MOOREBANK INTERMODAL COMPANY

Moorebank Intermodal Terminal Response to Submissions Report

Volume 4

May 2015

PARSONS BRINCKERHOFF

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Moorebank Intermodal Terminal

Revised Project Report

Noise and Vibration Impact Assessment

Report Number 620.10816 R2

27 April 2015

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Version: Revision 0

Moorebank Intermodal Terminal

Revised Project Report

Noise and Vibration Impact Assessment

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DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
620.10816 R2	Revision 0	21 April 2015	Steven Walker	Ben Hinze	Steven Walker

Executive Summary

The Moorebank Intermodal Terminal (IMT) Project ('the Project') involves the development of approximately 220 hectares (ha) of Commonwealth-owned land for the construction and operation of an intermodal terminal and associated infrastructure, facilities and warehousing. The Project will be on land currently occupied by the Australian Defence Force School of Military Engineering and a number of other Department of Defence units.

In December 2014 an Environmental Impact Statement (EIS) for the Project was exhibited, including a noise and vibration impact assessment prepared by SLR Consulting Australia Pty Ltd. Since the time of the EIS, a revised Project layout has been developed as a result of an agreement being reached between Moorebank Intermodal Company (MIC) and Sydney Intermodal Terminal Alliance (SIMTA). The agreement enables the development of both the MIC land and the SIMTA site to the east of Moorebank Avenue, to create an intermodal precinct solution.

Due to the differences in layout and phasing relative to the EIS, and the level of public interest, a description of the proposed amendments to the development have been documented in a Response to Submissions Report which will be exhibited. This technical paper details the assessment of noise and vibration impacts for the revised Project.

Key Findings

Where noise generating construction works such as excavation, piling and compaction are undertaken within 600 m of nearest residential receptors, the revised Project would need to investigate and implement reasonable and feasible noise management and mitigation measures to control noise levels to meet the construction noise management levels. If rail construction works are undertaken outside the daytime hours of 7.00 am to 6.00 pm, additional noise mitigation may be required to minimise potential impacts during the most sensitive night-time period.

Predicted noise levels during the operation of the Project, without noise mitigation, comply with the NSW Industrial Noise Policy assessment criteria at the majority of receptors during neutral and adverse weather conditions. At the nearest receptors at the northern extent of Casula and at the western extent Anzac Road in Wattle Grove, the predicted noise levels for the full build operations exceed the noise criteria during the night-time by up to 4 dB during neutral weather and up to 6 dB during adverse weather conditions. Noise levels at these receptor areas are influenced by the nearest rail mounted gantries at the interstate terminal and trucks operating on the haul road at the western boundary of the site.

The noise levels with the Revised Project are up to 7 dB less than the concept designs assessed in the EIS, with noise levels lower than the EIS at the majority of the assessed receptors. The concept design also removes the need for a rail loop within the site, which would reduce likelihood for wheel squeal from the trains.

A noise mitigation scenario allowing for both the IMEX and interstate terminal to be operated with electrified plant, automated container handling areas and a noise barrier at the western haul road has been demonstrated to control noise levels and achieve predicted compliance to the noise criteria at all receptors. If electrification of the terminals is not feasible, the revised Project should operate plant and equipment with low noise emissions equivalent to electrified plant.

In addition to the above recommendations, a range of reasonable and feasible noise mitigation measures has been recommended in the EIS and this report, including specific measures to control rail noise and issues such as wheel squeal.

Should the revised Project operate simultaneously with an intermodal or warehousing development on the SIMTA site, the predicted cumulative noise levels would comply with the noise criteria where both developments implement the noise mitigation recommended in this report and the respective EISs prepared for each project.

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1 INTRODUCTION

1.1 The Moorebank Intermodal Terminal Project

The Moorebank Intermodal Terminal (IMT) project ('the Project') involves the development of approximately 220 hectares (ha) of Commonwealth-owned land for the construction and operation of an intermodal terminal and associated infrastructure, facilities and warehousing. The Project will be located on land currently occupied by the Australian Defence Force School of Military Engineering and a number of other Department of Defence units. To the west, the southern rail access will connect the Project site to the Southern Sydney Freight Line (SSFL) via a bridge crossing the Georges River.

In accordance with Commonwealth and NSW State Government assessment requirements, an Environmental Impact Statement (EIS) for the Project was exhibited in December 2014. As part of the EIS, an assessment of potential noise and vibration impacts was prepared for the Project as detailed in the technical report; *Moorebank Intermodal Terminal EIS Noise and Vibration Impact Assessment*[1] (SLR Consulting Australia Pty Ltd).

1.2 The Intermodal Precinct at Moorebank

A revised Project layout has now been developed as a result of an agreement being reached between Moorebank Intermodal Company (MIC), the proponent of the Moorebank IMT, and the Sydney Intermodal Terminal Alliance (SIMTA) who are proposing to construct and operate an intermodal terminal to the east of the Moorebank site. The revised layout provides an intermodal precinct solution (the Revised Project) for the two projects.

The revised Project on MIC land would be progressively developed from 2016 with the Full Build phase of the Project completed in 2030. At Full Build the key features of the Project comprise:

- Operation of an IMEX (import/export) facility at a capacity of 1.05 million TEU (twenty foot equivalent containers) per annum to service 'port shuttle' train services between Port Botany and the revised Project.
- Operation of interstate facility of up to 500,000 TEU per annum to service freight trains travelling to and from regional and interstate destinations.
- Operation of up to 300,000 sq.m of warehousing to provide an interface between the IMT and commercial users of the facilities such as freight forwarders, logistics facilities and retail distribution centres.

1.3 Planning and Assessment Process

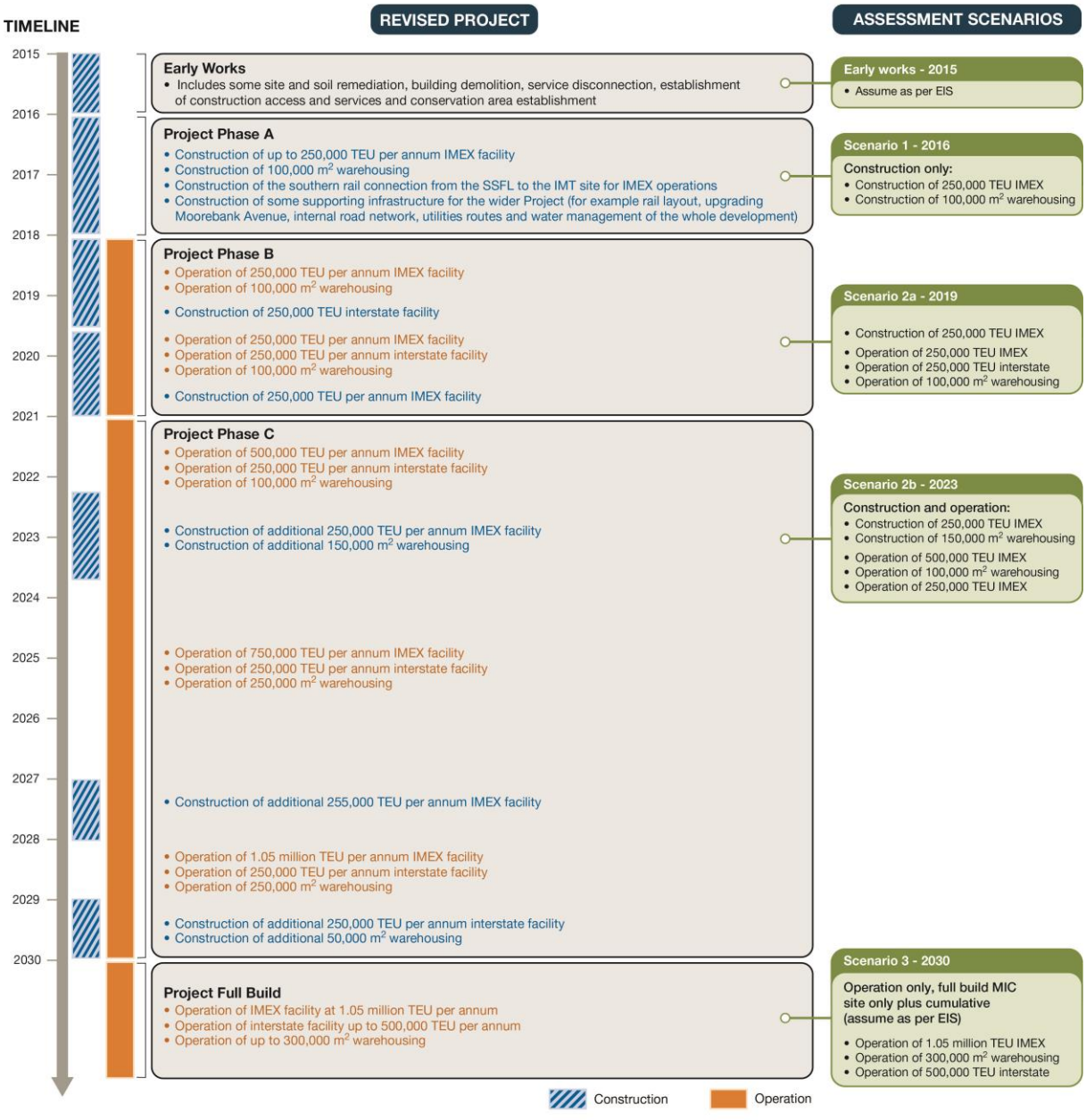
In accordance with the requirements of Section 89F (4) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) the Moorebank Intermodal Terminal revised Project is being exhibited due to the differences in the proposed layout and phasing between the revised Project and the EIS, and the level of public interest in the project. The revised Project design and assessment of potential environmental impacts is being presented in a Response to Submissions Report, to be exhibited in 2015.

To assess potential environmental impacts in the Response to Submissions Report, five project development phases have been identified as indicative of the type of construction and operation activities that would occur over time at the project site. Within each Phase an assessment scenario has been prepared to assess likely construction and operation impacts. The development phases and assessment scenarios are summarised in **Figure 1**.

[1] SLR Consulting Australia Pty Ltd, 2014. Moorebank Intermodal Terminal EIS – Noise and Vibration Impact Assessment, Report Number 620.10816, dated 1 October 2014.

The Early Works phase between 2015 and 2018 is consistent with the Early Works assessed in the EIS and impacts have not been reassessed for the revised Project.

Figure 1 Project Phases and Assessment Scenarios



1.4 Noise and Vibration Assessment

This technical paper details the assessment of potential noise and vibration levels associated with the proposed construction and operation of the revised Project. The assessment has referenced the noise and vibration impact assessment report prepared for the EIS, including the ambient noise surveys, assessment methodologies and recommended noise and vibration mitigation measures.

At this time the concept designs for the revised Project do not include noise mitigation measures such as noise walls/ barriers, earth mounds or acoustic enclosures. The assessed noise levels in this technical paper represent the worst case 'unmitigated' conceptual layout. To demonstrate the potential noise levels can achieve the noise assessment criteria, a concept design with reasonable and feasible noise mitigation has been assessed in **Section 16**.

2 CONCEPT DESIGN FOR THE PRECINCT

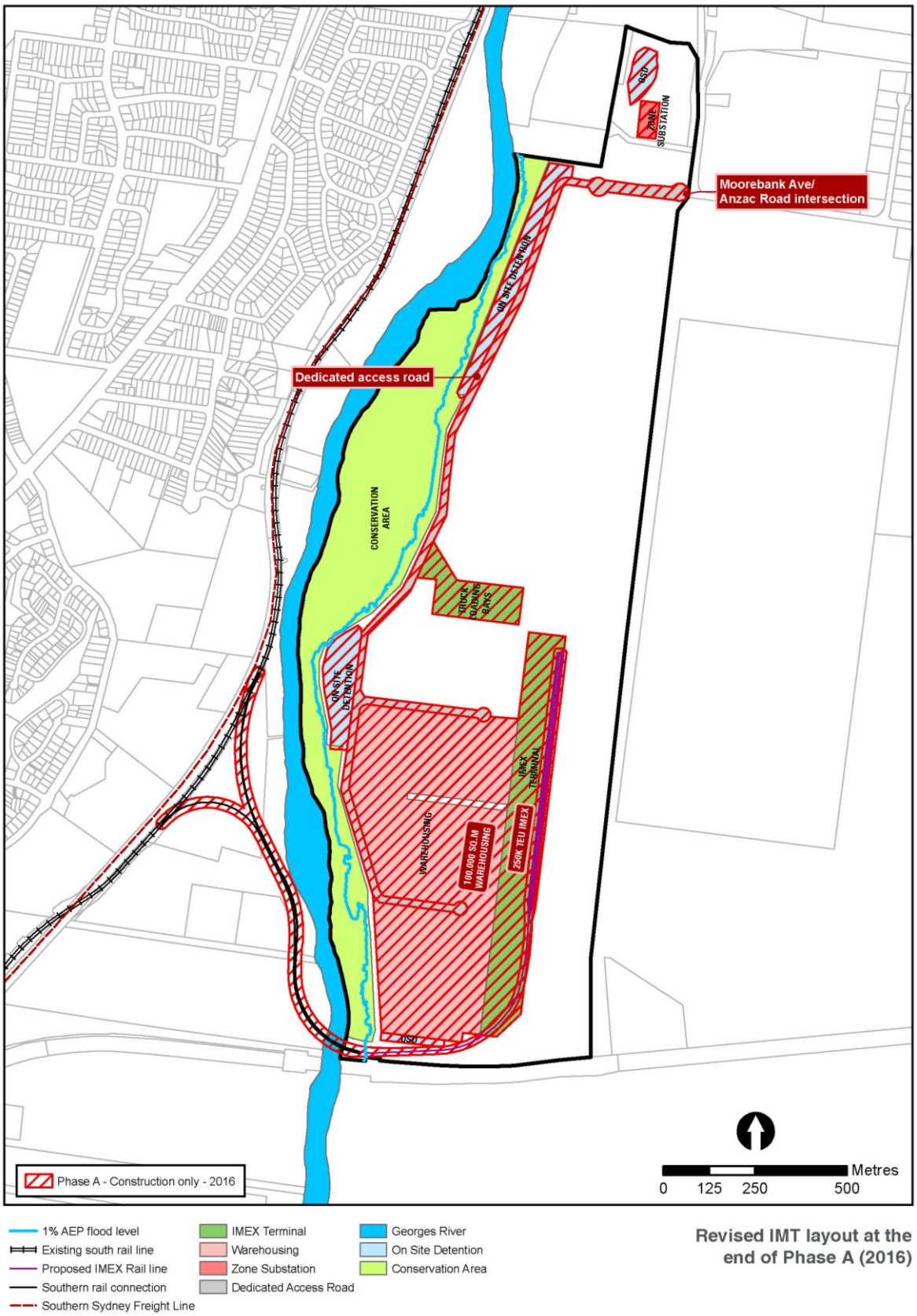
The concept layouts for the progressive development of the precinct on the MIC land at Moorebank are presented in **Figure 2** to **Figure 5**. The following features of the revised Project have the potential to change the noise levels previously assessed in the EIS.

