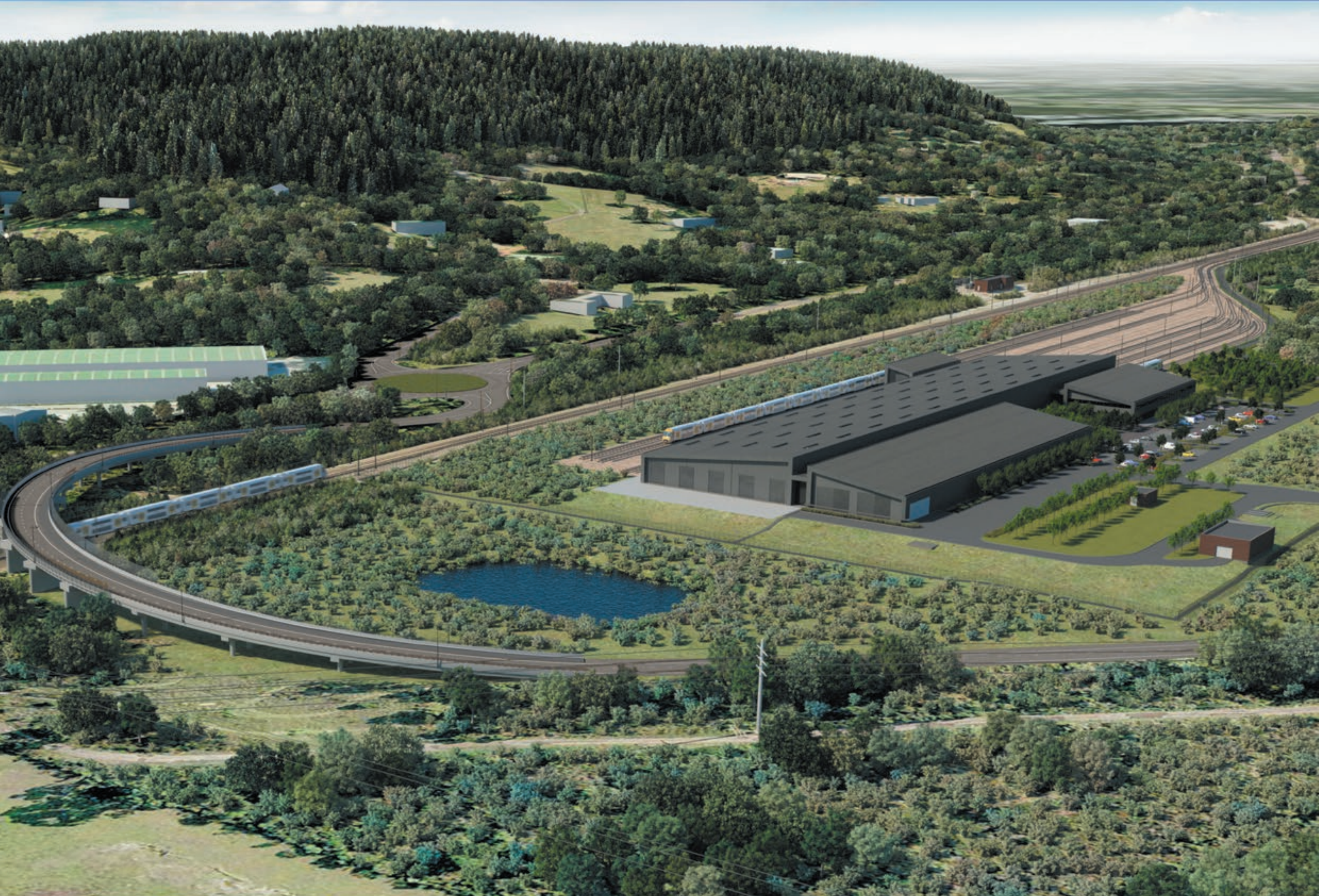
Transport for NSW

New Intercity Fleet Maintenance Facility Project

Volume 2 – Technical specialist assessments



June 2016

Appendix A

BIODIVERSITY ASSESSMENT REPORT

TRANSPORT FOR NSW

New Intercity Fleet Maintenance Facility

BIODIVERSITY ASSESSMENT REPORT

MAY 2016

WSP | PARSONS BRINCKERHOFF

New Intercity Fleet Maintenance Facility

BIODIVERSITY ASSESSMENT REPORT

Transport for NSW

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

GLOSSARY

Affected species	Subject species likely to be affected by the proposal.
Area of impact	Is defined as the area which is proposed for development.
BioBanking Assessment Methodology (BBAM)	Assessment methodology for the NSW BioBanking Scheme – Office of Environment and Heritage 2014, BioBanking Assessment Methodology 2014, Sydney.
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: ▪ Genetic diversity — the variety of genes (or units of heredity) in any population. ▪ Species diversity — the variety of species. ▪ Ecosystem diversity — the variety of communities or ecosystems.
Bioregion (region)	A bioregion defined in a national system of bioregionalisation. The study area is in the Sydney Basin Bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).
Biometric vegetation type (BVT)	Provides the occurrence of the PCT within a specific catchment management area. A BVT may be assigned catchment specific attributes such as benchmark data, per cent cleared in the catchment area value and associations with threatened species, populations and communities. A PCT may be distributed across one or more major catchment areas and is assigned a BVT with each major catchment area occurrence. BVTs are managed in the VIS Classification Database.
Critical habitat	The whole or any part or parts of an area or areas of land comprising the habitat of an Endangered species, an Endangered population or an Endangered Ecological Community that is critical to the survival of the species, population or ecological community (Department of Environment and Conservation 2004). Critical habitat is listed under either the TSC Act or the EPBC Act and both the state (Department of Environment, Climate Change and Water) and Federal (Department of the Sustainability, Environment, Water, Population and Communities) Directors-General maintain a register of this habitat. Capitalisation of the term 'Critical Habitat' in this report refers to the habitat listed specifically under the relevant state and Commonwealth legislation.
Department of the Environment	The department develops and implements national policy, programs and legislation to protect and conserve Australia's natural environment and cultural heritage and administers the EPBC Act. The Commonwealth Department of Department of the Environment was previously known as: ▪ Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) ▪ Department of the Environment, Water, Heritage and the Arts (DEWHA). ▪ Department of Environment and Heritage (DEH). ▪ Department of the Environment and Water Resources (DEWR).
Ecological community	An assemblage of species occupying a particular area.

Environmental weed	Any plant that is not native to a local area that has invaded native vegetation.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
Exotic	Introduced from outside the area (Stralberg *et al.* 2009). Used in the context of this report to refer to species introduced from overseas.
FM Act	NSW *Fisheries Management Act 1994*
GPS	Global Positioning System – a navigational tool which uses radio receivers to pick up signals from four or more special satellites to provide precise determination of location.
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic components.
Indigenous	Native to the area: not introduced (Stralberg *et al.* 2009).
Introduced	Not native to the area: not indigenous (Stralberg *et al.* 2009). Refers to both exotic and non-indigenous Australian native species of plants and animals.
Key threatening processes	A process that threatens, or could threaten, the survival, abundance or evolutionary development of native species, populations or ecological communities (Department of Environment and Conservation 2004). Key threatening processes are listed under the TSC Act, the FM Act and the EPBC Act. Capitalisation of the term 'Key Threatening Processes' in this report refers to those processes listed specifically under the relevant state and Commonwealth legislation.
Likely	Taken to be a real chance or possibility (Department of Environment and Conservation 2004).
Local population	The population that occurs within the site, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated as defined by Department of Environment and Climate Change (2007b).
Locality	The area within a 10 kilometre radius of the site.
Migratory species	Species listed as Migratory under the EPBC Act relating to international agreements to which Australia is a signatory. These include Japan-Australia Migratory Bird Agreement, China-Australia Migratory Bird Agreement, Republic of Korea-Australia Migratory Bird Agreement and the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Capitalisation of the term 'Migratory' in this report refers to those species listed as Migratory under the EPBC Act.
Noxious weed	An introduced species listed under the *Noxious Weeds Act 1993*. Under the Act, noxious weeds have specific control measures and reporting requirements.
NSW	New South Wales

Plant community type (PCT)	A NSW plant community type identified using the PCT classification system.
Priorities action statements (PAS)	Priorities action statements outline the broad strategies and detailed priority actions to be undertaken in NSW to promote the recovery of Threatened species, population and ecological communities and manage key threatening processes (Department of Environment and Climate Change 2007a).
Protected species	Those species defined as protected under the *National Parks and Wildlife Act 1974*. Includes all native animals, as well as all native plants listed on Schedule 13 of the *National Parks and Wildlife Act 1974*.
Recovery plan	A plan prepared under the TSC Act, FM Act or the EPBC Act to assist the recovery of a threatened species, population or ecological community.
Significant	Important, weighty or more than ordinary.
Species richness	Species richness is simply the number of species present in a sample, community, or taxonomic group. Species richness is one component of the concept of species diversity, which also incorporates evenness, that is, the relative abundance of species (Matteson & Langellotto 2010).
Subject species	Those threatened and significant species, populations and ecological communities that are known or considered likely to occur within the study area.
Project site boundary	Is defined as the Project site and adjacent areas of habitat which may be subject to direct or indirect impacts as a result of the proposed development.
Threatened biodiversity	Threatened species, populations or ecological communities as listed under the TSC Act, FM Act or the EPBC Act.
Threatened species, populations and ecological communities	Species, populations and ecological communities listed as Vulnerable, Endangered or Critically Endangered (collectively referred to as threatened) under the TSC Act, FM Act or the EPBC Act. Capitalisation of the terms 'Vulnerable', 'Endangered' or 'Critically Endangered' in this report refers to listing under the relevant state and/or Commonwealth legislation.
TSC Act	NSW *Threatened Species Conservation Act 1995.*
Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references (Department of Environment and Climate Change 2007b).
Weed	A plant growing out of place or where it is not wanted: often characterised by high seed production and the ability to colonise disturbed ground quickly (Stralberg *et al.* 2009). Weeds include both exotic and Australian native species of plant naturalised outside of their natural range.

EXECUTIVE SUMMARY

WSP | Parsons Brinckerhoff has been commissioned by Transport for NSW to prepare this Biodiversity Assessment Report (BAR) for the proposed New Intercity Fleet Maintenance Facility project at Kangy Angy. This BAR is one of a number of technical reports supporting the Review of Environmental Factors (REF) for the project.

Transport for NSW proposes to deliver a new train maintenance facility at a site in Kangy Angy on the Central Coast of NSW to support the procurement of the New Intercity Fleet. The facility would undertake light and heavy train maintenance activities. The proposed facility would include about six kilometres of electrified railway, seven tracks wide at its widest point, covering an area of approximately 50 hectares, and would be bounded by a perimeter fence.

As part of the site selection process, previous ecological surveys were undertaken by GHD to identify potential ecological constraints. In preparation for the REF, a preliminary ecological assessment (PEA) was completed by EMM (2015) to identify the likely impacts as a result of the project, and therefore determine the applicable planning approval requirements under relevant legislation. The PEA identified the presence of two threatened ecological communities and one threatened flora species as occurring within the Project site (Swamp Sclerophyll Forest, Lowland Rainforest and Biconvex Melaleuca (*Melaleuca biconvexa*)) as well as potential habitat for a number of other threatened species.

In light of the results of the PEA, it was recommended that additional targeted surveys should be completed to inform the environmental impact assessment process moving forward for species considered likely to occur within the study area. Specifically, this would require a Species Impact Assessment (SIS) under Part 5 of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act). Subsequently a request to the NSW Office of Environment and Heritage (OEH) for the Chief Executive Requirements (CERs) was made by Transport for NSW on 15 January 2016 to inform the preparation of an SIS for the project. The CER's were issued by the OEH on 11 February 2016.

This BAR is intended to provide an assessment of the potential ecological impacts to support the REF for the project in addition to informing the preparation of the SIS in accordance with the OEH CER's. The assessment for the BAR included a desktop review of available databases and literature as well as field surveys undertaken over nine days in late February and March 2016.

The desktop analysis of existing vegetation mapping and field validation surveys identified that the vegetation within the Project site was comprised of four vegetation communities. Of these, only one threatened ecological community was identified within the project survey area; *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion* listed as Endangered under the *Threatened Species Conservation Act 1995* (TSC Act). In addition, approximately 5,014 plant stems of *Melaleuca biconvexa,* listed as *Vulnerable* under the TSC Act and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), were recorded. Of these, 3,984 are to be impacted by the project whilst the remaining 1,030 will be retained.

A total of 92 species of animal were recorded during field surveys including five threatened species; Varied Sittella (*Daphoenositta chrysoptera*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bent-wing Bat (*Vespadelus pumilus*)**,** Southern Myotis (*Myotis macropus*), and Grey-headed Flying-fox (*Pteropus poliocephalus*). A further 28 species of threatened fauna were considered to have a moderate or greater chance of occurring within the site, due to the presence of potential habitat within the study area. In addition, two migratory species were recorded during field surveys (Rufous Fantail and Black-faced Monarch).

Significant impacts to biodiversity from the project would involve the potential removal of approximately 25 hectares of Swamp Sclerophyll Forest Endangered Ecological Community (listed under the TSC Act). In addition, the Project would result in the loss of approximately 3,984 *Melaleuca biconvexa* (listed as Vulnerable under the TSC Act and EPBC Act) and potential impacts to the habitat for a number of threatened fauna species, including the Swift Parrot, which is listed as Endangered under both the TSC Act and EPBC Act. These impacts are indicative based on the current concept design for the New Intercity Fleet Maintenance Facility and would be refined as part of the ongoing design and development of the project.

A detailed set of mitigation measures including a biodiversity offset framework and opportunities for revegetation and rehabilitation would also be developed for specific species identified within the Project site and these would be provided within the SIS for the project.

For the purposes of the project, the OEH would be a concurrent determining authority for the project (in addition to Transport for NSW) in accordance with Part 5 of the NSW EP&A Act.

1 INTRODUCTION

1.1 Background

WSP | Parsons Brinckerhoff has been commissioned by Transport for NSW (Transport for NSW) to prepare a Biodiversity Assessment Report (BAR) for a proposed New Intercity Fleet Maintenance Facility project ('the project'). This BAR is one of a number of technical reports supporting the Review of Environmental Factors (REF) for the project. The locality of the project is provided in Figure 1.1.

1.2 Project description

Transport for NSW proposes to deliver a new train maintenance facility at a site in Kangy Angy on the Central Coast of NSW to support the procurement of the New Intercity Fleet. The facility would undertake light and heavy train maintenance activities for the New Intercity Fleet, including but not limited to:

- Regular maintenance/servicing
- Repair/replacement of train components
- Interior and Exterior cleaning.

The proposed facility would include about six kilometres of electrified railway (in total), would be seven tracks wide at its widest point, would cover an area of approximately 500,000 square metres and would be bounded by a perimeter fence.

The key features of the proposed maintenance facility would comprise the following key elements:

- key maintenance facility elements:
  - fleet maintenance building
  - four enclosed maintenance roads and three external standing roads to accommodate the new trains within the site
  - auxiliary workshops
  - electronic clean room
  - material storage, including flammable liquid storage
  - wheel lathe
  - automatic train wash
  - site access roads
- miscellaneous buildings:
  - administration
  - facilities for presentation and train maintenance staff
  - operational control
  - security
  - training rooms
  - train simulator
  - power supply (traction power, bulk power, signalling power supply and backup generators).

- Other infrastructure including:
  - new railway track infrastructure on the western side of the existing rail corridor to allow for trains to enter and exit the maintenance facility site from the Main North railway
  - two new rail bridges over Chittaway Creek and Turpentine Road
  - a new access roadway to the maintenance facility site off Enterprise Drive
  - a new flood access road between Orchard Street and the proposed new access roadway
  - a series of drainage detention ponds
  - staff car park
  - relocation of the existing high voltage power transmission line and Combined Services Route (CSR).

1.3 Previous ecological surveys

1.3.1 Draft Central Coast Train Stabling and Maintenance Facility Comparative Site Analysis

As part of the site selection process, a series of ecological surveys were undertaken at a number of potential locations along the Central Coast to identify potential ecological constraints. The results of those surveys are provided in the *Central Coast Train Stabling and Maintenance Facility Comparative Site* Analysis (GHD 2014). The results from the preliminary survey at the Kangy Angy site suggested that two threatened ecological communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) occur within the Project site:

- River Flat Eucalypt Forest on the coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions; and
- Swamp Sclerophyll Forest on the coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

In addition, one threatened plant species (*Corunastylis* sp. Charmhaven) was predicted to occur at the Kangy Angy site. A targeted survey was undertaken as part of the study during the species flowering period (February 2015), however this species was not detected.

1.3.2 Preliminary Ecological Assessment – New Intercity Maintenance Facility

A preliminary ecological assessment (PEA) was completed by EMM (2015) for the Kangy Angy site to determine the likelihood of significant impacts likely to occur as a result of the project. The results of this study informed the Statement of Impact Assessment Report prepared by Transport for NSW as part of the preliminary phase of the REF process. Desk-based investigations indicated that 16 threatened ecological communities are known to occur within 10 kilometres of the study area. The surveys reported the presence of two threatened ecological communities:

- Swamp Sclerophyll Forest on the coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion listed as Endangered under the TSC Act
- Lowland Rainforest in the North Coast and the Sydney Basin Bioregion listed as Endangered under the TSC Act.

Desk-based searches and results from previous surveys identified potential habitat for seven threatened flora species to occur within the study area. Targeted surveys were undertaken within the flowering period of the three orchids considered to have potential habitat within the study area.

The seven species considered likely to occur included:

- Biconvex Paperbark (*Melaleuca biconvexa*)
- Charmhaven Apple (*Angophora inopina*)
- Magenta Lilly Pilly (*Syzygium paniculatum*)
- Tranquillity Mintbush (*Prostanthera askania*)
- Variable Midge Orchid (*Genoplesium insigne*)
- Wyong Sun Orchid (*Thelymitra adorata*); and
- Wyong Midge Orchid (*Corunastylis* sp. Charmhaven).

Surveys undertaken to inform the PEA identified several hundred individuals of *Melaleuca biconvexa* which is a threatened species listed as Vulnerable under both the TSC Act and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Potential habitat for the following species was also considered however none of these species were recorded during the surveys:

- Magenta Lilly Pilly (*Syzygium paniculatum*)
- Tranquillity Mintbush (*Prostanthera askania*)
- Rainforest Cassia (*Senna acclinis*).

Fauna habitat assessments undertaken as part of the survey indicated that potential habitat occurred for the following threatened and migratory species:

- eleven threatened species of bird; Black-necked Stalk, Gang-gang Cockatoo, Glossy Black Cockatoo, Little Lorikeet, Little Eagle, Masked Owl, Sooty Owl, Powerful Owl, Wompoo Fruit Dove, Regent Honeyeater and Swift Parrot
- three migratory species of bird; Rainbow Bee-eater, Black-faced Monarch and Spectacled Monarch
- two threatened amphibians; Wallum Froglet and Green-thighed Frog
- two threatened reptiles; Pale-headed Snake and Stephen’s Banded Snake
- nine threatened mammals; Golden-tipped Bat, Greater Broad-nosed Bat, Eastern Bentwing Bat, Eastern False Pipistrelle, Grey-headed Flying-fox, Koala, Long-nosed Potoroo, Squirrel Glider and Yellow-bellied Glider.

The study undertook preliminary assessments of significance which concluded that the project is likely to have significant impacts on Swamp Sclerophyll Forest threatened ecological community and *Melaleuca biconvexa*. In light of the results of the PEA, it was recommended that additional targeted surveys should be completed to inform the environment impact assessment process moving forward for species considered likely to occur within the study area. Specifically, this would require a Species Impact Assessment (SIS) under Part 5 of the NSW *Environment Protection and Assessment Act 1979* (EP&A Act).

1.3.3 Chief Executive Requirements

Preliminary investigations associated with the REF identified potential significant impacts to biodiversity, particularly to Swamp Sclerophyll Forest Endangered Ecological Community (EEC) and stands of *Melaleuca biconvexa* which are both listed under the TSC Act. Subsequently a request for the Chief Executive Requirements (CERs), for the preparation of an SIS, was made by Transport for NSW on 15 January 2016 to OEH for the project. CERs were issued on 11 February 2016. The results of this BAR are intended to provide an assessment of the potential ecological impacts to support the REF for the project in addition to informing the SIS in accordance with the CER’s. For the purposes of the project, the OEH would be a concurrent determining authority for the project (in addition to Transport for NSW) in accordance with Part 5 of the NSW EP&A Act. In addition to the preparation of an SIS, an EPBC referral has been made due to the likely significant impacts on the vulnerable listed species *Melaleuca biconvexa.* This referral is a separate process to the NSW state assessment process.

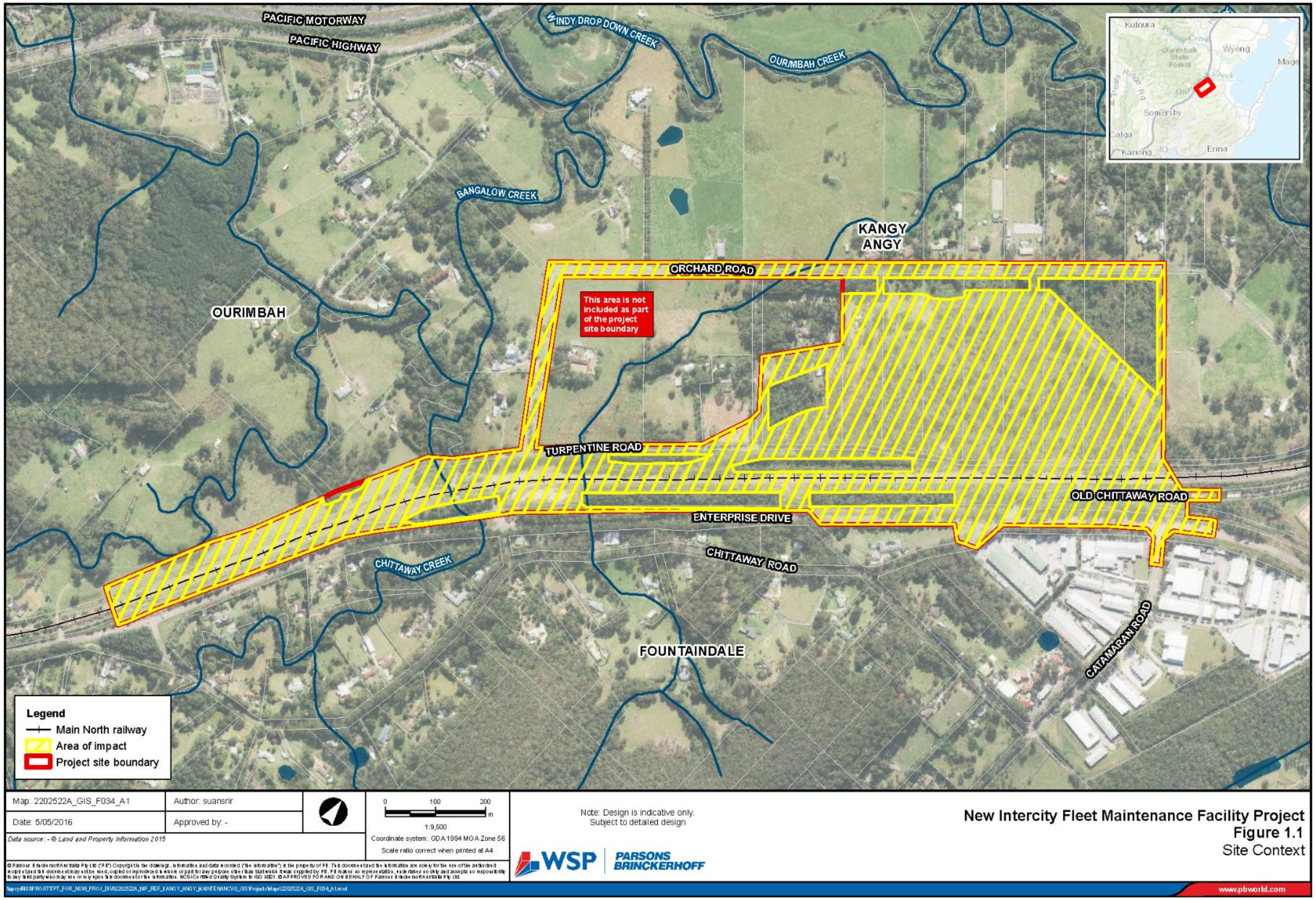

Figure 1.1 Project locality

2 METHODOLOGY

This assessment included a desktop review of available databases and literature as well as field surveys undertaken over nine days in late February and March 2016. The methods are described in detail below.

2.1 Definitions

For the purpose of this report the following definitions apply:

- **Project** is defined as the activities described in section 1.2
- **Project site** defined as the area which is proposed for development (Figure 1.1)
- **Study area** is defined as the Project site and adjacent areas of habitat which may be subject to direct or indirect impacts as a result of the proposed development
- **Locality** is defined as an approximate five kilometres radius around the project area
- **Region** is a bioregion defined in a national system of bioregionalisation. The project is located within the Sydney Basin Bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).

2.2 Personnel

The contributors to the preparation of this report, their qualifications and their role is provided in Table 2.1.

Table 2.1 Contributors and their qualifications

Name	Qualification	Role
Alex Cockerill	BSc (Hons)	Lead Ecologist – Project manager
Mark Stables	BSc (Hons)	Senior Ecologist – Report review
Debbie Landenberger	BSc (Hons)	Senior Ecologist – Flora survey
Tanya Bangel	BSc (Hons), Dip ConsLdMgt	Ecologist – Flora survey and reporting
Nathan Cooper	BEnvSc, Grad Dip Ornith	Senior ecologist – Fauna survey, Anabat analysis and reporting
Allan Richardson	BEnvSc (Hons)	Senior ecologist – Fauna survey and reporting
Clementine Watson	BEnvSc	Graduate Ecologist – Fauna survey and reporting
Matt Goganovski	BSc(Geosciences)	Mapping and data management – GIS operator

All work was carried out under the appropriate licences, including a scientific licence as required under Clause 22 of the National Parks and Wildlife Regulations 2002 and Section 132C of the *National Parks and Wildlife Act 1974*, and Animal Research Authority is issued by the Department of Industries and Investment NSW (Agriculture).

2.3 Nomenclature

Names of plants used in this document follow Harden (Harden 1992, 1993, 2000, 2002) with updates from PlantNet (Royal Botanic Gardens 2016). Scientific names are used in this report for species of plant. Introduced species are identified within the text with an asterisk following the name, for example ***Lantana camara****. Flora names are provided in Appendix A.

Vegetation community names have followed that of the NSW Plant Community Types (PCT) & Biometric Vegetation Type (BVT) (Office of Environment and Heritage 2015). Corresponding vegetation community names from the local broad scale vegetation mapping project and corresponding threatened ecological communities have been also provided in section 3.

Names of vertebrates follow the Australian Faunal Directory (Department of the Environment 2016a) maintained by the Commonwealth Department of the Environment (DoE). Common names, or scientific names where required for clarification, are used in the report for species of animal. Fauna names are provided in Appendix B.

2.4 Literature and database assessment

The aim of this background research was to identify threatened flora and fauna species, populations and ecological communities, Commonwealth listed Migratory species or critical habitat recorded previously or predicted to occur in the vicinity of the study area.

This review allowed for known habitat characteristics to be compared with those present within the study area to determine the likelihood of occurrence of each species, populations or communities. The results informed the identification of appropriate field survey effort and flora and fauna groups likely to occur.

Records of threatened species, populations and ecological communities known or predicted to occur in the locality of the project were obtained from a range of databases as detailed in Table 2.2.

Table 2.2 Database searches

Database	Search date	Area searched	References
BioNet Atlas of NSW Wildlife	25 January 2016	10 km x 10 km area centred on Project site	(Office of Environment and Heritage 2016b)
OEH Threatened Species CMA search	18 March 2016	Wyong sub-region of the Hunter/Central Rivers Catchment Management Authority	(Office of Environment and Heritage 2016e)
EPBC Protected Matters Search Tool	21 January 2016	5 km buffer around Project site	(Department of the Environment 2016b)
PlantNet	25 January 2016	5 km radius of Kangy Angy	(Royal Botanic Gardens 2016)
NSW Department of Primary Industries (Fishing and Aquaculture) threatened Aquatic Fauna Database	18 March 2016	Wyong Local Government Area	(Department of Primary Industries 2016)

In addition to the above database searches other relevant resources were reviewed including:

- Research papers, books and other published data
- Aerial photography
- Broad scale mapping of the region; '*The natural vegetation of the Wyong Local Government Areas, Central Coast, New South Wales*' (Bell 2002)
- Previous ecological assessment of the Project site; *'Preliminary Ecological Assessment: New Intercity Maintenance Facility'* (EMM 2015).

2.5 Field survey

The study area was inspected during daylight and nocturnal hours between 22 February 2016 and 25 March 2016 by a team of qualified ecologists.

2.5.1 Weather conditions

The weather conditions during the survey period varied from cool (minimum 13.6 ºC) to warm (maximum 30.0 ºC) temperatures with light to moderate rainfall and calm to strong wind (Table 2.3).

Table 2.3 Field survey dates and weather conditions

Date	Temperature ºC (min)	Temperature ºC (max	Rain (mm)	Wind (max speed (km/h)/direction)
22 February 2016	18.5	28.8	0.8	30/ENE
23 February 2016	17.0	30.0	0.2	30/NE
26 February 2016	22.8	26.7	0	48/S
29 February 2016	16.9	27.9	0	24/SE
17 March 2016	18.9	25.2	10.2	20/ENE
21 March 2016	15.8	21.4	38.4	31/SSW
22 March 2016	15.7	23.0	14.8	39/S
23 March 2016	15.2	24.6	0	13/WNW
24 March 2016	13.6	27.6	0	26/NE

Note: Data obtained from Bureau of Meteorology Gosford AWS (Station 061425).

2.5.2 Flora survey

The floristic diversity and possible presence of threatened species was assessed using a combination of random meander, plot-based (quadrat/transect) and rapid data point surveys generally in accordance with the resources outlined in section 2.4 and below.

