from surface infrastructure and facilities and mine ventilation shafts; and
- Assessment of predicted air quality emissions against assessment criteria using the DECCW Approved Methods (DEC, 2005).



8.2.1 Pollutants of Concern

A number of pollutants of concern have been identified and are currently monitored at the site. These include:

- **Gaseous pollutants:**
 - Hydrogen Fluoride (HF) - Clays used in brick making naturally contains fluoride in the form of hydrated micas, such as muscovite and illite. The production of bricks requires that clay be fired in a kiln to drive off water. At these elevated temperatures gaseous HF is evolved and released.
 - Sulfur Dioxide (SO₂) - SO₂ is a colourless gas with a sharp, irritating odour. It is formed in combustion processes through burning fossil fuel containing sulfur, in petroleum refining and smelting mineral ores. During the brick making process clay is fired in a kiln to drive off water. Pyrite within the clay is oxidised, thereby removing sulfur-containing compounds such as sulfur dioxide from the clay. The simultaneous presence of airborne particulate matter can compound these effects.
 - Sulfuric Acid Mist - During the clay firing process sulfur dioxide is released which can oxidize in the atmosphere to form sulfuric acid (H₂SO₄). Sulfuric acid enters the air during production, use and transport. In the air it would react with other chemicals present (ammonia, magnesium, calcium) to form salts, which neutralise the acid. The acid particles dissolve in clouds, fog, rain, or snow, resulting in very dilute acid solutions. This may impact the environment as wet acid deposition ('acid rain').
 - Gaseous Chlorine (Cl) - Gaseous Cl is a yellowish-green gaseous element of the halogen group. It has a strong, distinctive odour that is irritating to the respiratory tract and is poisonous if ingested or inhaled.
 - Nitrogen Oxides (NO_x) - NO_x is a generic term for mono-nitrogen oxides (NO and NO₂). These oxides are produced during combustion, especially combustion at high temperatures. At ambient temperatures, the oxygen and nitrogen gases in air would not react with each other. In an internal combustion engine or industrial heating applications e.g. boilers, combustion of a mixture of air and fuel produces combustion temperatures high enough to drive endothermic reactions between atmospheric nitrogen and oxygen in the flame, yielding various oxides of nitrogen.
 - Odour - Odour is a sensory response to the inhalation of one or more chemicals in the air we breathe. A person's perception of an odour can vary significantly depending on the sensitivity of the person, the acuteness of the person's sense of smell and the connotations that the odour bestows on that person. Odour primarily affects a person's quality of life and can have a large range of adverse effects including stress and other physical symptoms.
- **Dust emissions:**
 - Particulate Matter (TSP and PM₁₀) and dust deposition - Particulate matter refers to solid or liquid particles found in the air. Some particulate matter is visible to the naked eye including smoke, however fine particulate matter is generally not. Particulates are generally produced by the break-up of larger solid particles. Coarse particulate matter can include dust from roads, agricultural processes, exposed soil in mining operations and non-combustible materials released from burning fossil fuels.

8.2.2 Pollutant Sources

Two potential sources of gaseous air pollutants from the brick production facility are present at the site; the Kiln Stack and the Dryer Exhausts. In addition to these sources, the quarrying operation and exposed surfaces (including stockpiles) within the site are potential dust emission sources. Emissions inventories have been prepared for both gaseous pollutants and dust emissions which identify the source and characteristics of each of the pollutants of concern.

A full description of the pollutant source characteristics utilised in the AQIA for the brick production facility (kiln stack and dryer exhaust) and quarrying operations are detailed in the AQIA (**Appendix E**).

8.2.3 Assessment Criteria

The relevant impact assessment criteria specified by the DECCW *Approved Methods (Department of Environment and Conservation, 2005)* for the AQIA pollutants of concern are presented in **Table 19**. The relevant averaging period for each pollutant is provided.

Table 19: Relevant Air Quality Impact Assessment Criteria

Air Emission	Averaging Period	Assessment Criteria ($\mu\text{g}/\text{m}^3$)
PM ₁₀	24 hours	50
	Annual	30
TSP	Annual	90
Deposited Dust (maximum allowable increase)	Annual	2 g/m ² month
Deposited Dust (maximum measured levels)	Annual	4 g/m ² month
Hydrogen Fluoride	90 days	0.5
	7 days	1.7
	24 hours	2.9
Sulfur Dioxide (SO ₂)	10 minutes	712
	1 hour	570
	24 hours	228
	Annual	60
Sulfuric Acid Mist (H ₂ SO ₄ as SO ₃)	1 hour	18
Chlorine (Gaseous) (Cl)	1 hour	50
Nitrogen Dioxide (NO ₂) for assessment of Nitrogen Oxides (NO _x)	1 hour	246
	Annual	62
Odour	Peak Concentration	4 OU

Deposited dust criteria are provided in the Approved Methods for two parameters; maximum measured levels and maximum allowable increase. Modelled ground level impacts from operations are compared against the maximum allowable increase in dust of 2 g/m² per month (annual average).

The land use around the Site does not include any HF sensitive vegetation such as grape vines and stone fruits. Accordingly, the Approved Methods (DEC, 2005) HF assessment criteria for general land uses has been applied in the AQIA. It should also be noted that AUSPLUME cannot estimate ground level concentrations (GLCs) for the time period of 30 days. As such this assessment time period has not been considered in the AQIA.

The assessment criterion for NO₂ has been used for the assessment of NO_x in the AQIA.

It has been estimated that the local population potentially impacted by emissions from the Site is greater than 125 but less than 500 people. Based on this assumption the odour GLC impact assessment criterion to be applied in the assessment is 4 OU at the 100th percentile in accordance with the Approved Methods (DEC, 2005).

8.2.4 Dispersion Modelling

Dispersion modelling for the project was divided into different scenarios for gaseous pollutants, and dust emissions, as described below.