- The IMEX terminal will be operated with the electric powered mobile and fixed plant that would have lower source noise emissions than the diesel or hybrid plant assumed in the EIS.
- The container handling at the IMEX terminal will be an automated process that will not require staff to be within the container handling area and the rail-mounted gantries (RMGs) will thus not require audible alarms or beepers. Measured noise levels provided by the manufacturer of the RMGs are 10 dB less when operated without the audible warning alarms.
- The revised Project has amended the locations of the key noise sources at the interstate rail tracks, container handling areas, internal site traffic routes and container storage areas. This has changed the distance between the receptors and the noise sources.
- The warehousing for the IMEX and interstate terminals are located to the west of the Project site which will assist in screening noise emissions at the suburb of Casula.
- Only a southern rail access between the site and the SSFL is being considered.
- The revised Project has removed the need for a rail loop to manage the entry and departure of trains within the site, which by removing the curved track will reduce the likelihood for wheel squeal noise from the trains.

Consistent with the Section 1.5 of the EIS noise and vibration impact assessment, this assessment has assumed the following measures would be implemented:

- Modern, 'state of the art' plant and equipment would be selected with as low as reasonably practicable source noise emissions.
- At the interstate terminal the motors of the RMGs will be supplied as standard with an acoustic enclosure around the motor and the motor exhaust acoustically lagged/insulated.
- Plant and equipment would be designed to be at the greatest feasible separation distance from nearest receptors.
- Rail freight trains will be a modern state of the art fleet with noise emissions that would conform to noise emission limits in licenses for Railway Systems Activities.
- The detailed design of the revised Project would take advantage of on-site measures to impede noise propagation, such as situating plant and equipment behind container stacks.

Figure 2 Concept Plan Scenario 1



Revised IMT layout at the end of Phase A (2016)

Figure 3 Concept Plan Scenario 2a

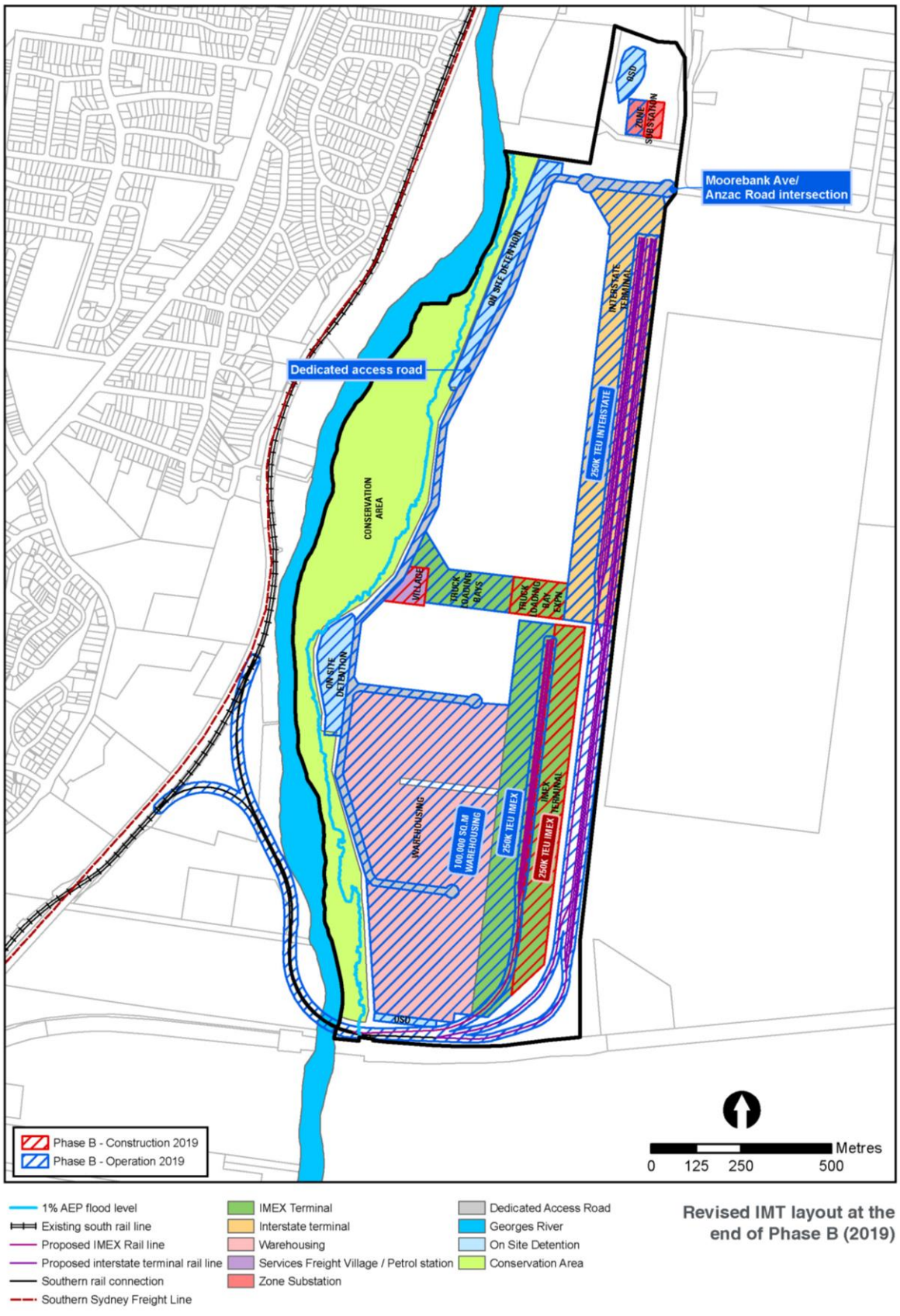


Figure 4 Concept Plan Scenario 2b

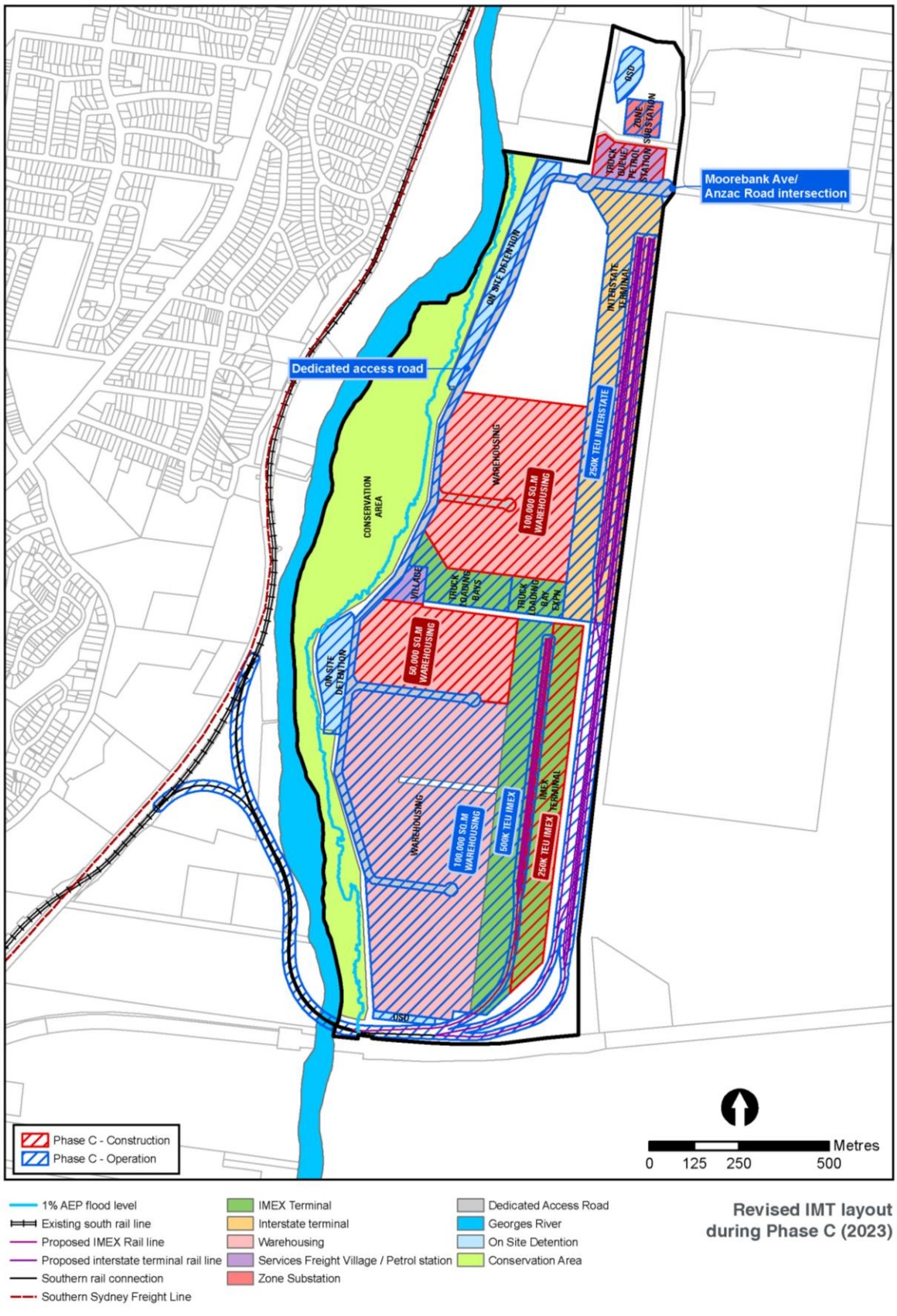
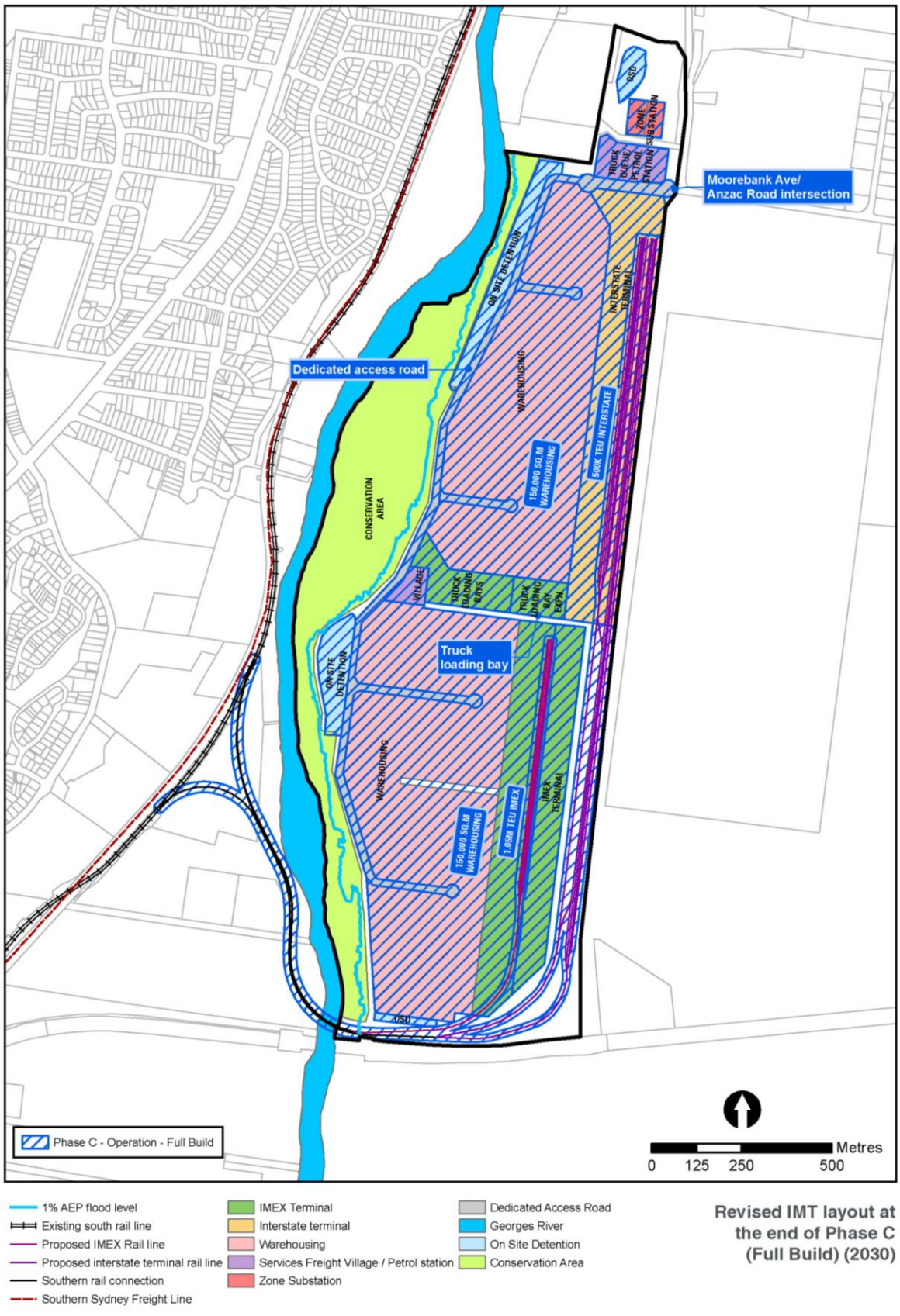


Figure 5 Concept Plan Scenario 3



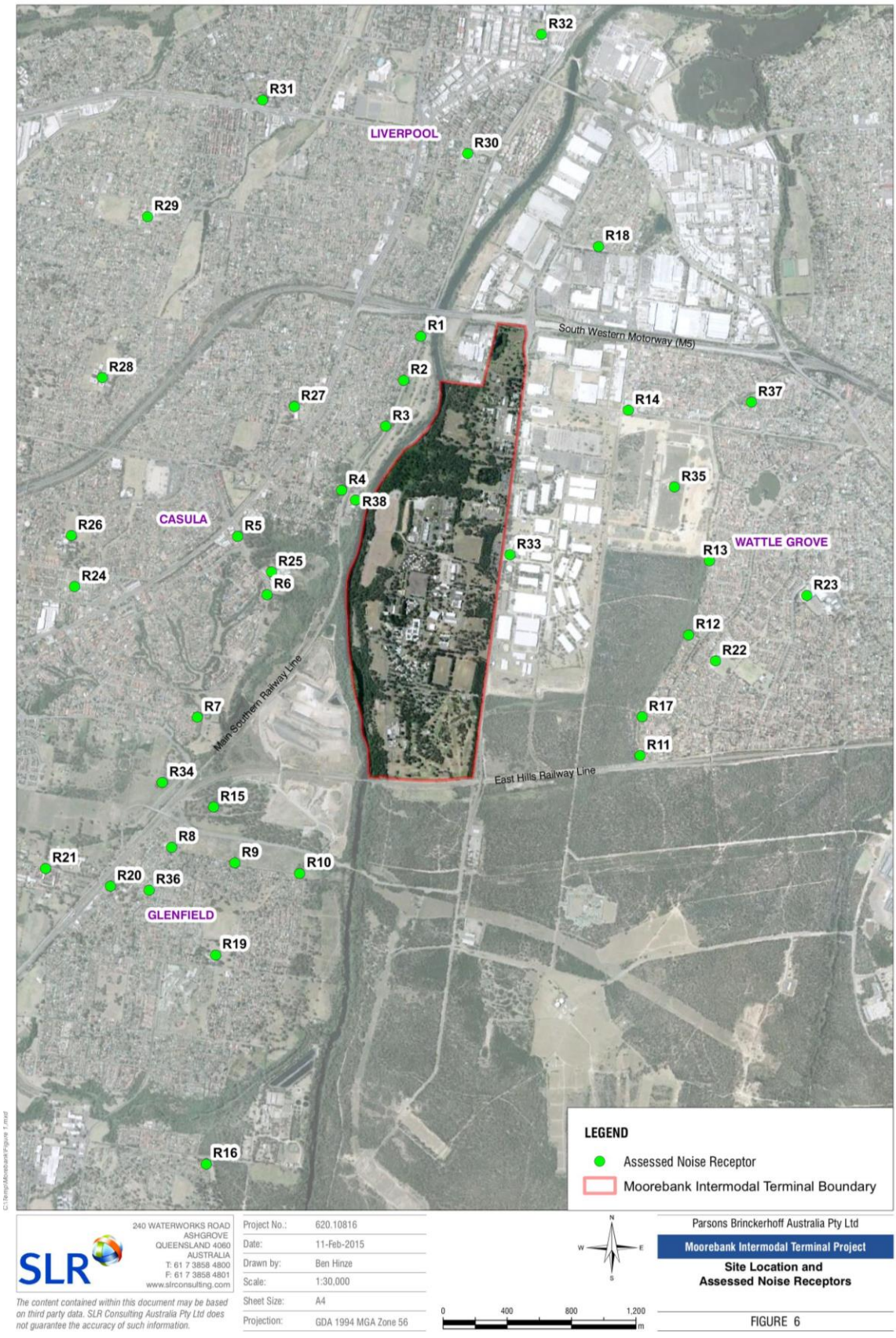
3 NOISE SENSITIVE RECEPTORS

Potential impacts have been assessed at the noise sensitive receptors in **Table 1** and **Figure 6**.