2.5.2.1 DESKTOP ANALYSIS OF VEGETATION

Preliminary mapping of vegetation community boundaries was undertaken through analysis of existing vegetation mapping and aerial photograph interpretation. Analysis of the aerial photographs was used to identify areas of disturbance (e.g. buildings, vehicle tracks, dams and power lines), vegetation structure and likely native versus exotic species composition throughout the site. This provided an initial definition of vegetation communities into simple structural and disturbance classifications for verification during field surveys.

Where access to vegetation was not available during the survey period vegetation community distribution was extrapolated by visual comparison of vegetation apparent in aerial photography with vegetation in areas which were subject to field survey and through consideration of landscape position and existing vegetation mapping.

2.5.2.2 FIELD VERIFICATION OF EXISTING VEGETATION

Vegetation within the Project site and locality has been previously mapped at the regional scale in *'The natural vegetation of the Wyong Local Government Area, Central Coast, New South Wales*' (Bell 2002). Additionally the Project site was previously mapped in a site-specific ecological report '*Preliminary Ecological Assessment: New Intercity Maintenance Facility'* prepared by EMM (2015).

Field validation (ground-truthing) of the initial vegetation classifications identified from aerial photograph interpretation and existing vegetation mapping (Bell 2002; EMM 2015) was undertaken to determine the vegetation types present, their condition and their relationship to threatened ecological community listings under NSW and Commonwealth legislation.

2.5.2.3 QUADRATS

Fourteen quantitative (quadrat/transect) site surveys (Figure 2.1) were completed as outlined in the procedure contained in the BioBanking Assessment Methodology (BBAM) (Office of Environment and Heritage 2014) and described below.

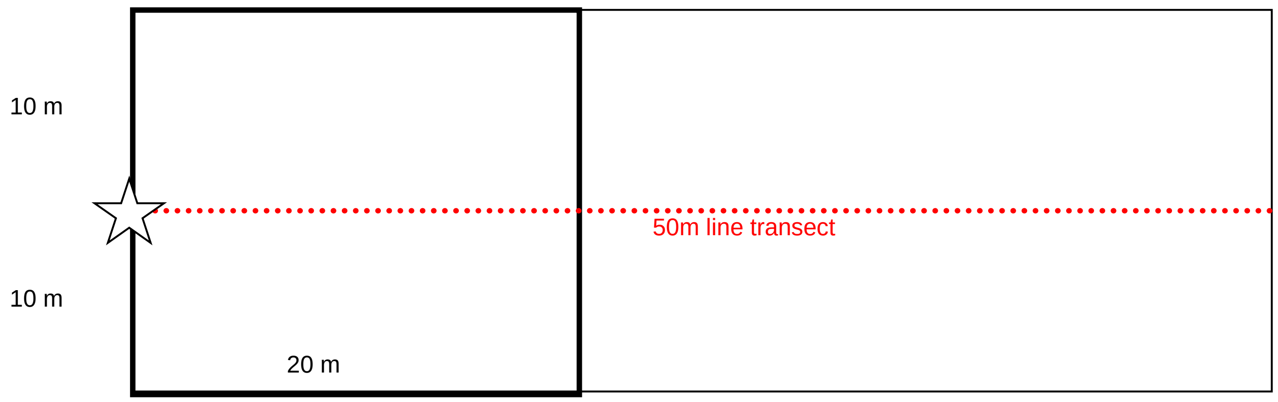

Figure 2.1 Schematic diagram illustrating the layout of the nested 20 metres x 50 metres and 20 metres x 20 metres quadrats used the assessment of condition attributes at each site

The following site attributes were recorded at each site:

- Location (easting – northing grid type MGA 94, Zone 56).
- Vegetation structure and dominant species and vegetation condition.

- Native and exotic species richness (within a 400 square metre quadrat): this consisted of recording all species by systematically walking through each 20 metre x 20 metre quadrat. The cover abundance of each species was estimated.
- Number of trees with hollows (1,000 square metre quadrat): this was the frequency of hollows within living and dead trees within each 50 metre x 20 metre quadrat. A hollow was only recorded if:
  - the entrance could be seen
  - the estimated entrance width was at least five centimetres across
  - the hollow appeared to have depth
  - the hollow was at least one metre above the ground
  - the centre of the tree was located within the sampled quadrat.
- Total length of fallen logs (1,000 square metre quadrat): this was the cumulative total of logs within each 50 metre x 20 metre quadrat with a diameter of at least 10 centimetres and a length of at least 0.5 metres.
- Native over-storey cover: this consisted of estimating the percentage cover of the tallest woody stratum present (greater than one metre and including emergents). The woody stratum included species that were native to NSW and not necessarily those that were locally endemic.
- Native mid-storey cover: this involved estimating the cover of vegetation between the over-storey stratum and a height of one metre (i.e. tall shrubs, under-storey trees and tree regeneration).
- Ground cover: this comprised estimating the cover of plants below one metre in height. The following categories of plants were recorded:
  - native ground cover (grasses): native grasses (*Poaceae* family native to NSW)
  - native ground cover (shrubs): all woody vegetation below one metre in height and native to NSW
  - native ground cover (other): non-woody vegetation (i.e. vascular plants–ferns and herbs) below one metre in height and native to NSW
  - exotic plant cover: vascular plants not native to Australia.
- Evaluation of regeneration: this was estimated as the proportion of over-storey species present at the site that were regenerating (i.e. saplings with a diameter at breast height less than or equal to five centimetres). The maximum value for this measure was one.

Table 2.4 Location of BBAM quadrats/transects

Quadrat/ Transect ID	Vegetation community	Easting[1]	Northing[1]	Transect orientation
BB1	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – High Quality)	351283	6310983	235º
BB2	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – High Quality)	350701	6310663	190º
BB3	Jackwood – Lilly Pilly – Sassafras Riparian Warm Temperate Rainforest (Moderate to Good – Medium Quality)	350221	6310157	210º
BB4	Jackwood – Lilly Pilly – Sassafras Riparian Warm Temperate Rainforest (Moderate to Good – Medium Quality)	340057	6309963	0º
BB5	Jackwood – Lilly Pilly – Sassafras Riparian Warm Temperate Rainforest (Moderate to Good – Medium Quality)	349990	6309966	335º

Quadrat/ Transect ID	Vegetation community	Easting[1]	Northing[1]	Transect orientation
BB6	Jackwood – Lilly Pilly – Sassafras Riparian Warm Temperate Rainforest (Moderate to Good – Medium Quality)	349888	6309708	250º
BB7	Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest (Moderate to Good – High Quality)	350789	6310807	180º
BB8	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – High Quality)	350854	6310704	145º
BB9	Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest (Moderate to Good – High Quality)	351112	6310833	270º
BB10	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – High Quality)	350647	6310445	215º
BB11	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – Medium Quality)	350869	6310825	350º
BB12	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Low Condition)	351264	6311054	15333º
BB13	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – Medium Quality)	350950	6311093	10º
BB14	*Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest (Moderate to Good – Medium Quality)	350841	6310929	195º

(1) GDS 94: Zone 56.

2.5.2.4 RANDOM MEANDER

Random meander surveys are a variation of the transect type survey and were completed in accordance with the technique described by Cropper (1993), whereby the recorder walks in a random meander throughout the site recording all species observed (including threatened species), boundaries between various vegetation communities and condition of vegetation. The time spent in each vegetation community was generally proportional to the size of the community and its species richness.

2.5.2.5 VEGETATION CONDITION

The condition of vegetation was assessed firstly against the BBAM definitions of ‘low’ and ‘moderate to good’ broad conditions and secondly against the BioBanking condition benchmark data for the relevant vegetation type and other parameters such as intactness, diversity, history of disturbance, weed invasion and health.

Under BBAM, vegetation in ‘low’ broad condition is:

> *a) woody native vegetation with native over-storey percent foliage cover less than 25% of the lower value of the over-storey percent foliage cover benchmark for that vegetation type, and where either: – less than 50% of ground cover vegetation is indigenous species, or greater than 90% of ground cover vegetation is cleared*
>
> OR
>
> *b) native grassland, wetland or herbfield where either: – less than 50% of ground cover vegetation is indigenous species, or more than 90% of ground cover vegetation is cleared.*

‘Moderate to good’ broad condition is native vegetation that is not in ‘low’ broad condition.

Three condition sub-categories within the ‘moderate to good’ broad BBAM condition class were used to further define the condition of the vegetation using factors such as levels of disturbance, weed invasion, resilience and comparison with BioBanking benchmark data:

- **Condition sub-category ‘High quality’ condition**: Vegetation that still retains the species complement and structural characteristics of the vegetation community. The vegetation displays resilience to weed invasion due to intact groundcover, shrub and canopy layers (greater than 25 per cent of the lower benchmark). Native species diversity is relatively high. Weeds may exist in this vegetation type but exhibit less than 10 per cent foliage cover.
- **Condition sub-category ‘Medium quality’ condition:** Vegetation generally retains most of the species complement and structural characteristics however may no longer contain one or more of the strata layers due to land use disturbances. This vegetation generally displays resilience to weed invasion and has regeneration potential. Weeds may exist in this vegetation type but exhibit 10 to 60 per cent foliage cover.
- **Condition sub-category ‘Low quality’ condition:** Vegetation generally no longer contains a native canopy but the understorey and groundcover layers are generally dominated or co-dominated by exotic species that exhibit between 61 to 70 per cent foliage cover. Native species diversity is generally relatively low and the mid and low stratums have been structurally modified due to weed incursions.

These sub-categories are based on a modified version of the Weed Invasion Mapping method developed by the Hawkesbury-Nepean Catchment Management Trust (2000).

2.5.2.6 BICONVEX MELALEUCA (MELALEUCA BICONVEXA) SURVEYS

Biconvex Melaleuca (*Melaleuca biconvexa*) individuals have been previously recorded by EMM (2015) and by the OEH BioNet Atlas of NSW Wildlife (Office of Environment and Heritage 2016b) within the Project site and greater locality.

A random meander survey (a technique developed by Cropper (1993) was initially completed across the entire Project site to identify the species presence/absence. In areas where the species was detected, a more intensive survey in the form of parallel transects was carried out to determine the extent of the population and the abundance of individuals present.

It is widely accepted that *Melaleuca biconvexa’* reproduces from seedlings and multiple stems may arise from a single rootstock. Subsequently, it is difficult to estimate the population size from visual inspection (Office of Environment and Heritage 2016a; Threatened Species Scientific Commitee 2008). To estimate the population size and abundance of *Melaleuca biconvexa* within the Project site two methods incorporating a broad visual abundance assessment and stem count were completed.

The visual abundance method was principally based on Duncan’s (2001) conservation assessment of abundance of each stand of *Melaleuca biconvexa* as High, Medium and Low and based on the following criteria:

- High: greater than 50 per cent cover abundance of *Melaleuca biconvexa*
- Medium: 5 to 50 per cent cover abundance of *Melaleuca biconvexa*
- Low: less than 5 per cent cover abundance of *Melaleuca biconvexa.*

To provide a more quantifiable estimate to the population size, a total stem count or estimate based on species density per hectare of *Melaleuca biconvexa* were completed for each age class classification. The three age classifications of *Melaleuca biconvexa* included:

- Mature/Intermediate: stem Diameter at Breast Height (DBH) at chest height greater than 200 millimetres and individual greater than six metres in height

- Immature: stem DBH at chest height less than 200 millimetres and individual less than six metres in height
- Saplings: stem DBH at chest height less than 200 millimetres and individual less than one metre in height.

The method used to determine the abundance of *Melaleuca biconvexa* was based upon the size of the population and density of individuals present. The two methods employed are descripted below.

1. Small population with low densities *Melaleuca biconvexa* (total stem count): performed parallel transects 20 metres apart counting all above ground stems of all age classes that had potential to be impacted upon by the project. Where possible each individual was marked using a GPS point with a five metre accuracy. Where dense thickets occurred a five metre radius counting all above stems were recorded and classified into the age class criteria.
2. Large populations with high numbers of *Melaleuca biconvexa* stems (estimate of stem count based on average densities)*:* boundary of each large population was delineated and a total stem count of individuals of each age class were recorded from within a 20 metre x 20 metre quadrat. The number and position of quadrats completed varied dependent on the size and location of the population. The total stem count of individuals present was then calculated based on the average density of *Melaleuca biconvexa* and the area that it occupied within the Project site.

2.5.3 Fauna survey

Terrestrial vertebrate surveys completed within the study area were carried out as described below and where applicable, considering the methodology detailed in the *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004), the Survey Guidelines for Australia's Threatened Birds (Department of Environment Water Heritage and the Arts 2010), the *Threatened Species survey and assessment guidelines: field survey and methods for fauna-Amphibians* (NSW Department of Environment 2009) and the *Survey guidelines for Australia's threatened frogs* (Department of the Environment Water Heritage and the Arts 2010).

The fauna survey methodology involved surveys at 'standard fauna survey sites' and supplementary sites. Standard trapping sites were established to survey broad habitat types within the study area and consisted of standard fauna survey sites (S1, S2 and S3). At each standard fauna survey site, the following methodologies were used:

- terrestrial mammal trapping
- arboreal mammal trapping
- arboreal hair-tubes
- diurnal bird survey
- ultrasonic echolocation detection (Anabat survey)
- spotlighting
- nocturnal call playback (nocturnal birds, mammals and amphibians)
- herpetofauna active search
- targeted Koala habitat and scat search
- fauna habitat assessment.

Supplementary sites (see Figure 2.2) were selected to target specific habitat features likely to be used by threatened species of fauna. Supplementary surveys included:

- harp trapping
- ultrasonic echolocation detection (Anabat survey)
- nest boxes trapping
- remote camera trapping
- diurnal bird survey
- targeted Koala habitat and scat search
- herpetofauna active search
- spotlighting
- call playback (amphibians).

A summary of the total fauna survey effort for threatened species is provided in Table 2.5 (see also Figure 2.2). All fauna species observed during field surveys were documented and combined into a total species list (see Appendix B).

Table 2.5 Summary of threatened fauna survey effort

Species targeted	Survey type	Survey effort and type	Dates surveyed	Habitat searched in study area
Threatened arboreal mammals → Eastern Pygmy-possum → Yellow-bellied Glider → Squirrel Glider	Arboreal mammal trapping Hair tubes Nest boxes Spotlight surveys Call playback Camera traps	72 trap nights 20 x 90 mm, 25 x 50 mm hair tubes 12 nest boxes 14 person hours 2 hours 6 camera traps	17, 21–23 March 2016	Swamp Forest (29.3 ha) Wet Open Forest (3.8 ha)
Threatened terrestrial mammals → Eastern Chestnut Mouse → Spotted-tailed quoll → Long-nosed Potoroo	Terrestrial mammal trapping Spotlight surveys Camera traps	225 trap nights 14 person hours 6 camera traps	17, 21–23 March 2016	Swamp Forest (29.3 ha) Wet Open Forest (3.8 ha)
Large forest owls → Powerful owl → Barking owl → Masked owl → Sooty owl	Call playback Spotlight surveys	2 hours 14 person hours	17, 21–23 March 2016	Swamp Forest (29.3 ha) Rainforest (1 ha) Wet Open Forest (3.8 ha)
Threatened diurnal birds → Regent Honeyeater → Bush Stone-curlew → Gang-gang Cockatoo → Glossy Black Cockatoo → Speckled warbler → Spotted Harrier → Varied Sittella → Black-necked stork → Black Falcon → Little Lorikeet	Standard 20 minute area search	6 person hours	17, 21–24 March 2016	Swamp Forest (29.3 ha) Wet Open Forest (3.8 ha)

Species targeted	Survey type	Survey effort and type	Dates surveyed	Habitat searched in study area
→ Painted Honeyeater → Little eagle → Black Bittern → Swift parrot → Square-tailed Kite → Eastern osprey → Scarlet Robin → Flame robin → Grey-crowned Babbler → Wompoo Fruit-Dove → Superb Fruit-Dove → Diamond Firetail				
Threatened microchiropteran bats → Easter False Pipistrelle → Golden-tipped Bat → Little Bentwing-bat → Eastern Bent-wing Bat → Eastern Freetail Bat → Large-footed Myotis → Yellow-bellied Sheath-tailed Bat → Greater Broad-nosed Bat	Active ultrasonic bat detection Passive ultrasonic bat detection	1 hr active during spotlight event 6 nights full recording	21–23 March 2016	Swamp Forest (29.3 ha) Rainforest (1 ha) Wet Open Forest (3.8 ha)
	Harp trapping	6 trap nights	21–23 March 2016	Swamp Forest (29.3 ha) Rainforest (1 ha) Wet Open Forest (3.8 ha)
Koala	(SPOT assessment technique) Spotlight survey Call playback	2 person hours 14 person hours	21–24 March 2016	Habitat containing Koala feed tree species Swamp Forest (29.3 ha)

Species targeted	Survey type	Survey effort and type	Dates surveyed	Habitat searched in study area
Threatened herpetofauna → Wallum Froglet → Giant Burrowing Frog → Green-thighed Frog → Green and Golden Bell Frog → Stuttering Frog → Giant Barred Frog → Stephens banded Snake → Pale-headed Snake → Rosenberg's Goanna	Opportunistic sightings Spotlight surveys Call playback Herpetofauna active searches	5 days 14 person hours 2 hours 3 person hours	17, 21–24 March 2016	Within entirety of the study area Swamp Forest (29.3 ha) Rainforest (1 ha) Wet Open Forest (3.8 ha
All threatened species	Opportunistic sightings	5 days	17, 21–24 March 2016	Within entirety of the study area

Note: Full details of fauna survey methodology is provided below

2.5.3.1 MICROCHIROPTERAN BAT SURVEYS

Ultrasonic Anabat bat detection (Anabat SD1 CF Bat Detector – Titley Electronics, Ballina) was used to record and identify the echolocation calls of microchiropterans foraging across six locations in the study area (refer to Figure 2.2). Passive monitoring of these survey sites was achieved by setting Anabat bat detectors to record throughout the night. Bat call analysis was completed by Nathan Cooper of WSP | Parsons Brinckerhoff, with the presentation of data (refer Appendix C) considering the guidelines of the Australasian Bat Society. Bat call of New South Wales Sydney Basin region (Pennay *et al.* 2004) was used as a reference collection for bat call identification.

Harp traps were used to trap foraging microchiropterans, with traps located at sites within the study area that had potential to be used as fly-ways. Four locations were targeted therein with harp traps set in two locations for two consecutive nights, and the another two locations for one night each (refer to Figure 2.2). Harp traps were checked every evening following spotlighting events and again the following day during morning hours. Microchiropteran species caught by harp traps were identified to species level, sexed and forearm measurement recorded. Microchiropterans caught before evening harp trap checks were released the same night.

2.5.3.2 DIURNAL BIRD SURVEYS

Eighteen formal 20 minute diurnal bird searches were completed within the study area (refer Figure 2.2). Bird surveys were completed by actively walking through the nominated site (transect) over a period of 20 minutes. All birds were identified to the species level, either through direct observation or identification of calls. Bird surveys were completed during different times of the day, but generally occurred during morning hours. Birds were also recorded opportunistically during all other surveys.

2.5.3.3 THREATENED BIRD SURVEYS

In addition to standard diurnal bird surveys, targeted surveys were conducted for threatened birds. Wherever threatened bird species were absent from the site, habitat assessments were conducted to determine the likelihood that study area might support those species that are known to occur in the region. Where seasonal conditions for some species were not suitable during the timing of onsite investigations, as was the case for endangered blossom nomads such as the Regent Honeyeater and Swift Parrot, likelihood of occurrence assessments were conducted by the presence/absence of suitable habitat and its condition.

2.5.3.4 TARGETED KOALA SURVEYS – SEPP 44

Targeted searches for the Koala were completed at three locations in the study area (refer to Figure 2.2), where stands of Koala feed trees were observed and consisted of inspecting feed trees for signs of usage, including Koala pellets and scratches. Koala feed tree species identified in the study area that are consistent with State Environmental Planning Policy 44 – Koala habitat protection (SEPP 44) and the Approved Recovery Plan for the Koala (Central Coast management area) (Department of Environment and Climate Change 2008) included, *Eucalyptus robusta* and *E. tereticornis*. At each survey location the Spot Assessment Technique (SAT) methodology was employed, which involved actively searching the ground between the drip-line of the canopy and the trunk of 30 trees for Koala pellets; specifically targeting feed tree species where possible.

2.5.3.5 SPOTLIGHTING

Spotlighting was used to target arboreal, flying and ground-dwelling mammals, as well as, nocturnal birds, reptiles and amphibians. Spotlighting was completed after dusk for four nights (17, 21–23 March) generally following the targeted nocturnal search transects, as shown in Figure 2.2. Surveys were completed on foot using high-powered headlamps and hand torches. Sighted animals were identified to the species level. Fourteen person hours of spotlighting were conducted within the study area.

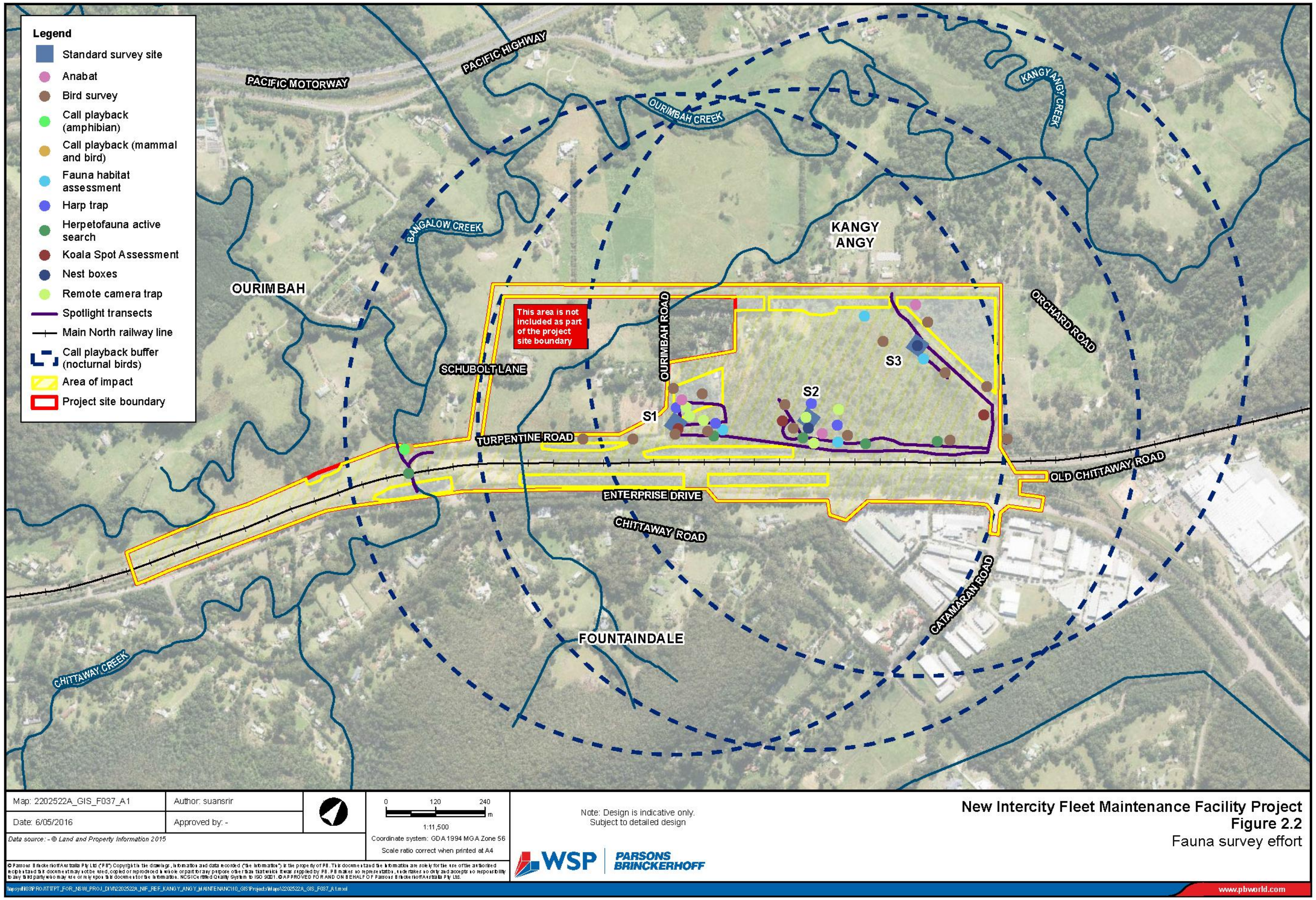

Figure 2.2 Fauna survey effort

2.5.3.6 CALL PLAYBACK

Call playback was used to survey for nocturnal birds (Powerful Owl, Barking Owl, Masked Owl, and Sooty Owl), nocturnal mammals (Koala, Yellow bellied Glider, and Squirrel Glider) and frogs (Wallum Froglet, Green-thighed Frog, Giant Barred Frog and Stuttering Frog), using standard methods (Debus 1995; Kavanagh & Debus 1994). Call playback was completed after dusk on four separate nights at four locations, in the study area (refer to Figure 2.2). A total of two person hours of call play-back were conducted within the study area.

For each survey, an initial listening period of 10 to 15 minutes was undertaken, followed by a spotlight search for 10 minutes to detect any animals in the immediate vicinity. The calls of the target species were then played intermittently for five minutes followed by a 10 minute listening period. After the calls were played, another 10 minutes of spotlighting was done in the vicinity to check for animals attracted by the calls, but not vocalising. Calls from Stewart and Pennay (Pennay *et al.* 2004; Stewart 1998) were broadcast using a portable media player and megaphone.

Call playback was also used to survey for the Wallum Froglet, Green-thighed Frog and Giant Barred Frog, the methodology described above was used for each species at appropriate locations within the project study area.

2.5.3.7 HERPETOFAUNA ACTIVE SEARCHES

Herpetofauna active searches during the day and at night, involved looking for active specimens and eye shine, turning over suitable ground shelter, such as fallen timber, sheets of iron and exposed rocks, raking debris, and peeling decorticating bark. Specimens were either identified visually, by aural recognition of call (frogs only) or were collected and identified using nomenclature outlined in *A Field Guide to Reptiles of New South Wales* (Swan *et al.* 2004).

Herpetofauna surveys were completed by one or two persons over a 30 minute period with all ground shelter returned to their original position. A total of three person hours were conducted throughout the project study area. Herpetofauna active searches were completed in conjunction with diurnal and nocturnal surveys. Frogs and reptiles were also surveyed opportunistically during all other surveys in the study area over a five day period. Reptiles were surveyed in reference to *Threatened species survey and assessment guidelines: field survey methods for fauna (reptiles)* (Department of Environment and Climate Change 2009).

2.5.3.8 ARBOREAL TRAPPING

Medium to large sized arboreal mammals were surveyed using arboreal set Elliott Type B trapping methods. Live capture/release Elliott Type B traps were set in three transects of eight traps for three nights per transect to target Squirrel Gliders and Eastern Pygmy-possum. Each trap was baited with a suitable food source containing honey, and each trap and immediate location was sprayed with an attractant of honey/vanilla essence water mix. Traps were checked at dawn each morning with captured animals identified to species level and released. All live trapping followed guidelines and policies for wildlife research in accordance with animal ethics protocols.

2.5.3.9 TERRESTRIAL TRAPPING

Small to medium sized terrestrial mammals were surveyed using Elliott Type A trapping methods. Live capture/release Elliott Type A traps were set in three transects of 25 traps for three nights per transect to target Eastern Chestnut Mouse and New Holland Mouse. Each trap was baited with a suitable food source containing honey. Traps were checked at dawn each morning with captured animals identified to species level and released. All live trapping followed guidelines and policies for wildlife research in accordance with animal ethics protocols.

2.5.3.10 NEST BOXES

Nest boxes were used to survey for small to medium sized arboreal mammals, specifically targeting Eastern Pygmy-possum and Squirrel Glider. Twelve nest boxes were set in appropriate habitat throughout the study area (Figure 2.2). Nest boxes were set over a period of 14 nights.

2.5.3.11 HAIR TUBES

Small (50 millimetres) and Medium (90 millimetres) hair tubes were used to target Eastern Pygmy-possum and Squirrel Gliders. Each trap was baited with a suitable food source containing honey, and each trap and immediate location was sprayed with an attractant of honey/vanilla essence water mix. Twenty 90 millimetres and twenty-five 50 millimetres hair tubes were set in the field for over 15 nights.

2.5.3.12 REMOTE CAMERA

Six remote motion sensing infra-red cameras were positioned in the study area to target Spotted-tailed Quoll, Long-nosed potoroo, Squirrel Glider and Eastern Pygmy-possum. Five remote cameras were used to target Spotted-tailed Quoll and Long-nosed Potoroo in appropriate microhabitats in the study area. One other camera trap was set with a suitable food source containing honey and sprayed with the attractant of honey/ vanilla essence water mix to target Squirrel Glider and Eastern Pygmy-possum in the appropriate microhabitat (inclusive of proteaceous shrubs). Cameras were also used to target other animals occurring within survey locations including introduced species.

2.5.3.13 FAUNA HABITAT ASSESSMENT

Fauna habitat assessments were completed to assess the likelihood of threatened species of animal occurring in the study area. Habitat assessments included the assessment and identification of habitat features through targeted meander surveys.

During habitat assessments and targeted meander surveys, opportunistic recordings of species were made through incidental sightings, aural recognition of calls and observations of indirect evidence of species' presence (such as Glossy-black Cockatoo chewed cones, nests/dreys, whitewash, burrows and scats). This provided supplementary information on faunal species presence.

Fauna habitats were assessed generally by examining characteristics such as the structure and floristics of the canopy, understorey and ground vegetation, the structure and composition of the litter layer, and other habitat attributes important for feeding, shelter roosting and breeding. The following criteria were used to evaluate habitat values:

- **Good:** A full range of fauna habitat components are usually present (for example, old-growth trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.
- **Moderate:** Some fauna habitat components are missing (for example, old-growth trees and fallen timber), although linkages with other remnant habitats in the landscape are usually intact, but sometimes degraded.
- **Poor:** Many fauna habitat elements in low quality remnants have been lost, including old growth trees (for example, due to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive past clearing.