Gaseous Pollutant Emission Modelling

The following pollutants have been modelled from the brick making facility (kiln stack and dryer exhausts) assuming maximum emission rates gained from previous stack tests. As such the scenario is considered to represent worst case typical operating conditions for the following parameters:

- HF;
- SO₂;
- H₂SO₄ as SO₃;
- Gaseous Cl;
- NO_x as NO₂; and
- Odour.

The pollutant modelling scenario outlined above assumed that the brick making facility was operating continuously all year (24 hours per day, 365 days per year). The facility is unlikely to operate at this level due to operational restrictions and as such the scenario is considered to be a conservative estimate of likely impacts.

Dust Emission Modelling

Dust modelling for TSP, PM₁₀ and dust deposition was performed for three scenarios to represent the three proposed quarry locations:

- Scenario 1 – Phase 3 Pit (current):
 - 1A – Quarrying activities modelled;
 - 1B – No quarrying activities modelled;
- Scenario 2 - Phase 4 Pit (future); and
- Scenario 3 - Phase 5 Pit (future).

As discussed previously, quarrying activities are undertaken for only 3 consecutive months each year. In order to gain realistic worst case predictions, the seasonal impact has been examined in the AQIA. A preliminary modelling run applying the quarry activities to all days in the year, showed that the worst case impacts were predominantly present in autumn and winter. As such quarrying activities were modelled for autumn and winter only for Scenario 1 (with normal operations during the rest of the year). Results indicated that dust impacts were worst during winter, and therefore quarrying activities were modelled during winter only (with normal operation during the rest of the year) for Scenarios 2 and 3. The brick making facility was modelled as a constant source for all model runs.

The dust impacts from areas of the Project Site not being quarried have also been predicted in the AQIA, designated as Scenario 1B. The scenario only examines the impacts from wind generated dust and the impacts from the typical operation of the brick making facility.

8.3 Potential Impacts

8.3.1 Gaseous Pollutants

The pollutant modelling results indicate that odour, HF, SO₂, H₂SO₄ as SO₃ and Gaseous Cl each meet the relevant assessment criteria at the representative sensitive receptors for both isolated and cumulative predicted GLCs. Detailed results of gaseous pollutant modelling are provided in section 7.2 of the AQIA included as **Appendix E** to this EA.

8.3.2 Dust Emissions

Total Suspended Particulates

The dust modelling results show that predicted TSP GLCs and dust deposition met the assessment criteria for all modelled scenarios (refer to section 7.1 of the AQIA located at **Appendix E**).

Particulate Matter (PM₁₀)

The predicted 24 hour average PM₁₀ GLCs in isolation from the background concentration, met the criteria for scenario 1B (no quarrying activities) only, with all other scenarios exceeding the criteria. Although the cumulative 24 hour average PM₁₀ GLCs exceeded the criteria for all scenarios, the isolated results only exceeded at receptor 6 which is 15m north of the Project Site boundary, 650m north east of the brick making facility and located in the predominant downwind direction from the Project Site.

Scenario 1B represents the typical operating conditions for at least 75% of the year (9 to 10 months of the year), indicating that for the majority of the year dust impacts at most receptors would be acceptable.

The PM₁₀ 24 hour GLC results for Scenario 1B met the criteria when in isolation from background concentrations but exceeded for cumulative GLCs. This suggests that the assumed mitigation measures applied to the Project Site may not be adequate to reduce the off-site dust impacts to below the assessment criteria during normal quarrying operations. Recommendations for achieving this goal during both normal operation and quarrying campaigns are discussed below.

The predicted annual average PM₁₀ GLCs in isolation from the background concentration met the assessment criteria for all modelled scenarios. The cumulative annual average PM₁₀ modelling results met the assessment criteria for scenario 1B (no quarrying activities) only, with all other scenarios exceeding the criteria at a small number of close receptors located to the north of the Project Site.

The modelling results showed that the worst case PM₁₀ GLCs were at Receptor 5 (400m north of the brick making facility) and Receptor 6 (650m north east of the brick making facility). Both are the closest receptors to the boundary of the Project Site. The meteorological data shows that the predominant wind direction was from the south west (blowing to the north east) which puts these two receptors generally downwind of the Project Site. Mitigation measures would therefore have to focus particularly on dust impacts in this direction.

As the Project Site was operational during the background data measurement program, it is expected that the Project Site would have had a contribution to the regional air shed and the measured background dust concentrations. This impact is particularly true for near field impacts. Applying the measured background concentrations to the predicted dust emissions for the Project Site may result in a degree of double counting of dust emissions from the Project Site. This is likely to result in an overestimation of predicted impacts.

Dust Deposition

The dust deposition results predicted from the modelling were below the average measured from the Project Site from October 2007 to October 2008. The predicted results were those related to Boral operations and do not incorporate other sources of dust from the local area including other anthropogenic activities such as other quarries, activities at ANL, wheel generated dust, or natural sources of dust such as bush fires. It is therefore expected that the predicted dust deposition results would be lower than the measured results (which would include impacts from off-Project Site dust sources as previously stated), which supports the modelling methodology and results.

8.4 Mitigation Measures

The following mitigation measures would be implemented as part of the Project to manage potential air quality impacts:

- Dust control measures would be employed on the Project Site as follows:
 - Haul roads to be watered at a rate equal to or greater than 2 L/m²/hr;
 - Dust generated during the unloading of trucks containing raw or unusable extracted material to be controlled using water sprays;
 - Dust from raw material stockpiles to be controlled using water sprays;
 - Dust from existing stockpiles of unusable material and open pits to be controlled using water sprays with chemical additives (surfactants); and
 - Completed pits to be revegetated as soon as practicable after completion of quarrying activities.
- Preparation of an AQMP for the Project Site. The AQMP would include measures to control dust and emissions from the Project Site. Specifically, the AQMP would include details of a dust mitigation program for the Project Site including:
 - Instantaneous dust monitoring at the most affected Project Site boundary through the installation of an instantaneous dust monitor (such as a Tapered Element Oscillating Microbalance (TEOM)) to alert Project Site personnel when elevated dust levels occur such that operations can be modified to reduce dust impacts;
 - Revegetation of disturbed soil surfaces on the Project Site in accordance with the RP (**Appendix D**); and
 - Review of operational practices to ensure 'best practice' techniques are being employed and that operational equipment is working efficiently.