Table 1 Assessed Receptors

Receptor	Location	Distance from Receptor to Project site, m
R1	Lakewood Crescent, Casula	443
R2	St Andrews Boulevard, Casula	376
R3	Buckland Road, Casula	381
R4	Dunmore Crescent, Casula	470
R5	Leacocks Lane, Casula	935
R6	Leacocks Lane, Casula	683
R7	Slessor Road, Casula	1,127
R8	Canterbury Road, Glenfield	1,431
R9	Ferguson Street, Glenfield	1,123
R10	Goodenough Street, Glenfield	862
R11	Wallcliffe Court, Wattle Grove	578
R12	Corryton Court, Wattle Grove	612
R13	Martindale Court, Wattle Grove	683
R14	Anzac Road, Wattle Grove	378
R15	Cambridge Avenue, Glenfield	1,108
R16	Guise Public School	2,721
R17	Yallum Court, Wattle Grove	425
R18	Church Road, Liverpool	870
R19	Glenwood Public School, Glenfield	1,588
R20	Glenfield Public School, Glenfield	1,876
R21	Hurlstone Agricultural School	2,218
R22	Wattle Grove Public School	798
R23	St Marks Coptic College, Wattle Grove	1,313
R24	Maple Grove Retirement Village, Casula	1,878
R25	All Saints Catholic College	673
R26	Casula High School	1,940
R27	Casula Primary School, Casula	944
R28	Lurnea High School	2,106
R29	St Francis Xaviers Catholic Church	2,255
R30	Impact Church Liverpool	1,285
R31	Liverpool West Public School	2,181
R32	Liverpool Public School / TAFE NSW	2,026
R33	DNSDC[1] Site up to end 2014	0
R34	Glenfield Rise Development, Glenfield	1,402
R35	DNSDC[1] Site after end 2014	408
R36	Playground Learning Centre Glenfield	1,669
R37	Wattle Grove Long Day Care Centre	968
R38	Casula Powerhouse Arts Centre	376

Figure 6 Assessed Receptors



4 ASSESSMENT CRITERIA

4.1 Overview

The *Protection of the Environment Operations Act 199*7 (POEO Act) regulates noise generation and prohibits the generation of "offensive noise" as defined under the POEO Act. To assist in the implementation of the requirements under the POEO Act, the NSW Environmental Protection Agency (EPA) and NSW Office of Environment and Heritage (OEH) provide guidelines for the assessment and management of noise and vibration.

The regulatory policy and guidelines referenced in Final EIS requirements from the Commonwealth and the NSW State Government were applied to establish the following noise and vibration assessment criteria in both the EIS and the Response to Submissions Report.

4.2 Rating Background Levels

A continuous ambient noise survey has been undertaken in the suburbs surrounding the Project site. The monitoring locations were representative of the quiet residential communities where noise levels were not adversely influenced by noise from the local road and rail transport corridors.

A total of 20 months of noise monitoring data was analysed to determine the Rating Background Level (RBL) for the day time, evening and night-time periods as presented in **Table 2**. The RBLs were derived from the measured L_{A90} noise levels in accordance with the NSW Industrial Noise Policy.

Table 2 Rating Background Levels

Monitoring Location		Representative Suburb	Rating Background Level, dBA		
			Daytime	Evening	Night-time
L7[1]	Corryton Court	Wattle Grove	35	36	32
L8[1]	Goodenough Street	Glenfield	35	37	33
L9[1]	Buckland Road	Casula/Liverpool	39	39	33

Note 1: Monitoring locations as reported in the EIS noise and vibration impact assessment.

4.3 Construction Noise Management Levels

The *Interim Construction Noise Guideline*[2] (ICNG) noise management levels (NMLs) for residential and other noise sensitive receptors are summarised in **Table 3**. The NMLs are criteria to identify where feasible and reasonable mitigation measures may be required to reduce noise levels.

Standard construction hours are defined as Monday to Friday 7.00 am to 6.00 pm and Saturday 8.00 am to 1.00 pm. The NMLs for construction works outside the standard hours are conservative, having adopted the RBLs for the night-time period when background noise levels were lowest.

Table 3 Construction NMLs for Residential Receptors

Suburb	RBL dBA		NML dBA $L_{Aeq(15minute)}$	
	Day	Night	Standard Hours	Outside Standard Hours
Casula	39	33	49	38
Glenfield	35	33	45	38
Wattle Grove	35	32	45	37
Liverpool	39	33	49	38

Note: RBL is the Rating Background Level

[2] Department of Environment and Climate Change. 2009. Interim Construction Noise Guideline.

The ICNG recommends NMLs for non-residential noise sensitive land uses, as detailed in **Table 4**.

Table 4 Construction NMLs for Other Noise Sensitive Land Use

Sensitive Land Use	NML dBA $L_{Aeq(15minute)}$
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generating theory own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, areas for reading or meditation)	External noise level 60 dB(A)
Commercial centres	Depends on the intended use of the centre. Refer to the recommended maximum internal levels in AS2107 for specific uses.

Note: The NMLs are applicable only during period when the land use is in use.

4.4 Operational Noise Criteria

In NSW noise from on-site industrial activity is assessed and managed in consideration to the *NSW Industrial Noise Policy*[3] (NSW INP). Referencing the RBLs from **Table 2**, the project specific noise assessment criteria for residential receptors are detailed in **Table 5**.

Table 5 Project Specific Noise Criteria at Residences

Receptor	RBL dBA			Intrusive Criteria dBA $L_{Aeq(15minute)}$		
	Daytime	Evening	Night	Daytime	Evening	Night
R1 Lakewood Crescent, Casula	39	39	33	44	44	38
R2 St Andrews Bd, Casula	39	39	33	44	44	38
R3 Buckland Road, Casula	39	39	33	44	44	38
R4 Dunmore Ct, Casula	39	39	33	44	44	38
R5 Leacocks Lane, Casula	39	39	33	44	44	38
R6 Leacocks Lane, Casula	39	39	33	44	44	38
R7 Slessor Road, Casula	39	39	33	44	44	38
R8 Canterbury Rd, Glenfield	35	37	33	40	42	38
R9 Ferguson Street, Glenfield	35	37	33	40	42	38
R10 Goodenough St, Glenfield	35	37	33	40	42	38
R11 Wallcliffe Ct, Wattle Grove	35	36	32	40	41	37
R12 Corryton Ct, Wattle Grove	35	36	32	40	41	37
R13 Martindale Ct, Wattle Grove	35	36	32	40	41	37
R14 Anzac Road, Wattle Grove	35	36	32	40	41	37
R15 Cambridge Ave, Glenfield	35	37	33	40	42	38
R17 Yallum Court, Wattle Grove	35	36	32	40	41	37

[3] NSW Environmental Protection Agency, 2000. NSW Industrial Noise Policy.

Receptor	RBL dBA			Intrusive Criteria dBA $L_{Aeq(15minute)}$		
	Daytime	Evening	Night	Daytime	Evening	Night
R18 Church Road, Liverpool	39	39	33	44	44	38
R24 Maple Grove, Casula	39	39	33	44	44	38
R34 Glenfield Rise Glenfield	35	37	33	40	42	38

The NSW INP has amenity noise criteria which are based on the surrounding land use to the Project site. The criteria are designed to preserve noise amenity of the land use and protect against noise impacts such as community annoyance and speech interference. The amenity criteria applied to the non-residential noise sensitive receptors are detailed in **Table 6**.

Based on SLR's experience in assessing internal noise levels, a 7 dBA adjustment to external noise levels was applied to assess potential internal noise levels at school classrooms and places of worship where windows are open for ventilation.

Table 6 Amenity Noise Criteria

Land Use	Period	Acceptable Noise Level dBA L_{Aeq}	Maximum Noise Level dBA L_{Aeq}
Residential - daytime	Monday to Saturday Sundays & Public Holidays	**55**	**60**
Residential - evening	6.00 pm – 10.00 pm	**45**	**50**
Residential - night-time	10.00 – 7.00 am	**40**	**45**
School classrooms	When in use	**35** (internal)	**40** (internal)
Places of worship	When in use	**40** (internal)	**45** (internal)
Passive recreation areas	When in use	**50**	**55**
Active recreation areas	When in use	**55**	**60**
Commercial premises	When in use	**65**	**70**
Industrial premises	When in use	**70**	**75**

Note: Existing noise levels at receptors were not influenced by industrial noise, consequently modifying adjustment factors were not applied to the amenity noise criteria.

4.5 Sleep Disturbance Noise Criteria

The current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background noise level plus 15 dB (as described in the Application Notes to the NSW INP). The sleep disturbance screening criterion in **Table 7** applies outside bedroom windows during the night-time period.

Table 7 Sleep Disturbance Noise Criteria

Residential Receptors	Night-time RBL dBA	Sleep Disturbance Criteria dBA $L_{A1(1\ minute)}$
Casula	33	48
Wattle Grove	32	47
Glenfield	33	48

4.6 Rail Noise Criteria

Rail freight for the revised Project will arrive and depart on the SSFL, a dedicated rail freight corridor to the west of the Project site. The rail connection between the SSFL and the Project site is a non-network rail line exclusively servicing an industrial site.

Airborne noise from rail freight movements between the SSFL and the Project site boundary are assessed in accordance with the *Rail Infrastructure Noise Guideline*[4] (RING). The RING requires rail noise levels from the rail access connection beyond the site boundary to be assessed to the NSW INP amenity noise criteria in **Table 6**. Rail freight operating within the Project site is assessed in accordance with the project specific noise levels from the NSW INP.

4.7 Road Traffic Noise Criteria

Road traffic noise levels on freeways, arterial and sub-arterial roads are under the NSW *Road Noise Policy*[5] (RNP) noise criteria set out in **Table 8**. In relation to the assessment criteria, the RNP notes that an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

Table 8 Road Traffic Noise Criteria

Road Category	Type of Proposal/Land Use	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Freeway/arterial /sub-arterial roads	Existing residences affected by **additional traffic** on existing freeways/arterial/ sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
	School classrooms	$L_{Aeq(1hour)}$ internal 40 dBA	Facility not in use
	Places of worship	$L_{Aeq(1hour)}$ internal 40 dBA	$L_{Aeq(1hour)}$ internal 40 dBA
	Aged care facilities	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(1hour)}$ internal 55 dB
Freeway/arterial /sub-arterial roads	Childcare facilities	Sleeping rooms $L_{Aeq(1hour)}$ internal 35 dBA Indoor play area $L_{Aeq(1hour)}$ internal 40 dBA Outdoor play area $L_{Aeq(1hour)}$ internal 35 dBA	Facility not in use

Note: All criteria are external, applicable at the facade of the affected residence.

4.8 Ground Vibration Criteria

During the construction and operation of the revised Project, required plant will not operate continuously and are considered intermittent sources of vibration that can be associated with two main types of impact; disturbance at receptors and potential cosmetic structural damage to buildings.

As discussed in Section 5.7 of the EIS noise and vibration impact assessment, the vibration assessment criteria have been referenced from the NSW *Assessing Vibration: a technical guideline*[6]. To comply with the criteria for intermittent sources of vibration at residential buildings, vibration levels should not exceed a maximum vibration dose value of 0.4 $m/s^{1.75}$.

[4] NSW Environmental Protection Authority, 2013. NSW Rail Infrastructure Noise Policy.
[5] NSW Environmental Protection Authority, 2011. NSW Road Noise Policy.
[6] NSW Environmental Protection Authority, 2006 (formerly Department of Environment and Conservation). Environmental Noise Management – Assessing Vibration: a technical guideline.

5 ASSESSMENT METHODOLOGY

This section provides an overview of the methodologies applied in the assessment of potential noise and ground vibration levels associated with the construction and operation of the revised Project.

5.1 Construction Noise Predictions

At the time of this assessment, an indicative construction program was available which identified key work activities and an estimation of the number of construction plant likely to be required. The assessment of construction noise was based on a worst case assumption that construction could, at some time, be carried out at the closest site boundary location to each receptor.

The construction scenarios in **Table 9** were developed for the purpose of assessing potential worst case noise levels from the construction works. A noise prediction spread-sheet was developed to determine potential noise levels at the nearest receptors during construction of the Project site and rail access connections.

Table 9 Assessed Construction Works

Construction Activity	Equipment	Sound Power Level, L_{Aeq} dBA
Piling works for rail access connection between the project site and the SSFL.	Vibratory Piling Rig	121
	Grout Pump	109
	Tipper Truck	107
Excavation	Backhoe	103
	Grader	102
	Excavator (30T)	110
	Bobcat	108
Excavation continued	D6 Dozer	113
	D8 Dozer	115
	Tipper Truck	107
Compaction	Vibratory Roller	117
	Smooth Drum Roller	113
	Loader	103
	Scraper	102
Heavy Vehicles Within the Project site	Tipper Truck	107
	Road Truck (12 – 15 tonne)	108
Concreting	Concrete Pump	109
	Concrete Saw	111
	Concrete Truck/Agitator	112
Rail construction works for the rail access connection and IMEX tracks within the Project site	Hi-Rail Dumper	103
	Rail Tamper	108
	Ballast Regulator	110
	Skid Steer Crane	110
	Rail Saw	113

5.2 Operational Noise Predictions

5.2.1 SoundPLAN Noise Modelling

To calculate the noise emission levels from the operation of the revised Project, a noise prediction model was developed using SoundPLAN V7.2 noise propagation software. Noise levels were predicted with the CONCAWE prediction methodology which is specially designed for large facilities and incorporates the influence of wind effects and the stability of the atmosphere.

Based on an analysis of the 2013 Liverpool AWS meteorological data, the weather conditions used to assess potential noise levels are shown in **Table 10**.