Specific fauna habitat features were assessed at each standard fauna survey site (refer to Figure 2.2) in the study area and an additional four locations in the study area.

2.6 Likelihood of occurrence

For this study, likelihood of occurrence of threatened species within the study area for species recorded or predicted to occur in the locality is defined in Table 2.6.

Table 2.6 Likelihood of occurrence of threatened species

LIKELIHOOD	DESCRIPTION
Low	Species considered to have a low likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria: → have not been recorded previously in the study area and surrounds and for which the study area is beyond the current distribution range → rely on specific habitat types or resources that are not present in the study area → are considered locally extinct → are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
Moderate	Species considered to have a moderate likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria: → have infrequently been recorded previously in the study area and surrounds → use habitat types or resources that are present in the study area, although generally in a poor or modified condition → are unlikely to maintain sedentary populations, however, may seasonally use resources within the study area opportunistically during variable seasons or migration → are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
High	Species considered to have a high likelihood of occurrence include species not recorded that fit one or more of the following criteria: → have frequently been recorded previously in the study area and surrounds → use habitat types or resources that are present in the study area, that are abundant and/or in good condition within the study area → are known or likely to maintain resident populations surrounding the study area → are known or likely to visit the site during regular seasonal movements or migration.
Recorded	Any threatened species recorded during field surveys.

2.7 Limitations

2.7.1 Study for the benefit of the client

This ecological assessment has been prepared for the exclusive benefit of the client and no other party. WSP | Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with in this study, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in this study (including without limitation matters arising from any negligent act or omission of WSP | Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in this study). Other parties should not rely upon this study or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

2.7.2 Field survey limitations

Even when field surveys are undertaken, no sampling technique can totally eliminate the possibility that a species is present on a site. For example, some species of plant may be present in the soil seed bank and some fauna species use habitats on a sporadic or seasonal basis and may not be present on site during surveys. The conclusions in this report are based upon data acquired for the site and the environmental field surveys and are, therefore, merely indicative of the environmental conditions of the site at the time field surveys are undertaken, including the presence or absence of species. It should be recognised that site conditions, including the presence of threatened species, can change with time.

Access to some locations were restricted as a result of dense undergrowth particularly associated with the *Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest vegetation type. Where access on foot was restricted or limited, but adjacent areas were accessible, vegetation community boundaries, condition and threatened flora and fauna habitat attributes were extrapolated from a distance with the aid of binoculars.

Fauna surveys were conducted during early autumn during a wet period, although rainfall was likely insufficient to promote activity in some amphibian species, which require high rainfall events to trigger breeding cycle responses. Surveys were also conducted outside of the flowering period for Swamp Mahogany, which may attract blossom nomads when in blossom. However a strong flowering season for Swamp Mahogany is not anticipated through the 2016 flowering season as few individual trees were noted as carrying buds during the survey.

2.7.3 Other limitations

To the best of WSP | Parsons Brinckerhoff's knowledge, the investigation presented and the facts and matters described in this study reasonably represent the client's intentions at the time of preparation of the study. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may result in a variation of the project and of its possible environmental impact.

WSP | Parsons Brinckerhoff will not be liable to update or revise this report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

3 EXISTING ENVIRONMENT

3.1 Landscape context

3.2 Vegetation communities

The desktop analysis of existing vegetation mapping and field validation surveys identified that the vegetation within the Project site was comprised of four vegetation communities, the distribution of which are related to geological, topographical and geomorphological characteristics as well as previous and current land uses. The vegetation communities mapped within the Project site are provided in Table 3.1 and illustrated in Figure 3.1.

Detailed descriptions of each vegetation community are provided in sections 3.2.1 to 3.2.4.

Table 3.1 Vegetation communities identified within the study area

WSP | PB 2016	Plant community type/Biometric vegetation type[1]	Existing broad-scale mapping[2]	EMM 2015[3]	TSC Act status	EPBC Act status	Extant within area of impact (ha)	Extant within project site boundary (ha)
Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest	PCT1723/HU937: Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm swamp forest of the Central Coast	MU17: Alluvial Robusta – Paperbark Sedge Palm Forest	Swamp Mahogany Forest	Endangered – Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Not listed	25.5	32.4
Jackwood – Lilly Pilly – Sassafras Rainforest	PCT1528/HU742: Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest on the Central Coast	MU40: Riverine Alluvial Gallery Rainforest – Moist Forest	Jackwood – Lilly Pilly	Not listed	Not listed	1.1	1.6
Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest	PCT1568/HU782: Blackbutt – Turpentine – Sydney Blue Gum mesic tall open forest on ranges of the central coast	MU27: Narrabeen Coastal Blackbutt Scrubby Forest	Not mapped	Not listed	Not listed	3.6	4.5
Exotic and planted vegetation	N/A	Not mapped	Not mapped	Not listed	Not listed	12.1	12.6

1) Plant Community Type (PCT) / Biometric Vegetation Type (BVT) derived from *'Vegetation Information Systems (VIS) Classification 2.1'* (Office of Environment and Heritage 2016f)
2) Existing broad-scale mapping derived from '*The natural vegetation of the Wyong Local Government Area, Central Coast, New South Wales'* (Bell 2002)
3) Previous vegetation mapping undertaken as part of the *Preliminary Ecological Assessment: New Intercity Maintenance Facility* (EMM 2015).

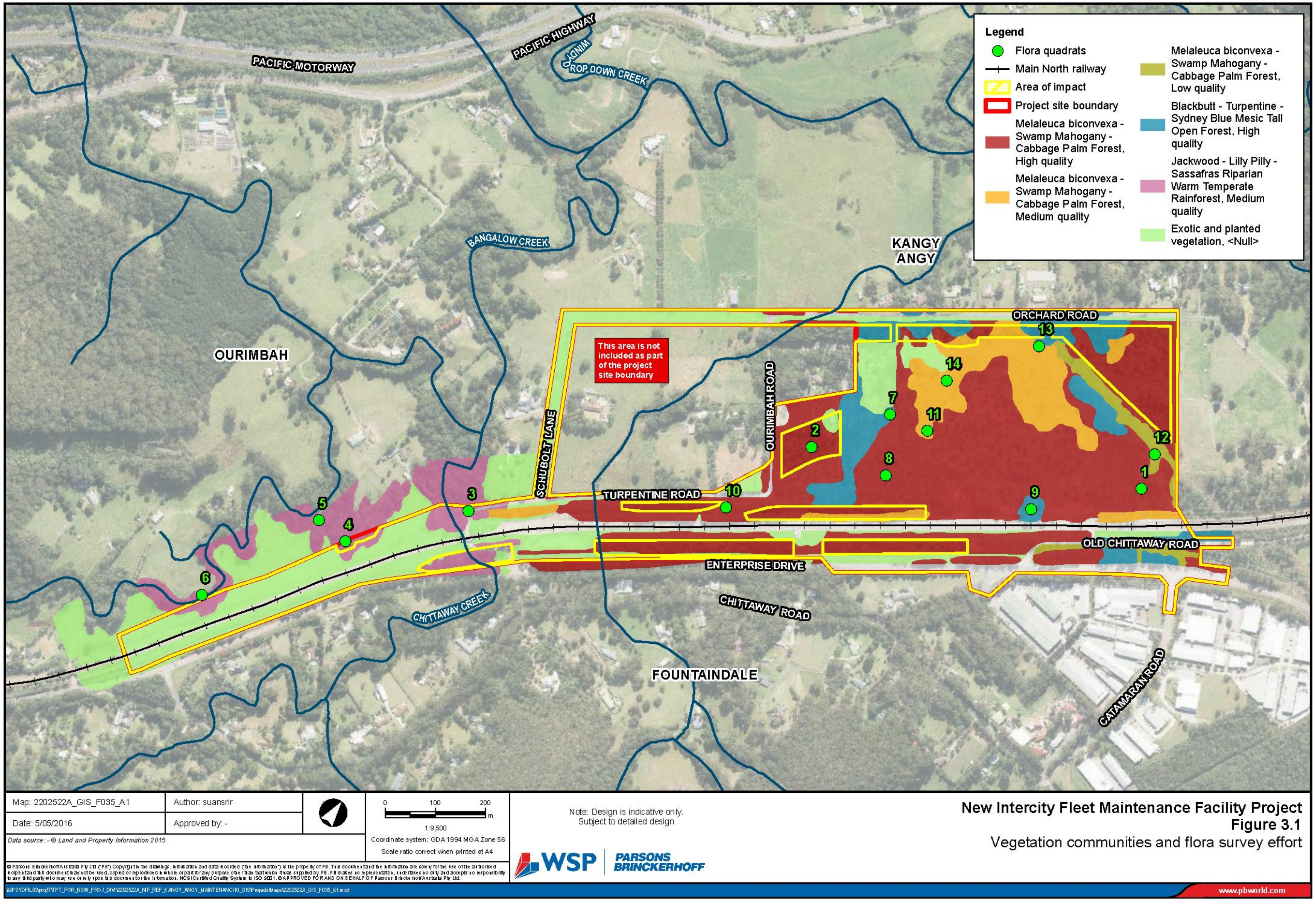

Figure 3.1 Vegetation communities

3.2.1 Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest

This was the dominant vegetation community within the Project site occurring predominantly within the northern portion of the Project site. This community was also recorded as the dominant vegetation type in the previous ecological study (EMM 2015) and within the existing broad-scale vegetation mapping (Bell 2002). The vegetation type was in Moderate to Good condition (High and Medium Quality) and in Low condition (dependent upon its location within the landscape and subsequently the level of disturbance the community is or has been subjected to). Some areas of this community, particularly along the railway line, roads and access tracks experienced sparse to dense weed infestations.

A summary description of this community is provided in Table 3.2 and shown in Photo 3.1, Photo 3.2 and Photo 3.3.

Table 3.2 Summary characteristics of *Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest within the Project site

Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	5–20	0–40	*Eucalyptus robusta, Syncarpia glomulifera, Glochidion ferdinandi* and the occasional *Eucalyptus pilularis, Livistona australis* and *Archontophoenix cunninghamiana* in transitional areas.
Sub-canopy	3–8	0–30	*Acacia longifolia, Glochidion ferdinandi, Elaeocarpus reticulatus, Melaleuca biconvexa*, *Melaleuca linariifolia* and *Melaleuca ericifolia.* In some locations the sub-canopy was dominated by exotic species i.e. *Ligustrum sinense**.
Shrub stratum	0.4–4	0–90	*Acacia longifolia, Persoonia linearis, Leptospermum polygalifolium, Elaeocarpus reticulatus, Melaleuca linariifolia* and *Melaleuca ericifolia.* In some locations the shrub stratum was dominated by exotic species i.e. *Lantana camara** as well as *Ligustrum sinense** and *Lantana camara** juveniles.
Groundcover	0.1–2	0–100	*Gahnia* spp., *Baloskion tetraphyllum, Baumea acuta, Pteridium esculentum, Gleichenia dicarpa, Calochlaena dubia, Cyperus* spp. and *Entolasia stricta.* In some locations the groundcover did experience high levels of weeds species including *Ehrharta erecta**, *Ligustrum sinense** saplings and *Rubus fruticosus**.
NSW PCT/BVT	PCT1723/HU937: Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm swamp forest of the Central Coast		
Conservational significance	High: This community forms part of the Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions threatened ecological community listed as Endangered under the TSC ACT. This community provides habitat for a variety of threatened flora and fauna species including *Melaleuca biconvexa* which was recorded within this vegetation type.		

Strata	Height range (m)	Foliage cover (%)	Dominant species
Condition	Moderate to Good (High Quality): Areas of good quality Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest predominantly within areas which retained a canopy and contained a high abundance and diversity of native species. These areas generally showed resilience to weed infestations as a result of an intact groundcover, shrub and canopy layers. These areas generally occurred in areas of lower disturbance and where vegetation was more intact i.e. few clearings, access tracks etc. Moderate to Good (Medium Quality): Areas of medium quality Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest predominantly occurred along the peripheries of the community or in areas where the canopy was absent. Within these areas the community lacked one or more strata and experienced low to moderate densities of exotic species, native species diversity did remain high. Low: Areas of low condition Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest occurred along the access track to the north of the Project site. Within this area the vegetation lacked one or more strata layers and was generally dominated by exotic groundcover species (native species <50 per cent).		
Extent and distribution within the site	This community covered the majority of the northern portion of the Project site covering an extant of 32.4 hectares or 62 per cent of the Project site. The community was situated on sandy alluvial soils with poor drainage with large stands of water observed in some locations. This community integrated with the Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest and Jackwood – Lilly Pilly – Sassafras Rainforest community preferring soils with lower drainage potential and at slightly lowered elevations.		

Photo 3.1 Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest Moderate to High (High Quality)

Photo 3.2 Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest Moderate to Good (Medium Quality)

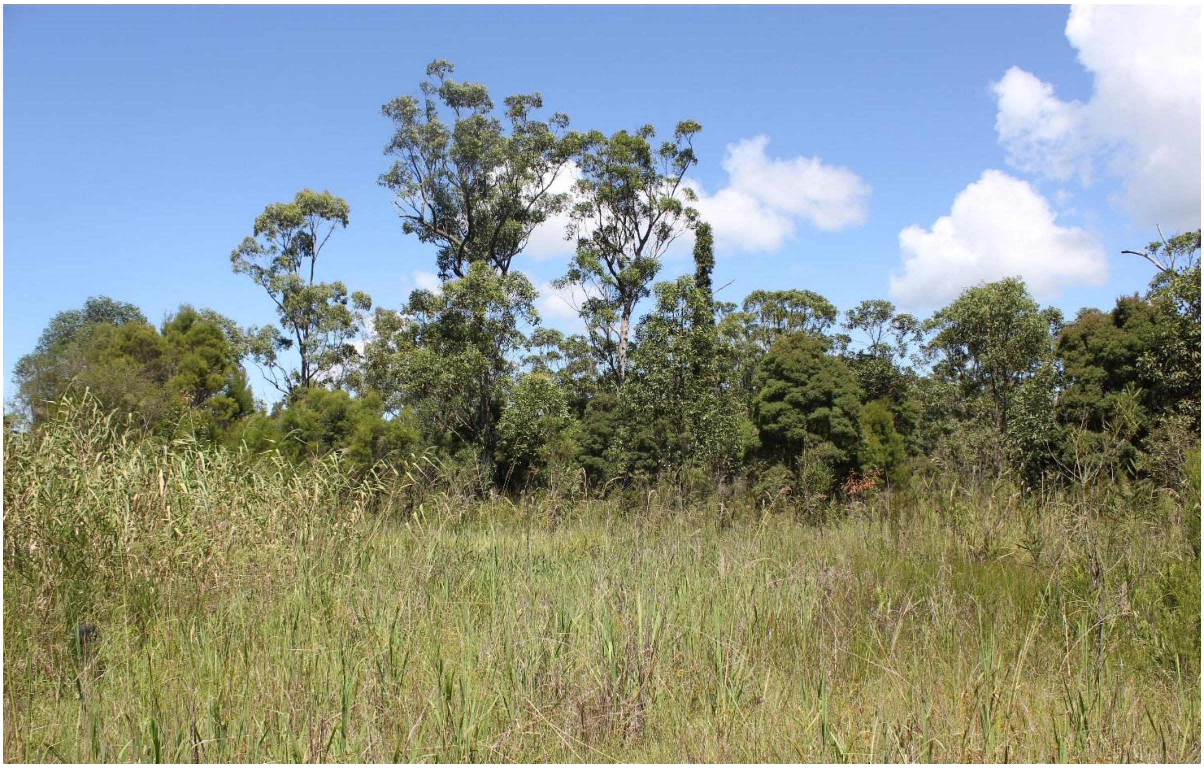

Photo 3.3 Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest Low Condition

3.2.2 Jackwood – Lilly Pilly – Sassafras Rainforest

This vegetation community dominated the southern portion of the Project site occurring along Bangalow Creek and Chittaway Creek which are tributaries of Ourimbah Creek. This community was also recorded in the previous ecological study (EMM 2015) and in the existing broad-scale vegetation mapping (Bell 2002). The vegetation type was in Moderate to Good (Medium Quality) condition with high native species richness and low to moderate weed infestations. Some areas of this community experienced sparse to dense woody weed infestations.

A summary description of this community is provided in Table 3.3 and shown in Photo 3.4 and Photo 3.5.

Table 3.3 Summary characteristics of Jackwood – Lilly Pilly – Sassafras Rainforest within the Project site

Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	8–30	30–70	*Eucalyptus saligna, Doryphora sassafras, Syncarpia glomulifera, Eucalyptus tereticornis, Livistona australis* and *Archontophoenix cunninghamiana.*
Sub-canopy	4–12	30–80	*Cryptocarya glaucescens, Cryptocarya microneura, Neolitsea australiensis, Synoum glandulosum subsp. glandulosum, Acmena smithii, Ripogonum album, Alphitonia excels, Diploglottis australis, Glochidion ferdinandi, Elaeocarpus reticulatus* and *Acacia parramattensis.* In some locations the sub-canopy was dominated by exotic species i.e. *Ligustrum lucidum** and *Ligustrum sinense*.*
Shrub stratum (incl. vines and scramblers)	0.4–5	0–80	*Breynia oblongifolia, Ficus coronata, Rapanea howittiana, Rapanea variabilis, Acmena smithii, Backhousia myrtifolia, Syzygium austral, Syzygium oleosum, Melicope micrococci, Zieria smithii* and *Acacia prominens.* This community also included a series of vines and scramblers including *Pandorea pandorana, Dioscorea transversa, Glycine clandestine, Eustrephus latifolius, Geitonoplesium cymosum, Sarcopetalum harveyanum, Trophis scandens* and *Smilax australis.*
Groundcover	0.1–3	0–100	*Blechnum indicum, Oplismenus aemulus, Dichondra repens, Commelina cyanea, Carex appressa, Livistona australis.* In some locations the groundcover did experience high levels of weeds species including *Axonopus fissifolius*, Ligustrum sinense*, Ehrharta erecta*, Sida rhombifolia** and *Tradescantia fluminensis**.
NSW PCT/BVT	PCT1528/HU742: Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest on the Central Coast		
Conservational significance	Moderate: This community does not form part of any listed threatened ecological community under the TSC ACT or the EPBC Act. This community does however provide habitat for a variety of threatened flora and fauna species. The community also creates a narrow wildlife corridors in some areas of the Project site linking vegetation to remnants of vegetation within the locality.		

Strata	Height range (m)	Foliage cover (%)	Dominant species
Condition	Moderate to Good (Medium Quality): Areas of medium quality Jackwood – Lilly Pilly – Sassafras Rainforest occurred within the southern portion of the Project site along Bangalow Creek and Chittaway Creek. Within these areas the community generally lacked an intact native groundcover layer, instead dominated it was dominated by exotic species. This is likely to be attributed to a high edge ratio. All other strata layers generally had a high diversity of native species.		
Extent and distribution within the site	This community was the dominant vegetation type within the southern portion of the Project site covering an extant of 1.6 hectares or three per cent of the Project site. The community occurred along Bangalow Creek which flows into Chittaway Creek and ultimately Ourimbah Creek. This community integrated with the Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest and exotic and planted vegetation.		

Photo 3.4 Jackwood – Lilly Pilly – Sassafras Rainforest Moderate to Good (Medium Quality)

Photo 3.5 Jackwood – Lilly Pilly – Sassafras Rainforest Moderate to Good (Medium Quality) grazed understorey

3.2.3 Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest

This community occurred as patches within the Project site; integrating with the Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest vegetation type. This community generally occurred on alluvial sandy soils which had higher drainage potential and were at slightly higher elevations that the surrounding vegetation. This community was not recorded within the Project site in the previous ecological study (EMM 2015) however has been recorded in the locality by existing broad-scale mapping (Bell 2002). This community occurred in good condition with high native species diversity.

A summary description of this community is provided in Table 3.4 and shown in Photo 3.6 and Photo 3.7.

Table 3.4 Summary characteristics of Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest within the Project site

Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	10–26	0–40	*Eucalyptus pilularis, Syncarpia glomulifera* and *Corymbia gummifera* within the occasional *Eucalyptus robusta* and *Angophora floribunda.*
Sub-canopy	0–10	0–60	Immature *Syncarpia glomulifera* and *Melaleuca linariifolia.*
Shrub stratum	0.4–2.2	0–50	*Ozothamnus diosmifolius, Leptospermum polygalifolium, Leucopogon lanceolatus, Zieria smithii, Epacris pulchella, Cassinia uncata, Lissanthe strigosa, Acacia longissimi, Livistona australis* and *Polyscias sambucifolia.*
Groundcover	0.1–1.8	0–60	*Baloskion tetraphyllum, Entolasia stricta, Pteridium esculentum, Hibbertia dentata, Pomax umbellata, Gahnia* spp., *Xanthosia pilosa, Dianella caerulea, Microlaena stipoides* and the occasional exotic species such as *Hypochaeris radicata**.
NSW PCT/BVT	PCT1568/HU782: Blackbutt – Turpentine – Sydney Blue Gum mesic tall open forest on ranges of the central coast.		
Conservational significance	Moderate: This community does not form part of any listed threatened ecological community under the TSC ACT or the EPBC Act. This community does however provide habitat for a variety of threatened flora and fauna species. The community also creates a narrow wildlife corridors in some areas of the Project site linking vegetation to remnants of vegetation within the locality.		
Condition	Moderate to Good (High Quality): Areas of good quality Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest retained an intact canopy and contained a high abundance and diversity of native species. These areas generally showed resilience to weed infestations as a result of an intact groundcover, shrub and canopy layers. Some areas of this community has been exposed to understorey clearing however retains a high diversity of native groundcover species which had good regeneration potential.		
Extent and distribution within the site	This community occurred as scattered patches within the north western portion of the Project site covering an extant of 4.5 hectare or nine per cent of the Project site. This community integrated with Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest preferring slightly perched sandier alluvial soils which had higher drainage potential.		

Photo 3.6 Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest Moderate to Good (High Quality)

Photo 3.7 Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest Moderate to Good (High Quality)

3.2.4 Exotic and planted vegetation

This vegetation type occurs across the Project site in areas subjected to past and current landuses such as residential properties, access tracks, infrastructure associated with the railway line and hobby farms. As a result of this vegetation type's poor condition, it is not consistent with any native vegetation community.

A summary description of this community is provided in Table 3.5 and shown in Photo 3.8.

Table 3.5 Summary characteristics of exotic and planted vegetation within the Project site

Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	5–25	0–30	Generally absent. If present consists of planted exotic tree species.
Shrub stratum	0.4–2	0–100	Generally absent. If present consists of planted exotic species.
Groundcover	0.1–1.8	0–100	Generally dominated by exotic species such as *Axonopus fissifolius**, *Ehrharta erecta**, *Pennisetum clandestinum**, *Tradescantia fluminensis**, *Paspalum dilatatum**, *Paspalum urvillei** and *Senecio madagascariensis**.
NSW PCT/BVT	Not consistent with any NSW PSCT/BVT.		
Conservational significance	Low: These areas generally contained planted or exotic vegetation with no or limited native vegetation. These areas provide limited habitat for threatened species and generally create small to large gaps between remnant vegetation reducing connectivity within the Project site.		
Condition	Poor: This community is in low condition as it is dominated by planted and exotic species. The structural integrity of this vegetation type generally lacks one more stratum and low regeneration potential.		
Extent and distribution within the site	This community occurred throughout the Project site covering an extant of 12.6 hectares or 25 per cent of the Project site. The community was not associated with soil or geology occurring on a variety of soil and geology types instead was associated with previous and current disturbances such as clearing for residential properties, access tracks, infrastructure associated with the railway line and hobby farms. This community bordered all other native vegetation communities recorded.		

Photo 3.8 Exotic and planted vegetation

3.3 Flora species recorded

A total of 173 species of plant were recorded within the Project site, of which 132 species (76 per cent) were native. The most diverse family was the Poaceae with 20 species, the Myrtaceae with 16 species and the Fabaceae with 12 species.

Of the 41 exotic species recorded, three are declared as noxious weeds under the *Noxious Weeds Act 1993* (NW Act) for the Wyong Shire Council Local Control Authority (Table 3.6). These are all classified as Class 4 Locally Controlled Weeds which means that '*The plant must not be sold, propagated or knowingly distributed'*. In addition two of these noxious species and one additional exotic species recorded within the Project site are listed as Weeds of National Significance (Wons) (Fireweed, Blackberry and Lantana) (Australian Weeds Committee 2016). Although not noxious weeds within the Wyong Shire local control area some species recorded do have potential to spread rapidly; *Lonicera japonica** (Japanese Honeysuckle), *Ligustrum lucidum** (Large-leaved Privet), *Ligustrum sinense** (Small-leaved Privet) and *Chloris gayana** (Rhodes Grass).

Table 3.6 Noxious weeds

Scientific name	Common name	Class 4 Under NW Act	Wons
*Senecio madagascariensis**	Fireweed	4	Yes
*Ageratina adenophora**	Crofton Weed	4	No
*Rubus fruiticosus**	Blackberry complex	4	Yes
*Lantana camara**	Lantana	-	Yes

3.4 Fauna habitats

The suitability, size and configuration of the fauna habitats correlated broadly with the vegetation communities, as summarised in Table 3.7 and illustrated in Photos 3.9 to 3.15. These areas provided habitat for a range of birds, herpetofauna and mammals, and vegetation communities within the study area and were observed to vary in suitability for native fauna from good to poor.

Habitat features recorded in the study area generally included those associated with swamp forest types occurring on flood plains in the Central Coast and wet sclerophyll forests occurring in sheltered gullies and drainage lines in the foot hills of near coastal ranges.

Table 3.7 Fauna habitat corresponding to vegetation communities

Fauna habitat description	Corresponding vegetation community (Refer to section 3.2)
Rainforest	Jackwood – Lilly Pilly – Sassafras Rainforest High Jackwood – Lilly Pilly – Sassafras Rainforest Moderate
Swamp Forest	Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest High Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest Moderate Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest Low
Wet Open Forest	Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest High Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest Moderate
Cleared land with scattered trees	Exotic and planted vegetation

Those areas that were relatively intact as native vegetation communities were largely fragmented by private land holdings managed as residential properties running livestock. Specific habitat attributes of each habitat type are described in further detail in the sections below with condition of each of the fauna habitats and their attributes are described in Table 3.8.

While the majority of vegetation within the study area is dominated by native species, it is evident by the general paucity of understorey debris, the relatively young age cohort of canopy trees, the lack of canopy strata in some areas and the dense understorey strata, suggested that the vegetation communities are recovering from previous widespread disturbance. As a consequence the vegetation communities do not occur as old-growth forms and important fauna habitat attributes such as hollows, fallen timber, connectivity and large patch size are lacking. The general lack of these important habitat attributes reduce the study area's capacity for supporting a wide diversity of local native species, including threatened species, in isolation from other higher quality habitats in the locality.

3.4.1 Rainforest

Rainforest habitats within the study area occurred as isolated patches of vegetation associated with Bangalow Creek (see Photo 3.9). Although much of this habitat was relatively intact, protective buffers of other forest types were generally absent due to adjacent land managed for rural residential land holdings. Rainforest habitats within the study area contained a variety of native broad-leaved trees providing seasonal fruits for frugivorous animals, such as fruit eating birds, flying foxes and possums. The understorey and canopy provides foraging habitats for insectivorous birds and bats and potential roosting sites for forest owls. Trees within onsite rainforest habitats were generally of an insufficient age-class to develop hollows for animals dependent on these resources for shelter and nesting purposes. The substrates associated with Bangalow and Chittaway Creeks and the flowing nature of the water column is suited to the breeding cycles of rainforest frog species, such as the Barred Frogs (*Mixophyes* sp.), but does not suit the ephemeral pond breeding preferences of other species such as Green-thighed Frog (*Litoria brevipalmata*). Some patches of this forest type have emergent *Eucalyptus saligna* in the upper canopy, which would provide seasonal nectar foraging resources for nectarivorous birds and bats, including threatened species.

Photo 3.9 Rainforest habitat occurring along Bangalow Creek in the south of the study area

3.4.2 Swamp Forest

Much of the study area was characterised by floodplain topography perched above Bangalow Creek. The underlying substrates are subject to variations in elevation, which form a mosaic of low areas holding water, as well as more elevated substrates less subject to waterlogging. Throughout the swampy sections of the study area *Eucalyptus robusta* (Swamp Mahogany) is the dominant canopy tree, sometimes associated with ferns and mesic mid-storey trees (see Photo 3.10), while other wetter areas with *Gahnia* sp. (Saw Sedge) and *Baloskion* sp. (Tassel Rush) species, with melaleucas dominating the mid-storey (see Photo 3.11). Swamp Mahogany is a winter-flowering eucalypt with strong flowering events every three years or so. Due to the relatively large numbers of Swamp Mahogany within the study area, it is likely that the study area's swamp forests would be used seasonally by nectarivorous birds and bats, including threatened species, during Swamp Mahogany flowering events.

Photo 3.10 Swamp Mahogany forest with ferns and mesic plants at standard survey site S1

The structural complexity of swamp forest community habitats within the study area was relatively diverse with a variety of canopy, mid-storey and understorey plants. Such habitats are well suited to the foraging and nesting requirements of many common forest birds, although the diversity of such species was limited in this and adjacent forest habitats by the domination of Bell Miners in the canopy and mid-storey strata. In those sections where mesic mid-storey trees occur, the presence of fruit-bearing trees, shrubs and vines provide fruit for local frugivorous birds, such as Satin Bowerbird (*Ptilonorhynchus violaceus*), Australian King-Parrot (*Alisterus scapularis*), Lewin's Honeyeater (*Meliphaga lewinii*) and White-headed Pigeon (*Columba leucomela*). The dense understorey of ferns with vine masses extending into the mid-storey provided shelter and excellent foraging opportunities for wet forest understorey animals as well as nesting opportunities for these species and arboreal mammals such as Common Ringtail Possum.

Where swamp forest community occurred in lower areas (see Photo 3.11) the canopy was dominated by Swamp Mahogany, the mid-storey strata by melaleucas and the understorey by *Gahnia sieberana*. This habitat provided cover and foraging microhabitats for smaller forest animals, with seasonal blossom from Swamp Mahogany and melaleucas likely to attract a range of nectarivorous animals including threatened nomadic species when they occur locally.