8.5 Greenhouse Gas Assessment

8.5.1 Methodology

GHG emissions were estimated using the National Greenhouse Accounts (NGA) Factors (June 2009) published by the Department of Climate Change (DCC) which include three assessment categories:

- **Scope 1**, which covers direct emissions from sources within the boundary of an organisation, such as fuel combustion and manufacturing processes;
- **Scope 2**, which covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation; and
- **Scope 3**, which includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation, such as product transport emissions and emissions from the generation of purchased electricity.

This assessment estimated emissions relating to:

- Fuel Combustion – Stationary Plant (Scope 1)
- Fuel Combustion – On-site Transport (Scope 1)
- Electricity Use (Scopes 2 and 3)
- Product Transport (Scope 3).

8.5.2 Estimates

Estimates of GHG emissions associated with the relevant activities on site are shown below.

Fuel Combustion – Stationary Plant (Scope 1)

The brick manufacturing process involves firing of bricks in a gas-fired kiln. Emission factors associated with combustion of natural gas are provided in **Table 20**.

As shown in **Table 21** and **Table 22**, emissions of GHG associated with brick making at the site at current production levels from the combustion of natural gas and solid fuels would increase by approximately 10,081,522 kg CO₂-e (0.01 Mt CO₂-e) per year while the proposed level of brick production occurs (approximately 250,000 tpa).

Table 20: Emission Factors – Combustion of Gaseous Fuels

Fuel Combusted	GHG Emission Factors (kg CO ₂ -e/GJ)		
	CO ₂	CH ₄	N ₂ O
Natural gas distributed in a pipeline	51.2	0.1	0.03

Source: Table 1, NGA Factors, June 2009

Table 21: Emission Estimates – Combustion of Gaseous Fuels

Scenario	Average Annual Amount (GJ)	GHG Emissions (kg CO ₂ -e)			
		CO ₂	CH ₄	N ₂ O	Total
Existing	230,734	11,813,564	23,073	6,922	11,843,559
Proposed	358,077	18,329,964	35,801	10,740	18,376,504
Difference	127,273	6,516,400	12,728	3,818	6,532,945

GJ = gigajoules

Table 22: Emission Estimates - Combustion of Solid Fossil Fuels (excluding coal or coke)

Scenario	Average Annual Usage (t)	GHG Emissions (kg CO ₂ -e)			
		CO ₂	CH ₄	N ₂ O	Total
Existing	3,108	6,408,478	4,121	20,606	6,433,206
Proposed	4,822	9,943,416	6,394	31,972	9,981,783
Difference	1,714	3,534,938	2,273	11,366	3,548,577

Fuel Combustion – On-site Transport (Scope 1)

On-site transport emissions relate to the combustion of fuel on site by vehicles and mobile plant. Emission factors for emissions of GHGs associated with on-site transport activities are shown in **Table 23**. On-site transport emissions would generate approximately 16 t CO₂-e which is shown in **Table 24**, an additional 5,849 kg CO₂-e (0.000006 Mt CO₂-e) per year above existing production levels based upon maximum proposed brick production.

Table 23: Emission Factors – Combustion During On-site Transport

Vehicle Type	Fuel Type	GHG Emission Factors (kg CO ₂ -e/kL)		
		CO ₂	CH ₄	N ₂ O
General transport	Diesel oil	69.2	0.2	0.5

Source: Table 4, NGA Factors, June 2009

Table 24: Emission Estimates - Combustion During On-site Transport

Scenario	Average Annual Amount (kL)	GHG Emissions (kg CO ₂ -e)			
		CO ₂	CH ₄	N ₂ O	Total
Existing	152	10,498	30	76	10,604
Proposed	235	16,288	47	118	16,453
Difference	83	5,790	17	42	5,849

Electricity Use (Scopes 2 and 3)

Scope 2 emissions associated with electricity use relate to the burning of fuels at a power station to produce the electricity consumed at the Project Site. The Scope 3 emissions relate to the distribution and transmission of that electricity. The relevant emission factors are provided in **Table 25**, while **Table 26** provides the emissions estimates calculated for the Project Site. As shown, approximately 12,261 t CO₂-e would be generated from electricity use at the Project Site per year under proposed maximum production rates, an increase of 4,358,881 kg CO₂-e (0.0043 Mt CO₂-e) per year over existing production levels.

Table 25: Emission Factors – Electricity Use

State, Territory or Grid	GHG Emission Factors (kg CO ₂ -e/kWh)	
	Scope 2	Scope 3
New South Wales and Australian Capital Territory	0.89	0.18

Source: Table 39, NGA Factors, June 2009

Table 26: Emission Estimates – Electricity Use

Scenario	Average Annual Amount (kWh)	GHG Emissions (kg CO ₂ -e)		
		Scope 2	Scope 3	Full Fuel Cycle
Existing	7,385,236	6,572,860	1,329,343	7,902,203
Proposed	11,458,956	10,198,471	2,062,612	12,261,083
Difference	4,073,720	3,625,611	733,269	4,358,880

Product Transport (Scope 3)

GHG emissions associated with transport of the product produced at the Project Site were estimated based on the approximate fuel usage associated with this activity. The NGA Factors provide Scope 3 emission factors for liquid fuels. Factors relating to diesel fuel are shown in **Table 27**.

Table 27: Scope 3 Emission Factors - Diesel Fuel

Liquid fuel combusted	GHG Emission Factors (kg CO ₂ -e/kL)
Diesel oil	69.2

Source: Table 38, NGA Factors, June 2009

Products produced at the Project Site are distributed throughout Sydney. In order to estimate product transport emissions, the average trip distance was assumed to be half the width of the city (i.e. 30 km). Data used for the estimates are shown in **Table 28**.