Table 10 Weather Conditions in the Noise Modeling

Parameter	Neutral Weather	Adverse (Worst Case) Weather
Temperature	19°C	14°C
Humidity	63%	84%
Pasquill Stability Category	D	F
Wind Speed	0 m/s	1 m/s prevailing WSW direction.

With regard to the rail access connection and on-site rail tracks, it is noteworthy that if the curve radius is of rail tracks is small - ie at the lower end of the ≥300m and <500 m range or below 300 m - there are recent studies showing in some instances that small radius curves have given rise to curve squeal, increasing the maximum noise levels by 20 dB or more when compared to normal straight track conditions.

Whilst at this stage the curve radius for the rail tracks are not known, MIC advised SLR that the curve radius of all track will be close to or above 500 m and additional mitigation measures, such as track greasing systems, would be implemented as part of a strategy to limit the potential for wheel squeal. Accordingly, only a minor curve noise correction of +3 dB to both the L_{AE} and L_{Amax} noise emissions being applied in the noise model.

5.2.2 Intermodal Terminal Noise Emissions Sources

The adopted source noise levels for the key equipment noise emission sources are provided in **Table 11**. The source noise levels for the IMEX terminal account for the proposed operation with an automated container handling area, electric powered plant and the truck noise emission noise level has been adjusted for trucks manoeuvring for only 35% of their time on-site.

It has been assumed that all equipment at the IMEX and interstate terminals will be designed to control potential noise characteristics of tonality, low frequency and impulsivity.

Table 11 Source Noise Emission Levels

Noise Source	Sound Power Level, L_{Aeq} dBA	
	IMEX terminal	Interstate Terminal
In-terminal Vehicles (ITV)	98	104
Working track lifting equipment - Rail Mounted Gantry (RMG)	98	108
Side pick	102	108
Switch engine	103	103
Road Trucks	97	104
Stationary Locomotive	94	100

Whilst there will be other equipment such as bomb carts, yard chassis and forklifts at the main site they have not been modelled as the sound power levels are expected to be at least 10 dBA below the sound power levels of the equipment listed in **Table 11**, or operated within the warehousing buildings.

The source noise emission levels for the rail freight in **Table 12** have been taken from SLR's extensive measurements of rail freight on the NSW rail network are representative of the modern state-of-the-art rail freight.

Table 12 Rail Freight Noise Emission Levels

Noise Source	Noise Emission Level, dBA at 15 m At 80 km/h	
	Sound Exposure Level	**L_{Amax}**
Class 82 Locomotive (IMEX)	85	89 (exhaust)
C44Aci Locomotive (Interstate)	88	92 (exhaust)
Freight wagons (1,000 m in length)	100	93

6 NOISE ASSESSMENT – SCENARIO 1

Scenario 1 includes the construction of the initial 250,000 TEU per annum IMEX terminal and 100,000 sq.m warehousing at the Project site. There will be no operations at the main IMT at this time.

6.1 Construction Works

The predicted construction noise levels at the nearest residential receptors are provided in **Table 13**.

Table 13 Predicted Noise Levels Scenario 1 Construction

Construction Activity	Predicted Noise Level at Residential Receptors, dBA $L_{Aeq,15min}$			
	Casula NML = 49 dBA	**Wattle Grove NML = 45 dBA**	**Glenfield NML = 45 dBA**	**Liverpool NML = 49 dBA**
Piling Works	41 – **55**	**48** – **57**	43 – **48**	47 – **50**
Excavation	38 – **52**	**46** – **51**	41 – 45	45 – 47
Compaction	38 – **52**	**46** – **51**	41 – 45	45 – 47
Heavy Vehicles with Project site	30 – 44	38 – 43	32 – 37	36 – 38
Concreting	35 – 49	43 – **48**	37 – 42	42 – 45
SSFL Rail Access & On-site Track	38 – **52**	38 – 40	42 – **46**	34 – 36

Note **Bold** highlight denotes predicted noise level is above the daytime noise management level

Construction at the Main IMT Site

Where piling, excavation and compaction works are undertaken adjacent to the nearest residential receptors the predicted worst case noise levels trigger the requirement for construction noise mitigation to reduce potential levels by up to 12 dBA $L_{Aeq(15minute)}$. For concreting works, predicted noise levels trigger the daytime NML by 3 dBA $L_{Aeq(15minute)}$ at nearest receptors in Wattle Grove.

Potential noise levels from heavy vehicles operating within the onsite haul roads are within the daytime NMLs and would not require specific noise mitigation to reduce the predicted noise levels.

At all non-residential noise sensitive receptors, the predicted noise levels were within the relevant NMLs and would not trigger the requirement for noise mitigation.

Construction of the Southern Rail Access Connection

During standard daytime construction hours the predicted noise levels for the construction of the southern rail access connection to the SSFL exceed the NMLs at nearest residences at the west of Casula and north of Glenfield by up to 3 dB.

There is potential for rail construction works to be required during rail possessions that would be outside of the standard daytime construction hours. Based on NMLs of 37 dBA $L_{Aeq(15minute)}$ for Wattle Grove and 38 dBA $L_{Aeq(15minute)}$ at all other suburbs, the predicted noise levels of up to 52 dBA $L_{Aeq(15minute)}$ would trigger the requirement for specific noise mitigation to control potential sleep disturbance impacts at Casula, Wattle Grove and Glenfield.

7 NOISE ASSESSMENT – SCENARIO 2A

Scenario 2a includes the following operations; the 250,000 TEU per annum IMEX facility, the 250,000 TEU per annum interstate facility and up to 100,000 sq.m warehousing. During this time construction works would be required for the additional 250,000 TEU per annum IMEX facility.

7.1 Construction Works

The predicted construction noise levels at the nearest residential receptors are provided in **Table 14**.

Table 14 Predicted Noise Levels Scenario 2a Construction

Construction Activity	Predicted Noise Level at Residential Receptors, dBA L_{Aeq}			
	Casula NML = 49 dBA	**Wattle Grove NML = 45 dBA**	**Glenfield NML = 45 dBA**	**Liverpool NML = 49 dBA**
Piling Works	41 – **51**	43 – **49**	41 – 45	48 – **50**
Excavation	38 – 49	41 – **46**	39 – 42	45 – 47
Compaction	38 – 49	40 – **46**	39 – 42	45 – 47
Heavy Vehicles with Project site	30 – 40	32 – 38	30 – 34	37 – 39
Concreting	35 – 46	37 – 43	35 – 39	42 – 45

Where construction works are undertaken adjacent to the nearest residential receptors, the predicted worst case noise levels for piling, excavation and compaction works would trigger the requirement for construction noise mitigation to reduce potential noise levels by up to 4 dBA $L_{Aeq(15minute)}$ at Casula, Wattle Grove and Liverpool.

Predicted noise levels for heavy vehicles within the Project site and concreting works are within the NMLs and would not require specific noise mitigation measures to be implemented.

At all non-residential noise sensitive receptors, the predicted noise levels were within the relevant NMLs and would not trigger the requirement for noise mitigation.

7.2 Operation at the Main IMT Site

To assess potential noise emissions during the operation of the revised Project, the equipment in **Table 15** was included in the noise prediction model to represent the operations for Scenario 2a.

Table 15 Assessed Operations Scenario 2a

Equipment	Total Number of Items	
	IMEX terminal	Interstate Terminal
RMG	7	6
Side Pick	3	1
ITV	6	8
Switch Engine	1	1
Heavy Vehicles	5	1
Stationary Locomotive	1	1
On-site Rail Freight Movements	13 daytime/4 evening/1 night-time	

Note: The number of items (sources) includes a 10% reduction in total capacity to account for idling plant.

The predicted noise levels for the operation of Scenario 2a during neutral weather and adverse weather conditions are detailed in **Table 16**.

Predicted noise levels are for the unmitigated concept design, including rail freight operations within the Project site, and any exceedance of the most conservative noise criteria from the NSW INP is highlighted in bold.

Table 16 Predicted Unmitigated Noise Levels for Scenario 2a Operation

Receptor		Conservative Noise Criteria, $L_{Aeq(15min)}$ dBA	$L_{Aeq(15min)}$ dBA Noise Level	
			Neutral	Adverse
R1	Lakewood Crescent, Casula	38	35	38
R2	St Andrews Boulevard, Casula	38	37	**40 (+2)**
R3	Buckland Road, Casula	38	**39 (+1)**	**41 (+3)**
R4	Dunmore Crescent, Casula	38	**39 (+1)**	**41 (+3)**
R5	Leacocks Lane, Casula	38	32	34
R6	Leacocks Lane, Casula	38	33	35
R7	Slessor Road, Casula	38	30	31
R8	Canterbury Road, Glenfield	38	27	27
R9	Ferguson Street, Glenfield	38	30	30
R10	Goodenough Street, Glenfield	38	30	31
R11	Wallcliffe Court, Wattle Grove	37	33	37
R12	Corryton Court, Wattle Grove	37	35	**39 (+2)**
R13	Martindale Court, Wattle Grove	37	34	**39 (+2)**
R14	Anzac Road, Wattle Grove	37	37	**42 (+5)**
R15	Cambridge Avenue, Glenfield	38	30	30
R16	Guise Public School	42	23	23
R17	Yallum Court, Wattle Grove	37	35	**39 (+2)**
R18	Church Road, Liverpool	38	30	35
R19	Glenwood Public School, Glenfield	42	27	28
R20	Glenfield Public School, Glenfield	42	24	25
R21	Hurlstone Agricultural School	42	23	24
R22	Wattle Grove Public School	42	32	37
R23	St Marks Coptic College, Wattle Grove	42	28	33

Receptor		Conservative Noise Criteria, $L_{Aeq(15min)}$ dBA	$L_{Aeq(15min)}$ dBA Noise Level	
			Neutral	Adverse
R24	Maple Grove Retirement Village, Casula	38	24	26
R25	All Saints Catholic College	42	34	36
R26	Casula High School	42	23	25
R27	Casula Primary School, Casula	42	32	35
R28	Lurnea High School	42	22	25
R29	St Francis Xaviers Catholic Church	47	19	24
R30	Impact Church Liverpool	47	24	29
R31	Liverpool West Public School	42	19	24
R32	Liverpool Public School / TAFE NSW	42	21	26
R33	DNSDC Site up to end 2014*	70	62	63
R34	Glenfield Rise Development, Glenfield	38	28	28
R35	DNSDC Site after end 2014	70	37	41
R36	Playground Learning Centre Glenfield	42	25	26
R37	Wattle Grove Long Day Care Centre	42	29	34
R38	Casula Powerhouse Arts Centre	50	40	42

Note **Bold** highlight denotes predicted noise level exceeds the Project specific noise level criteria.
* Receptor R33 will not be occupied at the time of Scenario 2a operations.

Neutral Weather Conditions

Predicted noise levels comply with the daytime and evening noise criteria at all receptors. Noise levels comply with the night-time noise criteria at all receptors in Wattle Grove, Liverpool and Glenfield. At the northern extent of Casula, noise levels marginally exceed the 38 dBA $L_{Aeq(15minute)}$ night-time noise criteria by 1 dB.

Adverse Weather Conditions

Predicted noise levels comply with the daytime and evening noise criteria at all assessed receptors, with the exception of the western extent of Anzac Road where a marginal 1 to 2 dB exceedance of the noise criteria was predicted.

During the night-time, predicted noise levels comply with the noise criteria at the majority of receptors, but exceed the noise criteria by 2 to 3 dB at nearest receptors at the northern extent of Casula and by 2 dB at nearest receptors at Wattle Grove.

At the western extent of Anzac Road noise levels exceed the night-time noise criteria by up to 5 dB.

8 NOISE ASSESSMENT – SCENARIO 2B

Scenario 2b includes the following operations; the 500,000 TEU per annum IMEX facility, the 250,000 TEU per annum interstate facility and up to 100,000 sq.m warehousing.

During this time construction works would be required for the additional 250,000 TEU per annum IMEX facility and 150,000 sq.m warehousing.

8.1 Construction Works

A summary of potential Scenario 2b construction noise levels at the nearest residential receptors is provided in **Table 17**.

Table 17 Predicted Noise Levels Scenario 2b Construction

Construction Activity	Predicted Noise Level at Residential Receptors, dBA L_{Aeq}			
	Casula NML = 49 dBA	Wattle Grove NML = 45 dBA	Glenfield NML = 45 dBA	Liverpool NML = 49 dBA
Piling Works	41 – **53**	43 – **49**	41 – 45	47 – 49
Excavation	38 – **50**	40 – **47**	39 – 42	44 – 46
Compaction	38 – **50**	40 – **47**	39 – 42	44 – 46
Heavy Vehicles with Project site	30 – 42	32 – 39	30 – 42	36 – 38
Concreting	35 – 47	37 – 44	35 – **47**	41 – 43

Note **Bold** highlight denotes predicted noise level is above the daytime noise management level

Where construction works are undertaken adjacent to the nearest residential receptors, the predicted worst case noise levels for piling, excavation, compaction and concreting works would trigger the requirement for construction noise mitigation to reduce potential noise levels by up to 4 dBA $L_{Aeq(15minute)}$ at Casula and Wattle Grove.

Predicted noise levels for heavy vehicles within the Project site are within the NMLs and would not require specific noise mitigation measures to be implemented.

At all non-residential noise sensitive receptors, the predicted noise levels are within the relevant NMLs and would not trigger the requirement for noise mitigation.

8.2 Operation at the Main IMT Site

To assess potential noise emissions during the operation of the revised Project, the equipment in **Table 18** were included in the noise model to represent the operations for Scenario 2b.

Table 18 Assessed Operations Scenario 2b

Equipment	Total Number of Items	
	IMEX terminal	Interstate Terminal
RMG	7	6
Side Pick	3	1
ITV	6	8
Switch Engine	2	1
Heavy Vehicles	11	2
Stationary Locomotive	2	1
On-site Rail Freight Movements	19 daytime/6 evening/15 night-time	

The predicted noise levels during the operation of Scenario 2b are detailed in **Table 19**.

Predicted noise levels are for the unmitigated concept design, including rail freight operations within the Project site. Exceedances of the most conservative noise criteria from the NSW INP are highlighted in bold.