Photo 3.11 Swamp Mahogany forest with *Melaleuca biconvexa* and *Gahnia sieberana* near standard survey site S2

In the northern sections of the study area swamp forest habitats are reduced to understorey strata, with only occasional emergent trees, largely *Syncarpia glomulifera* (Turpentine) and melaleucas (see Photo 3.12). This habitat is suitable to understorey frequenting animals for shelter and foraging opportunities, but, for many native animals, its habitat value is compromised by large areas without mid-storey and canopy strata.

Photo 3.12 Swamp forest reduced to understory strata near standard survey site S3

3.4.3 Wet open forest

Wet open forest canopy-strata were dominated by *Eucalyptus pilularis* (Blackbutt) with some areas also *Corymbia gummifera* (Red Bloodwood), *Eucalyptus saligna* (Sydney Blue Gum) or *Syncarpia gummifera* (Turpentine). Understorey strata was usually dominated by ferns and *Leptospermum* sp. (Tea Tree) (see Photo 3.13), but other areas were more open and grassy in the lower strata (see Photo 3.14). The canopy stratum of this forest type provides summer seasonal nectar foraging resources for nectarivorous birds, bats and arboreal mammals. This community contains the largest and most mature trees in the study area which are most likely to contain hollows, however very few hollows were observed within the study area, with total numbers appearing consistent with the 12 recorded in the EMN report (2015). As such, although the study area is likely to represent part of the home range for large forest owls occurring locally, the canopy trees within the study are not of sufficient age-class to develop hollows of the dimensions required for nesting forest owls or cockatoos; especially the larger species.

Understorey shrubs in the vicinity of Plot 2 (see Photo 3.13) provide good cover for smaller forest birds and both nesting and foraging opportunities for common arboreal mammals, such as Common Ringtail Possum and Sugar Glider.

Photo 3.13 Wet open forest with leptospermum, fern and mesic plant understorey near standard survey site S1

Photo 3.14 shows wet open forest habitat occurring on more elevated substrates, hence the dryer understorey plants dominated by grasses with bracken fern. This section of the community contained Red Bloodwood amongst the dominant Blackbutts, which would provide nectar and pollen during late summer for canopy nectarivorous fauna, including birds, bats and arboreal mammals. The under-storey stratum in this section of habitat was open with little structural diversity, so fauna habitat opportunities in this stratum were relatively poor.

In the northeast of the study area an isolated patch of this community (see Photo 3.15) is surrounded by swamp forest reduced to the understorey layer (see Photo 3.12). This patch of wet open forest is subject to incursions of *Lantana camara* (Lantana), which provides sufficient shelter for small animals, but displaces the natural structure provided by native vegetation.

Photo 3.14 Wet open forest with a grassy understorey near standard survey site S2

Photo 3.15 Wet open forest with under-storey *Gahnia* sp. and lantana at standard survey site S3

3.4.4 Cleared land with scattered trees

Relatively large areas of land within and surrounding the study area have been managed for residential and rural land-uses, largely horse husbandry. While these areas are dotted with scattered trees suited to larger canopy animals, understorey strata are highly managed and do not offer any cover for small animal species. As a consequence these areas are suited to open common country birds and introduced mammals.

3.5 Fauna microhabitats

Table 3.8 describes the details of microhabitats recorded during habitat assessments in each fauna stratification unit.

Table 3.8 Fauna microhabitats

Microhabitat attributes	Fauna habitat stratification			
	Rainforest	Swamp forest	Wet open forest	Cleared land with scattered trees
Upper canopy	*Eucalyptus saligna, Doryphora sassafras, Syncarpia glomulifera, Eucalyptus tereticornis, Livistona australis* and *Archontophoenix cunninghamiana.*	*Eucalyptus robusta, Syncarpia glomulifera, Glochidion ferdinandi, (occasional E. pilularis* and *Archontophoenix cunninghamiana in ecotonal areas*)	*Eucalyptus pilularis, Syncarpia glomulifera* and *Corymbia gummifera* within the occasional *Eucalyptus robusta* and *Angophora floribunda.*	Generally absent. If present consists of planted exotic tree species.
Sub-canopy	*Cryptocarya glaucescens* , *Cryptocarya microneura, Neolitsea australiensis, Synoum glandulosum subsp. glandulosum, Acmena smithii, Ripogonum album, Alphitonia excels, Diploglottis australis,* Glochidion ferdinandi, *Elaeocarpus reticulatus* and *Acacia parramattensis.* Occasional exotic species i.e. *Ligustrum lucidum** and *Ligustrum sinense*.*	*Acacia longifolia, Glochidion ferdinandi, Elaeocarpus reticulatus, Melaleuca linariifolia* and *Melaleuca ericifolia*	Immature *Syncarpia glomulifera* and *Melaleuca linariifolia*	Absent
Shrub layer	*Breynia oblongifolia, Ficus coronata, Rapanea howittiana, Rapanea variabilis, Acmena smithii, Backhousia myrtifolia, Syzygium austral, Syzygium oleosum, Melicope micrococci, Zieria smithii* and *Acacia prominens.* This community also included a series of vines and scramblers including *Pandorea pandorana, Dioscorea transversa, Glycine clandestine, Eustrephus latifolius, Geitonoplesium cymosum, Sarcopetalum harveyanum, Trophis scandens* and *Smilax australis.*	*Acacia longifolia, Glochidion ferdinandi, Elaeocarpus reticulatus, Melaleuca linariifolia* and *Melaleuca ericifolia*	*Ozothamnus diosmifolius, Leptospermum polygalifolium, Leucopogon lanceolatus, Zieria smithii, Epacris pulchella, Cassinia uncata, Lissanthe strigosa, Acacia longissimi, Livistona australis* and *Polyscias sambucifolia*	Generally absent. If present consists of planted exotic species.

Microhabitat attributes	Fauna habitat stratification			
	Rainforest	**Swamp forest**	**Wet open forest**	**Cleared land with scattered trees**
Grasses, herbs, forbs, sedges, and rushes	*Blechnum indicum, Oplismenus aemulus, Dichondra repens, Commelina cyanea, Carex appressa, Livistona australis.* In some locations the groundcover did experience high levels of weeds species including *Axonopus fissifolius*,* Ligustrum sinense*, *Ehrhata erecta*, Sida rhombifolia** and *Tradescantia fluminensis**	*Gahnia* spp., *Baloskion tetraphyllum, Baumea acuta, Pteridium esculentum, Gleichenia dicarpa, Calochlaena dubia, Cyperus* spp. and *Entolasia stricta.* In some locations the groundcover did experience high levels of weeds species including *Ehrhata erecta*, Ligustrum sinense** saplings and *Rubus fruticosus*.*	*Baloskion tetraphyllum, Entolasia stricta, Pteridium esculentum, Hibbertia dentata, Pomax umbellata, Gahnia* spp., *Xanthosia pilosa, Dianella caerulea, Microlaena stipoides* and the occasional exotic species such as *Hypochaeris radicata**	Generally dominated by exotic species such as *Axonopus fissifolius*, Ehrhata erecta**, *Pennisetum clandsetinum**, *Tradescantia fluminensis**, *Paspalum dilatatum*, Paspalum urvillei** and *Senecio madagascariensis**
Leaf litter	60–80%	20–30%	20–30%	Absent
Fallen timber	Present	Absent	Present	Absent
Tree hollows and stags	Absent	Absent	Present	Present
Rocks and rock shelves	Absent	Absent	Absent	Absent
Drainage lines and water bodies	Bangalow and Chittaway Creeks	Occurred as ephemeral ponds.	Occurred as ephemeral ponds.	Absent
Overall condition	Moderate	Poor to Moderate	Poor to moderate	Poor

3.6 Fauna species recorded

A total of 91 species of animal were recorded during field surveys (refer to Table 3.9 and Appendix B), including five threatened species; Varied Sittella (*Daphoenositta chrysoptera*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bentwing Bat (*Vespadelus pumilus*)**,** Southern Myotis (*Myotis macropus*), and Grey-headed Flying-fox (*Pteropus poliocephalus*) (refer to Table 3.9). A total of seventeen native mammal species were recorded. Two introduced species including Spotted Turtle-dove and Rabbit were recorded. No threatened aquatic species are considered likely to occur within the project site boundary.

Table 3.9 Species of animal recorded

Group	Introduced	Native	Threatened	Total
Frogs	–	6	-	6
Reptiles	–	6	-	6
Birds	1	59	1	61
Mammals	1	14	4	19
Total	2	85	5	92

3.6.1 Frogs

Frog surveys were conducted under showery conditions during nocturnal hours. Although frog surveys were conducted during March, conditions were still warm enough to illicit frog calling activity throughout the study area. Three common frog species were calling on the survey nights, including Common Eastern Froglet (*Crinia signifera*), Brown-striped Frog (*Limnodynastes peronii*) and Dusky Gungan (*Uperoleia fusca*). One common species occurring at the southern end of its range, the Dainty Green Tree Frog (*Litoria gracilenta*) was observed calling in numbers during the survey. Two other common frogs the Eastern Dwarf Tree Frog (*Litoria fallax*) and Bleating Tree Frog (*Litoria dentata*) were observed during the day as young frogs from recent breeding events.

3.6.2 Reptiles

Only a small number of common reptiles were observed within the study area; three skinks, one dragon and two snakes. The study area was characterised by dense understorey vegetation, which would provide a diversity of micro-habitats for the prey species reptiles, so it is likely that the study area supports a diversity of common reptile species beyond those species that were observed.

3.6.3 Birds

Although the study area was generally well vegetated, not all areas were structurally complex in relation to a full complement of different strata. Large areas were devoid of mid-storey and canopy layers. As a consequence largely understorey aerial birds frequented these areas. In most other areas where canopy and midstorey strata represented good habitat for forest passerines, the upper forest layers were dominated by Bell Miners (*Manorina melanophrys*), which suppressed the potential for a higher diversity of small to medium sized passerines in these habitats.

The ferny understorey was found to support a good dense occurrence of ground dwelling birds, a relatively high density of Yellow-throated Scrubwren (*Sericornis citreogularis*) being of note.

A moderately diverse list of common forest and open country birds were observed, with only a single threatened species recorded, the Varied Sittella (*Daphoenositta chrysoptera*).

3.6.4 Mammals

A number of common native terrestrial mammal species were observed within the study area, including, in order of density, Brown Antechinus (*Antechinus stuartii*), Bush Rat (*Rattus fuscipes*), Swamp Rat (*Rattus lutreolus*), and Dusky Antechinus (*Antechinus swainsonii*). The cover provided by the dense understorey across the study area was well suited to the habitat requirements of these species. Two arboreal mammals were observed, a Common Ringtail Possum (*Pseudocheirus peregrinus*) and Sugar Glider (*Petaurus breviceps*). The viny mid-storey of the swamp forest habitats were well suited to the habitat requirements of the possum and the Sugar Glider (*Petaurus breviceps*) was observed feeding on the sap of acacias within the same habitat type.

Grey-headed Flying-foxes (*Pteropus poliocephalus*) were observed flying over the study area during nocturnal surveys and would likely make use of seasonal blossom within the study area when available. The Grey-headed Flying-fox (*Pteropus poliocephalus*) is listed as Vulnerable under both the TSC Act and the EPBC Act and the study area showed no evidence that this species might set up camps within it.

A relatively diverse number of common microchiropteran bat species were observed throughout the study area including Ride's Free-tailed Bat, Eastern Broad-nosed Bat (*Scotorepens orion*), Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Wattled Bat (*Chalinolobus gouldii*), Little Forest Bat (*Vespadelus vulturnus*), Eastern Forest Bat (*Vespadelus pumilus*), Gould's Long-eared Bat (*Nyctophilus gouldi*) and White-striped Freetail-bat (*Tadarida australis*).

The Southern Myotis (*Myotis aelleni*), Little Bent-wing Bat (*Miniopterus australis*) and Eastern Bent-wing Bat (*Miniopterus fuliginosus*), which are listed as Vulnerable under the TSC Act, were also recorded within the study area. The Little Bent-wing Bat (*Miniopterus australis*) at site 1 and 2, the Eastern Bent-wing Bat (*Miniopterus fuliginosus*) at site 3 and the Southern Myotis (*Myotis aelleni*) was recorded in rainforest habitat in the southern portion of the site. Due to their nomadic habits, it is likely that a number of other microchiropteran bats, which occur in the wider locality would occur within the study area on at least an intermittent basis. The study area does not provide any roosting opportunities for cave-dwelling microchiropteran bats, and there is a paucity of small hollows throughout the study area, which might provide roosting sites for hollow-dwelling species.

3.6.5 Threatened species

Five threatened fauna species were recorded during recent fauna surveys conducted over the study area, being; Varied Sittella (*Daphoenositta chrysoptera*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bent-wing Bat (*Miniopterus fuliginosus*)**,** Southern Myotis (*Myotis aelleni*), and Grey-headed Flying-fox (*Pteropus poliocephalus*). All threatened species recorded within the study area are listed as Vulnerable under the TSC Act, while the Grey-headed Flying-fox (*Pteropus poliocephalus*) is listed as Vulnerable under the EPBC Act as well. As a consequence of onsite investigations and habitat assessments a further 33 threatened fauna species are considered to have a moderate or greater chance of occurring within the study area (see section 4.4).

3.6.6 Migratory species

Two migratory species listed under the EPBC Act were observed during the current site assessment, they are, Rufous Fantail (*Rhipidura rufifrons*) and Black-faced Monarch (*Monarcha melanopsis*). After onsite habitat assessments a further four EPBC Act listed Migratory species were considered to have a moderate or greater likelihood of occurring within the study area (see section 4.5).

3.6.7 Koala habitat assessment

The study area was found to contain two Koala feed tree species as listed in Schedule 2 of SEPP 44, being *Eucalyptus robusta* (Swamp Mahogany) and *E. tereticornis* (Forest Red Gum). *Eucalyptus robusta* (Swamp Mahogany) occurred within the study area at a density of greater than 15 per cent of the canopy layer therefore the study area was assessed as potential Koala habitat under the conditions contained in SEPP 44.

Spot Assessment Technique (SAT) methodology was employed at three locations within Swamp Mahogany stands with no sign of Koala activity with these stands. Opportunistic surveys over the study area found no evidence of Koala habitation with the study area.

4 THREATENED BIODIVERSITY

Threatened biodiversity (species, populations and communities) are listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This section includes an overview of the threatened biodiversity that has been previously recorded or considered to occur within the Project site based on database searches and results of previous ecological surveys undertaken within the study area, including:

- *Central Coast Train Stabling and Maintenance Facility Comparative Site Analysis* (GHD 2014)
- *Preliminary Ecological Assessment (PEA) – New Intercity Maintenance Facility* (EMM 2015)
- Chief Executive Requirements (CERs) for proposed New Intercity Fleet Maintenance Facility at Kangy Angy (OEH, 2016g).

4.1 Threatened ecological communities

Results of the desk based investigation have predicted that 16 threatened ecological communities could occur within the locality (Table 4.1). One of these communities was recorded during the recent survey; *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion* listed as Endangered under the TSC Act.

One additional threatened ecological community was recorded in the project's PEA (Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions). Detailed field survey and analysis of this vegetation has revealed that this plant community type does not qualify to form part of this threatened ecological community. A detailed rational for this position is outlined in section 4.1.2.

Table 4.1 Threatened ecological communities predicted to occur within the locality

Threatened ecological community	TSC Act listing	EPBC Act listing	Recorded within the study area
Swamp Sclerophyll Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	**Endangered**	**-**	**Recorded within the study area.**
Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions	Endangered	Critically Endangered	Previously identified in the PEA. Not recorded as part of the current study (see section 4.1.2)
Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Critically Endangered	Not recorded.
Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions	Endangered	-	Not recorded.
Low Woodland with Heathland on indurated sand at Norah Head	Endangered	-	Not recorded.
Quorrobolong Scribbly Gum Woodland in the Sydney Basin Bioregion	Endangered	-	Not recorded.
River Flat Eucalypt Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	-	Not recorded.

Threatened ecological community	TSC Act listing	EPBC Act listing	Recorded within the study area
Sydney Freshwater Wetlands in the Sydney Basin Bioregion	Endangered	-	Not recorded.
Umina Coastal Sandplain Woodland in the Sydney Basin Bioregion	Endangered	-	Not recorded.
Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions Subtropical and Temperate Coastal Saltmarsh	Endangered	Vulnerable	Not recorded.
Freshwater Wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	-	Not recorded.
Lower Hunter Spotted Gum-Ironbark Forest in the Sydney Basin Bioregion	Endangered	-	Not recorded.
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	-	Not recorded.
Themeda grassland on headlands and coastal seacliffs of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	-	Not recorded.
Kincumber Scribbly Gum Forest in the Sydney Basin Bioregion	Endangered	-	Not recorded.
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered	Endangered	Not recorded.

4.1.1 Swamp Sclerophyll Forest on the Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion

Swamp Sclerophyll Forest on the Coastal Floodplains on the NSW North Coast, Sydney Basin and South East Corner Bioregion is listed as Endangered under the TSC Act. To be listed as Endangered under the TSC Act vegetation must be consistent with the criteria outlined in the Swamp Sclerophyll Community NSW Scientific Committee Final Determination (Office of Environment and Heritage 2016c).

One vegetation community within the study area (PCT1723/HU937: Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm swamp forest of the Central Coast) is considered consistent with the Swamp Sclerophyll Forest threatened ecological community based on the following characteristics which are consistent with the NSW Scientific Committee Determination for the community:

- study area is located within the Sydney Basin Bioregion and Wyong LGA
- associated with humic clay and sandy loams on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains
- occurred at elevations approximately 10–20 metres above sea level
- occurred as open forest and as partially cleared areas with scattered canopy trees
- floristic composition characteristic of the threatened ecological community i.e. canopy, sub-canopy, shrub and groundcover species.

This threatened ecological community was previously also recorded during previous surveys (EMM 2015; GHD 2014). The PEA for the project indicated that the project would be likely to have a significant impact upon this community (EMM 2015).

4.1.2 Lowland Rainforest threatened ecological community

The Preliminary Ecological Assessment (EMM 2015) identified a small patch of rainforest vegetation that was aligned to PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast and considered to form part of the threatened ecological community listed as Endangered under the TSC Act: Lowland Rainforest in the North Coast and Sydney Basin Bioregion.

Detailed field survey and analysis of this vegetation confirmed the presence of PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast although consideration of this community against the final determination listing for Lowland Rainforest in the North Coast and Sydney Basin Bioregion has revealed that this plant community type does not qualify to form part of this threatened ecological community. A detailed rational for this position is outlined below.

Given the similarities of PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast to the TSC Act listed threatened ecological community consideration of this community against the Commonwealth listing advice for Lowland Rainforest of Subtropical Australia was also undertaken. Although the TSC Act listed Lowland Rainforest community is recognised as being representative of the Commonwealth listed Lowland Rainforest of Subtropical Australia a review of the Commonwealth listing advice has revealed that this plant community type does not qualify to form part of this threatened ecological community.

4.1.2.1 NSW LISTED LOWLAND RAINFOREST IN THE NSW NORTH COAST AND SYDNEY BASIN BIOREGION

To be listed as Endangered under the TSC Act vegetation must be consistent with the criteria outlined in the Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregion NSW Scientific Committee final determination (Office of Environment and Heritage 2016d).

As outlined in the final determination, in order to form part of the Lowland Rainforest in NSW North Coast and Sydney Basin Bioregion – endangered ecological community listing, the vegetation must form part of the Subtropical Rainforests class described by Keith (2004) or form part of a related structurally complex form of Dry Rainforests class. Whilst the final determination generally excludes warm temperate rainforest from the listing, three Floyd (1990) suballiances of this rainforest subformation in NSW are included if they occur in conjunction with any of the subtropical Floyd (1990) suballiances listed in paragraph 4 of the determination. The three warm temperate rainforest (Floyd 1990) suballiances that are included if they occur in conjunction with those suballiances in paragraph four include:

- 33. *Ceratopetalum apetalum – Schizomeria – Argyrodendron spp – Sloanea suballiance*
- *34. Ceratopetalum – Diploglottis australis – Acmena smithii suballiance*
- *35. Ceratopetalum – Schizomeria – Caldcluvia suballiance.*

Consideration of this community against the above criteria identified that the PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast within the Project site:

- Forms part of the Northern Warm Temperate Rainforests **NOT** the Subtropical Rainforests class described by Keith (2004)
- Floristic characteristics of the vegetation recorded within the Project site align to suballiance 37 **NOT** to any of the subtropical suballiances detailed in paragraph four of the final determination based on the following:
  - Examination of VIS Classification 2.1 (Office of Environment and Heritage 2016f) identifies the reference community for this PCT as MU 9 Jackwood/Lilly Pilly riparian rainforest of the Central Coast (Somerville 2009). This community has also been aligned to the Northern Warm Temperate

Rainforests class and identified as having a relationship to PCT 768 Coachwood – Crabapple warm temperate rainforest of the NSW North Coast Bioregion and northern Sydney Basin Bioregion. The reference communities for PCT 768 are Floyd (1990) suballiances 35 *Ceratopetalum – Schizomeria – Caldcluvia suballiance* and 37 *Ceratopetalum/Schizomeria – Acmena – Doryphora*.

- NSW suballiance 35 generally occurs north of Barrington Tops to the Queensland Border. In areas to the south of the Hunter River, *Caldcluvia* is replaced by *Acmena* and *Doryphora* and are associated with suballiance 37 Floyd (1990).
- Characteristics of the vegetation within the Project site that align with suballiance 37 (Floyd 1990) include:
  - South of the Hunter River
  - Below 750 metres above sea level (generally below 20 metres above sea level within the Project site)
  - High abundances of *Acmena* and presence of *Doryphora*
  - Scattered *Eucalyptus saligna* and *Syncarpia glomulifera*
  - Sandstone, alluvium, gravel, sand, silt and clay soils derived from Quaternary and Triassic geologies.

In conclusion, PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast within the Project site does not form part of the Subtropical Rainforests class as described by Keith (2004) and does not align with the three warm temperate rainforest Floyd (1990) suballiances listed in paragraph 4 of the determination. Therefore this vegetation within the Project site is not considered to form part of the threatened ecological community listed as Endangered under the TSC Act; Lowland Rainforest in the North Coast and Sydney Basin Bioregion.

4.1.2.2 COMMONWEALTH LISTED LOWLAND RAINFOREST OF SUBTROPICAL AUSTRALIA

Lowland Rainforest of Subtropical Australia is listed as Critically Endangered under the EPBC Act. To be listed as Critically Endangered under the EPBC Act, vegetation must be consistent with the criteria outlined in the Commonwealth listing advice on Lowland Rainforest of Subtropical Australia (Threatened Species Scientific Commitee 2011).

The Commonwealth listing advice details that vegetation considered to be part of the threatened ecological community listed as Critically Endangered under the EPBC Act occurs within the South East Queensland Bioregion and NSW North Coast Bioregions, however may also occur within the Hunter-Central Rivers Catchment Management Authority (CMA). Although it can occur within the Hunter-Central Rivers CMA it is generally restricted to Grafton and isolated patches between the Clarence River and Hunter River in the south and therefore outside of the Project site.

The Commonwealth listing provides a list of equivalent vegetation classifications and ecological communities which are representative of the Commonwealth listed Lowland Rainforest community. Although Northern Warm Temperate Rainforest class as described by Keith (2004) is recognised as being representative of this community the vegetation within the Project site forms part of suballiance 37 as described by Floyd (1990). Under the Commonwealth listing advice this suballiance is not listed as being representative Critically Endangered ecological community.

In conclusion, PCT 1528/BVT HU742 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast within the Project site does not form part of the Lowland Rainforest of Subtropical Australia as it is outside the communities range and does not align with the Floyd (1990) suballiances recognised as being representative of the community.

4.2 Endangered populations

Two Endangered populations are known to occur within the Wyong LGA which include:

- *Eucalyptus oblonga* population at Bateau Bay, Forresters Beach and Tumbi Umbi in the Wyong LGA
- *Eucalyptus parramattensis* C. Hall. subsp*. parramattensis* in Wyong and Lake Macquarie LGAs.

Neither of these populations are considered likely to occur within the study area based on the lack of available habitat within the study area, species known distributions and as they were not recorded during previous or current surveys.

4.3 Threatened species of plant

One threatened flora species was recorded during previous and current surveys completed for the project; *Melaleuca biconvexa* (Figure 4.1).

The initial assessment undertaken as part of the SIS (Section 3), which is being prepared concurrent to this report, identified 51 threatened flora species as potentially occurring within the locality. Six of these species are 'subject species' that have been identified in the CERs for the proposed New Intercity Fleet Maintenance Facility at Kangy Angy.

In addition to *Melaleuca biconvexa* recorded, four species have been identified as having potential habitat within the project area (Table 4.2). The likelihood of these species occurring within the project site was determined as moderate. These species will be the subject of further consideration as part of the SIS.

Table 4.2 Threatened species of flora recorded or considered to have potential habitat within the survey area

Scientific name	Common name	TSC Act[1]	EPBC Act[2]	Likelihood of occurrence
Melaleuca biconvexa	**Biconvex Paperbark**	**V**	**V**	**Recorded**
Syzygium paniculatum	Magenta Lilly Pilly	E	V	**Moderate**
Maundia triglochinoides	-	V	-	**Moderate**
Senna acclinis	Rainforest Cassia	E	-	**Moderate**
Prostanthera askania	Tranquillity Mintbush	E	E	**Moderate**
Streblus pendulinus	Siah's Backbone	-	E	Low
Caladenia tessellata	Thick-lipped Spider Orchid	E	V	Low
Epacris purpurascens var. purpurascens	-	V	-	Low

1) E = Endangered, V = Vulnerable as listed on the TSC Act
2) E = Endangered, V = Vulnerable as listed on the EPBC Act

4.3.1 Melaleuca biconvexa

Melaleuca biconvexa grows as shrub to small tree usually to 10 metres in height (but is known to reach 20 metres). The species has typical paperbark bark with small leaves to 18 millimetres in length and two millimetres in width. Each of the leaves has a characteristic centre-vein groove from which the leaf blade curves upright on either side (Office of Environment and Heritage 2016a) (Photo 4.1). This species is listed as Vulnerable under both the TSC Act and EPBC Act.

Photo 4.1 *Melaleuca biconvexa* recorded within the Project site

The distribution of *Melaleuca biconvexa* was associated with the Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest vegetation type. Within these areas the species occurred in high, medium and low abundances forming small to large populations across the Project site (Figure 4.1).

Melaleuca biconvexa occurred in all three age class categories, the dominant being the immature cohort (i.e. stem DBH at beast height less than 200 millimetres and less than six metres in height) whist the abundance of saplings and mature specimens were considerably less Photo 4.2. The juvenile individuals generally occurred at the peripheries of the population along access tracks and roads. In one location the species was recorded only as juveniles and no immature or mature specimens were recorded (Photo 4.3).

The population recorded within the Project site forms part of local population (population two) within the Wyong Shire which was described by Duncan (2001). Duncan (2001) maps the distribution of this local population as occurring approximately four kilometres south of the Project site and north to Tuggerah. This local population contains numerous subpopulations such as that recorded within the Project site of varying sizes and abundances. The Project site is also mapped as a priority area for conservation reserves and habitat protection in accordance with Duncan's (2001) conservation strategy for the species within the Wyong LGA.

Photo 4.2 High density immature *Melaleuca biconvexa* within the Project site

Photo 4.3 Juvenile *Melaleuca biconvexa* within Project site

Melaleuca biconvexa recorded within the Project site were subjected to population counts and age class estimates to identify the number of plant stems likely to be impacted upon by the project. Given that determining the population size of *Melaleuca biconvexa* through visual inspections is difficult (i.e. reproduced from seedlings and rhizome growth) the population size and abundance within the Project site were estimated via total counts or density average quadrats which included stem counts and a broad visual abundance assessment. In order to gain a more accurate extent and population estimate, the distribution of *Melaleuca biconvexa* within the proposed construction footprint was split into 20 areas as shown in Figure 4.1. A summary of this assessment is provided below in Table 4.3 (Figure 4.1).