Table 28: Product Transport Data

Parameter	Value
Number of trips per year	32,448
Fuel consumption rate of trucks (L/km)*	0.547
Average distance per trip (km)	30
Total annual distance travelled (km)	973,440
Total fuel consumed (kL)	532
Density of diesel fuel (kg/L)**	0.836
Energy content of diesel fuel (GJ/t)***	45.6
Diesel use (t)	0.45
Diesel use (GJ)	20,299
* ABS Data (2007); http://www.abs.gov.au ** Table 61, NPI Emission Estimation Technique Manual for Combustion Engines, v3.0, June 2008 *** http://www.ior.com.au/ecflist.html	

Using the data in **Table 27** and **Table 28**, the GHG emissions associated with product transport were estimated to be approximately 107,583 kg CO₂-e (0.0001 Mt CO₂-e) per year.

8.5.3 Emissions Summary

Emissions estimates from the sources outlined above are summarised in **Table 29**. As shown, the greatest source of emissions from the facility (approximately 60 % of total emissions) are those associated with the combustion of natural gas in the production process, followed by electricity use.

Table 29: Greenhouse Gas Emissions Summary

Activity		Estimated Annual Average Emissions (t CO ₂ -e)		
		Existing	Proposed	Difference
Scope 1	Fuel combustion – stationary plant*	18,277	28,358	10,082
	Fuel combustion – on-site transport	11	16	6
	<i>Total Scope 1</i>	<i>18,288</i>	<i>28,374</i>	<i>10,088</i>
Scope 2	Electricity use	6,573	10,198	3,626
	<i>Total Scope 2</i>	<i>6,573</i>	<i>10,198</i>	<i>3,626</i>
Scope 3	Electricity use	1,329	2,063	733
	Product transport	108	108	0
	<i>Total Scope 3</i>	<i>1,437</i>	<i>2,170</i>	<i>733</i>
Total		26,298	40,743	14,447
* Natural gas and solid fuel				

Total emissions from the Project Site were estimated to increase by a total of 14,447 t CO₂-e, or 0.01 Mt CO₂-e per year based upon the maximum proposed level of production. As such, the proposed development would not result in significant increased GHG emissions or cause significant additional environmental impacts. Total potential emissions associated with the proposed project (0.041 Mt CO₂-e) represent approximately 0.4 % of the total emissions from the mining non-energy sector in Australia (9.2 Mt CO₂-e), and 0.007 % of total Australian emissions (597.2 Mt CO₂-e). As such, the contribution of the proposal to GHG emissions overall is not considered to be significant.

8.6 Conclusion

An AQIA was undertaken in accordance with the DECCW's Approved Methods (DEC, 2005). Maximum predicted pollutant GLCs on a gridded modelling domain and at identified sensitive receptors were compared against relevant guideline values. The modelling results show that odour, HF, gaseous Cl, SO₂ and H₂SO₄ mist all met the stated assessment criteria at the discrete sensitive receptors for both isolated and cumulative predicted GLCs.

The dust modelling results indicated that TSP GLCs and dust deposition met the assessment criteria for all modelled scenarios. In relation to PM₁₀ the modelling indicated the following:

- The predicted 24 hour PM₁₀ GLCs, in isolation from background concentrations and cumulatively, showed exceedances of assessment criteria for all scenarios (except scenario 1B (no quarrying activities) in isolation from background concentrations); and
- The predicted annual PM₁₀ GLCs in isolation from background concentrations met the assessment criteria for all scenarios. The cumulative annual PM₁₀ GLCs showed exceedances of assessment criteria for all scenarios (except scenario 1B).

Due to exceedances of PM₁₀ GLC assessment criteria, mitigation measures would be included in the AQMP for the proposal to reduce dust impacts from the Project Site. Provided the mitigation measures outlined in **Section 8.4** are implemented as part of an AQMP to meet relevant assessment criteria, impacts in relation to dust are not expected to be significant.

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9.0 Noise

A Noise Assessment was undertaken to inform the EA. The assessment established the existing noise sources within the study area and identified potential sensitive receptors. Predicted environmental noise impacts of the proposed Project were established and assessed in relation to criteria determined in accordance with the DECCW's Industrial Noise Policy (INP).

9.1 Existing Environment

9.1.1 Noise Sensitive Receptors

Residences surrounding the Project Site and the receptor locations where noise predictions were carried out (i.e. noise sensitive receptors) are highlighted in **Figure 7** and listed below.

- R1 - Fuller Street (Lot 1 DP 838361)
- R2 - 255 Longleys Road
- R3 - 255 Lawson Road
- R4 - 217 Martin Road
- R5 - 225 Martin Road
- R6 - 82 Victor Avenue
- R7 - 80 Victor Avenue
- R8 - 70 Victor Avenue
- R9 - 50 Victor Avenue
- R10 - 32 Victor Avenue

It is noted that the residence at 225 Martin Road (R5) is owned by Boral. Consequently, Boral would have the option to unoccupy this residence and noise levels at this location do not strictly need to comply with the environmental noise criteria.

9.1.2 Existing Noise Environment

Environmental noise measurements were performed to quantify the existing noise environment at receptors in the area of the Project Site, and to allow determination of the applicable environmental noise criteria in accordance with the NSW INP.

Measurements were performed at 10 Victor Avenue and 210 Lawson Road, shown on **Figure 7** as these sites were considered representative of the typical noise environments present at the receptors potentially most-affected by noise from the proposed operations. Noise levels measured at 10 Victor Avenue are representative of the typical background noise levels at the Victor Avenue residences included in the assessment. The noise levels measured at 210 Lawson Road are considered to be generally representative of the background noise levels at the receptors to the north and west of the Project Site.

Rating Background Levels (RBLs) (L_{A90}) measured at these locations is shown in **Table 30**.