Table 19 Predicted Unmitigated Noise Levels for Scenario 2b Operation

Receptor		Conservative Noise Criteria, $L_{Aeq(15min)}$ dBA	$L_{Aeq(15min)}$ dBA Noise Level	
			Neutral	Adverse
R1	Lakewood Crescent, Casula	38	36	**39 (+1)**
R2	St Andrews Boulevard, Casula	38	**39 (+1)**	**41 (+3**)
R3	Buckland Road, Casula	38	**40 (+2)**	**42 (+4)**
R4	Dunmore Crescent, Casula	38	**39 (+1)**	**41 (+3)**
R5	Leacocks Lane, Casula	38	33	35
R6	Leacocks Lane, Casula	38	34	35
R7	Slessor Road, Casula	38	31	32
R8	Canterbury Road, Glenfield	38	28	28
R9	Ferguson Street, Glenfield	38	31	31
R10	Goodenough Street, Glenfield	38	31	31
R11	Wallcliffe Court, Wattle Grove	37	34	37
R12	Corryton Court, Wattle Grove	37	34	**38 (+1)**
R13	Martindale Court, Wattle Grove	37	34	**38 (+1)**
R14	Anzac Road, Wattle Grove	37	37	**42 (+4)**
R15	Cambridge Avenue, Glenfield	38	31	31
R16	Guise Public School	42	24	25
R17	Yallum Court, Wattle Grove	37	35	**39 (+2)**
R18	Church Road, Liverpool	38	30	35
R19	Glenwood Public School, Glenfield	42	29	29
R20	Glenfield Public School, Glenfield	42	25	26
R21	Hurlstone Agricultural School	42	25	25
R22	Wattle Grove Public School	42	32	37
R23	St Marks Coptic College, Wattle Grove	42	28	33
R24	Maple Grove Retirement Village, Casula	38	25	27
R25	All Saints Catholic College	42	35	36
R26	Casula High School	42	24	26
R27	Casula Primary School, Casula	42	32	35
R28	Lurnea High School	42	22	25
R29	St Francis Xaviers Catholic Church	47	20	25
R30	Impact Church Liverpool	47	25	31
R31	Liverpool West Public School	42	20	25
R32	Liverpool Public School / TAFE NSW	42	22	27
R33	DNSDC Site up to end 2014*	70	62	63
R34	Glenfield Rise Development, Glenfield	38	29	30
R35	DNSDC Site after end 2014	70	36	41
R36	Playground Learning Centre Glenfield	42	27	27
R37	Wattle Grove Long Day Care Centre	42	29	34
R38	Casula Powerhouse Arts Centre	50	41	43

Note **Bold** highlight denotes predicted noise level exceeds the Project specific noise level criteria.

* Receptor R33 will not be occupied at the time of Scenario 2b operations.

Neutral Weather Conditions

Predicted noise levels comply with the daytime, evening and night-time noise criteria at all assessed receptors, with the exception of nearest receptors at the northern extent of Casula where predicted noise levels marginally exceed the night-time noise criteria by up to 2 dB.

Adverse Weather Conditions

Predicted noise levels comply with the daytime and evening noise criteria at all assessed receptors with the exception of the western extent of Anzac Road where a marginal 1 to 2 dB exceedance was predicted.

During the night-time, predicted noise levels exceed the noise criteria by up to 4 dB at the northern extent of Casula and the nearest receptors in Wattle Grove. Noise levels comply with the night-time noise criteria at all other assessed receptors.

9 NOISE ASSESSMENT – SCENARIO 3

Scenario 3 includes the operation of the 1.05 million TEU per annum IMEX facility, the 500,000 TEU per annum interstate facility and up to 300,000 sq.m warehousing.

9.1 Operation at the Main IMT Site

To assess potential noise emissions during the operation of the revised Project, the equipment in **Table 20** were included in the noise prediction model to represent the capacity operations for Scenario 3.

Table 20 Assessed Operations Scenario 3

Equipment	Total Number of Items	
	IMEX terminal	**Interstate Terminal**
RMG	15	9
Side Pick	5	2
ITV	6	25
Switch Engine	2	1
Heavy Vehicles	25	5
Stationary Locomotive	3	1
On-site Rail Freight Movements	20 daytime/7 evening/16 night-time	

The predicted noise levels during the Scenario 3 operation of the Project are detailed in **Table 21**.

Predicted noise levels are for the unmitigated concept design, including rail freight operations within the Project site and any exceedance of the most conservative noise criteria from the NSW INP are highlighted in bold.

Table 21 Predicted Noise Levels for Scenario 3 Operation

Receptor		Conservative Noise Criteria, $L_{Aeq(15min)}$ dBA	$L_{Aeq(15min)}$ dBA Noise Level	
			Neutral	Adverse
R1	Lakewood Crescent, Casula	38	38	**41 (+3)**
R2	St Andrews Boulevard, Casula	38	**40 (+2)**	**43 (+5)**
R3	Buckland Road, Casula	38	**42 (+4)**	**44 (+6)**
R4	Dunmore Crescent, Casula	38	**41 (+3)**	**43 (+5)**
R5	Leacocks Lane, Casula	38	35	37
R6	Leacocks Lane, Casula	38	36	37
R7	Slessor Road, Casula	38	33	34
R8	Canterbury Road, Glenfield	38	29	30
R9	Ferguson Street, Glenfield	38	32	33
R10	Goodenough Street, Glenfield	38	32	33
R11	Wallcliffe Court, Wattle Grove	37	35	**39 (+2)**
R12	Corryton Court, Wattle Grove	37	36	**40 (+3)**
R13	Martindale Court, Wattle Grove	37	36	**40 (+3)**
R14	Anzac Road, Wattle Grove	37	**39 (+2)**	**43 (+6)**
R15	Cambridge Avenue, Glenfield	38	32	33
R16	Guise Public School	42	25	26
R17	Yallum Court, Wattle Grove	37	37	**41 (+4)**
R18	Church Road, Liverpool	38	32	37
R19	Glenwood Public School, Glenfield	42	30	30
R20	Glenfield Public School, Glenfield	42	27	27
R21	Hurlstone Agricultural School	42	26	27
R22	Wattle Grove Public School	42	34	38
R23	St Marks Coptic College, Wattle Grove	42	30	35
R24	Maple Grove Retirement Village, Casula	38	27	29
R25	All Saints Catholic College	42	37	39
R26	Casula High School	42	26	28
R27	Casula Primary School, Casula	42	34	37
R28	Lurnea High School	42	24	27
R29	St Francis Xaviers Catholic Church	47	22	26
R30	Impact Church Liverpool	47	28	33
R31	Liverpool West Public School	42	21	27
R32	Liverpool Public School / TAFE NSW	42	24	30
R33	DNSDC Site up to end 2014*	70	64	64
R34	Glenfield Rise Development, Glenfield	38	31	31
R35	DNSDC Site after end 2014	70	38	42
R36	Playground Learning Centre Glenfield	42	28	29
R37	Wattle Grove Long Day Care Centre	42	31	35
R38	Casula Powerhouse Arts Centre	50	43	44

Neutral Weather Conditions

Predicted noise levels comply with the daytime and evening noise criteria at all assessed receptors. Noise levels in the night-time are predicted to comply with the noise criteria at the majority of receptors with exceedances of up to 4 dB predicted at the northern extent of Casula and by 2 dB at the western extent of Anzac Road.

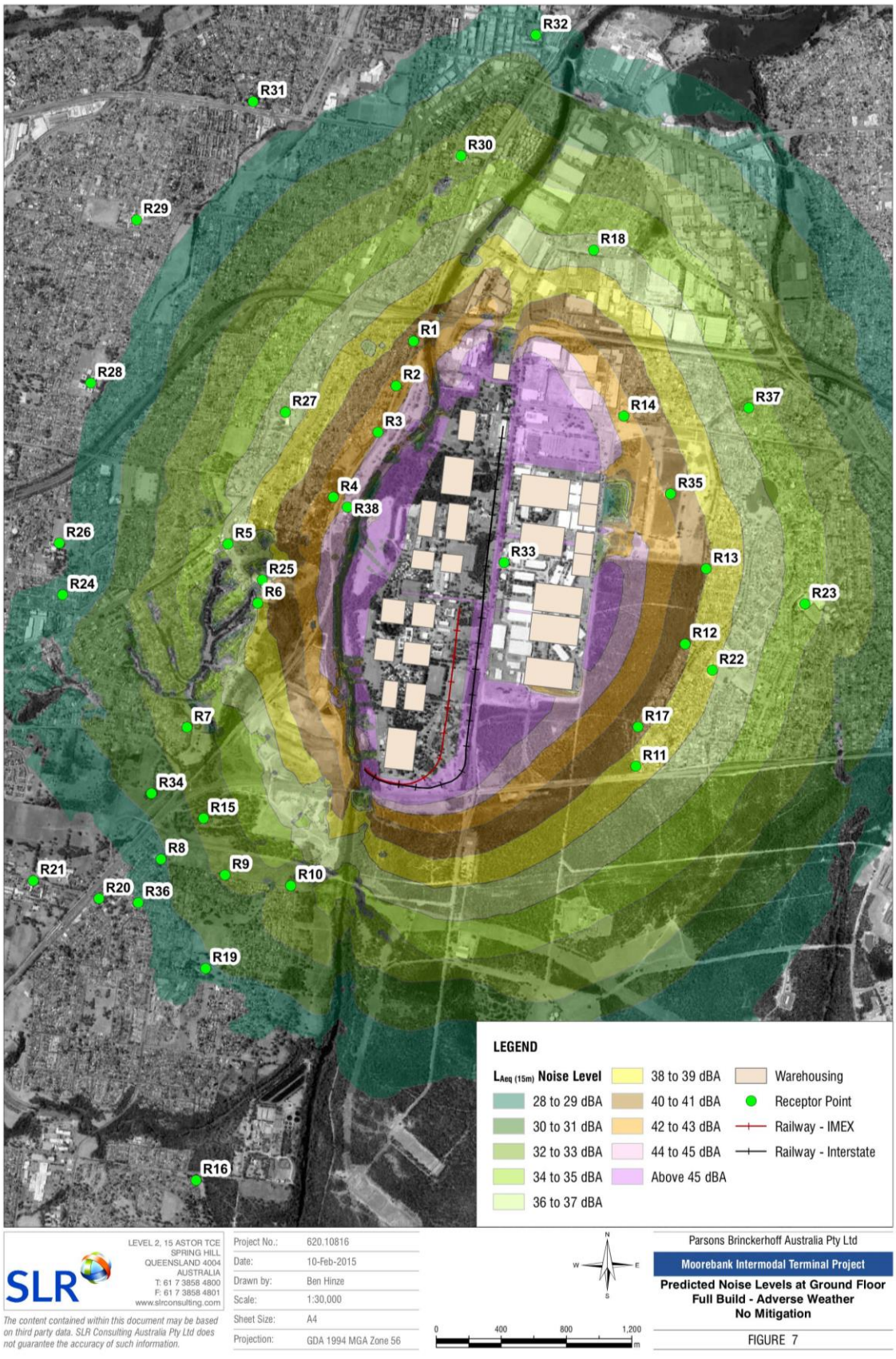
Adverse Weather Conditions

Predicted noise levels comply with the daytime and evening noise criteria at all assessed receptors in Casula, Glenfield and Wattle Grove with the exception of the western extent of Anzac Road, where noise levels are up to 2 to 3 dB in exceedance of the daytime and evening noise criteria.

During the night-time, predicted noise levels exceed the noise criteria by up to 6 dB at nearest receptors in the north of Casula, by up to 4 dB at the northern and southern most extents of Wattle Grove and 6 dB at the western extent of Wattle Grove. Noise levels comply with the night-time noise criteria at all other assessed receptors.

To assist the interpretation of predicted noise levels for the Scenario 3 operations, without noise mitigation, a noise contour map is presented in **Figure 7**. The noise levels were predicted during adverse weather conditions.

Figure 7 Noise Contours for Scenario 3 Operations (Unmitigated)



10 RAIL ACCESS CONNECTION

The revised Project has adopted the concept design for the southern rail access from the EIS and daily train movements are as proposed in the EIS. Consequently, a revised assessment of rail noise form the southern rail access has not been required for the Response to Submissions Report.

As presented in Sections 10, 11 and 12 of the EIS noise and vibration impact assessment report, the predicted noise levels from the southern rail access connection comply with the RING noise assessment criteria at all assessed receptors during the phased development of the revised Project.

11 ASSESSMENT OF MITIGATED NOISE LEVELS

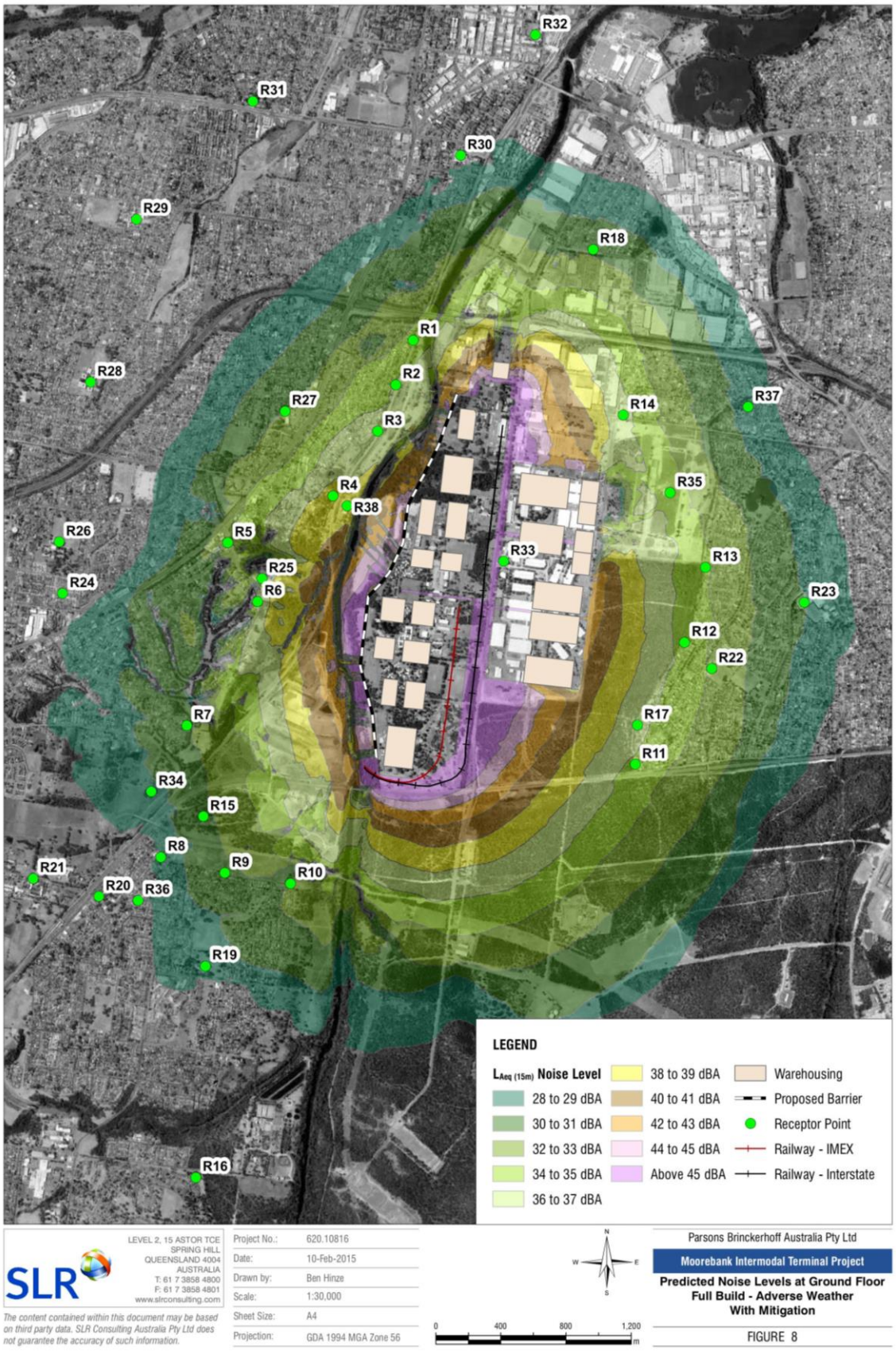
The predicted exceedance of the noise criteria at Casula and Wattle Grove are predominantly due to the RMG's located at the north of the interstate terminal and road trucks operating on the haul route at the west of the Project site.