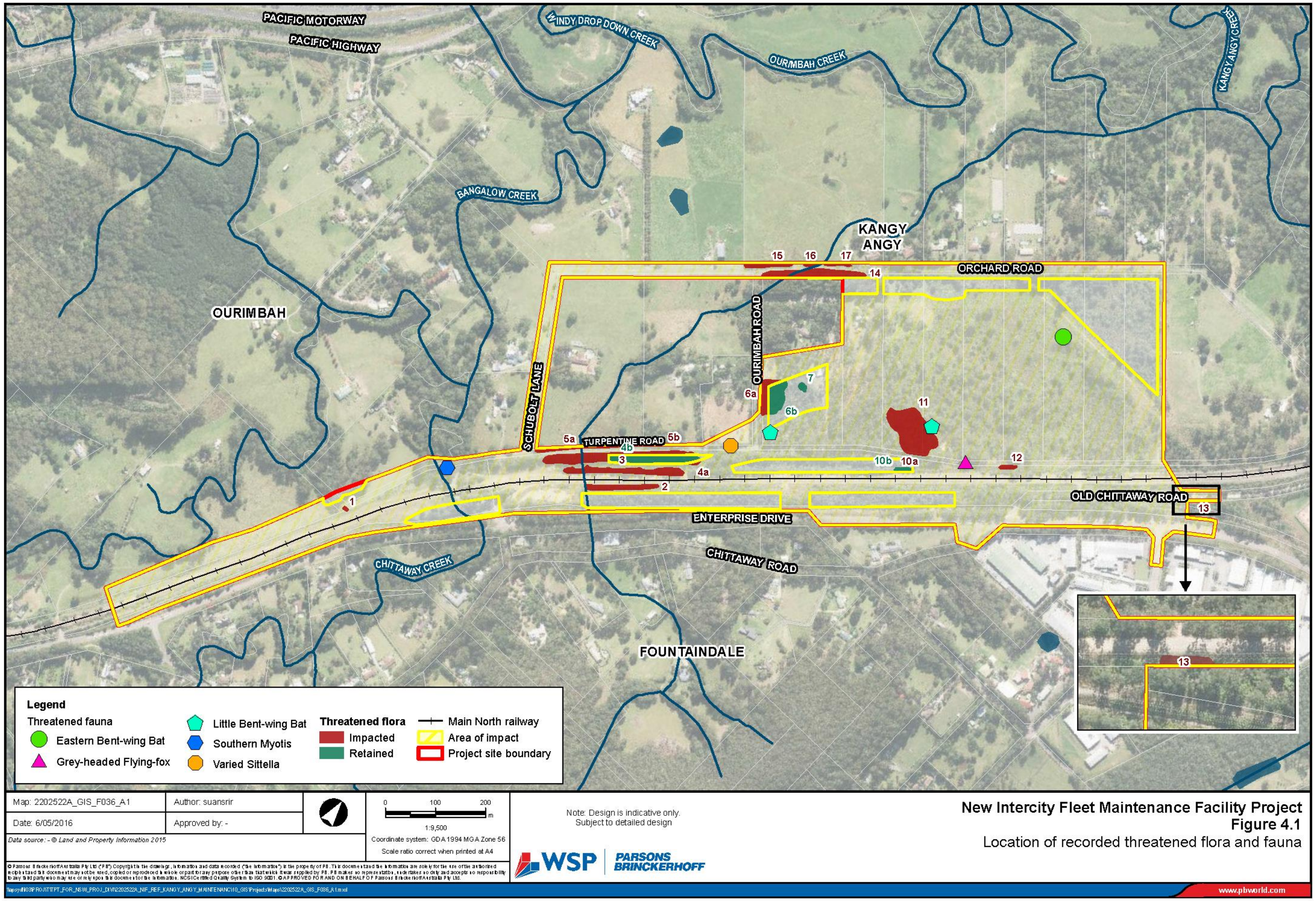

Figure 4.1 Location of recorded threatened flora and fauna

Table 4.3 Summary of *Melaleuca biconvexa* within the proposed construction footprint

Impacted area	Age classification: Mature	Age classification: Immature	Age classification: Saplings	Total	Visual abundance assessment (Duncan 2001)	Count method[1]
Inside area of impact						
Area 1	0	0	30	30	Low	Total count
Area 2	1	57	0	58	Medium	Density average
Area 3	154	167	247	568	High	Total count
Area 4a	1	28	5	34	High	Density average
Area 4c	34	938	176	1,148	High	Density average
Area 5a	9	243	44	296	High	Density average
Area 5b	0	8	2	10	High	Density average
Area 6a	26	49	72	147	High	Total count
Area 10a	0	1	1	2	High	Total count
Area 11	32	227	32	291	Medium	Density average
Area 12	0	12	6	18	Medium	Total Count
Area 13	1	23	4	28	High	Density average
Area 14	29	816	153	998	High	Density average
Area 15	6	174	33	213	High	Density average
Area 16	2	44	8	54	High	Density average
Area 17	3	72	14	89	High	Density average
Total inside area of impact				**3,984**		
***Melaleuca biconvexa* to be retained within the project site boundary**						
Area 4b	23	634	119	776	High	Density count
Area 6b	32	62	92	186	High	Total count
Area 7	2	9	4	15	High	Total count
Area 10b	3	40	10	53	High	Total count
Total be retained within the project site boundary				**1,030**		

Note: 1) High density abundance stem counts based on 83 mature stems, 2,317 immature stems and 433 sapling stems per ha; Medium density abundance stem counts based on 100 mature stems, 350 immature stems and 150 sapling stems per hectare; Low density abundance stem counts based on 50 mature stems, 350 immature stems and 50 sapling stems per hectare.

Results of the population estimate surveys identified that 5,014 *Melaleuca biconvexa* plant stems occur within the Project site. Of these, 3,984 will be removed by the project whilst the remaining 1,030 will be retained within the Project site boundary. The majority of *Melaleuca biconvexa* plants likely to be impacted occur as immature to sapling age class.

4.4 Threatened species of animal

The initial assessment undertaken as part of the SIS (Section 3), which is concurrently being prepared, identified 68 threatened fauna species that could occur within the locality. Of these, 52 species have been identified as 'subject species' in the CERs for the proposed New Intercity Fleet Maintenance Facility at Kangy Angy.

Five threatened species were recorded within the study area, being; Varied Sittella, Little Bentwing-bat, Eastern Bent-wing Bat**,** Southern Myotis, and Grey-headed Flying-fox (Figure 4.1). In addition to the five threatened species recorded, 33 species have been identified as having potential habitat within the project site boundary (Table 4.2). The likelihood of these species occurring within the project site was determined based on the results of the survey.

Table 4.4 Threatened fauna species recorded or likely to occur within the survey area locality

Common name	Scientific name	TSC Act[1]	EPBC Act[2]	Likelihood of occurrence*
Birds				
Barking Owl	*Ninox connivens*	V	-	Low
Black Bittern	*Ixobrychus flavicollis*	V	-	Moderate
Black Falcon	*Falco subniger*	V	-	Low
Black-necked Stork	*Ephippiorhynchus asiaticus*	E	-	Low
Bush Stone-curlew	*Burhinus grallarius*	E	-	Low
Diamond Firetail	*Stagonopleura guttata*	V	-	Low
Eastern Osprey	*Pandion cristatus*	V	-	Low
Flame Robin	*Petroica phoenicea*	V	-	Low
Gang-gang Cockatoo	*Callocephalon fimbriatum*	V	-	Moderate
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V	-	Moderate
Grey-crowned Babbler	*Pomatostomus temporalis*	V	-	Low
Little Eagle	*Hieraaetus morphnoides*	V	-	Moderate
Little Lorikeet	*Glossopsitta pusilla*	V	-	High
Masked Owl	*Tyto novaehollandiae*	V	-	Low
Painted Honeyeater	*Grantiella picta*	V	-	Low
Powerful Owl	*Ninox strenua*	V	-	High
Regent Honeyeater	*Anthochaera phrygia*	CE	E	Moderate
Rose crowned Fruit Dove	*Ptilinopus regina*	V	-	Moderate
Scarlet Robin	*Petroica boodang*	V	-	Low
Sooty Owl	*Tyto tenebricosa*	V	-	Low
Speckled Warbler	*Chthonicola sagittata*	V	-	Low

Common name	Scientific name	TSC Act[1]	EPBC Act[2]	Likelihood of occurrence[*]
Spotted Harrier	*Circus assimilis*	V	-	Low
Square-tailed Kite	*Lophoictinia isura*	V	-	Moderate
Superb Fruit-Dove	*Ptilinopus superbus*	V	-	Moderate
Swift Parrot	*Lathamus discolor*	E	E	High
Varied Sittella	***Daphoenositta chrysoptera***	**V**	**-**	**Recorded**
Wompoo Fruit Dove	*Ptilinopus magnificus*	V	-	Moderate
Frogs				
Giant Barred Frog	*Mixophyes iteratus*	E	E	Moderate
Giant Burrowing Frog	*Heleioporus australiacus*	V	V	Low
Green and Golden Bell Frog	*Litoria aurea*	E	V	Moderate*
Green-thighed Frog	*Litoria brevipalmata*	V	-	Moderate*
Stuttering Frog	*Mixophyes balbus*	E	V	Low
Wallum Froglet	*Crinia tinnula*	V	-	Moderate
MAMMALS				
Common Planigale	***Planigale maculata***	**V**	**-**	**Moderate**
Eastern Bent-wing Bat	***Miniopterus schreibersii oceanensis***	**V**	**-**	**Recorded**
Eastern Chestnut mouse	*Pseudomys gracilicaudatus*	V	-	Moderate
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V	-	Moderate
Eastern Freetail Bat	*Mormopterus norfolkensis*	V	-	Moderate
Eastern Pygmy-possum	*Cercartetus nanus*	V	-	Moderate
Golden-tipped Bat	*Kerivoula papuensis*	V	-	Moderate
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-	Moderate
Grey-headed Flying-fox	***Pteropus poliocephalus***	**V**	**V**	**Recorded**
Koala	*Phascolarctos cinereus*	V	V	Moderate
Large-eared Pied Bat	***Chalinolobus dwyeri***	**V**	**V**	**Moderate**
Little Bentwing-bat	***Miniopterus australis***	**V**	**-**	**Recorded**
Long-nosed Potoroo	*Potorous tridactylus tridactylus*	V	V	Moderate
New Holland Mouse	*Pseudomys novaehollandiae*	-	V	Low
Parma Wallaby	*Macropus parma*	V	-	Moderate

Common name	Scientific name	TSC Act[1]	EPBC Act[2]	Likelihood of occurrence*
Southern Myotis	***Myotis macropus***	**V**	**-**	**Recorded**
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E	Moderate
Squirrel Glider	*Petaurus norfolcensis*	V	-	Moderate
Yellow-bellied Glider	*Petaurus australis*	V	-	Moderate
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*	V	-	Moderate
Reptiles				
Pale-headed Snake	*Hoplocephalus bitorquatus*	V	-	Moderate
Rosenberg's Goanna	*Varanus rosenbergi*	V	-	Low
Stephen's Banded Snake	*Hoplocephalus stephensii*	V	-	Moderate

Note: 1) CE = Critically Endangered, E = Endangered, V = Vulnerable as listed on the TSC Act. 2) E = Endangered, V = Vulnerable as listed on the EPBC Act 4) Asterisk denotes awaiting expert report to determine likelihood.

4.5 Migratory species

Migratory species are protected under international agreements to which Australia are a signatory, including Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea-Australia Migratory Bird Agreement (RoKAMBA) and the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Migratory species are considered Matters of National Environmental Significance and are protected under the EPBC Act.

Based on EMM's EPBC Protected Matters area search and other desk-top database searches, nine migratory fauna species were identified that could occur within the locality. During WSP | Parsons Brinckerhoff on site investigations and database searches a number of other migratory species were found to occur or have suitable habitat within the study area, and its wider locality and/or may occur occasionally. In addition to EMM's report a further six migratory species have been identified as having a potential habitat within the project area (Table 4.5). Two migratory species were recorded during the field surveys; Rufous Fantail and Black-faced Monarch.

Table 4.5 Migratory species recorded or considered to have the potential to occur within 10 kilometres of the study area according to EMM

Common name	Scientific name	EPBC Act[1]	Likelihood of occurrence
Black-faced Monarch	*Monarcha melanopsis*	M	Recorded
Cattle Egret	*Ardea ibis*	M	Moderate
Rainbow Bee-eater	*Merops ornatus*	M	Moderate
Rufous Fantail	*Rhipidura rufifrons*	M	Recorded
Satin Flycatcher	*Myiagra cyanoleuca*	M	Moderate
Spectacled Monarch	*Monarcha trivirgatus*	M	Moderate

1) M=Migratory as listed on the EPBC Act

4.6 Pelagic, estuarine or wetland fauna

Due to the Project site's location within coastal floodplain topography, it occurs in relatively close proximity to pelagic, estuarine and wetland habitats. As a consequence, a number of records of these threatened species came up in database searches of the locality. There is no suitable habitat within the study area for threatened species dependent upon pelagic, estuarine and/or wetland species, so they have not been entered into Tables 4.5 and 4.6 and are considered no further.

4.7 Groundwater dependent ecosystems

Groundwater dependant ecosystems (GDEs) are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater (Department of Land and Water Conservation 2002). When considering GDEs, groundwater is generally defined as the saturated zone of the regolith (the layer of loose rock resting on bedrock, constituting the surface of most land) and its associated capillary fringe, however it excludes soil water held under tension in soil pore spaces (the unsaturated zone or vadose zone) (Eamus *et al.* 2006).

GDEs include a diverse range of ecosystems as shown in Figure 4.2. These ecosystems range from those entirely dependent on groundwater to those that may use groundwater while not having a dependency on it for survival (i.e. ecosystems or organisms that use groundwater opportunistically or as a supplementary source of water) (Hatton & Evans 1998). Serov et al. (2012) considers the following broad classes of these ecosystems:

- Subsurface Ecosystems, which include the following:
  - Karst and cave ecosystems, where stygofauna (groundwater-inhabiting organisms) may reside within the groundwater resource.
  - Subsurface phreatic aquifer ecosystems, ecosystems which support invertebrate, microbial species and occasionally vertebrate species. These hypogean species exist in a continuum of different types of aquifers including kartic, cave, porous and fissured aquifers, and can exist been the subsurface and surface water.
  - Subsurface baseflow streams or hyporheic zones (see ecosystem 5 in Figure 4.2) of rivers and floodplains are also included in this category because these ecotones often support stygobites (obligate groundwater inhabitants).
- Surface Ecosystems, which include the following:
  - Groundwater dependant wetlands – these wetlands exist at the boundary of the surface water and groundwater systems.
  - Baseflow streams (surface water ecosystems).
  - Estuarine and near shore marine ecosystems.
  - Phreatophytes – Groundwater dependent terrestrial ecosystems, these GDEs can be dependent upon groundwater intermittently or permanently depending upon the groundwater table level. Groundwater is often accessed via the capillary fringe (non-saturated zone above the saturated zone of the water table) when roots penetrate this zone. Roots can be shallow or deep (e.g. River Red Gum Forest on the Murray–Darling basin) (see ecosystems 1 and 4 in Figure 4.2). No surface expression of groundwater is required in this class of groundwater dependant ecosystems.

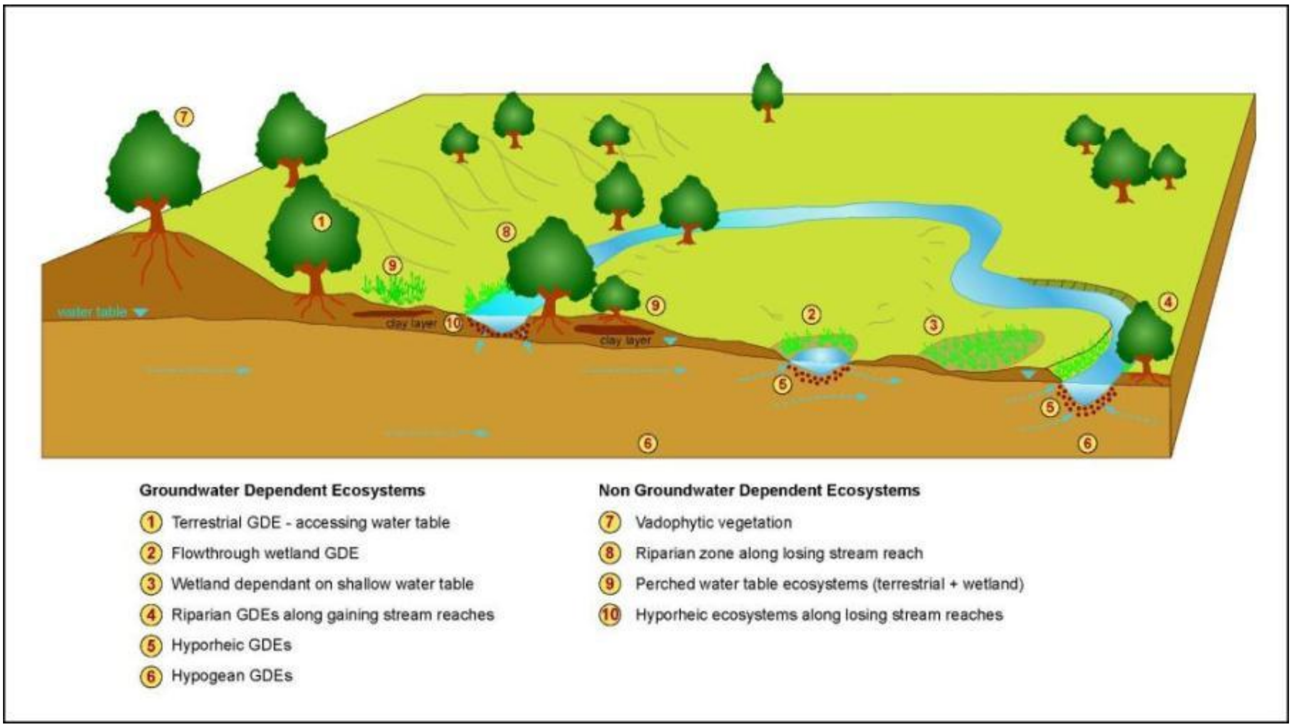

Figure 4.2 Conceptual biophysical model of groundwater dependant ecosystems

GDEs possess a range of values, including being important and sometimes rare ecosystems in themselves, as well as providing important ecosystem services such as water purification (Department of Land and Water Conservation 2002). Groundwater is also an increasingly important resource for human uses in Australia (there was a 90 per cent increase in groundwater extraction between 1985 and 1997 (National Land and Water Resources Audit 2001). Nationally groundwater is extracted for uses including irrigation (48 per cent), urban and industrial use (33 per cent) and stock watering and rural use (19 per cent) (Department of the Environment and Heritage 2001).

The potential for groundwater extraction to exceed recharge has resulted in awareness of the effects of groundwater availability or regimes that may result in adverse impacts to groundwater dependent ecosystems (2003), and thereby threaten the values they provide.

4.7.1 Legislation

Due to the concern of the impacts upon groundwater dependent ecosystems several levels of legislation have been developed. These include state legislation and state planning polices and these include the following:

- *Water Management Act 2000* in which the Minister for Land and Water Conservation manages and controls the extraction of groundwater. Section 5(2)a of the Act relates to protection of water source: and Section 5(2)c relates to water quality. Both of these sections of the Act would directly relate to GDEs as both water quality and quantity would impact upon these ecosystems.
- The NSW State Groundwater Dependent Ecosystem Policy (2002) has been developed to protect ecosystems which have a reliance on groundwater for survival. This document outlines a rapid assessment process which is used for identifying and valuing GDEs which assists in the management of GDEs at a state level.

- Groundwater Dependent Ecosystems Assessment, Registration and Scheduling of High Priority (Department of Land and Water Conservation 2006). This document was written by Department of Land and Water Conservation and was developed to classify GDEs in order of priority of protection.
- Risk Assessment Guidelines for Groundwater Dependant Ecosystems, consisting of four volumes (Kuginis *et al.* 2012a; Kuginis *et al.* 2012b; Serov *et al.* 2012; Williams *et al.* 2012). These documents were commissioned by the Department of Primary Industries – Office of Water as part of the National Water Commission Coastal Groundwater Dependent Ecosystem Project. This project was commissioned to gain further information on the Coastal GDE environment to support ecological and dependency evaluations for GDEs.

The above documents have been used in this report to assist in the identification and will in future be used to assess of the impacts upon GDEs within the survey area.

4.7.2 GDEs in the Project site

Whether or not ecosystems show some level of groundwater dependence will depend, in part, on their location in the landscape relative to the level of groundwater. Two plant community types within the Project site has been determined as being groundwater dependent; Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest and Jackwood – Lilly Pilly – Sassafras Rainforest (Table 4.6).

Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest was determined as not being groundwater dependent. This was determined by following the GDE classification decision tree provided in the Risk Assessment Guidelines for Groundwater Dependant Ecosystems Volume One (Kuginis *et al.* 2012a; Kuginis *et al.* 2012b; Serov *et al.* 2012; Williams *et al.* 2012).

Dependence (or interaction) of the vegetation on groundwater was determined by aligning it with the groundwater dependant ecosystem types identified by the Risk Assessment Guidelines for Groundwater Dependant Ecosystems, Volume 1 (Serov *et al.* 2012).

Table 4.6 GDEs identified within the Project site

Vegetation type recorded[1]	GDE name[2]	GDE type	Subtype 1	Subtype 2	High ecological value ecosystem
Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest	Melaleuca biconvexa/Swamp Mahogany/ Cabbage Palm swamp forest of the Central Coast (40)	Coastal Freshwater Wetlands	Coastal floodplain swamps	Not identified	Yes
Jackwood – Lilly Pilly – Sassafras Rainforest	Jackwood/Lilly Pilly/Sassafras riparian warm temperate rainforest of the Central Coast (32)	Perennial rivers and streams	Surface water riverine ecosystems	Continuous river	Yes

1) Vegetation communities as per Parsons Brinckerhoff vegetation communities described in section 3.2.
2) Hunter-Central Rivers CMA high ecological value ecosystems (Kuginis *et al.* 2012a; Kuginis *et al.* 2012b; Serov *et al.* 2012; Williams *et al.* 2012).

5 POTENTIAL IMPACTS AND MITIGATION

5.1 Potential impacts

Potential impacts to biodiversity resulting from the construction and operation phases of the proposed project are considered in this section and summarised in Table 5.1. Where applicable, impacts are also correlated with relevant key threatening processes in section 5.1.12.

Table 5.1 Potential impacts associated with the proposal

Potential impact	Potential phase of impact	
	Construction	Operation
Removal of native vegetation (including threatened ecological communities)	●	
Removal of threatened fauna species habitat	●	
Removal of threatened plant species	●	
Aquatic Impacts	●	●
Impacts to groundwater dependant ecosystems (Swamp Forest)	●	●
Changes to hydrology	●	●
Erosion and sedimentation	●	●
Increase in fauna injury and/or mortality	●	●
Wildlife connectivity and habitat fragmentation	●	●
Edge effects on adjacent native vegetation and habitat	●	●
Potential environmental impact of noise, light and vibration on wildlife	●	●
Weed and pest invasion	●	●
Invasion and spread of pathogens and disease	●	●

5.1.1 Removal of native vegetation and fauna habitat

Clearing of native vegetation is listed as a Key Threatening Process under both the TSC Act and the EPBC Act. Under the TSC Act, native vegetation is made up of plant communities, comprising primarily indigenous species. Clearing is defined as the destruction of a sufficient proportion of one or more strata layers within a stand or stands of native vegetation so as to result in the loss, or long-term modification, of the structure, composition and ecological function of a stand or stands (NSW Scientific Committee 2001).

Where possible, areas of the Project site have been identified for the retention of existing vegetation as shown on Figure 5.1. Notwithstanding these areas, construction of the project would require the clearing of vegetation and habitats as summarised in Table 5.2. This includes the loss of habitat features, such as a seasonal foraging resource for threatened blossom nomads and variations in micro elevation that provide a mosaic of soaks after rain. However, it is evident by the general paucity of understorey debris, the relatively young age cohort of canopy trees, the lack of canopy strata in some areas and the dense understorey strata; that the vegetation communities are recovering from previous widespread disturbance. Consequently, the vegetation communities do not occur as old-growth forms and important fauna habitat attributes such as hollows, fallen timber, and large patch size are typically lacking.

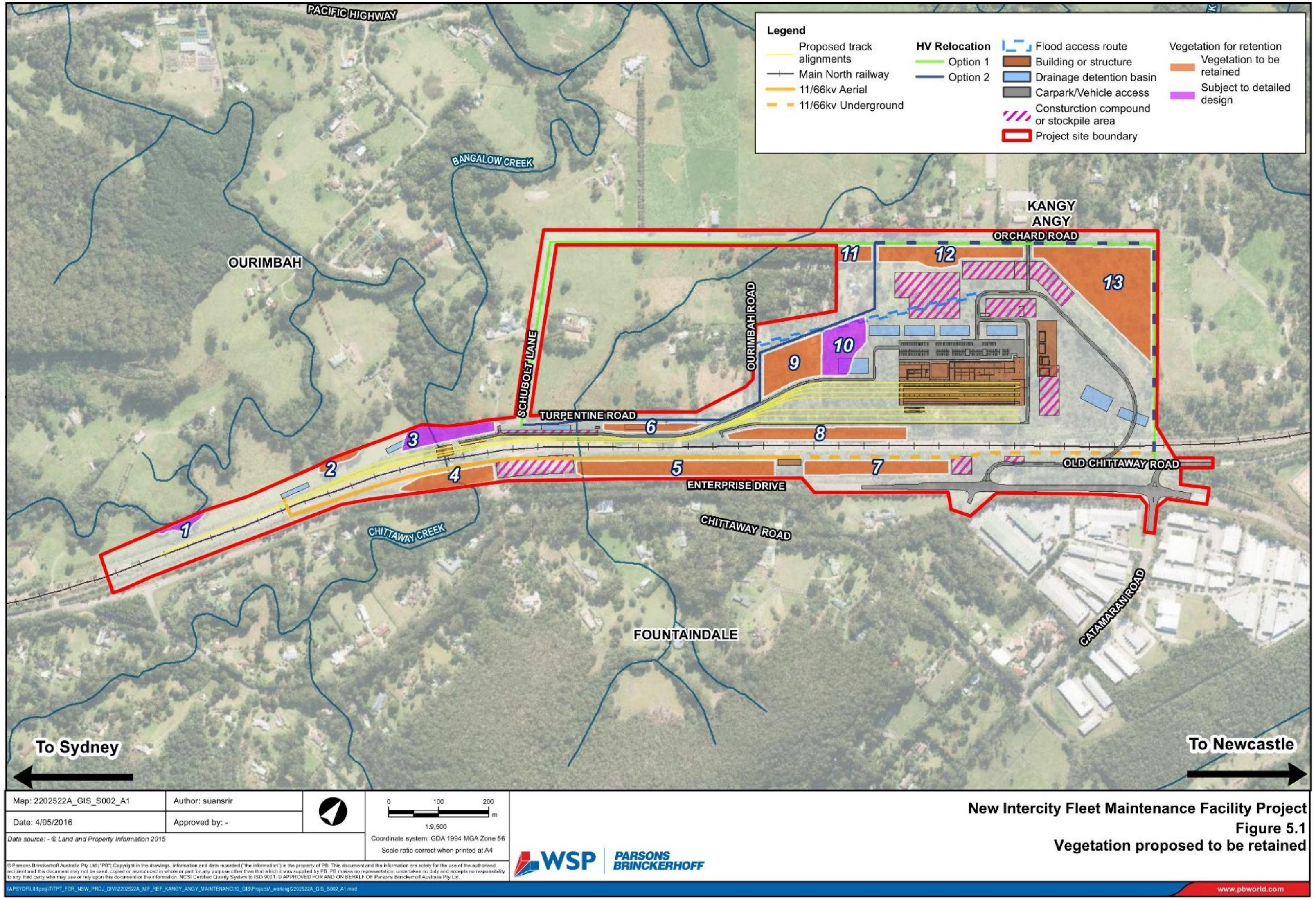

Figure 5.1 Location of recorded threatened flora and fauna

The general lack of these habitat attributes reduce the study area's capacity for supporting a wide diversity of local native species in isolation from other higher quality habitats in the locality. Nevertheless, the project would affect up to approximately 42.3 hectares known and potential habitat for 38 threatened fauna species, inclusive of Varied Sittella, Southern Myotis, Grey-headed Flying-fox, Eastern Bent-wing Bat and Little Bentwing-bat, which were recorded in the study area during targeted surveys. This impacted would be refined during the detailed design of the project with the aim of reducing the overall impact of the project.

One vegetation community within the study area (PCT1723/HU937: *Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm swamp forest of the Central Coast) is considered consistent with the Swamp Sclerophyll Forest on the Coastal Floodplains on the NSW North Coast, Sydney Basin and South East Corner Bioregion which is listed as Endangered under the TSC Act.

Table 5.2 Potential loss of native vegetation and corresponding fauna habitat within the Project site

Vegetation community	Fauna habitat	Potential vegetation clearing (ha)
Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm Forest[1]	Swamp Forest	25.5
Jackwood – Lilly Pilly – Sassafras Rainforest	Rainforest	1.1
Blackbutt – Turpentine – Sydney Blue Gum Mesic Tall Open Forest	Wet Open Forest	3.6
Cleared and disturbed land	Cleared land	12.1
Total area of vegetation to be impacted		**42.3**

(2) This native vegetation forms part of the endangered ecological community, Swamp Sclerophyll Forest on the Coastal Floodplains on the NSW North Coast, Sydney Basin and South East Corner Bioregion listed as Endangered under the TSC Act

5.1.2 Direct removal of threatened plants (*Melaleuca biconvexa*)

Melaleuca biconvexa is listed as Vulnerable under both the TSC Act and EPBC Act. It is estimated that approximately 3,984 *Melaleuca biconvexa* plant stems would be impacted by the project. An additional 1,030 *Melaleuca biconvexa* were recorded within the Project site boundary would be retained by the project. Due to restricted access, not all neighbouring properties where surveyed during the surveys undertaken to inform this report, subsequently the population within this location is likely to be far larger given suitable habitat available.

The population of *Melaleuca biconvexa* recorded forms part of a local population (number two) within the Wyong Shire described by Duncan (2001). This population is separate to the *Melaleuca biconvexa* population at Lisarow that is subject to impacts from the Roads and Maritime Pacific Highway upgrade project.

5.1.3 Hydrological changes

The Project would remove the existing mosaic of water-holding soaks associated with Swamp Forest that occupies much of the study area. The project is also likely to require the installation of additional culverts or water crossings along Chittaway Creek. Waterway crossings could modify the natural hydrology of creeks in the study area, which could ultimately affect the aquatic assemblages that use the area (Fairfull & Witheridge 2003). Impacts from waterway crossings may include:

- Excessive flow velocities, which could erode creek banks and lead to changes in water quality, as well as acting as a barrier to fish movement
- Modified water depths of the creek

- Increased water turbulence, which could lead to the avoidance of the area by various aquatic organisms.

Excavation and earthworks undertaken during the construction phase of the project would expose soils that have potential to enter receiving environments. Sediment runoff during earthworks has the potential to introduce storm flow and increase suspended solids in adjacent streams and drainage lines. Further, it is likely that runoff intensity would increase and any drainage design or improvements to existing structures would need to consider the existing receiving environment.

5.1.4 Impacts to groundwater dependant ecosystems

The project is likely to have potential impacts on 33.3 hectares of groundwater dependent ecosystems (GDEs) identified within the study area; *Melaleuca biconvexa* – Swamp Mahogany – Cabbage Palm Forest and Jackwood – Lilly Pilly – Sassafras Riparian Warm Temperate Rainforest.

Within the study area the project would require the removal of vegetation from these GDEs and modifications to the existing hydrology within the study area. Changes in hydrology may include alteration of natural flow regimes as a result of installing culverts and water crossings. Additionally excavation and earthworks associated with vegetation clearing and levelling of the land for the project may impact on the groundwater present which could lead to modifications of the existing natural ecological function of these GDEs.