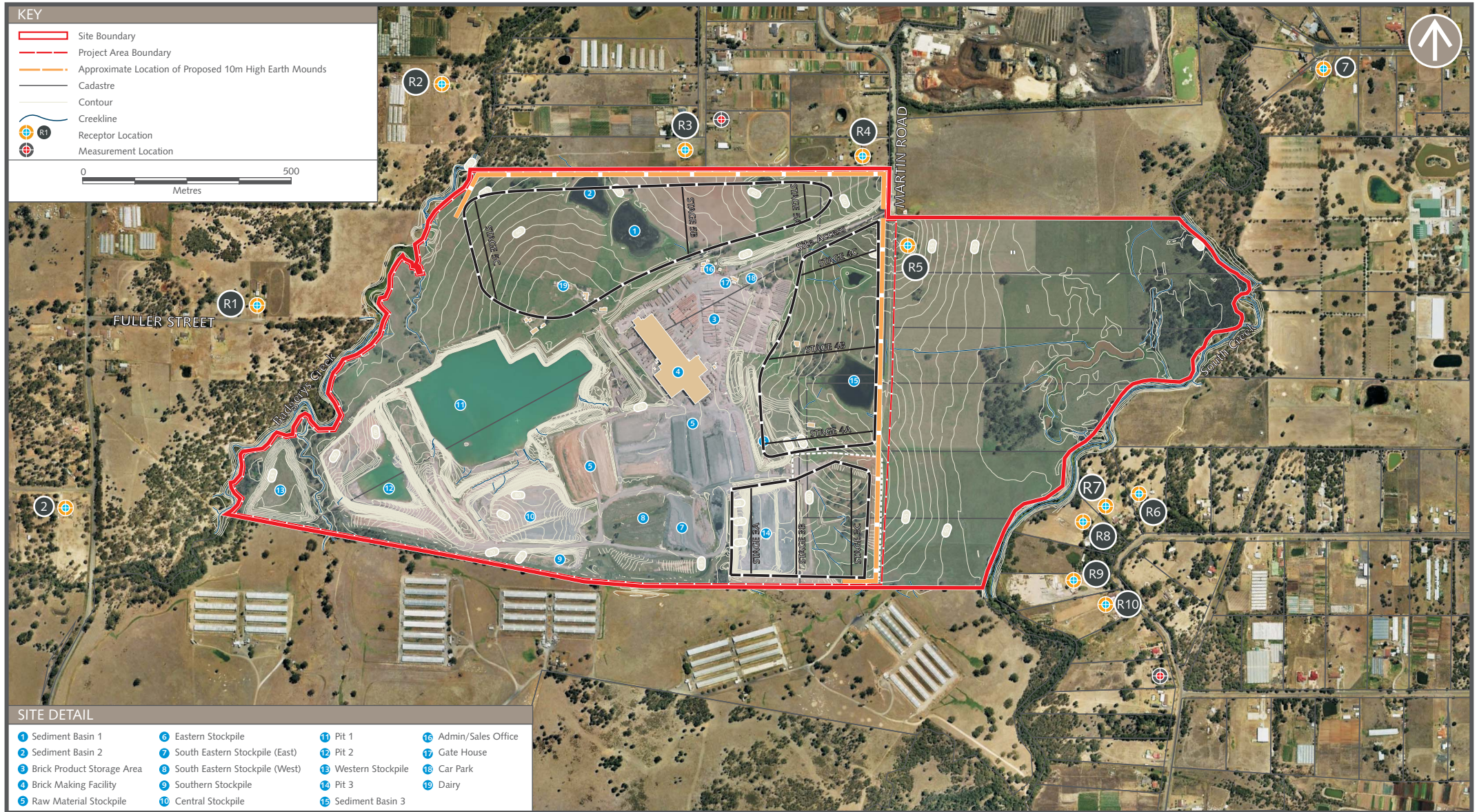
Table 30: Rating background Levels

Location	Rating Background Level (Tenth Percentile L_{A90})		
	Day	Evening	Night
10 Victor Avenue	35	33	30
210 Lawson Road	38	35	34

Notes:

The time periods presented in the tables above are as per the definitions provided in the INP:

- Day period is defined as 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays
- Evening period is defined as 6pm to 10pm on any day
- Night period is defined as 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.



NOISE RECEPTORS, PROPOSED MITIGATION AND STAGING

Environmental Assessment
Boral Quarry and Brick Making Facility, Badgerys Creek

Figure 7

The ambient noise environment at both measurement locations is typical of a rural residential setting, with noise from wildlife, vegetation, occasional traffic, and other rural residential activities, dominating the noise environment.

9.1.3 Environmental Noise Criteria

Operational Noise

The INP provides the relevant guidance in relation to acceptable noise limits for the proposed operations. Noise criteria determined in accordance with the procedures presented in the INP have therefore been used as the basis of the operational noise assessment. The assessment procedure used in the INP is comprised of two components, which are controlling intrusive noise impacts in the short term for residences and maintaining noise level amenity for residences and other land uses

Based on the measured background noise levels (RBL) at the sample locations as discussed previously and on the INP Intrusiveness and Amenity Criteria, operational noise criteria are presented in **Table 31** and **Table 32**. The criteria are formulated to satisfy the lower of the amenity and intrusiveness criteria for each time period.

Table 31 presents the operational criteria applied for the receptors located on Victor Avenue to the south east of the quarry, based on the background noise levels measured at 10 Victor Avenue. **Table 32** presents the operational noise criteria applied for all of the other receptors included in the assessment, based on the background noise levels measured at 210 Lawson Road.

Table 31: Operational Noise Criteria for Victor Avenue Receptors

Period	RBL (Tenth Percentile L_{A90})	Intrusiveness Criterion (RBL + 5 dB)	Ambient Noise Level (dB L_{Aeq})	Amenity Criterion (Ambient-10 dB)	Environmental Noise Criterion (dB L_{Aeq})*
Day	35	40	52	42	40
Evening	33	38	52	42	38
Night	30	35	51	41	35
Shoulder	37	42	60	50	38**

* Represents the lower of the amenity and intrusiveness criterion for the time period.

** Mid-point between Daytime and Night-time criteria

Table 32: Operational Noise Criteria for all Other Receptors

Period	RBL (Tenth Percentile L_{A90})	Intrusiveness Criterion (RBL + 5 dB)	Ambient Noise Level (dB L_{Aeq})	Amenity Criterion (Ambient-10 dB)	Environmental Noise Criterion (dB L_{Aeq})*
Day	38	43	54	44	43
Evening	35	40	58	48	40
Night	34	39	46	36	36
Shoulder	40	45	51	41	39**

* Represents the lower of the amenity and intrusiveness criterion for the time period.