To demonstrate that noise levels during the operation of the revised Project can be controlled to achieve the noise assessment criteria, a conceptual design with reasonable and feasible noise mitigation has been assessed. The following noise mitigation measures have been included in the Scenario 3 concept design:

- It has been assumed the interstate terminal could either be operated with an automated container handling area and electrically power plant, as per the IMEX terminal, or alternatively the interstate terminal would use plant with the lowest available noise emissions that are not greater with source noise emissions modelled for the electrified plant at the IMEX terminal (refer **Table 11)**. To achieve the lowest noise emissions, individual plant may require a combination of acoustic enclosures, acoustic insulation (lagging and silencers.
- To the west of the site, a noise barrier 4.5 m in height at the haul road has been included to mitigate noise from trucks operating within the Project site. The noise barrier can be a combination of acoustic barriers, solid walls or earth mounding as long as it fully impedes the line of sight between nearest receptors in Casula and the haul road.

Predicted noise levels during neutral and adverse weather conditions comply with the noise assessment criteria at all assessed receptors with the on-site mitigation. The predicted mitigated noise levels during adverse weather conditions are presented in the noise contour map in **Figure 8**.

Figure 8 Noise Contours for Scenario 3 Operations with Noise Mitigation



12 SLEEP DISTURBANCE ASSESSMENT

Section 13 of the EIS noise and vibration assessment report included an assessment of potential sleep disturbance impacts by applying a noise source at the boundary of the main IMT with a sound power level of 120 dBA maximum to represent containers being manoeuvred heavily, the shunting of rail freight or reversing beepers/vehicle alarms.

The predicted maximum noise levels of up to 47 dBA L_{Amax} at nearest receptors complied with the sleep disturbance objectives of 47 dBA L_{Amax} at Casula and 48 dBA L_{Amax} at Wattle Grove and Glenfield.

At the nearest residential receptors in Casula and Glenfield, maximum noise levels from IMEX and interstate rail freight movements on the rail access connection were predicted to be 63 dBA L_{Amax}. Whilst noise levels may exceed the 47 dBA L_{Amax} OEH sleep disturbance objective for industrial premises they would however comply with typical maximum noise criteria of 80 to 85 dBA L_{Amax} applied to rail freight operations in NSW.

Because sleep disturbance is a subjective response and night-time operations may be audible at the external façade of nearest receptors it is recommended that, whilst predicted noise levels from main IMT operations are predicted to meet the sleep disturbance screening criterion, a detailed assessment of sleep disturbance impacts is undertaken during the detailed design of the revised Project. The additional analysis should consider the level of exceedance as well as factors such as:

- How often high noise events would occur
- The time of day (normally between 10.00 pm and 7.00 am)
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

13 ROAD TRAFFIC NOISE ASSESSMENT

Road traffic for the construction and operation of the revised Project will utilise the existing road network with light and heavy vehicles accessing the Project site from Moorebank Avenue. The majority of road traffic will operate on the M5 Motorway in the east and west directions with a small proportion of road traffic using Anzac Road.

Whilst access and circulation of heavy and light vehicle access to the site has changed with the new precinct design, the distance between the road network and nearest receptors has not been affected.

The forecast light and heavy vehicle road traffic volumes with the revised Project have been revised as part of the Response to Submissions Report. The updated road traffic volumes have changed the predicted L_{Aeq} road traffic noise levels in Section 15 of the EIS noise and vibration impact assessment report by no more than -0.8 dB to +0.2 dB. Consequently, there has been no change to the assessed road traffic noise impacts in the EIS.

The predicted road traffic noise levels from the M5 Motorway, Moorebank Avenue and Anzac Road would comply with the NSW RNP and would not require mitigation to reduce road traffic noise levels from the local road network.

The predicted road traffic noise levels for each scenario are presented in **Appendix B**.

14 NOISE ON NETWORK RAIL LINE

Rail freight for the revised Project will operate on the SSFL with IMEX and interstate trains accessing the site via the SSFL on the purpose built rail access. The SSFL officially opened in January 2013 and the initial operation of the Project will be within the capacity of the SSFL.

Analysis of future demand on the SSFL undertaken for the EIS determined a likely need to upgrade the SSFL in the future and this need for capacity increase is foreshadowed by the Australian Rail Track Corporation (ARTC's 2013) *SSFL Operational Noise and Vibration Management Plan* (ONVMP). The assessed rail noise levels in the noise and vibration management plan are representative of SSFL operations including the capacity for IMEX and interstate rail freight.

As discussed in Section 14 of the EIS noise and vibration impact assessment report, the existing and any future noise mitigation implemented for the SSFL would be expected to attenuate noise contributions from rail freight associated with the IMT project where the IMT project operates within the design capacity of the SSFL.

15 GROUND VIBRATION ASSESSMENT

15.1 Construction Activity

The EIS recommended safe working distances for construction plant referenced from the Transport for NSW *Construction Noise Strategy* which identifies that vibration management would be potentially be required where vibration generating works are undertaken within 100 m of receptors.

Based on the general work zones for the revised concept layout, the proposed construction equipment is expected to be operated greater than 375 m from nearest receptors. Consistent with the EIS, all construction equipment will therefore be operated within the recommended safe working distances and potential ground vibration levels at nearest receptors would comply with the vibration criteria for human comfort and limit the potential for cosmetic damage at vibration sensitive structures.

15.2 Intermodal Terminal Operations

The Project site is located at least 375 m from nearest receptors; at this distance any potential ground vibration generated from IMT operations would not be perceptible. It is expected that ground vibration levels at nearest receptors will comply with the human comfort (disturbance) and cosmetic structural damage criteria.

The greater potential for ground vibration is likely to be the operation of rail freight accessing the SSFL on the rail access connection. Section 16 of the EIS noise and vibration impact assessment report referenced the US Federal Transit Administration's (FTA's) *Transit Noise and Vibration Impact Assessment*[7] report provides indicative vibration levels versus distance for a variety of transport systems, including freight systems.

The lowest threshold of perceptible vibration for most people is approximately 0.13 mm/s rms. This equates to a L_{Vmax} of 103 dB. For rail freight at 60 km/h the FTA's calculated vibration level of 103 dB is anticipated to be achieved at distances of 30 m or greater from the track.

Based on the conceptual layouts, the rail access connection to the SSFL will be at least 380 m from nearest residences; as such any perceptible ground vibration levels are expected to be within the vibration criteria for both human comfort (VDV) and the less conservative criteria for cosmetic structural damage.

[7] Federal Transit Administration, 2006. Transit Noise and Vibration Impact Assessment, FTA-VA-90-1003-6, May 2006.

16 RECOMMENDED NOISE MANAGEMENT AND MITIGATION

The EIS noise and vibration impact assessment included detailed recommendations for reasonable and feasible noise mitigation measures to reduce and control potential noise levels during construction and operation of the revised Project. The recommendations included specific approaches to mitigate noise during potential night-time rail construction works, limit the likelihood for sleep disturbance during night-time operations and measures to limit wheel squeal from rail operations.

The recommendations in the EIS are directly applicable to the assessed noise and vibration impacts for the revised Project. A summary overview of the mitigation and additional mitigation recommendations from the assessment of the revised Project are provided below. It is noteworthy that noise mitigation measures targeted to control noise levels at the most sensitive residential receptors during the construction and operation of the revised Project would have a commensurate benefit to controlling noise at all receptors.

16.1 Construction Noise and Vibration Mitigation

Based on the predicted noise levels at nearest residences, construction noise mitigation would be required where works are undertaken within 600 m of residences. The requirements for noise and vibration management during construction will be defined in a Construction Noise and Vibration Management Plan that will form part of a Project wide Construction Environmental Management Plan.

The Construction Noise and Vibration Management Plan would define the hours of construction, construction NMLs for noise sensitive receptors and include the noise mitigation measures and safe working distances for vibration generating plant included in the noise and vibration impact assessment prepared for the EIS.

16.2 Noise and Vibration Mitigation during Operation

Prior to the commencement of operations of each stage of development the Proponent should develop and implement an Operational Noise and Vibration Management Plan (ONVMP). The ONVMP would detail the staged operation of the Project, the potential off-site operational noise levels as determined during the detailed design process and all measures to manage and mitigation operational noise and vibration.

In order to reduce the predicted noise levels for the unmitigated revised concept design by at least 6 dB to comply with the NSW INP noise criteria, a comprehensive mitigation strategy will need to be developed. As discussed in the EIS noise and vibration impact assessment, the revised Project will need to investigate a combination of noise mitigation measures such as:

- Acoustic enclosures,
- Noise barriers/walls/earth mounds,
- Plant and equipment with as low as reasonably practicable noise emissions,
- Track greasing systems and the radius of track curves would be at least 500 m to address potential wheel squeal issues.
- Designing the Project site to utilise on-site buildings and container stacks as noise screens.

In consideration to the revised Project and the assessed noise levels in this report, the investigation of reasonable and feasible noise mitigation measures should include:

- Automated container handling areas in the IMEX and interstate terminals to avoid the use of alarms or beepers on the RMGs.
- Electrification of all plant and equipment at the IMEX and interstate terminals, or alternatively sourcing plant and equipment with noise emission levels equivalent to electrified plant.

- Permanently coupled wagons to limit impact noise events from wagon bunching on the freight trains.
- Reversing of vehicles operating within the Project site equipment would be minimised so as to prevent nuisance caused by reversing alarms. This can be achieved through one-way traffic systems and the use of traffic lights which can also limit the use of vehicle horns.
- To further mitigate potential noise from vehicle horns, the practical application of radio contact between operators and limiting the use of vehicle horns to the daylight hours only would be investigated.
- Broadband reversing alarms are to be used instead of tonal reversing alarms, in particular between the hours of 6.00 pm to 7.00 am. This requirement would extend to the heavy vehicles (trucks) entering and leaving the site and where possible (particularly for night works). This should be included as a contractual requirement for all operators accessing the Project site.

17 ASSESSMENT OF CUMULATIVE IMPACTS

SIMTA is proposing to develop an intermodal terminal facility on the site currently occupied by the Defence National Storage Distribution Centre (DNSDC) on Moorebank Avenue. The site for the SIMTA development is to the immediate east of the Project site and the two projects would, if both approved, operate simultaneously.

Assessment scenarios have been developed to assess potential noise impacts where the Moorebank IMT Project and the SIMTA Project sites are utilised for intermodal activities. These scenarios have been developed by MIC purely for the purposes of an indicative cumulative impact assessment should these types of developments operate adjacent to each other in this location. All predicted noise levels are based on the unmitigated concept designs for the Moorebank IMT project.

Due to the conceptual nature of the possible cumulative operation of the Moorebank IMT and SIMTA projects, the NSW INP amenity noise criteria (refer **Table 6**) have been applied for the purpose of evaluating potential cumulative noise impacts.

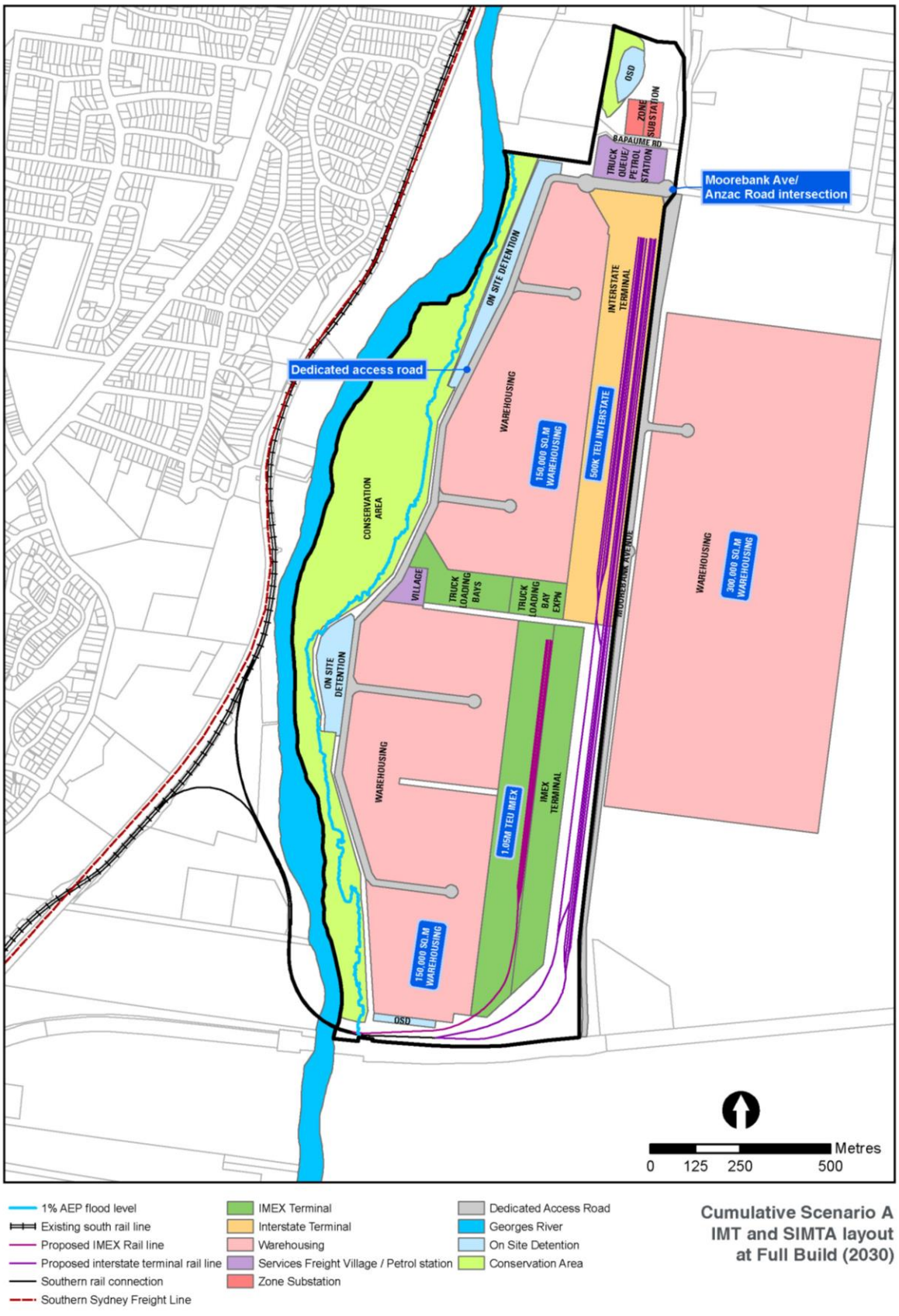
17.1 Scenario A – SIMTA site as intensified warehousing

The scenario assumes that the SIMTA site would operate as an intensified warehousing development that would support the operation of the Moorebank IMT project, as shown in **Figure 9**.

A number of assumptions have been made to define the scenario, including:

- The Moorebank IMT would operate as defined in the Response to Submissions Report.
- The SIMTA development would have an indicative warehousing capacity of 300,000 sq.m,
- Both sites would operate 24 hours a day, 7 days a week.

Figure 9 Concept Plan – Cumulative Scenario A



The predicted cumulative noise levels for Scenario A are summarised in **Table 22** for neutral and adverse weather conditions.