5.1.5 Aquatic disturbance

Much of the study area was characterised by floodplain topography perched above Bangalow Creek, Chittaway Creek and Ourimbah Creek with the underlying substrates subject to variations in elevation, which form a mosaic of low water-holding soaks, as well as more elevated substrates less subject to waterlogging. The project would require the in-filling of such areas to accommodate the proposed development. Up to approximately 31.8 hectares of Swamp Forest, which provides potential habitat for threatened frogs (Wallum Froglet and Green-thighed Frog) has the potential to be impacted (subject to detailed design and refinement of the footprint for the Project site).

The project traverses Chittaway Creek and Bangalow Creek in the southern portion of the study area. Construction of the project would directly impact riparian rainforest habitat and potentially important in-stream microhabitat features (e.g. woody debris, snags and rocks). Such riparian rainforest habitat also provided potential habitat for the threatened Stuttering Frog and Giant Barred Frog.

Run-off from disturbed surfaces and earthworks could potentially affect water quality in adjacent creeks and drainage lines due to sedimentation during construction and operation of the project. In addition, there is the potential for accidental spillage/leakage of rail construction materials including fuels, lubricants and hydraulic oils from construction plant and equipment. During operation, increased paved surfaces associated with the proposal would likely result in an increase in stormwater run-off volumes and flows. This could potentially increase flow velocities in drainage lines downstream, although this is may not be significant.

5.1.6 Direct fauna mortality

Fauna injury or death could occur as a result of the project's construction phase when vegetation and habitats are being cleared. Fauna injury or mortality also has the potential to occur as a result of collisions with increased road and rail traffic.

While some mobile species, such as birds, have the potential to move away from the path of clearing, other species that are less mobile may have difficulty moving over relatively large distances. Species of animal that may be at particularly high risk of injury or death during vegetation clearing include, amphibians, nocturnal arboreal mammals, microchiropteran bats, reptiles, small terrestrial mammals and nesting birds.

5.1.7 Habitat fragmentation and wildlife connectivity

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with the occurrence of a new habitat type in the area between the fragments. This new dividing habitat is often artificial and inhospitable to the species remaining within the fragments ((Bennett 1990),(Johnson *et al.* 2007)). Although newly created habitat is generally used by some species, those species are usually generalists and are often aggressive (i.e. Noisy Miners (Grey *et al.* 1998)), further decreasing population levels of the species remaining in the fragments. Habitat fragmentation can result in a number of impacts including barrier effects to the movement of small and sedentary fauna such as ground-dwelling mammals, reptiles and amphibians. Habitat fragmentation can also create barriers to pollination (movement of pollinator vectors), such as restricting insect movements, thereby affecting the lifecycle of both common and threatened flora.

Within the project locality, key wildlife corridors are associated with the large contiguous tracts of native vegetation associated with the coastal ranges, foothills and sheltered gullies, which occur to the west, north-west and south of the study area. As much of the study area and associated lands is characterised by floodplain topography perched above Bangalow Creek and Ourimbah Creek, land immediately adjacent is fragmented due to historical clearing for rural residential land holdings. This has created a mosaic of smaller, fragmented patches of habitat on flat alluvial valleys leading to forested foothills and ranges. The project locality creek lines, Ourimbah Creek and Bangalow Creek, retain sufficient riparian habitat that provide connectivity through an otherwise largely cleared and managed landscape.

Whilst vegetation in the study area is not likely to be used solely in isolation of surrounding high quality vegetation for most mobile guilds of animal, the study area would be used as a stepping stone between habitat patches. Although the study area is surrounded by cleared and managed rural residential tenures; construction and operation of the project would add incrementally to the fragmentation of habitat in an approximate north – south alignment from the coastal range south of the existing rail corridor to riparian habitat associated with Ourimbah Creek in the north. The existing rail corridor, however, may already act as a barrier in the landscape to less mobile species of animal, in which case the project would add incrementally to the width of an existing barrier.

5.1.8 Edge effects

Edge effects are zones of changed environmental conditions (i.e. altered light levels, wind speed and/or temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types and allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators. Edge effects have mainly been recorded adjacent to roads and at distances greater than 1,000 metres from the road surface (Forman *et al* 2000). However, Bali (2005), in a comparison of edge effects in a variety of different habitat types, estimated that average edge effects generally occur up to 50 metres away from the road edge.

While the majority of vegetation within the study area is dominated by native species, it is evident by the general paucity of understorey debris, the relatively young age cohort of canopy trees, the lack of canopy strata in some areas and the dense understorey strata, suggest that the vegetation communities are recovering from previous widespread disturbance. Further, the existing rail corridor abuts the south-eastern boundary of the study area, whilst land managed for rural residential land holdings adjoins the majority of the remaining study area. Accordingly, as areas adjoining the study area occur as largely managed and high disturbed areas, it is not likely that the proposed project would increase edge effects any more than is occurring within and adjoining the study area.

5.1.9 Potential environmental impact of noise, light and vibrations on wildlife

Many animals detect and depend on sound to communicate, navigate, evade danger and find food, but human-made noise can alter the behaviour of animals or interfere with their normal functioning (Bowles 1997). In some cases it can harm their health, reproduction, survivorship, habitat use, distribution, abundance, or genetic composition (Forman *et al.* 2000). However, variation in ambient noise, such as from wind or other animals, is part of the natural environment and many animals display behavioural adaptations to this variation. For example, certain species of frogs avoid vocalising during loud calling by cicadas or other frogs and some species will time their calls during brief periods of silence (Schwartz & Henderson 1991).

It is likely that noise from the existing rail corridor and arterial roads would already impact background levels of noise in the study area. However, construction and operation phases of the project (along with its ancillary activities) may cause disturbance to animals. The impacts from noise emissions are likely to be localised close to the project and are not likely to have a significant long-term impact on wildlife populations, given that populations are already exposed to noise associated with the existing rail corridor. Furthermore, it is likely that most animal species would habituate to periodic noise disturbance from regular maintenance activities (Forman *et al.* 2000; Larkin 2005).

5.1.10 Weeds

A total of 41 exotic species were recorded within the Project site during the survey period. The distribution and abundance of weeds recorded varied across the Project site associated generally with areas that had been exposed to disturbances such as vegetation clearing, pasture grazing and existing infrastructure (rail, road and power). Weeds were most prolific along the existing railway situated in the centre of the Project site.

Of the 41 environmental weeds identified within the Project site, three exotic species are listed as noxious weeds under the *Noxious Weeds Act 1993* (NW Act) for the Wyong Shire Council Local Control Authority. Although not noxious weeds within the Wyong Shire local control area, other environmental weeds recorded have potential to spread rapidly if not managed appropriately; *Lonicera japonica** (Japanese Honeysuckle), *Ligustrum lucidum** (Large-leaved Privet), *Ligustrum sinense** (Small-leaved Privet) and *Chloris gayana** (Rhodes Grass).

Invasion of perennial grasses (such as *Pennisetum clandestinum*, Chloris gayana** and *Paspalum dilatatum**) and invasion and establishment of escaped garden plants, exotic vines and scramblers and other exotic species (such as *Lonicera japonica**) are listed as Key Threatening Processes under the TSC Act.

Construction within the study area has the potential to disperse weeds into areas where they do not currently occur. The most likely causes of weed dispersal associated with the proposed construction would include earthworks, movement of soil and attachment of seed (and other propagules) to vehicles and machinery. This may, in turn, reduce the habitat quality of the sites for threatened species. Spread of weeds during the operation phase would relate generally to the vehicles travelling along access tracks.

Given the moderate level of weed invasion, 41 exotic species were recorded including three noxious weeds under the *Noxious Weeds Act 1993* (NW Act) within the Project site. Construction and to a lesser extent, the operation phase, has the potential to spread weeds from the study area to other sites.

5.1.11 Invasion and spread of pathogens and disease

Plant and animal pathogens can affect threatened biodiversity through direct mortality and modification to vegetation structure and composition. The following pathogens are considered to have potential to affect the biodiversity of the site and are the subject of Key Threatening Processes listings:

- Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)

- Exotic Rust Fungi (order Pucciniales, e.g. Myrtle rust fungus *Uredo rangelii*)
- Phytophthora Root Rot Fungus (*Phytophthora cinnamomi*).

These three pathogens have all been recorded in the Sydney Basin bioregion and have potential to occur within the study area at present or in the future. Amphibian Chytrid Fungus can be spread through water, soil, mulch or other landscape material containing spores of Chytrid Fungus being imported onto the work site. Alternatively, Chytrid Fungus can be spread through the movement of infected individuals.

The main way in which Exotic Rust Fungi and Phytophthora Root Rot Fungus may be spread is through the movement of infected plant material and/or soil. The construction and operation of the project may increase the risk of disturbing and spreading these pathogens. With the implementation of hygiene procedures for the use of vehicles and the importation of materials to the site, the risk of introducing these pathogens would, however, be low. Preferential use of plant materials sourced on-site (e.g. mulch, seeds) used for vegetation restoration would also help to minimise this risk.

5.1.12 Key threatening processes

Key Threatening Processes are listed under Schedule 3 of the TSC Act, the FM Act and EPBC Act. A process is defined as a Key Threatening Process if it threatens or may threaten the survival, abundance, or evolutionary development of a native species or ecological community. A process can be listed as a key threatening process if it could cause a native species or ecological community to become eligible for adding to a threatened list (other than conservation dependant), or cause an already listed threatened species or community to become more endangered, or if it adversely affects two or more listed threatened species or ecological communities.

The project has the potential to contribute to the following threatening processes:

- clearing of native vegetation – EPBC Act and TSC Act
- loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants – EPBC Act
- invasion of native plant communities by exotic perennial grasses – TSC Act
- loss of hollow-bearing trees – TSC Act
- invasion, establishment and spread of *Lantana camara* – TSC Act
- invasion of native plant communities by African Olive *Olea europaea* L. subsp. *cuspidate* – TSC Act
- invasion and establishment of exotic vines and scramblers – TSC Act
- instream structures and other mechanism that alter natural flow – FM Act
- degradation of native riparian vegetation along NSW water courses – FM Act.

5.2 Mitigation measures

As part of overall construction environmental management plan for the project, a vegetation management plan (VMP) would be developed to address potential biodiversity impacts. The following general measures would be incorporated into the VMP to ensure ecological impacts are minimised (in particular during construction):

- Opportunities to further reduce the clearing of native vegetation would be investigated during detailed design.

- Implement pre-clearing protocols, including:
  - An experienced fauna egologist will check for the presence of flora and fauna species and habitat on site before clearing begins such as the presence of bird nests.
  - Prior to construction, site personnel should be adequately informed of environmental management procedures including, but not limited to, issues related to flora and fauna management, weed control, erosion and sediment control (in accordance with Landcom Soil and Construction Managing Urban Stormwater March 2004).
  - Establish exclusion zones to protect vegetation and fauna habitat outside of the assessed and approved clearing limits, including the threatened ecological communities recorded within the study area (including Swamp Sclerophyll Forest, *Biconvex Melaleuca* and riparian areas). Vegetation to be retained are to be clearly defined on ground and 'no go zones' clearly signposted and fenced to prevent unauthorised clearing and vehicular and/foot traffic.
  - The limits of clearing would be clearly demarcated on-site (where appropriate) prior to construction to avoid unnecessary vegetation and habitat removal. This could include the installation of fencing around the Project site footprint.
- during construction, the following general measures would be implemented:
  - All workers would be provided an environmental induction prior to starting work on site. This would include information on the ecological values of the site, protection measures to be implemented to protect biodiversity, and penalties for breaches.
  - The limits of clearing would be clearly demarcated on-site (where appropriate) prior to construction to avoid unnecessary vegetation and habitat removal. This could include the installation of fencing around the Project site footprint.
- Implement clearing and construction protocols, including:
  - Carefully clear vegetation so as not to mix topsoil with debris and to avoid impacts to surrounding native vegetation.
  - Avoid excessive soil disturbance.
  - When accessing construction sites, contractors should only use designated access tracks.
  - An experienced and licensed wildlife carer and/or ecologist would be present to supervise vegetation clearing and capture and relocate fauna.
- Implement flora and fauna control measures including:
  - Clearing of vegetation would be minimised, to only vegetation that is absolutely required to be removed in order to undertake work.
  - Noxious weeds within the study area would be managed in accordance with the *Noxious Weeds Act 1993.*
  - Protocols to prevent the introduction and/or spread of Chytrid fungus would be implemented. These protocols would be based on OEH Hygiene Protocol for the Control of Disease in Frogs.
- Weed species within the study area would be managed in order to control them from further spread. Management techniques may include immediate weed removal and disposal without stockpiling, disposal of weed-contaminated soils at appropriate weed disposal facilities and to ensure that all equipment is cleaned prior to and on completion of works to ensure weeds are not introduced or spread to other locations.
- A Biodiversity Offset Strategy shall be prepared in accordance with the BioBanking Assessment Methodology (2014) to offset impacts associated with the project on biodiversity values in particular impacts to Swamp Sclerophyll Forest and *Melaleuca biconvexa*.

A more detailed set of mitigation measures including biodiversity offsets, revegetation and rehabilitation would also be developed for specific species identified within the Project site and these would be provided within the SIS for the project.

5.3 Significant impact assessments

An SIS is concurrently being prepared for the project which has recognised all threatened biodiversity having a moderate or higher likelihood of occurrence as ‘subject species’. Section 5 of the SIS provides a detailed assessment on whether each of these species are considered likely to impacted upon by the project and therefore qualify as ‘affected species’ for further assessment. The detailed assessments completed identified one threatened ecological community, one flora species and 11 fauna species as being ‘affected species’ a summary of which is provided in Table 5.3 below.

The project’s impacts on affected species will be assessed under Section 5A of the *Environmental Planning & Assessment Act 1979* (EP&A Act). Section 5A of the EP&A Act requires that a seven part test is undertaken to assess the likelihood of significant impact upon Threatened species, populations or ecological communities listed under the TSC Act.

Significant impact assessments for affected species are concurrently being completed in Section 8 of the SIS to determine whether a significant impact is still likely to occur due to the impacts associated with the project. In addition, threatened biodiversity listed under the EPBC Act require assessment in accordance with the Matters of National Environmental, Significant Impact Guidelines (Department of the Environment 2013). In respect to this, a referral of this project to the Department of the Environment has been undertaken.

Table 5.3 Affected species that will be the subject of impact assessments within the SIS

Scientific name	Common name	TSC Act[1]	EPBC Act[2]	Likelihood of occurrence
Threatened ecological communities				
Swamp Sclerophyll Forest on Coastal Floodplain of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		V	-	**Recorded**
Threatened flora				
Melaleuca biconvexa	Biconvex Paperbark	V	V	**Recorded**
Threatened fauna – birds				
Black Bittern	*Ixobrychus flavicollis*	V	-	Moderate
Little Eagle	*Hieraaetus morphnoides*	V	-	Moderate
Little Lorikeet	*Glossopsitta pusilla*	V	-	High
Regent Honeyeater	*Anthochaera phrygia*	CE	E	Moderate
Square-tailed Kite	*Lophoictinia isura*	V	-	Moderate
Swift Parrot	*Lathamus discolor*	E	E	High
Varied Sittella	*Daphoenositta chrysoptera*	V	-	**Recorded**
Threatened fauna – mammals				
Eastern Bent-wing Bat	*Miniopterus schreibersii oceanensis*	V	-	**Recorded**
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	**Recorded**
Little Bentwing-bat	*Miniopterus australis*	V	-	**Recorded**
Southern Myotis	*Myotis macropus*	V	-	**Recorded**

1) CE = Critically Endangered, E = Endangered, V = Vulnerable as listed on the TSC Act
2) E = Endangered, V = Vulnerable as listed on the EPBC Act

6 CONCLUSIONS AND RECOMMENDATIONS

This BAR has been prepared as a technical report to support the project's REF in accordance with the EP&A Act. Results of the field surveys and desktop assessments identified a number of ecological constraints within the Project site. Specifically, these ecological constraints included:

- One threatened ecological community: *Swamp Sclerophyll Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions* listed as Endangered under the TSC Act (up to approximately 25.5 hectares)
- One threatened flora species: large population of *Melaleuca biconvexa* (approx. 5,014 plant within the Project site of which 3,984 would be removed) listed as Vulnerable under the TSC Act and EPBC Act
- Five threatened fauna species: Varied Sittella, Eastern Bent-wing Bat, Little Bentwing-bat, Southern Myotis and Grey-headed Flying-fox which are all listed under the TSC Act. Grey-headed Flying-fox is also listed as Vulnerable under the EPBC Act
- Two threatened Migratory species: Black-faced Monarch and Rufous Fantail listed as Migratory under the EPBC Act
- Potential habitat for an additional two threatened flora species known or predicted to occur within the Project site (*Syzygium paniculatum* and *Maundia triglochinoides*)
- Potential habitat for an additional 33 threatened fauna species known or predicted to occur within the Project site (refer to Table 4.4) including 13 bird, four frog, 12 mammal and two reptile species
- Potential habitat for an additional four migratory fauna species known or predicted to occur within the Project site (Cattle Egret, Rainbow Bee-eater, Satin Flycatcher and Spectacled Monarch)
- Detailed assessments completed in Section 5 of the SIS have recognised the following affected species which will be further assessed in the SIS:
  - Swamp Sclerophyll Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions
  - *Melaleuca biconvexa*
  - Seven threatened bird species – Regent Honeyeater, Varied Sittella, Little Lorikeet, Little Eagle, Black Bittern, Swift Parrot and Square-tailed Kite
  - Three microchiropteran bat species – Southern Myotis, Little Bentwing-bat and Eastern Bentwing-bat
  - Grey-headed Flying-fox.

Preliminary investigations associated with the REF (EMM 2015) identified potential significant impacts to biodiversity, particularly to Swamp Sclerophyll Forest Endangered Ecological Community and stands of *Melaleuca biconvexa*, which are both listed under the TSC Act. This finding has been confirmed as part of this study and as such, a request was made to the OEH for the preparation of CERs for the project in order to inform the preparation of an SIS. This request was made by Transport for NSW on 15 January 2016 to OEH for the project. CERs were issued on 11 February 2016.

Based on the received CER's , an SIS is currently being prepared for ecological matters considered to occur and/or be impacted upon by the project, chiefly to significant impacts likely to occur to Swamp Sclerophyll Forest Endangered Ecological Community and stands of *Melaleuca biconvexa*. The results of this BAR are intended to provide an assessment of the potential ecological impacts to support the REF for the project in addition to informing the more detailed SIS. For the purposes of the project, the OEH would be a concurrent determining authority for the project (in addition to Transport for NSW) in accordance with Part 5 of the NSW EP&A Act.

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Appendix A

PLANT SPECIES RECORDED

Appendix A – Flora species recorded

Table A1.1 Plant species recorded from within the subject site/study area

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower			Native
Apiaceae	*Centella asiatica*	Pennywort			Native
Apiaceae	*Cyclospermum leptophyllum*	Slender Celery			Exotic
Apiaceae	*Hydrocotyle bonariensis*	American Pennywort			Exotic
Apiaceae	*Hydrocotyle peduncularis*				Native
Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia			Native
Apocynaceae	*Parsonsia straminea*	Common Silkpod			Native
Araliaceae	*Hedera helix*	English Ivy			Exotic
Araliaceae	*Polyscias sambucifolia*	Elderberry Panax			Native
Araliaceae	*Schefflera actinophylla*	Umbrella Tree			Exotic
Arecaceae	*Archontophoenix cunninghamiana*	Bangalow Palm		P13	Native
Arecaceae	*Livistona australis*	Cabbage Palm		P13	Native
Asteraceae	*Ageratina adenophora*	Crofton Weed			Exotic
Asteraceae	*Bidens pilosa*	Cobblers Pegs			Exotic
Asteraceae	*Cassinia uncata*	Sticky Cassinia			Native
Asteraceae	*Cirsium vulgare*	Spear Thistle			Exotic
Asteraceae	*Conyza albida*	Tall Fleabane			Exotic
Asteraceae	*Hypochaeris radicata*	Catsear			Exotic
Asteraceae	*Ozothamnus diosmifolius*	White Dogwood			Native
Asteraceae	*Senecio madagascariensis*	Fireweed			Exotic
Asteraceae	*Sigesbeckia orientalis*				Native
Asteraceae	*Tagetes minuta*	Stinking Roger			Exotic
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine			Native
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern			Native
Blechnaceae	*Blechnum indicum*	Swamp Water Fern			Native

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Caprifoliaceae	*Lonicera japonica*	Japanese Honeysuckle			Exotic
Casuarinaceae	*Allocasuarina torulosa*	Forest Oak			Native
Celastraceae	*Maytenus silvestris*	Narrow-leaved Orangebark			Native
Commelinaceae	*Commelina cyanea*	Native Wandering Jew			Native
Commelinaceae	*Tradescantia fluminensis*	Wandering Jew			Exotic
Convolvulaceae	*Dichondra repens*	Kidney Weed			Native
Cyperaceae	*Baumea acuta*	Pale Twig-sedge			Native
Cyperaceae	*Carex appressa*	Tussock Sedge			Native
Cyperaceae	*Carex inversa*	Knob Sedge			Native
Cyperaceae	*Carex sp.*				Native
Cyperaceae	*Cyperus brevifolius*	Mullumbimby Couch			Exotic
Cyperaceae	*Cyperus congestus*	Dense Flat-sedge			Exotic
Cyperaceae	*Cyperus polystachyos*	Bunchy Flat-sedge			Native
Cyperaceae	*Cyperus sphaeroideus*	Globe Kyllinga			Native
Cyperaceae	*Fimbristylis dichotoma*	Common Fringe-sedge			Native
Cyperaceae	*Gahnia erythrocarpa*				Native
Cyperaceae	*Gahnia sieberiana*	Red-fruit Saw-sedge		P13	Native
Dennstaedtiaceae	*Pteridium esculentum*	Bracken			Native
Dicksoniaceae	*Calochlaena dubia*	Common Ground Fern			Native
Dilleniaceae	*Hibbertia dentata*	Twining Guinea Flower			Native
Dilleniaceae	*Hibbertia scandens*	Climbing Guinea Flower			Native
Dioscoreaceae	*Dioscorea transversa*	Native Yam			Native
Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash			Native
Epacridaceae	*Epacris pulchella*	NSW Coral Heath			Native
Epacridaceae	*Leucopogon juniperinus*	Long-flower Beard-heath			Native

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Epacridaceae	*Leucopogon lanceolatus*	Lance Beard Heath			Native
Epacridaceae	*Leucopogon margarodes*				Native
Euphorbiaceae	*Breynia oblongifolia*	Coffee Bush			Native
Euphorbiaceae	*Glochidion ferdinandi*	Cheese Tree			Native
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant			Exotic
Fabaceae (Faboideae)	*Glycine clandestina*	Twining Glycine			Native
Fabaceae (Faboideae)	*Kennedia rubicunda*	Red Kennedy Pea			Native
Fabaceae (Faboideae)	*Lotus sp.*				Native
Fabaceae (Faboideae)	*Trifolium repens*	White Clover			Exotic
Fabaceae (Faboideae)	*Vicia sp.*				Exotic
Fabaceae (Mimosoideae)	*Acacia irrorata*	Green Wattle			Exotic
Fabaceae (Mimosoideae)	*Acacia longifolia*	Sydney Golden Wattle			Native
Fabaceae (Mimosoideae)	*Acacia longissima*	Narrow-leaved Wattle			Native
Fabaceae (Mimosoideae)	*Acacia maidenii*	Maidens Wattle			Native
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle			Native
Fabaceae (Mimosoideae)	*Acacia podalyriifolia*	Queensland Silver Wattle			Native
Fabaceae (Mimosoideae)	*Acacia prominens*	Gosford Wattle			Native
Flacourtiaceae	*Scolopia braunii*	Flintwood			Native
Geraniaceae	*Geranium sp.*				Native
Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral-fern			Native
Goodeniaceae	*Dampiera stricta*	Blue Dampiera			Native
Goodeniaceae	*Goodenia paniculata*	Branched Goodenia			Native
Haloragaceae	*Gonocarpus micranthus*	Creeping Raspwort			Native

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Haloragaceae	*Gonocarpus tetragynus*	Common Raspwort			Native
Juncaceae	*Juncus australis*	Austral Rush			Native
Juncaceae	*Juncus cognatus*				Exotic
Juncaceae	*Juncus planifolius*	Broad-leaf Rush			Native
Juncaceae	*Juncus sp.*				Native
Juncaceae	*Juncus sp. I*				Native
Juncaceae	*Juncus sp. M*				Native
Lauraceae	*Cassytha sp.*				Native
Lauraceae	*Cinnamomum camphora*	Camphor Laurel			Exotic
Lauraceae	*Cryptocarya glaucescens*	Jackwood			Native
Lauraceae	*Cryptocarya microneura*	Murrogun			Native
Lauraceae	*Neolitsea australiensis*	Green Bolly Gum			Native
Lobeliaceae	*Pratia purpurascens*	Whiteroot			Native
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush			Native
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry			Native
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily			Native
Malvaceae	*Sida rhombifolia*	Paddys Lucerne			Exotic
Meliaceae	*Synoum glandulosum subsp. glandulosum*	Scentless Rosewood			Native
Menispermaceae	*Sarcopetalum harveyanum*	Pearl Vine			Native
Menyanthaceae	*Villarsia exaltata*	Erect Marsh-flower			Native
Monimiaceae	*Doryphora sassafras*	Sassafras			Native
Moraceae	*Ficus coronata*	Creek Sandpaper Fig			Native
Moraceae	*Trophis scandens*				Native
Myrsinaceae	*Rapanea howittiana*	Brush Muttonwood			Native
Myrsinaceae	*Rapanea variabilis*	Muttonwood			Native
Myrtaceae	*Acmena smithii*	Lilly Pilly			Native
Myrtaceae	*Angophora floribunda*	Rough-barked Apple			Native

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle			Native
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush			Native
Myrtaceae	*Corymbia gummifera*	Red Bloodwood			Native
Myrtaceae	*Eucalyptus pilularis*	Blackbutt			Native
Myrtaceae	*Eucalyptus robusta*	Swamp Mahogany			Native
Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum			Native
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum			Native
Myrtaceae	*Leptospermum polygalifolium*				Native
Myrtaceae	*Melaleuca biconvexa*	Biconvex Paperbark	V	V	Native
Myrtaceae	*Melaleuca ericifolia*	Swamp Paperbark			Native
Myrtaceae	*Melaleuca linariifolia*				Native
Myrtaceae	*Syncarpia glomulifera*	Turpentine			Native
Myrtaceae	*Syzygium australe*	Brush Cherry			Native
Myrtaceae	*Syzygium oleosum*	Blue Lilly Pilly			Native
Oleaceae	*Ligustrum lucidum*	Large-leaved Privet			Exotic
Oleaceae	*Ligustrum sinense*	Small-leaved Privet			Exotic
Onagraceae	*Ludwigia sp.*				Native
Oxalidaceae	*Oxalis perennans*	Grassland Wood-sorrel			Native
Passifloraceae	*Passiflora edulis*	Common Passionfruit			Exotic
Philydraceae	*Philydrum lanuginosum*	Frogsmouth			Native
Phormiaceae	*Dianella caerulea*				Native
Phormiaceae	*Dianella sp.*				Native
Phytolaccaceae	*Phytolacca octandra*	Inkweed			Exotic
Pinaceae	*Pinus sp.*				Exotic
Pittosporaceae	*Billardiera scandens*	Appleberry			Native
Pittosporaceae	*Hymenosporum flavum*	Native Frangipani			Native
Pittosporaceae	*Pittosporum multiflorum*	Orange Thorn			Native
Plantaginaceae	*Plantago lanceolata*	Lambs Tongues			Exotic
Poaceae	*Andropogon virginicus*	Whisky Grass			Exotic

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass			Exotic
Poaceae	*Briza subaristata*				Exotic
Poaceae	*Chloris gayana*	Rhodes Grass			Exotic
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass			Native
Poaceae	*Ehrharta erecta*	Panic Veldtgrass			Exotic
Poaceae	*Eleusine tristachya*	Goose Grass			Exotic
Poaceae	*Entolasia marginata*	Bordered Panic			Native
Poaceae	*Entolasia stricta*	Wiry Panic			Native
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass			Native
Poaceae	*Imperata cylindrica*	Bladey Grass			Native
Poaceae	*Microlaena stipoides*				Native
Poaceae	*Oplismenus aemulus*				Native
Poaceae	*Oplismenus imbecillis*	Creeping Beard Grass			Native
Poaceae	*Panicum maximum var. maximum*	Guinea Grass			Exotic
Poaceae	*Paspalum dilatatum*	Paspalum			Exotic
Poaceae	*Paspalum distichum*	Water Couch			Native
Poaceae	*Paspalum urvillei*	Vasey Grass			Exotic
Poaceae	*Phragmites australis*	Common Reed			Native
Poaceae	*Setaria gracilis*	Slender Pigeon Grass			Exotic
Polygonaceae	*Persicaria lapathifolia*	Pale Knotweed			Native
Polygonaceae	*Persicaria orientalis*	Princes Feathers			Native
Polygonaceae	*Rumex brownii*	Swamp Dock			Native
Proteaceae	*Banksia collina*				Native
Proteaceae	*Banksia spinulosa*	Hairpin Banksia		P13	Native
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung		P13	Native
Ranunculaceae	*Ranunculus inundatus*	River Buttercup			Native
Ranunculaceae	*Ranunculus sp.*				Native
Restionaceae	*Baloskion tetraphyllum*				Native

Family name	Scientific name	Common name	EPBC Act status[1]	TSC Act status[2]	Native
Restionaceae	*Empodisma minus*	Spreading Rope-rush			Native
Rhamnaceae	*Alphitonia excelsa*	Red Ash			Native
Ripogonaceae	*Ripogonum album*	White Supplejack			Native
Rosaceae	*Rubus fruiticosus*	Blackberry complex			Exotic
Rosaceae	*Rubus rosifolius*	Rose-leaf Bramble			Native
Rubiaceae	*Pomax umbellata*	Pomax			Native
Rutaceae	*Melicope micrococca*	Hairy-leaved Doughwood			Native
Rutaceae	*Zieria smithii*	Sandfly Zieria			Native
Sapindaceae	*Diploglottis australis*	Native Tamarind			Native
Scrophulariaceae	*Veronica plebeia*	Trailing Speedwell			Native
Smilacaceae	*Smilax australis*	Sarsaparilla			Native
Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush			Exotic
Typhaceae	*Typha orientalis*	Broad-leaved Cumbungi			Native
Verbenaceae	*Lantana camara*	Lantana			Exotic
Verbenaceae	*Verbena bonariensis*	Purpletop			Exotic
Violaceae	*Viola hederacea*	Ivy-leaved Violet			Native

1) Listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
2) Listed as Vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or listed as protected under Schedule 13 Protected native plants of the NSW *National Parks and Wildlife Act 1974.*

Appendix B

ANIMAL SPECIES RECORDED

Table B1.1 Fauna species recorded from within the subject site/study area

Scientific name	Common name	Native	EPBC Act[1]	TSC Act[2]	Obs. type[3]
Amphibians					
Crinia signifera	Common Eastern Froglet	Native			O
Limnodynastes peronii	Brown-striped Frog	Native			O
Litoria dentata	Bleating Tree Frog	Native			O
Litoria fallax	Eastern Dwarf Tree Frog	Native			O
Litoria gracilenta	Dainty Green Tree Frog	Native			O
Uperoleia fusca	Dusky Gungan	Native			O
Reptiles					
Amphibolurus muricatus	Jacky Lizard	Native			O
Demansia psammophis	Yellow-faced Whip Snake	Native			O
Egernia major	Land Mullet	Native			T
Eulamprus quoyii	Eastern Water Skink	Native			O
Hemiaspis signata	Black-bellied Swamp Snake	Native			O
Lampropholis delicata	Grass Skink	Native			O
Birds					
Acanthiza lineata	Striated Thornbill	Native			O
Acanthiza nana	Yellow Thornbill	Native			O
Acanthiza pusilla	Brown Thornbill	Native			O
Acanthorhynchus tenuirostris	Eastern Spinebill	Native			O
Alisterus scapularis	Australian King-Parrot	Native			O
Anthochaera carunculata	Red Wattlebird	Native			O
Anthochaera chrysoptera	Little Wattlebird	Native			O
Ardea pacifica	White-necked Heron	Native			O
Cacatua galerita	Sulphur-crested Cockatoo	Native			O
Cacatua tenuirostris	Long-billed Corella	Native			O
Caligavis chrysops	Yellow-faced Honeyeater	Native			O
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	Native			O
Columba leucomela	White-headed Pigeon	Native			O
Coracina novaehollandiae	Black-faced Cuckoo-shrike	Native			O

Scientific name	Common name	Native	EPBC Act[1]	TSC Act[2]	Obs. type[3]
Corvus coronoides	Australian Raven	Native			O
Coturnix ypsilophora australis	Brown Quail	Native			O
Cracticus nigrogularis	Pied Butcherbird	Native			O
Cracticus tibicen	Australian Magpie	Native			O
Cracticus torquatus	Grey Butcherbird	Native			O
Dacelo novaeguineae	Laughing Kookaburra	Native			O
Daphoenositta chrysoptera	Varied Sittella	Native		V	O
Dicaeum hirundinaceum	Mistletoebird	Native			O
Eopsaltria australis	Eastern Yellow Robin	Native			O
Eudynamys scolopacea	Common Koel	Native			O
Geopelia humeralis	Bar-shouldered Dove	Native			O
Gerygone mouki	Brown Gerygone	Native			O
Grallina cyanoleuca	Magpie-lark	Native			O
Haliastur sphenurus	Whistling Kite	Native			O
Hirundo neoxena	Welcome Swallow	Native			O
Lopholaimus antarcticus	Topknot Pigeon	Native			O
Malurus cyaneus	Superb Fairy-wren	Native			O
Malurus lamberti	Variegated Fairy-wren	Native			O
Manorina melanocephala	Noisy Miner	Native			O
Manorina melanophrys	Bell Miner	Native			O
Meliphaga lewinii	Lewin's Honeyeater	Native			O
Melithreptus lunatus	White-naped Honeyeater	Native			O
Monarcha melanopsis	Black-faced Monarch	Native	M		O
Myzomela sanguinolenta	Scarlet Honeyeater	Native			O
Neochmia temporalis	Red-browed Finch	Native			O
Ocyphaps lophotes	Crested Pigeon	Native			O
Oriolus sagittatus	Olive-backed Oriole	Native			O
Pachycephala pectoralis	Golden Whistler	Native			O
Pachycephala rufiventris	Rufous Whistler	Native			O
Pardalotus punctatus	Spotted Pardalote	Native			O
Philemon corniculatus	Noisy Friarbird	Native			O
Phylidonyris nigra	White-cheeked Honeyeater	Native			O

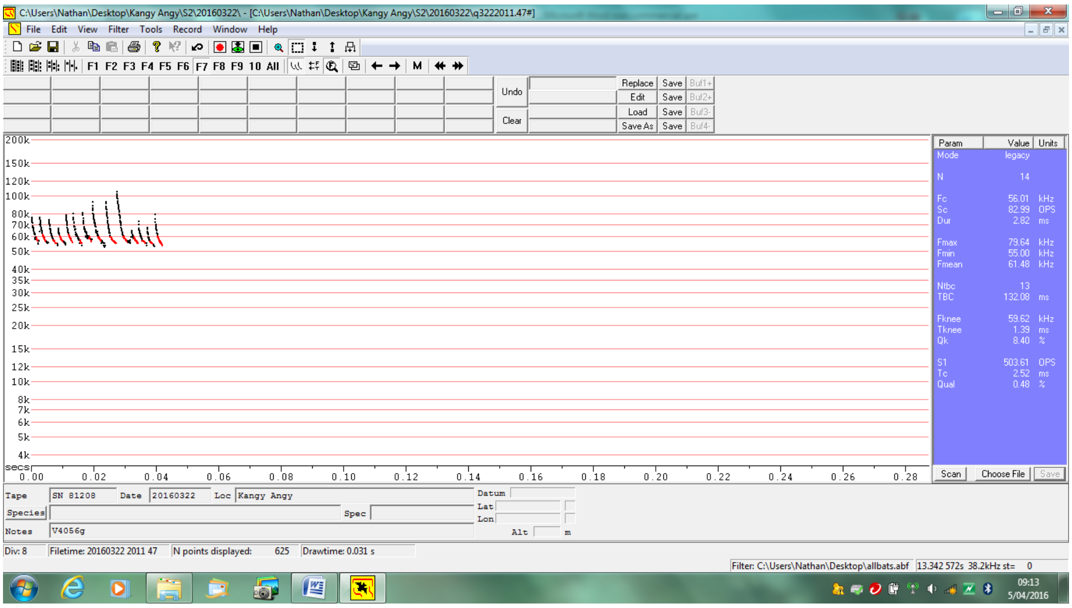
Scientific name	Common name	Native	EPBC Act[1]	TSC Act[2]	Obs. type[3]
Platycercus eximius	Eastern Rosella	Native			O
Psophodes olivaceus	Eastern Whipbird	Native			O
Ptilonorhynchus violaceus	Satin Bowerbird	Native			O
Rhipidura fuliginosa	Grey Fantail	Native			O
Rhipidura leucophrys	Willie Wagtail	Native			O
Rhipidura rufifrons	Rufous Fantail	Native	M		O
Sericornis citreogularis	Yellow-throated Scrubwren	Native			O
Sericornis frontalis	White-browed Scrubwren	Native			O
Sericornis magnirostris	Large-billed Scrubwren	Native			O
Strepera graculina	Pied Currawong	Native			O
Streptopelia chinensis	Spotted Turtle-Dove	Exotic		U	O
Threskiornis spinicollis	Straw-necked Ibis	Native			O
Trichoglossus haematodus	Rainbow Lorikeet	Native			O
Vanellus miles	Masked Lapwing	Native			O
Zosterops lateralis	Silvereye	Native			O
Mammals					
Antechinus stuartii	Brown Antechinus	Native			T
Antechinus swainsonii	Dusky Antechinus	Native			T
Austronomus australis	White-striped Freetail-bat	Native			D
Chalinolobus morio	Chocolate Wattled Bat	Native			D
Miniopterus australis	Little Bent-wing Bat	Native		V	D
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	Native		V	D
Mormopterus ridei	Ride's Free-tailed Bat	Native			D
Myotis macropus	Southern Myotis	Native		V	D
Nyctophilus gouldi	Gould's Long-eared Bat	Native			T
Nyctophilus sp.	Long-eared Bat	Native			D
Oryctolagus cuniculus	Rabbit	Exotic		U	O
Petaurus breviceps	Sugar Glider	Native			O
Pseudocheirus peregrinus	Common Ringtail Possum	Native			O
Pteropus poliocephalus	Grey-headed Flying-fox	Native	V	V	O

Scientific name	Common name	Native	EPBC Act[1]	TSC Act[2]	Obs. type[3]
Rattus fuscipes	Bush Rat	Native			T
Rattus lutreolus	Swamp Rat	Native			T
Scotorepens orion	Eastern Broad-nosed Bat	Native			D
Vespadelus pumilus	Eastern Forest Bat	Native			D
Wallabia bicolor	Swamp Wallaby	Native			CT

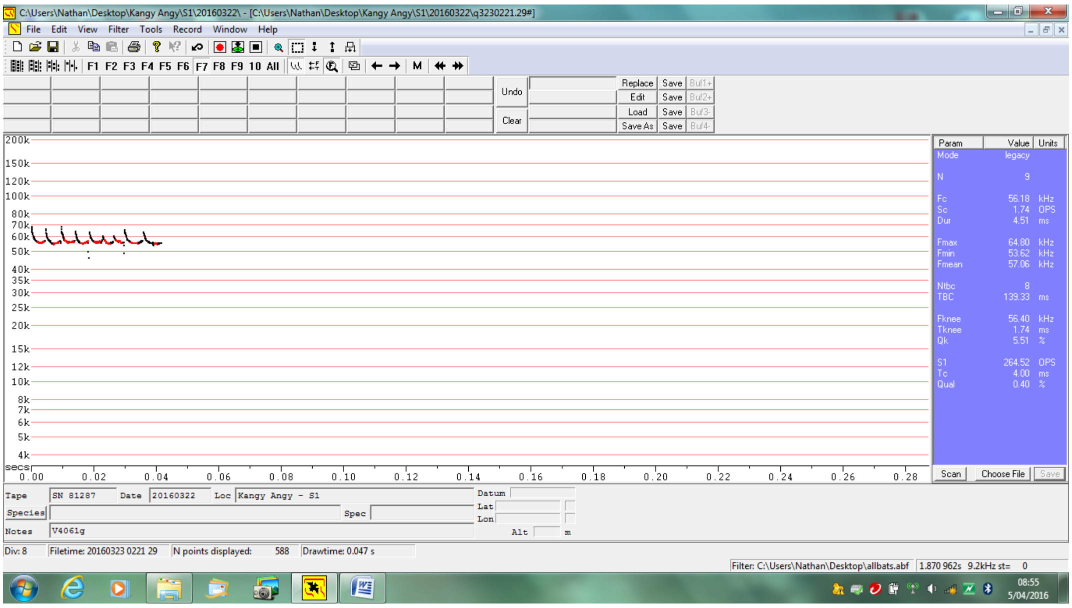
(1) Listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as V = Vulnerable, M=Migratory
(2) Listed under the NSW *Threatened Species Conservation Act 1999* (TSC Act) as V = Vulnerable, U= Introduced
(3) Observation type = O = observed, T= trapped , D = Detected by Anabat survey, CT= Camera Trap

Appendix C

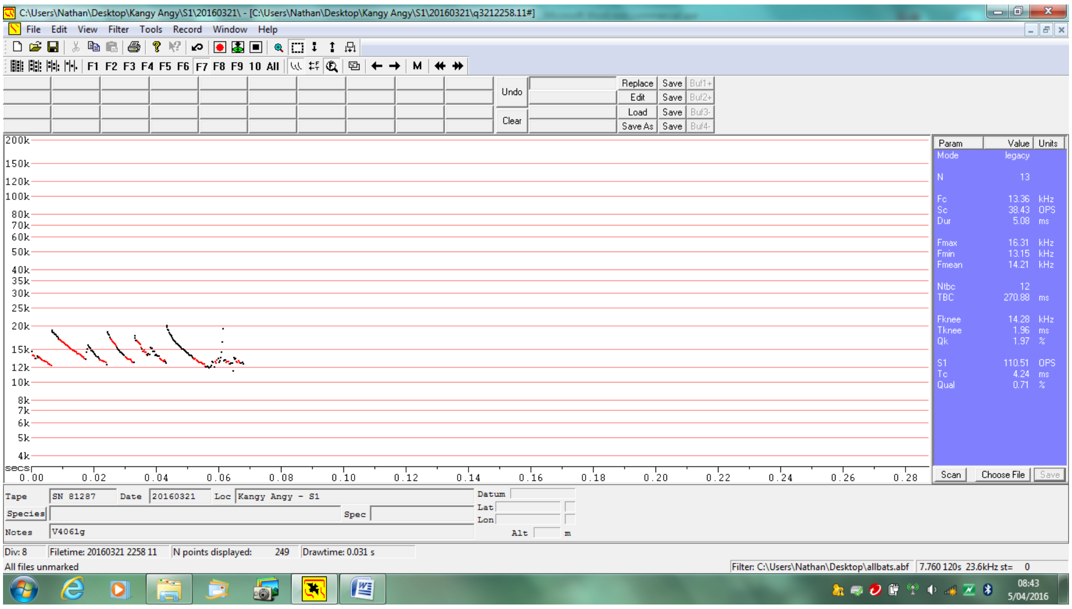
EXAMPLES OF BAT CALL SONOGRAMS



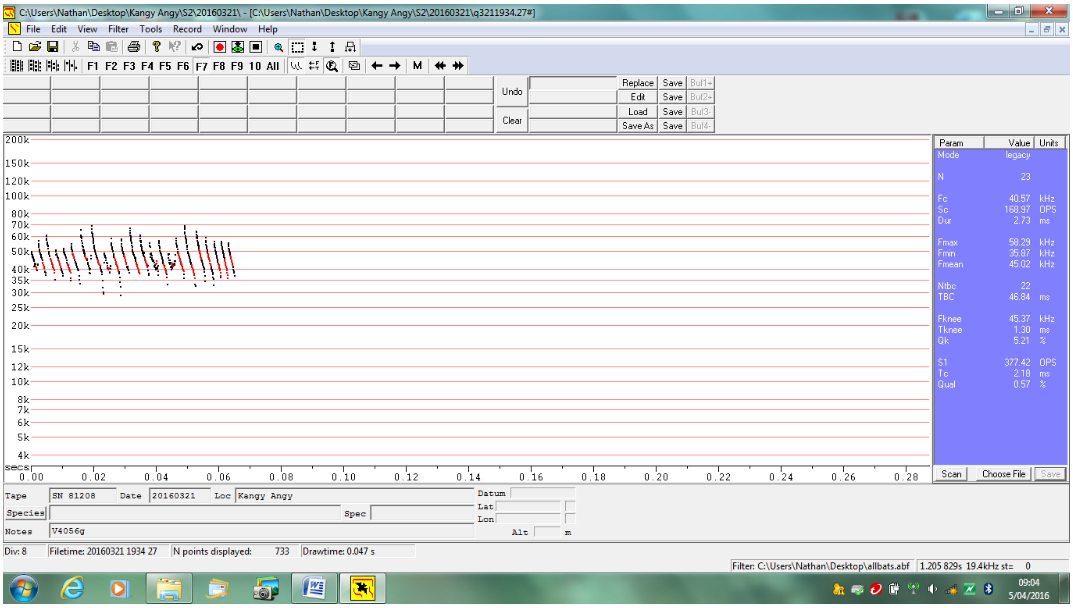
Little Bentwing-bat *Miniopterus australis*



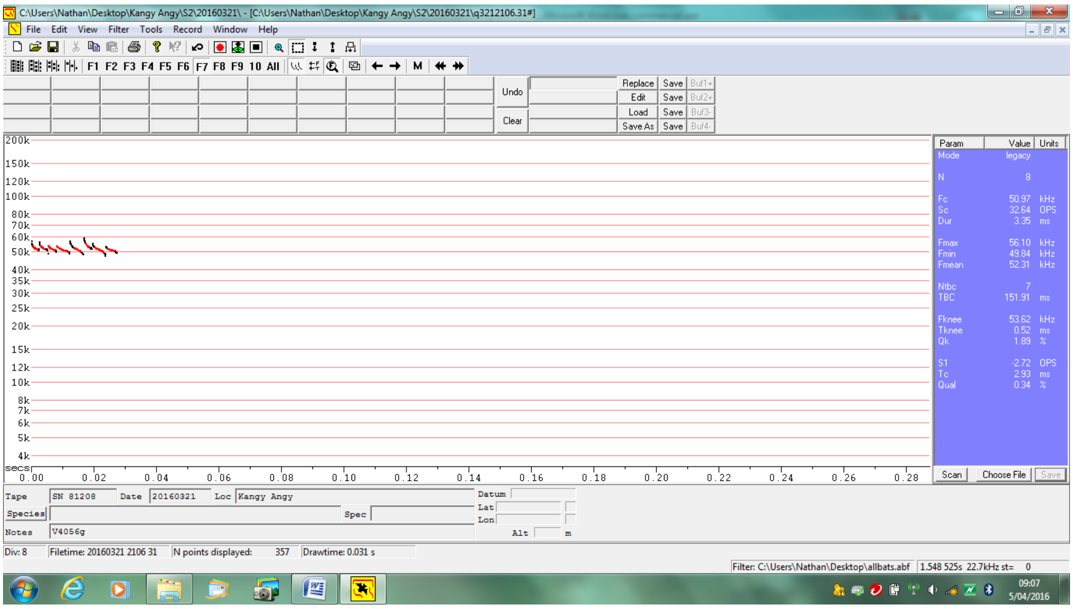
Eastern Forest Bat *Vespadelus pumilus*



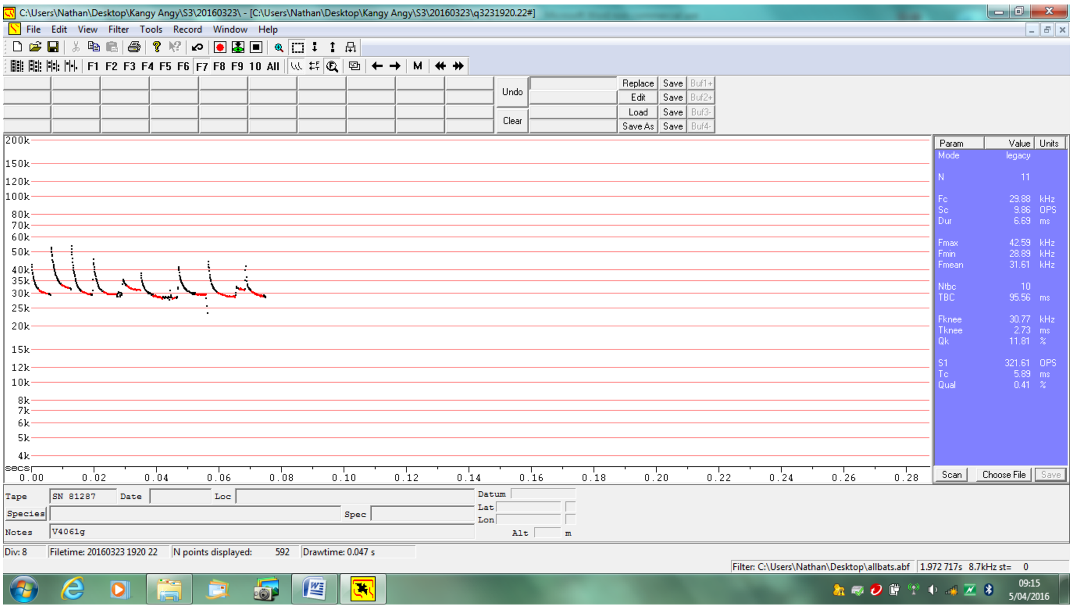
White-striped Freetail-bat *Austronomus australis*



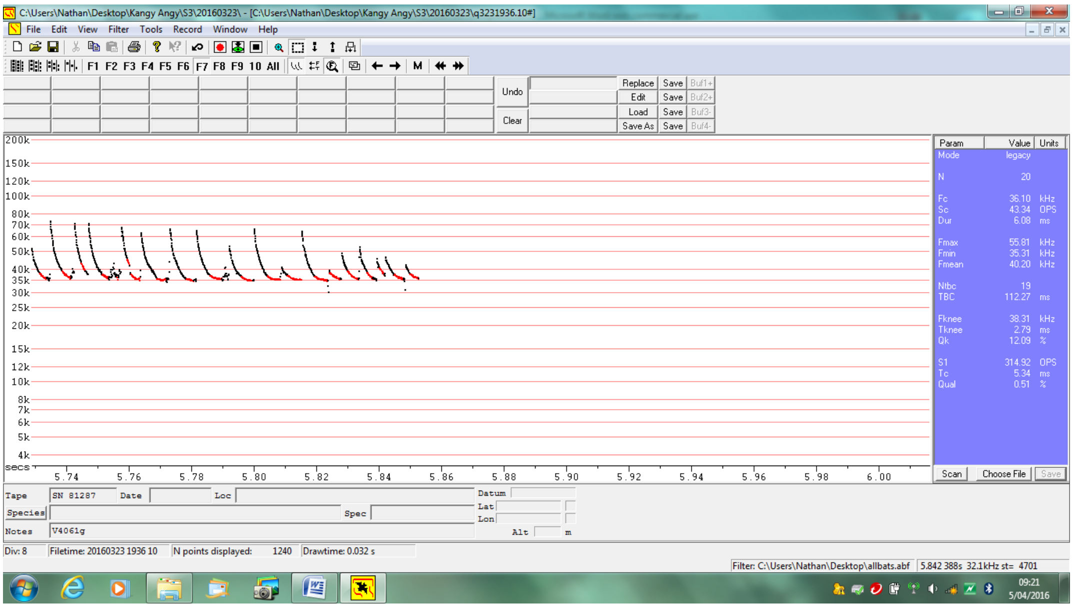
Southern Myotis *Myotis macropus*



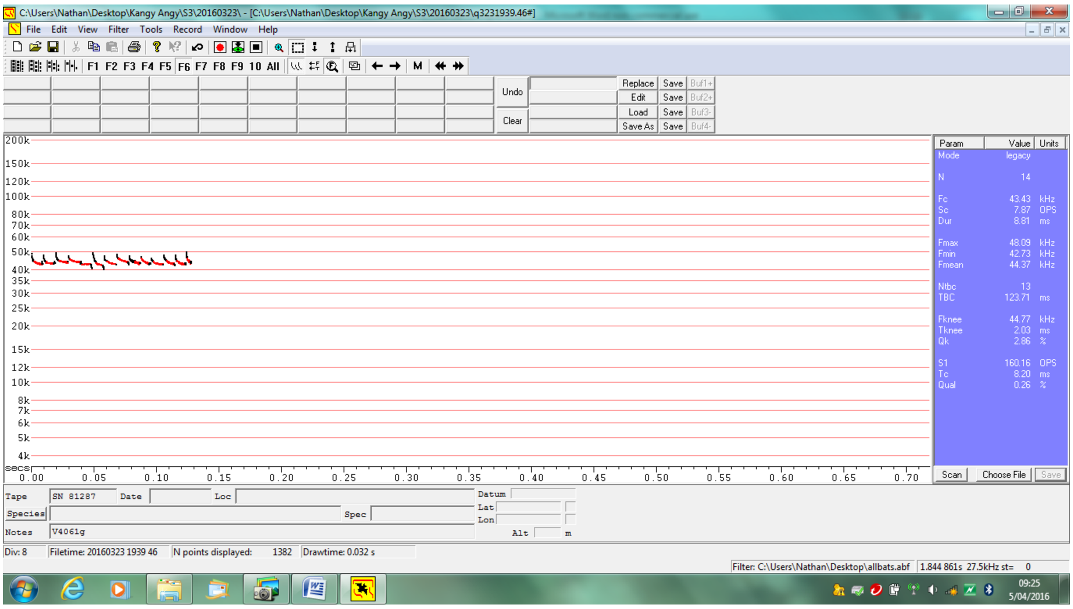
Chocolate Wattled Bat *Chalinolobus morio*



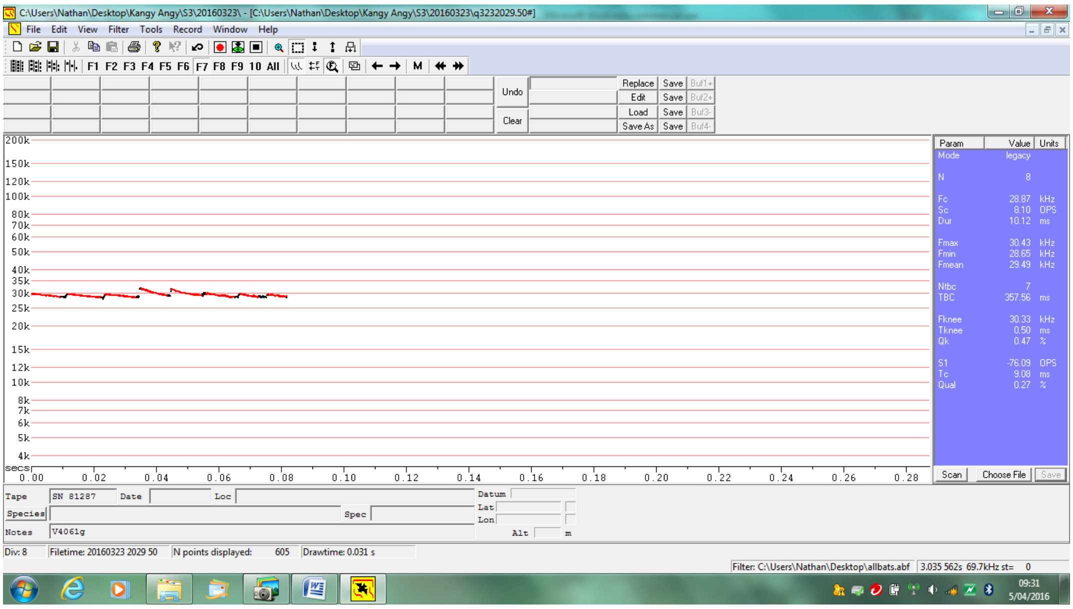
Gould's Wattled Bat *Chalinolobus gouldii*



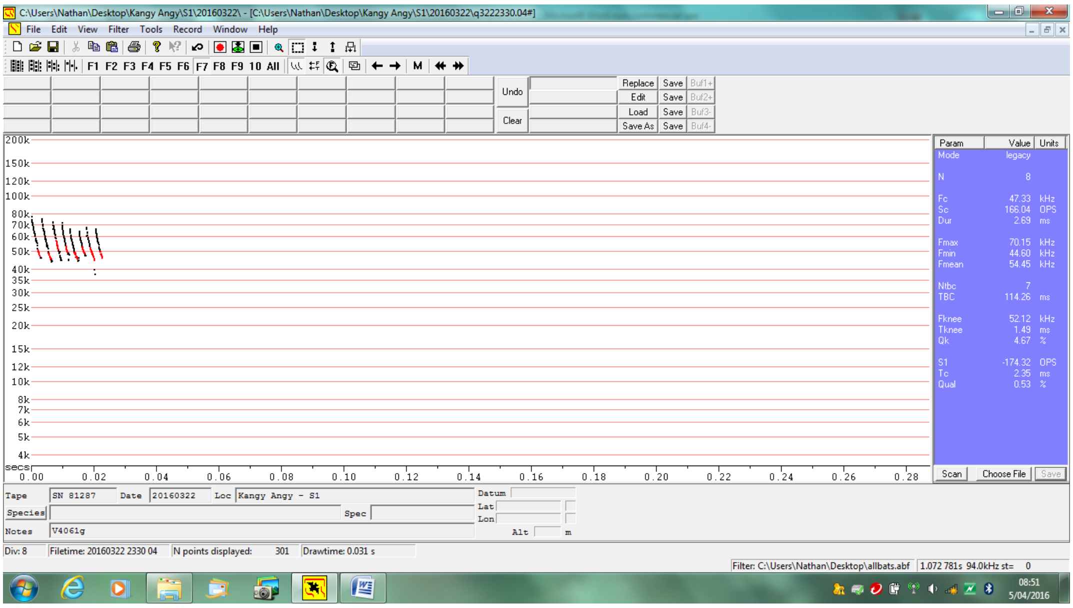
Eastern Broad-nosed Bat *Scotorepens orion*



Eastern Bent-wing Bat *Miniopterus schreibersii oceanensis*



Ride's Free-tailed Bat *Mormopterus ridei*



Appendix B

NOISE AND VIBRATION IMPACT ASSESSMENT

New Intercity Fleet - Maintenance Facility

NOISE AND VIBRATION IMPACT ASSESSMENT

16/05/2016

NEW INTERCITY FLEET MAINTENANCE FACILITY

NOISE AND VIBRATION IMPACT ASSESSMENT

Project no: ACG1522100
Date: 16/05/2016

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Quality Management

Issue/revision	Issue 1	Issue 2	Issue 3	Issue 4
Remarks	Draft for client comment	Final draft for client comment	Report	
Date	04/05/2016	11/05/2016	16/05/2016	
Prepared by	C. Marsh	C. Marsh	C. Marsh	
Signature				
Checked by	Z. Lai	Z. Lai	Z. Lai	
Signature				
Authorised by	A. Campbell	A. Campbell	A. Campbell	
Signature				
project number	ACG1522100	ACG1522100	ACG1522100	
Report number	001 Draft	001 Draft Final	001 Report	
File reference				

Table of Contents

Executive Summary

WSP | Parsons Brinckerhoff (WSP | PB) has been commissioned on behalf of Transport for NSW to prepare a noise and vibration impact assessment (NVIA) for the proposed New Intercity Fleet Maintenance Facility project (hereafter, referred to as 'the project'). The purpose of the NVIA is to support the review of environmental factors (REF) for the project.