** Mid-point between Daytime and Night-time criteria

In addition to the criteria presented for the time periods that normally apply under the INP (i.e. Daytime, Evening, and Night-time), morning “Shoulder” period criteria have been determined for the period between 6am and 7am. It is considered that this is justified in accordance with Section 3.3 of the INP, because the typical background noise levels measured between 6am and 7am are either at a similar level to the daytime background noise levels, or rising rapidly towards the daytime levels.

Operational noise criteria for the day time period is 40 (dB(A) L_{Aeq}) at Victor Avenue and 43 (dB(A) L_{Aeq}) at all other receptors, and 38 (dB(A) L_{Aeq}) at Victor Avenue and 39 (dB(A) L_{Aeq}) at all other receptors during the Shoulder period. The higher background noise levels during the shoulder period mean that it is unnecessarily stringent to apply the Night-time period noise criteria for operations between 6am and 7am. The rise in

background noise levels during and prior to this period is shown by the graphed noise measurement results presented in the Noise Assessment Report in **Appendix F** to the EA.

The “Shoulder” period criteria have been determined as the mid-point between Daytime and Night-time criteria, as suggested by Section 3.3 of the INP. The “Shoulder” period criteria resulting from this approach are less than the criteria that would be calculated for the period if the normal method for determining criteria under the INP (as used for the other periods) is applied. On this basis it is considered that the approach of taking the mid-point between Daytime and Night-time criteria is slightly conservative but appropriate.

Construction Noise

Under the definitions provided in the INP, it is considered that temporary noise associated with the construction of noise mitigation measures that may be required to control noise from the proposed activities (e.g. earth mounds), would be classified as a construction activity and would therefore not be covered by the INP. Noise from these types of activities would therefore be assessed in relation to the guidelines presented in the *NSW Interim Construction Noise Guideline* (ICNG), as maintained by the DECCW. The ICNG are structured towards managing the impact of construction noise as far as is feasible and reasonable, rather than specifying strict construction noise limits.

For residential receptors and work within “standard” construction hours (7am to 6pm Monday to Friday, 8am to 1pm Saturday), the ICNG sets the Management Level equal to the RBL (as determined in accordance with the INP) plus 10 dB. Outside of “standard” construction hours, the Management Level for residential receptors is equal to the RBL plus 5 dB.

Based on the established RBLs for the area, the Management Levels for the receptors in the vicinity of the quarry are as follows:

Table 33: Construction Noise Management Levels

Location	Management Level, dB $L_{Aeq,15min}$	
	Standard Construction Hours (7am-6pm Mon-Fri, 8am-1pm Sat)	Outside Standard Construction Hours
Victor Avenue Receptors	45	40 (1pm to 6pm Saturday) 38 (6pm to 10pm Monday to Saturday) 35 (All other times)
All Other Receptors	48	43 (1pm to 6pm Saturday) 40 (6pm to 10pm Monday to Saturday) 39 (All other times)

Where the construction noise levels are predicted to exceed the Management Level at any given receptor, the receptor would be considered to be “noise-affected” and the noise management procedures outlined in the INCG should be implemented.

Where construction noise levels are predicted to be in excess of 75 dB $L_{Aeq,15min}$ at any given receptor, the receptor would be considered to be “highly noise-affected”. In this case, the ICNG allows for the relevant authority (consent, determining or regulatory) to require respite periods by restricting the hours when very noisy activities can occur.

Traffic Noise

The changes in traffic noise levels along public roads, as a consequence of changes in traffic movements generated by the proposed continuation of operations, has been assessed using the DECCW’s document *Environmental Criteria for Road Traffic Noise* (ECRTN).

Traffic noise was assessed on Martin Road only as it was considered that traffic generated by the Project would be insignificant in comparison to the existing traffic volume on arterial roads such as Elizabeth Drive and would give rise to negligible changes to the noise levels.

Table 34 sets out the DECCW's road traffic noise criteria for land use developments with potential to create additional traffic on existing roads. The external criteria are applied at 1 metre from the affected residential building façades.

Table 34: Land use developments with the potential to create additional traffic on existing roads traffic noise criteria

Road Classification	Period	Parameter	Criterion, dB(A)
Local	Day (7:00 am to 10:00 pm)	L _{Aeq(1hr)}	55
	Night (10:00 pm to 7:00 am)	L _{Aeq(1hr)}	50

Notes:

In cases where noise from an existing road already exceeds the above criteria:

- (1) The DECCW recommends that "where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments."
- (2) In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB(A).

9.2 Methodology

The noise model considers noise from the Project Site and the worst case scenario for noise generated from the Project Site has been adopted for the purposes of the assessment. The modelling has included a review of historical meteorological data to establish and factor the predominant conditions into the modelling.

9.2.1 Quarry

The noise impact from the quarry would vary as the quarrying location progresses over the life of the proposed operation. To allow assessment of the changing noise levels as the quarry progresses, noise from the quarry was modelled for nine separate stages during the life of the proposed operation. These stages are noted in the bullet points below and shown in **Figure 7**:

- Stage 3A – Pit 3, early life.
- Stage 3B – Pit 3, mid life.
- Stage 3C – Pit 3, late life.
- Stage 4A – Pit 4, early life.
- Stage 4B – Pit 4, mid life.
- Stage 4C – Pit 4, late life.
- Stage 5A – Pit 5, early life.
- Stage 5B – Pit 5, mid life.
- Stage 5C – Pit 5, late life.

For each stage, the processes of overburden removal and clay / raw material extraction were modelled in separate scenarios. The modelling adapted a worst case noise scenario that included locating equipment working in tandem within the pits towards the sensitive receptors and operating at existing ground level for the process of overburden removal. Using this approach, the predicted noise levels from the quarry pits can be considered to represent the maximum levels that would typically be expected for each stage of the quarry. Generally, noise levels from the quarry pits could be expected to be marginally less than those predicted by the model.