Table 22 Predicted Cumulative Noise Levels – Scenario A

Residential Receptor	Predicted Noise Levels, L_{Aeq} dBA	
	Neutral Weather	**Adverse Weather**
Casula	27 – **42**	29 – **44**
Wattle Grove	35 – 40	39 – **44**
Glenfield	29 – 32	29 – 33
Liverpool	32 – 34	38 – 40
Non-Residential Noise Sensitive Receptors	21 – 43	25 – 44

Note **Bold** highlight denotes predicted noise level exceeds the night-time NSW INP amenity noise criteria.

Neutral Weather Conditions

The predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors in Wattle Grove, Glenfield and Liverpool. The noise levels at assessed receptors at Casula comply with the daytime and evening amenity noise criteria, but exceed the night-time amenity noise criteria by 2 dB at the northern extent of Casula.

Adverse Weather Conditions

During adverse weather conditions, the predicted cumulative noise levels comply with the daytime, evening and night-time NSW amenity noise criteria at all assessed receptors in Wattle Grove, Glenfield and Liverpool. Predicted noise levels at the north of Casula comply with the daytime and evening amenity noise criteria but exceed the night-time noise criteria by up to 4 dB at the northern extent of Casula and the western extent of Wattle Grove at Anzac Road.

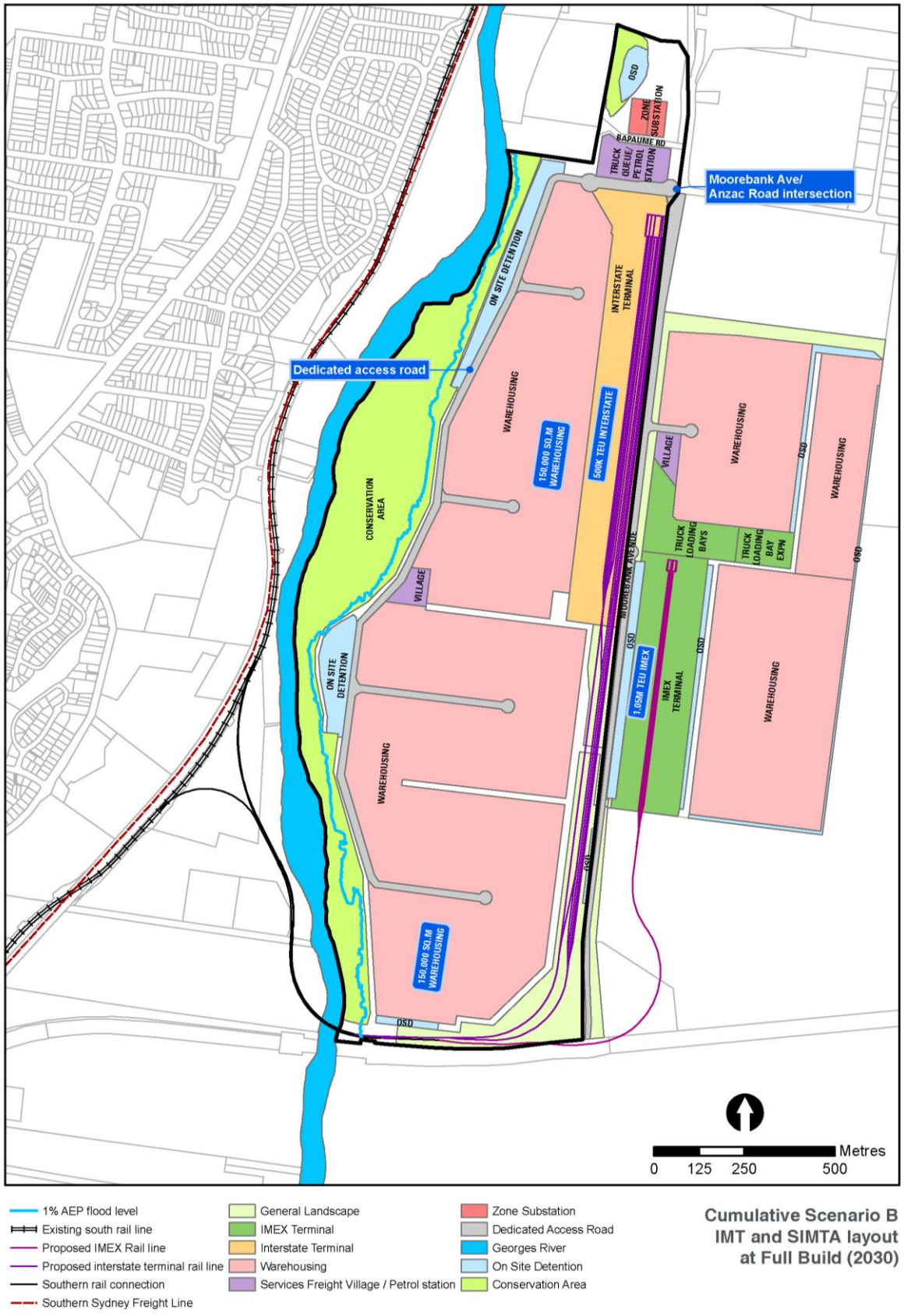
17.2 Scenario B – SIMTA as an IMEX terminal

Scenario B consists of an IMEX terminal on the SIMTA site only with a throughput of 1 million TEU per annum, as well as 300,000 sq. m of warehousing. An interstate terminal of 500,000 TEU per annum and 300,000 sq.m of warehousing would be located on the Project site. The concept plant for cumulative Scenario B is shown in **Figure 10**. It has been assumed that:

- Both developments would operate 24 hours a day, seven days a week.
- The assessment of the IMEX terminal at the SIMTA site has referenced predicted noise levels from the SIMTA EIS[8] with the proposed noise mitigation barrier.

[8] Wilkinson Murray, May 2013. Noise Impact Assessment Report (12186-C Version C).

Figure 10 Concept Plan – Cumulative Scenario B



The predicted cumulative noise levels for Scenario B are summarised in **Table 23** for neutral and adverse weather conditions. Note, the predicted cumulative noise levels are contingent on noise levels from the SIMTA IMEX terminal not exceeding 40 dBA L_{Aeq}.

Table 23 Predicted Cumulative Noise Levels – Scenario B

Residential Receptor	Predicted Noise Levels, L_{Aeq} dBA	
	Neutral Weather	Adverse Weather
Casula	27 – **43**	28 – **45**
Wattle Grove	38 – **43**	40 – **45**
Glenfield	31 – 34	31 – 34
Liverpool	33 – 33	38 – 38
Non-Residential Noise Sensitive Receptors	26 – 43	26 – 44

Note **Bold** highlight denotes predicted noise level exceeds the night-time NSW INP amenity noise criteria.

Neutral Weather Conditions

The predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors in Glenfield and Liverpool. The noise levels at assessed receptor in Casula and Wattle Grove comply with the daytime and evening amenity noise criteria but exceed the night-time amenity noise criteria by 3 dB at the northern extent of Casula and the western extent of Wattle Grove at Anzac Road.

Adverse Weather Conditions

The predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors in Glenfield and Liverpool. The noise levels at assessed receptors in Casula and Wattle Grove comply with the daytime and evening amenity noise criteria but exceed the night-time amenity criteria by 5 dB at the northern extent of Casula and the western extent of Wattle Grove at Anzac Road.

17.3 Cumulative Scenario C –Intermodal terminals at Moorebank and SIMTA

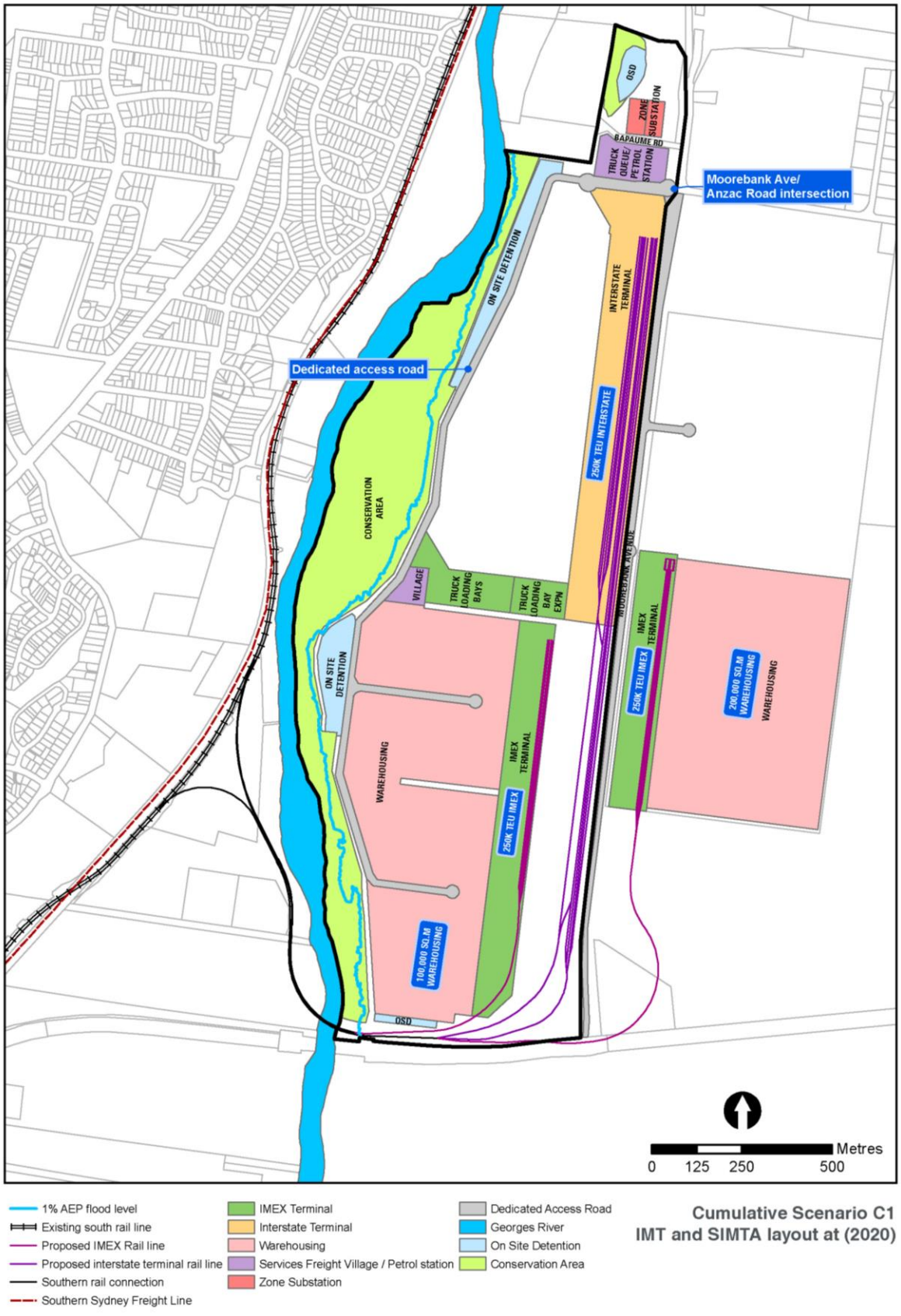
Cumulative Scenario C1 assumes the Moorebank site will include an IMEX and interstate terminal with an IMEX terminal also in operation within the SIMTA site. Both sites would include associated warehousing facilities. The assessment of cumulative impacts has been split into C1 (an interim scenario at the year 2020) and C2 (final scenario from year 2030).

17.3.1 Scenario C1

Scenario C1 consists of the Moorebank IMT site operating at 250,000 TEU IMEX, 250,000 TEU interstate terminal and 100,000 sq.m warehousing. The SIMTA site would operate at 250,000 TEU IMEX (their Stage 1 Development Approval) and 200,000 sq.m warehousing. The concept plan for Scenario C1 is shown in **Figure 11**. It has been assumed that:

- Both developments would operate 24 hours a day, seven days a week.
- To account for the reduced operations with the proposed 250,000 TEU IMEX terminal, the assessment for the IMEX terminal at the SIMTA site has adopted a 6 dB reduction to the predicted noise levels from the SIMTA EIS which was based on a 1 million TEU IMEX terminal.

Figure 11 Concept Plan – Cumulative Scenario C1



The predicted cumulative noise levels for Scenario C1 are summarised in **Table 24** for neutral and adverse weather conditions.

Table 24 Predicted Cumulative Noise Levels – Scenario C1

Residential Receptor	Predicted Noise Levels, L_{Aeq} dBA	
	Neutral Weather	Adverse Weather
Casula	25 – 40	26 – **42**
Wattle Grove	35 – 39	38 – **42**
Glenfield	29 – 32	30 – 32
Liverpool	30 – 30	35 – 35
Non-Residential Noise Sensitive Receptors	22 – 40	24 – 42

Note **Bold** highlight denotes predicted noise level exceeds the night-time NSW INP amenity noise criteria.

Neutral Weather Conditions

The predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors.

Adverse Weather Conditions

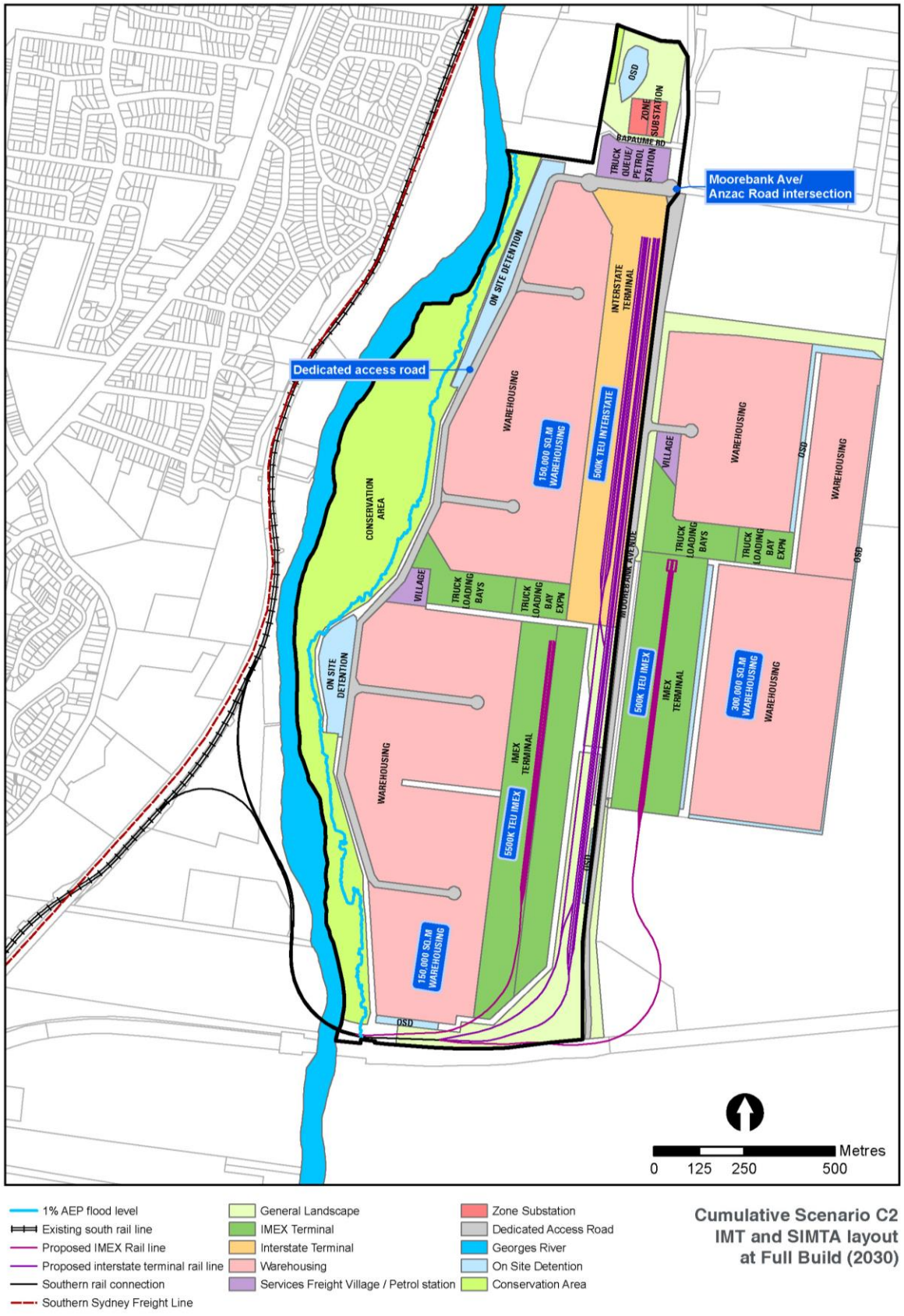
During adverse weather conditions the predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors, with the exception of the northern extent of Casula and the nearest receptors on Anzac Road in Wattle Grove where the night-time noise criteria is marginally exceeded by 2 dB.