It was also assured that equipment would only operate in the quarry during the Day assessment period (7am to 6pm Monday to Saturday).

9.2.2 Brick Making Facility and Storage Yard

The brick making facility would operate 24 hours per day, seven days per week (as per current operations), and the storage yard from 6am to 10pm Monday to Friday, and 6am to 6pm on a Saturday.

For the purpose of the noise modelling, the maximum number of plant items likely to operate on a typical basis in any given assessment period (Day, Evening or Night as defined by the INP) was considered.

The modelling included both vehicles and fixed plant associated with the brick making facility based on site observations and noise measurements performed by AECOM during a site visit in November 2009.

No account has been made in the modelling for the potential shielding effects of stacked bricks in the storage yard. It is anticipated that the heights and location of the bricks in the storage yard could vary considerably over

the life of the quarry, and therefore acoustic shielding from the bricks cannot be relied upon as a noise control measure. However, it is expected that some acoustic shielding would generally result from the stacked bricks in the storage yard, and therefore the model may slightly over-predict the noise levels due to the brick making facility and storage yard.

9.2.3 Site Access Road

AECOM's Traffic Impact Assessment Report indicates that the number of vehicles using the access road would be highest on weekdays. The Traffic Impact Assessment Report prepared as part of this EA states that 60 trucks per weekday would travel along the site access road to the storage yard and brick making facility, and 76 employee vehicles per weekday would travel along the site access road to the employee car park.

Noise from the site access road has been modelled as a line source. In the model, the line source extends the full length of the access road from Martin Road to the storage yard, and includes a loop around the storage yard, to simulate the path that trucks would typically take on their way to / from being loaded (employee vehicle noise has not been included in this loop since the employee car park is located before the storage yard on the access road).

The sound power level of the line source has been calculated using the methodology presented in Equation D.6 of the British Standard 5228-1:1997 (Refer to **Appendix F**).

In order to make the model representative of the maximum noise impact that would typically occur due to vehicles on the site access road, the calculation of the line source sound power level has been based on the expected peak vehicle flow rates along the access road for each assessment period. Based on the data presented AECOM's Traffic Impact Assessment Report, the peak vehicle movements on the access road were modelled as follows:

Table 35: Peak Vehicle Movements Modelled for Each Assessment Period

	Daytime (7am to 6pm)	Evening (6pm to 10pm)	Night-time (10pm to 6am)	Night-time (6am to 7am)
Truck Movements Per Peak Hour	12	12	0	12
Employee Vehicle Movements Per Peak Hour	6	6	6	6

Typical vehicle speed on the access road has been modelled as 30 km/h.

9.3 Potential Impacts

9.3.1 Noise Modelling Results

Details of the Predicted Operational Noise Levels without mitigation are provided in Section 6.0 of the *Noise Assessment Report* in **Appendix F**, and discussed as follows.

Quarry

Noise levels at the Victor Avenue receptors are predicted to exceed the criterion during quarrying in Pits 3 and 4. The highest noise levels at Victor Avenue are predicted to occur when quarrying is being performed near to the end of the life of Pit 3 (Stage 3C). At that time, noise levels at the Victor Avenue receptors are predicted to be up to 7 dB in excess of the noise criterion.

Noise levels at the other receptors considered in the assessment are also predicted to exceed the noise criterion at certain stages during the life of the proposal. Most notably, the noise levels at 217 Martin Road, 225 Martin Road, and 255 Lawson Road are predicted to be up to 30 dB in excess of the criterion during the late stages of Pit 4 through the mid stages of Pit 5. There are also a number of other residences around these locations, which are not included in the model, but would be similarly affected by noise from the quarry. Noise reduction measures would therefore be required in order to comply with the noise criterion at these locations.

Noise levels at the receptor at Fuller Street are predicted to be slightly in excess of the noise criterion for most of the life of the proposed expansion. This would primarily be due to noise from the bulldozer and other mobile plant working on the overburden dump and western stockpile.

Noise impacts may also result from warning beepers on vehicles and equipment at the Project Site, which would be audible at some or all of the most-affected locations at certain times. Particularly affected residences are likely to be 217 Martin Road (and the other residences near to this location), 225 Martin Road, and 255 Lawson Road (and the other residences near to this location). An additional +5 dB noise adjustment is therefore required at these residences under the INP.

Brick Making Facility

Noise levels due to Evening period operations (6pm – 10 pm) at the brick making facility and brick product storage yard are predicted to exceed the noise criteria at 225 Martin Road and 255 Lawson Road without mitigation under neutral meteorological conditions, due primarily to trucks using the access road. However, it is predicted that noise from forklift operations in the area of the brick making facility and storage yard would also contribute to noise levels. Noise from the brick making facility between the hours of 10pm and 6am is predicted to comply with the Night period noise criteria under neutral meteorological conditions for all locations except 255 Lawson Road, which would be only marginally in excess of the criterion. However, between 6am and 7am, the noise levels at 217 Martin Road, 225 Martin Road, and 255 Lawson Road (40, 49 and 44 dB(A) L_{Aeq} respectively) would exceed the Night period noise criterion of 36 dB L_{Aeq} . Background noise levels are rapidly increasing towards normal daytime levels during this period and can be therefore be considered a “shoulder” period by the INP and as such it is considered that it may be unduly stringent to apply the Night period criterion.

An appropriate criterion considered for this project would be the mid value between the Day and Night period criteria i.e. 39 dB L_{Aeq} for the receptors concerned. It is noted that even if a shoulder period criterion of 39 dB L_{Aeq} is applied, the predicted noise levels at 217 Martin Road, 225 Martin Road, and 255 Lawson Road (40, 49 and 44 dB L_{Aeq} respectively) would still not comply with the criterion without taking measures to reduce the noise levels at the affected receptors.