17.3.2 Scenario C2

Scenario C2 consists of the Moorebank IMT site operating at 550,000 TEU IMEX, 500,000 TEU interstate and 300,000 sq.m warehousing. The SIMTA site would operate at 500,000 TEU IMEX (their ultimate capacity under the NSW Planning Assessment Commission determination) and 300,000 sq.m warehousing. The concept plan for Scenario C2 is shown in **Figure 12** . It has been assumed that:

- Both developments would operate 24 hours a day, seven days a week.
- To account for the reduced operations with the proposed 500,000 TEU IMEX terminal, the assessment of the IMEX terminal at the SIMTA site has adopted a 3 dB reduction to the predicted noise levels from the SIMTA EIS which was based on a 1 million TEU IMEX terminal.

Figure 12 Concept Plan – Cumulative Scenario C2



The predicted cumulative noise levels for Scenario C2 are summarised in **Table 25** for neutral and adverse weather conditions.

Table 25 Predicted Cumulative Noise Levels – Scenario C2

Residential Receptor	Predicted Noise Levels, L_{Aeq} dBA	
	Neutral Weather	Adverse Weather
Casula	27 – **41**	28 – **43**
Wattle Grove	35 – 40	37 – **42**
Glenfield	31 – 33	31 – 34
Liverpool	30 – 32	34 – 34
Non-Residential Noise Sensitive Receptors	24 – 41	26 – 43

Note **Bold** highlight denotes predicted noise level exceeds the night-time NSW INP amenity noise criteria.

Neutral Weather Conditions

The predicted cumulative noise levels comply with the daytime, evening and night-time amenity noise criteria at all assessed receptors with the exception of a minor 1 dB exceedance of the night-time noise criteria at the northern extent of Casula.

Adverse Weather Conditions

During adverse weather conditions the predicted cumulative noise levels comply with the daytime and evening amenity noise criteria at all assessed receptors. Noise levels comply with the night-time noise criteria at the majority of receptors with exceedance of up to 3 dB predicted at the northern extent of Casula and 2 dB at the western extent of Wattle Grove at Anzac Road.

17.4 Cumulative Road Traffic

The *Traffic, Transport and Accessibility Impact Assessment* for the PPR considered the daily total road traffic movements for the cumulative scenarios. The road traffic volumes do not significantly change from those assessed for the Scenario 3 in **Section 13** of this report and the EIS.

During cumulative scenarios A, B and C1 the road traffic noise levels from the M5 Motorway, Moorebank Avenue and Anzac Road comply with the NSW RNP. During cumulative Scenario C2, the predicted noise levels from the M5 Motorway and Anzac Road comply with the NSW RNP and whilst road traffic noise levels from Moorebank Avenue are marginally 1 dB above the daytime and night-time noise criteria, the NSW RNP considers this to be a minor impact and would not trigger the requirement for noise mitigation.

The predicted road traffic noise levels are presented in **Appendix B**.

17.5 Noise Mitigation for Cumulative Operations

To comply with the amenity noise criteria, predicted noise levels would need to be reduced by up to 4 dB for cumulative Scenario A, up to 5 dB for Scenario B, up to 2 dB for Scenario C1 and up to 3 dB for Scenario C2.

Adopting the noise mitigation measures recommended in **Section 16** would reduce predicted noise levels by at least 5 dB and achieve compliance at all assessed receptors. The designs of the proposed development on the SIMTA site are also likely to require noise mitigation in the form of electrified/low noise plant and noise barriers (similar to the mitigation proposed in the SIMTA EIS).

18 COMPARISON TO THE EIS ASSESSMENT

18.1 Noise Levels during Construction

Predicted noise and vibration levels during the construction of the revised Project are generally consistent with predicted construction noise levels in the EIS noise and vibration impact assessment as construction activities would occur within the same site. The recommendations in the EIS for the management and mitigation of noise levels during the construction are applicable to the revised Project.

18.2 Noise Levels during Operation

As discussed in **Section 2** of this report, the revised concept designs have changed the potential noise emissions from within the Project site and the propagation of noise within the surrounding environment when compared to the concept designs for the EIS.

To evaluate the potential changes in received noise levels during the operation of the revised Project, the predicted noise levels for the unmitigated concept design at Scenario 3 (Full Build) have been comparted between the EIS and revised Project in **Table 26**. The noise levels in **Table 26** were predicted for the worse case adverse weather conditions.

Table 26 Comparison of EIS and PPR Noise Levels for Scenario 3

Receptor		L_{Aeq} Noise Level, dB		Change in Noise Level, dB
		EIS	Revised Project	
R1	Lakewood Crescent, Casula	45	41	-4
R2	St Andrews Boulevard, Casula	48	43	-5
R3	Buckland Road, Casula	51	44	-7
R4	Dunmore Crescent, Casula	50	43	-7
R5	Leacocks Lane, Casula	40	37	-3
R6	Leacocks Lane, Casula	41	37	-4
R7	Slessor Road, Casula	33	34	1
R8	Canterbury Road, Glenfield	28	30	2
R9	Ferguson Street, Glenfield	29	33	4
R10	Goodenough Street, Glenfield	31	33	2
R11	Wallcliffe Court, Wattle Grove	41	39	-2
R12	Corryton Court, Wattle Grove	41	40	-1
R13	Martindale Court, Wattle Grove	41	40	-1
R14	Anzac Road, Wattle Grove	44	43	-1
R15	Cambridge Avenue, Glenfield	31	33	2
R16	Guise Public School	18	26	8
R17	Yallum Court, Wattle Grove	42	41	-1
R18	Church Road, Liverpool	38	37	-1
R19	Glenwood Public School, Glenfield	25	30	5
R20	Glenfield Public School, Glenfield	24	27	3
R21	Hurlstone Agricultural School	22	27	5
R22	Wattle Grove Public School	40	38	-2
R23	St Marks Coptic College, Wattle Grove	36	35	-1
R24	Maple Grove Retirement Village, Casula	29	29	0

Receptor		L_{Aeq} Noise Level, dB		Change in Noise Level, dB
		EIS	Revised Project	
R25	All Saints Catholic College	43	39	-4
R26	Casula High School	29	28	-1
R27	Casula Primary School, Casula	42	37	-5
R28	Lurnea High School	30	27	-3
R29	St Francis Xaviers Catholic Church	29	26	-3
R30	Impact Church Liverpool	35	33	-2
R31	Liverpool West Public School	30	27	-3
R32	Liverpool Public School / TAFE NSW	31	30	-1
R33	DNSDC Site up to end 2014*	58	64	6
R34	Glenfield Rise Development, Glenfield	30	31	1
R35	DNSDC Site after end 2014	43	42	-1
R36	Playground Learning Centre Glenfield	37	29	-8
R37	Wattle Grove Long Day Care Centre	25	35	10
R38	Casula Powerhouse Arts Centre	52	44	-8

In comparison to the EIS, the predicted unmitigated noise levels at the noise sensitive receptors are generally lower with the revised Project. At all receptor communities the changes are due to a combination of the updated IMEX terminal operations, the revised location of noise sources within the Project site and the relocation of warehousing to the west of the Project site.

Predicted noise levels at the residential receptors in Casula are up to 7 dB lower with the revised Project with only a marginal increase of 1 dB predicted at Slessor Road. At the assessed residences in Wattle Grove and in Liverpool, noise levels have been predicted to be up to 2 dB lower with the revised Project.

At the assessed residences in Glenfield the predicted noise levels are up to 4 dB higher with the revised Project. Nonetheless, the predicted noise levels comply with the noise assessment criteria, which is consistent with the EIS.

At some of the assessed non-residential receptors predicted noise levels are up to 8 dB lower with the revised Project. However, noise levels at other non-residential receptors have been predicted to increase by up to 10 dB. Notwithstanding, the predicted noise levels at all non-residential receptors in the EIS and with the revised Project comply with the noise assessment criteria.

18.3 Rail Noise Levels

There has been no change in the predicted rail noise levels from the southern rail access connection to the SSFL and noise levels are predicted to comply with the relevant noise assessment criteria from the RING without the requirement for noise mitigation.

18.4 Road Traffic Noise Levels

Whilst the revised Project concept designs have resulted in a marginal change in predicted road traffic noise levels (less than ±1 dB L_{Aeq}), the revised concept designs are predicted to comply with the RNP which is consistent with the outcomes of the road traffic noise assessment in Section 15 of the EIS noise and vibration impact assessment report.

18.5 Ground Vibration Levels

There has been no change in the assessed ground vibration levels during the construction and operation of the revised Project. Potential ground vibration levels assessed in the Section 16 of the EIS noise and vibration impact assessment report and the Response to Submissions Report are expected to comply with the vibration criteria at all receptors.

19 CONCLUSION

This technical paper presents the assessment of potential noise and vibration impacts of the proposed revised Project for the Moorebank Intermodal Terminal Project.

The assessment has determined that predicted noise levels during the construction and operation of the operation can achieve the noise assessment criteria with the implementation of reasonable and feasible noise mitigation. Specific recommendations have been made in this report and in the EIS to control the overall noise levels within the surrounding environment and mitigate potential impacts associated with sleep disturbance and community annoyance from events such as night-time rail construction works and wheel squeal from freight trains.

In comparison to the EIS, the predicted operational noise levels at the most affected receptors are up to 7 dB lower with the revised Project design, with noise levels lower than the EIS at the majority of assessed receptors. Potential rail noise levels, road traffic noise levels and ground vibration levels predicted to comply with the relevant criteria and the assessment of impacts is consistent with the EIS.

Acoustic Terminology

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

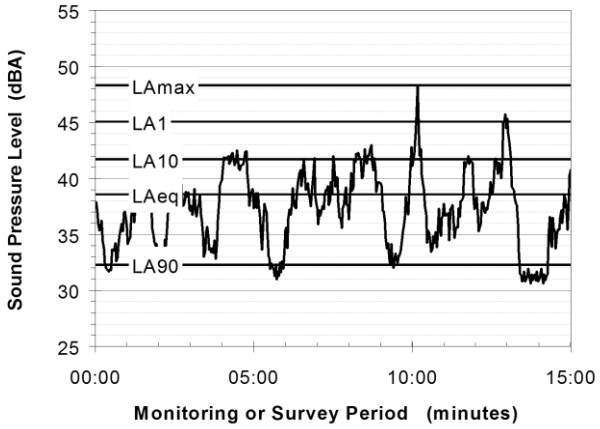
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or Lw, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

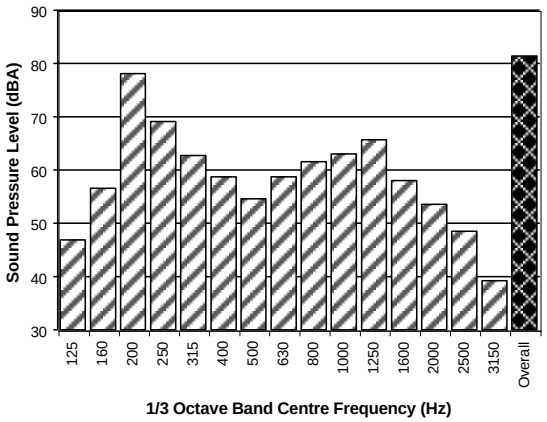
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

Predicted Change in Road Traffic Noise – M5 Motorway

Phase	M5 Motorway	Change in Road Traffic Noise Level, dBA	
		Daytime	Night-time
Scenario 1	Total traffic between Hume Highway and Heathcote Road	0.2	0
Scenario 2a	Total traffic between Hume Highway and Heathcote Road	0	0.1
Scenario 2b	Total traffic between Hume Highway and Heathcote Road	0.1	0.1
Scenario 3	Total traffic between Hume Highway and Heathcote Road	0	0.3
Cumulative Scenario A	Total traffic between Hume Highway and Heathcote Road	0.4	0.4
Cumulative Scenario B	Total traffic between Hume Highway and Heathcote Road	0.2	0.3
Cumulative Scenario C1	Total traffic between Hume Highway and Heathcote Road	0.2	0.3
Cumulative Scenario C2	Total traffic between Hume Highway and Heathcote Road	0.2	0.4

Predicted Road Traffic Noise – Moorebank Avenue

Phase	Moorebank Avenue	Received Road Traffic Noise with IMT, dBA	
		Daytime $L_{Aeq(15hour)}$	Night-time $L_{Aeq(9hour)}$
Scenario 1	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	58	50.5
Scenario 2a	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	59	51
Scenario 2b	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	59.5	51.5
Scenario 3	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	60	52
Cumulative Scenario A	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	60.5	53
Cumulative Scenario B	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	60.5	55
Cumulative Scenario C1	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	60	54.5
Cumulative Scenario C2	Between Anzac Road and M5 Motorway and Anzac Road and Cambridge Avenue	60.5	56

Predicted Road Traffic Noise – Anzac Road

Phase	Anzac Road	Change in Road Traffic Noise Level, dBA	
		Daytime	**Night-time**
Scenario 1	Between Delfin Drive East & Delfin Drive West	0.2	0.1
Scenario 2a	Between Delfin Drive East & Delfin Drive West	0.6	0.1
Scenario 2b	Between Delfin Drive East & Delfin Drive West	0.1	0
Scenario 3	Between Delfin Drive East & Delfin Drive West	1.8	0.3
Cumulative Scenario A	Between Delfin Drive East & Delfin Drive West	1.8	0.4
Cumulative Scenario B	Between Delfin Drive East & Delfin Drive West	1.8	0.3
Cumulative Scenario C1	Between Delfin Drive East & Delfin Drive West	0	0.3
Cumulative Scenario C2	Between Delfin Drive East & Delfin Drive West	0	0.4