Traffic Noise

The Traffic Impact Assessment Report (AECOM, January 2010) predicted that the number of daily traffic movements generated by the Project would not increase compared with the existing operations owing to the installation of a Dehacker at the brick making facility. The Dehacker improves the efficiency of brick transport by packing bricks more efficiently enabling a greater quantity of bricks to be transported by truck. The forecast changes in traffic movements due to the project are predicted to result in a slight reduction in the maximum $L_{Aeq(1hr)}$ traffic noise levels on Martin Road. As such, traffic noise from public roads generated by vehicle movements associated with the proposed operation would be no greater than the existing case, and would comply with the traffic noise criteria.

Due to the different hours of operation, the peak hour traffic volumes are predicted to change. Under the ECRTN, traffic noise generated by the project is to be assessed in terms of the $L_{Aeq(1hr)}$ noise levels. The highest $L_{Aeq(1hr)}$ traffic noise levels would occur during the peak hour traffic flow, and therefore it is appropriate to assess the traffic noise impact of the Project in relation to the peak hour traffic flows.

Based on the peak hour traffic volumes predicted in the Traffic Impact Assessment Report, the changes in the traffic noise level from Martin Road have been predicted. **Table 36** presents the changes in peak hour traffic movements on Martin Road as discussed in the Traffic Noise Assessment Report, along with the predicted changes in traffic noise level.

Table 36 Predicted Changes in Noise Level from Martin Road

Peak Hour Vehicle Movements due to Existing Operation, (veh/hr)	Total Existing (2009) Peak Hour Traffic on Martin Road Including Existing Operations, (veh/hr)	Peak Hour Vehicle Movements due to Proposed Continuation of Operations, (veh/hr)	Total Peak Hour Traffic on Martin Road Including Proposed Operations, (veh/hr)	Percentage Change in Traffic Volume on Martin Road due to Proposed Continuation of Operations	Predicted Change in Traffic Noise Level
28 ⁽¹⁾	43 ⁽²⁾	24 ⁽³⁾	39 ⁽⁴⁾	-10%	-0.4 dB(A)

Notes:

- (1) 16 truck movements plus 12 employee vehicle movements per peak hour (Source: AECOM Traffic Noise Assessment Report, January 2010).
- (2) From AECOM Traffic Noise Assessment Report, January 2010
- (3) 12 truck movements plus 12 employee vehicle movements per peak hour (Source: AECOM Traffic Noise Assessment Report, January 2010).
- (4) Calculated as the existing 2009 peak hour traffic on Martin Road plus difference between the peak hour vehicle movements due to the existing and proposed operations.

Traffic noise resulting from project-generated traffic movements must not exceed the specified $L_{Aeq(1hr)}$ criteria, or, where the existing noise levels exceed the criteria, project-related traffic must not increase the existing noise levels by more than 2 dB(A).

The forecast changes in traffic movements due to the project are predicted to result in a slight reduction in the maximum $L_{Aeq(1hr)}$ traffic noise levels on Martin Road. As such, traffic noise from public roads generated by vehicle movements associated with the proposed operation would be no greater than the existing case, and would therefore comply with the traffic noise criteria.

9.4 Mitigation Measures

The following noise mitigation measures would be implemented to ensure that noise levels resulting from the proposed operations comply with relevant noise criteria.

9.4.1 Earth mounds

Two 10 m high earth mounds would be constructed along the northern and eastern Project Site boundary, wrapping around to the western boundary for a length of 150 m and extending along the southern boundary for 100 m, as illustrated in **Figure 7** and Figure 10 of the Noise Assessment Report in **Appendix F**. The earth mound is to be constructed in stages as specified in **Figure 7** of the EA and Figure 12 of the *Noise Assessment Report*.

Construction of the 10m high earth mounds, in combination with one or more of the noise control methods discussed below, is considered to be the most suitable approach to achieve satisfactory noise levels at the Victor Avenue receptors.

Noise levels during the construction of the earth mounds would, at certain times exceed the Management Levels recommended in the ICNG, however these works would be temporary and transient in nature.

9.4.2 Construction Work Hours

Construction works associated with the earth mound within 300 m of any residences, shall be limited to 7am to 6pm Monday to Friday and 8am to 1pm on Saturdays.

9.4.3 Mobile Plant Noise Reduction

Noise from mobile plant in the quarry is predicted to be the main contributor to daytime quarry noise levels at receptors. Noise reduction could be achieved by acoustically treating mobile plant by:

- Enclosure of the engine within an acoustic enclosure and/or sealing of gaps around the engine bay;
- Use of acoustic louvres / treatments on engine air intakes and cooling air exhausts;
- Installation of high attenuation engine exhaust mufflers; and/or

- Lining of the trays/bodies of dump trucks with high impact rubber to reduce loading noise, or using specially designed suspended dump bodies (e.g. Duratray).

Implementation of some of the above treatments in combination with the use of the 10m high earth mound would satisfy the noise criteria at all locations except 255 Lawson Road, during all stages of the quarry life. At 255 Lawson Road, the noise levels during quarrying of the middle stages of Pit 5 may still be marginally (2 dB) over the noise criterion for that location. This exceedence is considered to be insignificant and would occur for a limited time period.

9.4.4 Use of Alternative Vehicle Movement and Warning Alarms

Alternative vehicle movement and warning alarms could be utilised at the Project Site such as broadband movement and warning alarms on mobile plant rather than beepers, proximity sensing alarms that operate at low level (or not at all) until a person or object is sensed in the immediate proximity of the vehicle and/or vibrating safety vests activated by proximity to moving plant. These measures would reduce the +5 dB tonality adjustment required by the INP, which may apply at 217 Martin Road (and the other residences near to this location), at 225 Martin Road, and at 255 Lawson Road (and the other residences near to this location), if conventional vehicle movement and warning beepers were to be used.

9.5 Conclusion

The Noise Assessment undertaken for the subject site found that a number of residences to the north, west, and east of the Project Site may be affected by noise from the proposed operation. Noise modelling of various stages during the life of the proposed operation has shown that mitigation measures would be required in order to satisfy the noise criteria at noise sensitive locations. With these measures fully implemented, it is predicted that noise from the Project Site would generally comply with the INP noise criteria.

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