The project proposes to construct and operate a train maintenance facility in Kangy Angy, NSW for the New Intercity Fleet of trains to service the Newcastle/Central Coast, Wollongong and Blue Mountains lines. The site is located next to the Main North railway and contains an access track off the Main North railway, a train wash, a wheel lathe, a maintenance shed with capacity for four trains, standing tracks in front of the maintenance shed and additional standing tracks to the east of the maintenance shed next to the existing Main North railway.

It is proposed that trains regularly arrive and depart from the project and receive maintenance, cleaning and standing during the day and night. Trains may stand overnight at the facility and regular cleaning of trains would take place during the day. Internal cleaning would take place at the facility and external cleaning would take place in the train wash and on a dedicated track where a gurney would be used to clean off graffiti etc. Scheduled and unscheduled maintenance would also be undertaken for the New Intercity Fleet at the Kangy Angy Facility.

The facility also includes a new access road with a bridge across the Main North railway joining the facility to Enterprise Drive via Old Chittaway Road. The new access road would also provide a link between Orchard Road and Enterprise Drive for potential future use by residents (subject to agreement with Wyong City Council).

The work force is expected to be organised into three shifts with up to approximately 60 staff expected to work on each shift. The shift change over times are currently expected to be around 6.00am, 1.00pm and 10.00pm.

The site is generally surrounded by residential receivers, with the closest being approximately 100 metres away on Ourimbah Road, Kangy Angy. Residential receivers are also located across the Main North railway on Old Chittaway Road, Station Road and Enterprise Drive. A school and a child care centre are also located near to the project. Other receivers include the Sanitarium Factory located north of the site and a commercial/industrial area on Catamaran Road located east of the site.

The major roads in the area include Pacific Motorway, located approximately one kilometre from the project and Enterprise Drive which follows the Main North railway line close to the project.

Existing noise environment

The existing noise environment was characterised by unattended noise monitoring at four representative locations. Attended measurements were also undertaken during the day and night across the project site to characterise the existing noise environment including industrial and transportation (road and rail) noise.

The results of the noise monitoring indicated that the background noise environment is generally controlled by distant traffic noise during the day with natural sounds also contributing across the area. Industrial noise due to the Sanitarium Factory was observed at all times of the day and the Catamaran Road commercial area was only audible during the night.

In addition to the noise monitoring, traffic counting was carried out on Enterprise Drive to quantify the existing road volumes on this road which is potentially impacted by the project.

Assessment guidelines

The operational noise (including potential sleep disturbance impacts) from the project has been assessed with reference to the *Industrial Noise Policy* (INP) (EPA, 2000) and guidance within the *Road Noise Policy* (RNP) (EPA, 2011) as the project consists of a maintenance facility and the *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013) specifically excludes assessment of maintenance and stabling facilities against trigger levels intended for rail noise. The assessment included consideration of both general noise emission and short duration high level noise events such as noise from horns.

Construction noise and vibration was assessed with reference to the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and *Assessing Vibration: A Technical Guideline* (Vibration Guideline) (DEC, 2006) respectively. Additional assessment of construction impacts was conducted with reference to the *Construction Noise Strategy* (CNS) (Transport for NSW, 2013).

Operational noise

Operational noise of the maintenance facility was assessed by determining a number of scenarios for the potentially most noise intensive activities, including 15 minute scenarios (L_{eq}) and short duration noise events (L_{max}) such as horn testing. The assessment evaluated 16 scenarios which included arrivals, departures, maintenance activities, testing activities and standing of trains.

A three dimensional noise model was constructed in SoundPLAN version 7.4 to predict noise levels from the project to the surrounding residential receivers for the 16 scenarios. Each scenario was predicted under neutral and adverse wind and temperature inversion meteorological conditions.

The modelling of noise emissions from the activities were based on Waratah train sets, Asset Standard Authority documentation and previous assessment and measurement of similar activities.

The predicted noise levels indicated that a number of exceedances at the closest receivers on Ourimbah Road, Turpentine Road, Orchard Road, Enterprise Drive and Old Chittaway Road for the L_{eq} scenarios during the evening and night periods. The level of exceedance increased under adverse meteorological conditions. The trains standing, arrivals and departures in addition to train washing were identified as the scenarios which would cause the highest exceedance of the L_{eq} criteria.

The L_{max} predicted noise levels indicated that the testing of the country horn had the highest noise impact and the majority of receivers considered in the assessment were predicted to experience noise level in excess of the sleep disturbance screening criteria. In addition, trains travelling on the access track were predicted to cause an exceedance of the sleep disturbance screening criteria at the closest receivers on Ourimbah Road and Turpentine Road.

As a result of the predicted exceedances, a number of mitigation and management measures were considered. These included development of an operational management plan, noise barriers and the acoustic performance of the maintenance shed and substation building.

Barriers of different heights were investigated. The height of barriers were considered in terms of the height of the most dominant noise sources, the location of the sources relative to the barrier and receiver in addition to project constraints including available land and drainage provisions. The barriers investigated included a five metre barrier to the west of the standing tracks outside of the maintenance shed and a barrier to the full height of the train wash blocking line of sight to 26 Turpentine Road.

Predicted noise levels with the barriers for arrival, departure and standing activities indicated that after the implementation of these mitigation measures there would be residual impacts at some of the closest receivers on Ourimbah Road, Turpentine Road, Enterprise Drive and Old Chittaway Road. The predicted levels of exceedance with mitigation are generally within 1 to 4 dB above the evening and night L_{eq} criteria.

Testing of the country horn is expected to be the dominant maximum noise source and is likely to be audible at large distances from the project. Measures to reduce the potential impact of the use of horns including selecting alternative testing locations, development of low noise horn testing and ground based warning systems should be investigated during further stages of the project.

The assessment indicated that the following mitigation measures should be considered for implementation:

- Development of an operational noise and vibration management plan including strategies developed by the train and maintenance facility operators to reduce noise impacts on receivers including:
  - Alternative methodologies for horns, warning signals and horn testing at the facility.
  - Standing of trains outside of the shed and on tracks 6 and 7 during the evening and night period.
  - Restrictions on external cleaning during the evening and night period.
  - Controls and mitigation strategies for noise sources which are unable to be quantitatively assessed at this stage.
- During the detailed design stage, all mobile and fixed noise sources and activities forming the overall operation of the project should be designed to meet the environmental noise objectives of the project.
- The maintenance shed should be constructed to achieve a sound insulation performance no less than 26 dB R_w.

- The maintenance shed doors should remain closed when activities are occurring inside the shed.
- A barrier of five metres high above the track along the standing tracks east of the maintenance shed. The side of the barrier facing the noise sources should be acoustically absorptive or the barrier should include a combination of a vegetated earth berm and barrier.
- Noise barriers should be solid and continuous with no gaps between the ground and barrier and between barrier panels. Barriers should be constructed of a material with a surface density of at least 12 kilograms per square metre.
- A barrier to the full height of the train wash which extends to fully block line of sight from the train wash exit to 26 Turpentine Road.
- Where noise levels are greater than those listed in this report or their locations differ significantly from those assessed in this report, additional assessment should be carried out.

It is recommended that further investigation of the location and height of barriers is carried out during the detailed design phase when more specific details of the train fleet and operations at the maintenance facility are known.

For receivers with residual exceedances due to the project with source controls and barriers in place, individual property treatments may be considered.

The implementation of any mitigation or provision of individual property treatment is subject to further assessment as part of the detailed design stage and consideration by Transport for NSW.

If approved, the conditions of consent should set limits no lower than the INP criteria presented in this report.

Construction noise and vibration

The assessment of construction noise and vibration considered a number of the main constructions stages. The construction of the bridge across the railway line for the new access road is expected to occur first to allow access to the project site. The construction is expected to occur over a period of approximately 36 months. Works would generally occur during standard construction hours with some activities requiring possession of the existing Main North railway, and therefore are required to take place during the night and at weekends to minimise the chance of disruption to rail services.

The construction stages were assessed as 14 scenarios using the model developed for the operational noise assessment. The assessment indicated that a number of receivers would be impacted by noise levels in excess of the ICNG noise management levels during both standard working hours and outside of standard hours. The receivers were also assessed with regard to the CNS and additional mitigation measures were highlighted for affected receivers where required.

The assessment of potential impacts from construction vibration indicated that there is not a significant risk of building damage from the works as they generally take place at least 75 metres from sensitive receivers.

As a result of the predicted construction noise impacts and to minimise the risk from vibration associated with the works, a number of construction management measures have been recommended.

Road traffic noise

The potential for additional traffic generated by the project on existing roads and on the new access road to cause noise impacts at the surrounding receivers has been assessed with reference to the *Road Noise Policy* (RNP) (EPA, 2013).

The project is expected to generate traffic during the construction phases and also during shift change overs in the operational phase. The assessment considered potential increase in noise on Enterprise Drive and new road noise source from the new access road during the construction and operational phases.

The assessment indicated that the project would not cause a significant increase in noise level on Enterprise Drive during either the construction or operational phases of the project.

Predicted noise levels on the new access road indicated compliance with the RNP new road criteria would be achieved during the operational phase. During the construction phases, if 75 percent of the expected construction vehicles arrive at site within one hour, the new road criteria would be exceeded for the nearest receivers on Orchard Road.

As a result it is recommended that the arrival of construction vehicles is managed, where feasible, to avoid adverse noise impacts for receivers on Orchard Road.

1 Introduction

WSP | Parsons Brinckerhoff (WSP | PB) has been commissioned on behalf of Transport for NSW to prepare the noise and vibration impact assessment (NVIA) for the proposed New Intercity Fleet Maintenance Facility project (hereafter, referred to as 'the project'). The purpose of the NVIA is to support the review of environmental factors (REF) for the project.

This NVIA is one of a number of technical reports supporting the REF for the project.

Transport for NSW proposes to deliver a new train maintenance facility at a site in Kangy Angy on the Central Coast of NSW to support the procurement of the New Intercity Fleet. The facility would be undertake light and heavy train maintenance activities for the New Intercity Fleet, including but not limited to

- Regular maintenance/servicing
- Repair/replacement of train components
- Interior and exterior cleaning

The proposed facility would include about six kilometres of electrified railway (in total), would be seven tracks wide at its widest point, would cover an area of approximately 500,000 square metres and would be bounded by a perimeter fence. The fleet maintenance building would be approximately 270 metres long by 60 metres wide.

The key features of the proposed maintenance facility would comprise the following key elements:

Key maintenance facility elements:

- Fleet maintenance building
- Four enclosed maintenance roads and three external standing tracks to accommodate the new trains within the site
- Auxiliary workshops
- Electronic clean room
- Material storage, including flammable liquid storage
- Wheel lathe
- Automatic train wash
- Site access roads

Miscellaneous buildings:

- Administration
- Facilities for presentation and train maintenance staff
- Operational control
- Security
- Training rooms
- Train simulator
- Power supply (traction power, bulk power, signalling power supply and backup generators).

Other infrastructure including:

- New railway track infrastructure on the western side of the existing rail corridor to allow for trains to enter and exit the maintenance facility site from the Main North railway
- Two new rail bridges over Chittaway Creek and Turpentine Road
- A new access roadway to the maintenance facility site off Enterprise Drive
- A new flood access road between Orchard Street and the proposed new access roadway

- A series of drainage detention ponds
- Staff car park
- Relocation of the existing high voltage power transmission line and Combined Services Route (CSR).

This assessment addresses the noise from activities, including rail movements, within the maintenance facility. It does not include an assessment of noise or vibration rail movements outside of the maintenance facility on the Main North railway.

2 Project description

The proposed project is a purpose built maintenance facility located in Kangy Angy within the Wyong Shire Local Government Area (LGA). The site is located at on the down-track side (the line on which trains travel away from Sydney towards Newcastle) of the Main North railway, between Tuggerah and Ourimbah railway stations. The site is bounded by Chittaway Creek to the south, Ourimbah Creek to the north, Orchard Road to the west, and the Main north Railway Line to the east.

The area lies within a semi-rural suburban area, with residential receivers on rural properties generally surrounding the site to the north, south and west and with industrial precincts to the south east and north-east (on the opposite side of the rail corridor to the site). The M1 Pacific Motorway is located approximately 850 metres to the north-west, and Tuggerah Lake is approximately 3.5 kilometres to the east of the site. The existing nature of the project site is typically densely planted with large areas of vegetation and contains one existing residential dwelling and associated structures.

Figure 2-1 shows the location of the project site in the local area. The project would provide a maintenance facility for the proposed New Intercity Fleet. This would include the following typical operational activities/elements:

- Early morning and later evening routine arrivals and departures for train maintenance
- Routine maintenance including interior and exterior cleaning
- Maintenance provided for trains on an as needs basis
- Exterior train wash facility
- Enclosed maintenance sheds where all maintenance, except external cleaning and wheel lathe would take place.
- A wheel lathe
- Stabling area in front of the maintenance shed and to the east of the maintenance shed.
- Staff and deliveries entering and exiting on the access road.
- Mechanical plant for building services to the administration and office buildings.
- New substations located on the other side of the Main North railway to the maintenance shed.

Figure 2 -2-2 shows the layout of the site.

The facility would have a maximum of 200 employees over a 24 hour period during the operational stage, with 50 to 60 employees on duty at any one time. During the normal weekday day shift, this number could increase by a further 10 office staff. The facility is expected to be run using three eight hour shifts as follows:

- 6.00am to 2.00pm
- 2.00pm to 10.00pm
- 10.00pm to 6.00am.

The maintenance and standing activities are expected to be carried out as follows:

- Maintenance carried out over a 24 hour period with train arrivals and departures occurring at any time.
- Stable three trains overnight. The trains would leave between 4.00am and 7.00am in the morning.
- During the day, five trains are expected to arrive at various points to be washed inside and out and then depart taking approximately 30 minutes each.
- In the evening and night period, three trains would arrive between 7.00pm and 2.00am to be retained overnight.
- Maintenance is expected to occur in two periods between 9.30am and 3.00pm with the second period between 6.30pm and 1.30am with the trains departing between 5.00am and 7.00am.
- Maintenance including wheel lathing, exterior cleaning and train washing.

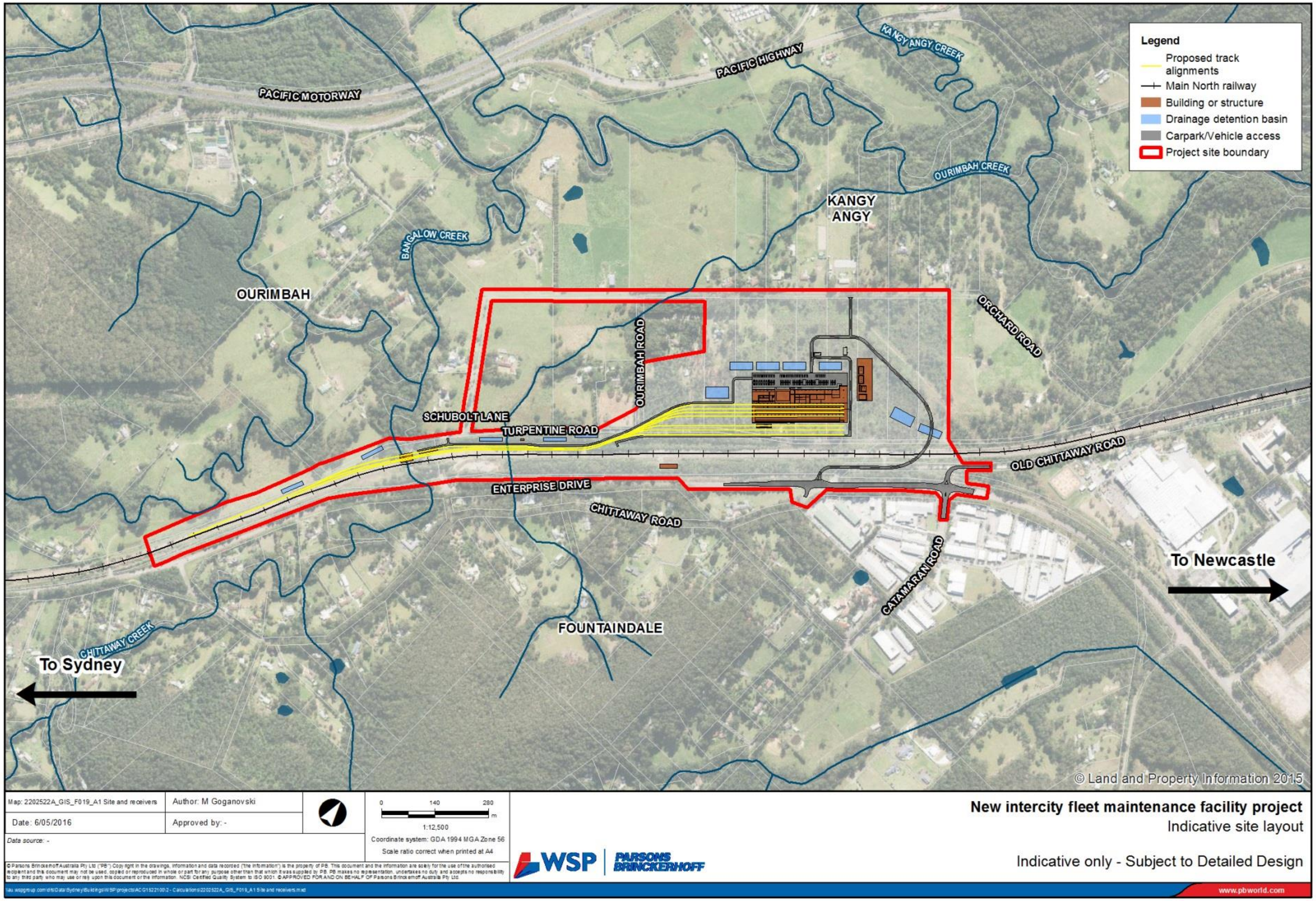

Figure 2-1 - Site overview

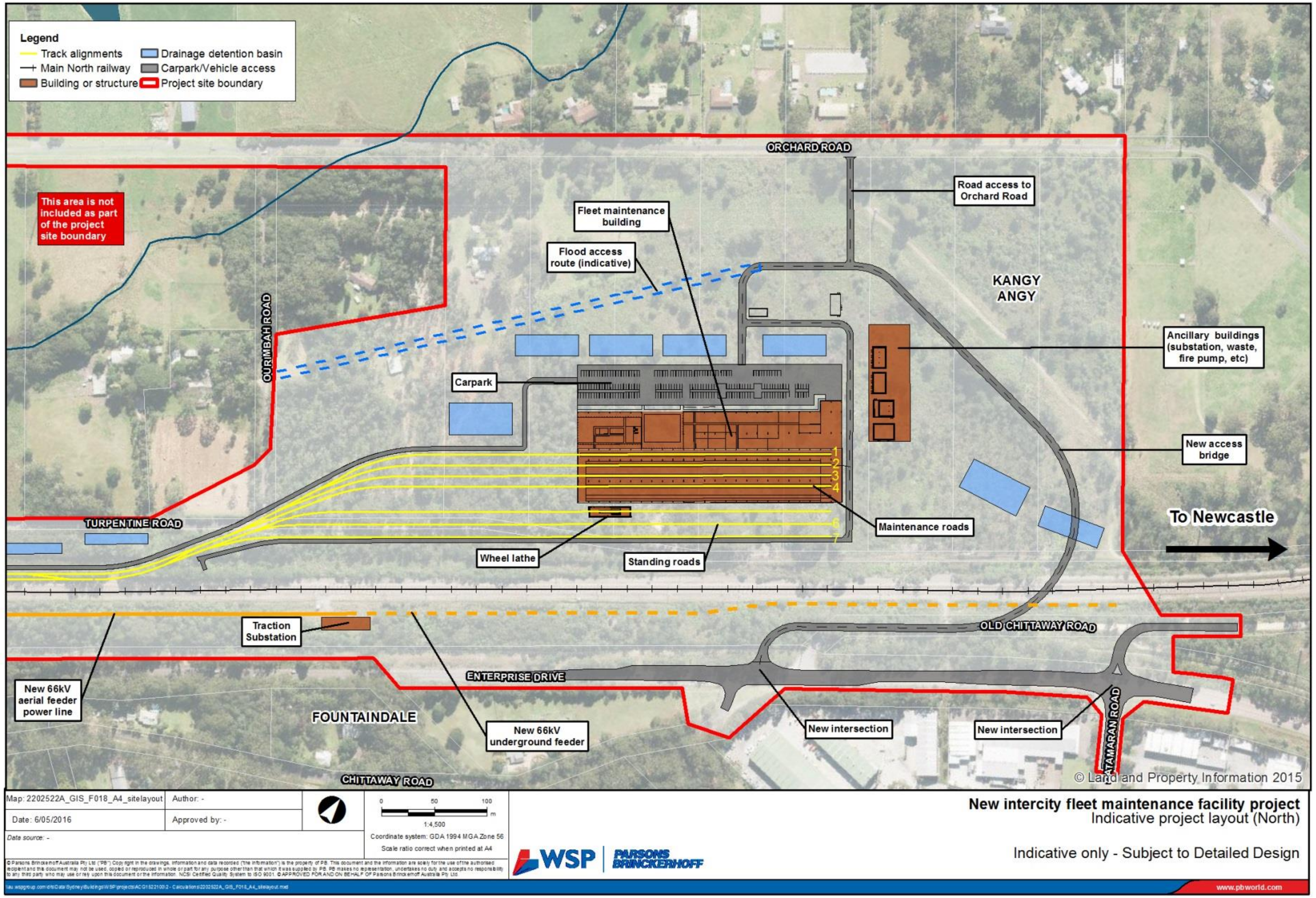

Figure 2 -2-2- Site layout

3 Sensitive receivers

The site is surrounded by residential receivers in the suburbs of Kangy Angy and Fountaindale, NSW. To the north, east and south of the site, the nearest residential receivers are located on Orchard Road, Ourimbah Road, Turpentine Road bridge Road and Schubolt Lane. Residential receivers are also located across the main railway on Old Chittaway Road, Station Road and Enterprise Drive. Two commercial/light industrial areas are located to the north east and the south east of the site on Catamaran Road and Sanitarium Road.

A child care centre is located at 98 Old Chittaway Road and the Central Coast Rudolf Steiner School is located at 10 Catamaran Road, Fountaindale.

Figure 3-1 shows the location of the receivers and Table 3-1 provide a summary of the nearest, potentially most affected sensitive receivers to the site. A full list of receivers considered in the assessment and the corresponding representative background noise monitoring location is provided in Appendix A.

As part of the project, 53 Orchard Road and 11 Ourimbah Road are to be acquired and have not been considered in the assessment. Other partial acquisitions of private land on Turpentine Road are not expected to result in the existing occupants having to vacate their respective premises, and these receivers have therefore been considered in the assessment.

Table 3-1 –Closest and potentially most affected sensitive receivers

Receiver address	Receiver type
12 Ourimbah Road	Residential
19 Ourimbah Road	Residential
15 Schubolt Lane	Residential
16 Turpentine Road	Residential
26 Turpentine Road	Residential
50 Orchard Road	Residential
54 Orchard Road	Residential
62 Orchard Road	Residential
72 Orchard Road	Residential
80 Orchard Road	Residential
127 Old Chittaway Road	Residential
141 Old Chittaway Road	Residential
149 Old Chittaway Road	Residential
150 Old Chittaway Road	Residential
157 Old Chittaway Road	Residential
161 Old Chittaway Road	Residential
165 Old Chittaway Road	Residential
170 Old Chittaway Road	Residential
3 Station Road	Residential
7 Station Road	Residential
16 Station Road	Residential
11 Station Road	Residential

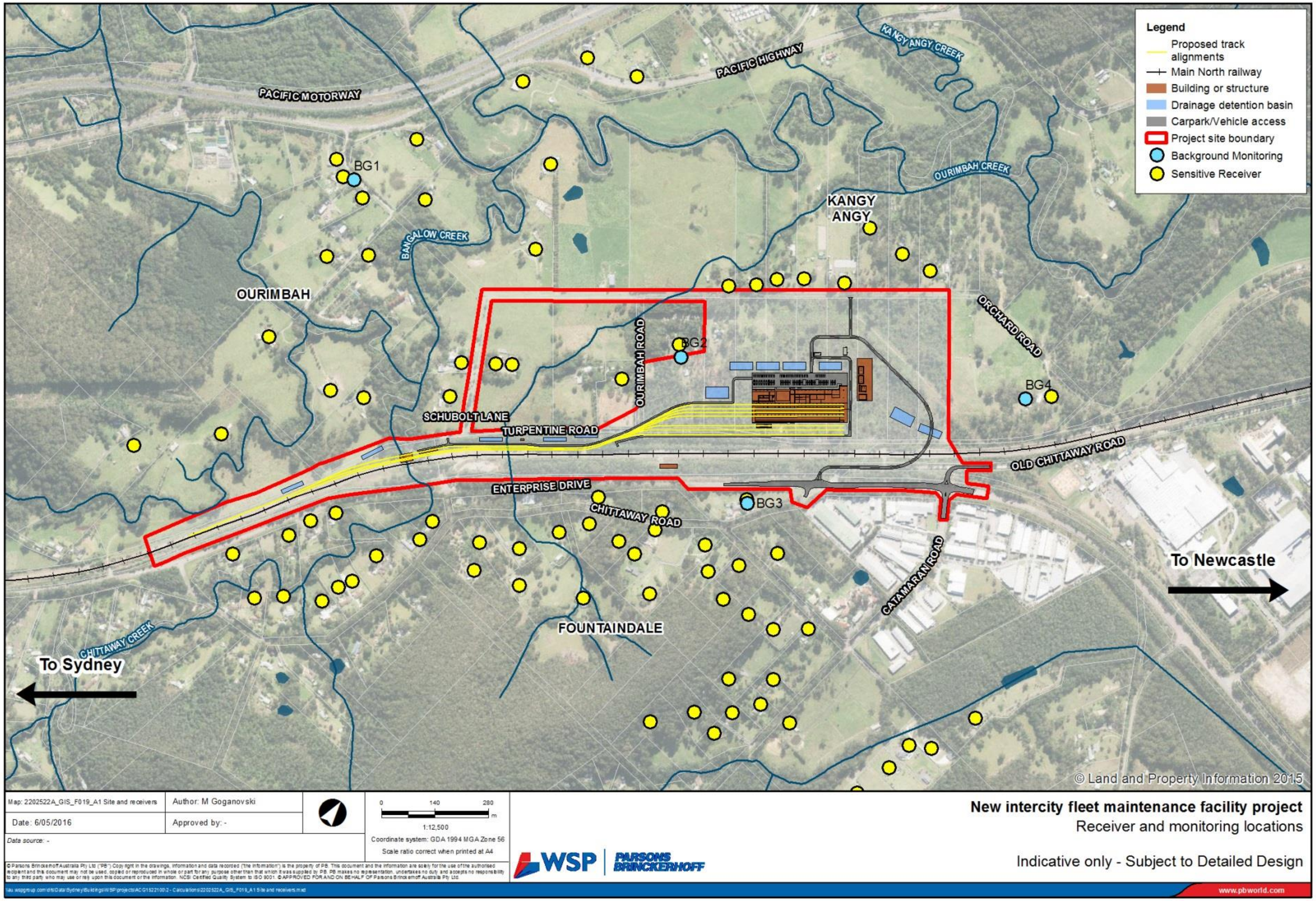

Figure 3-1 - Receiver and background monitoring locations

4 Existing environment

4.1 Noise monitoring

4.1.1 Noise monitoring methodology

Short term attended and long term unattended noise measurements were taken between 17 and 29 February 2016, and 30 March and 6 April 2016. The noise monitoring was conducted with reference to Australian Standard AS 1055 *Acoustics, Description and Measurement of Environmental Noise*. Table 4-1 describes the noise monitoring equipment used onsite, with the monitoring location shown in Table 4-1

Measurements initially carried out at BG2 between 17 and 29 February 2016, were adversely affected by insect noise and were repeated between 30 March and 6 April 2016.

Table 4-1 - Noise measurement equipment

ID	Equipment Description	Location	Date	Manufacturer & Type No.	Serial No.
BG1	Environmental noise monitor	11 Bridge Street, Ourimbah	17 to 29 February 2016	Norsonic 140	1406502
BG2	Environmental noise monitor	19 Ourimbah Road, Kangy Angy	30 March 6 April 2016	ARL EL-316	16-207-023
BG3	Environmental noise monitor	170 Old Chittaway Road, Fountaindale	17 to 29 February 2016	ARL EL-316	16-707-005
BG4	Environmental noise monitor	139 Orchard Road, Kangy Angy	30 March 6 April 2016	Svan 958	36659
-	Calibrator	All	All	Rion NC-73	11248294

The data were gathered over a period of typical traffic movement and activity in the area (i.e. outside of school holiday periods). The monitoring equipment was fitted with windshields and were field calibrated before and after monitoring. No significant drifts in calibration (± 1.0dB) were noted.

The weather conditions at the time of monitoring were recorded at Gosford Narara Research Station Automatic Weather Station (Bureau of Meteorology station number 061087), which is located approximately nine kilometres south-west of the project

Periods of inclement weather (wind speeds greater than five metres per second and significant rainfall) and extraneous noise that were identified to adversely affect the noise monitoring were excluded from the analysis of monitoring data.

Operator attended noise surveys and observations were conducted at the noise monitoring locations on 17 February 2016, 29 February 2016, 30 March 2016 and 31 March 2016. The primary purpose of the attended monitoring was to characterise the existing ambient environment based on a short term noise measurement sample.

4.1.2 Noise monitoring results

Table 4-2 summaries the long term unattended noise monitoring results. The data are reported as the average equivalent continuous average sound levels ($L_{eq,15min}$) and rating background levels (RBL) as defined in the NSW *Industrial Noise Policy* (INP) (EPA, 2000).

Graphs of the long term measurement results are presented in Appendix B.

Table 4-2 - Unattended noise measurement results (dBA)

ID	Address	Day $L_{eq,15min}$	Day RBL	Evening $L_{eq,15min}$	Evening RBL	Night $L_{eq,15min}$	Night RBL
BG1	11 Bridge Street, Ourimbah	53	45	55	46	49	43
BG2	19 Ourimbah Road, Kangy Angy	60	44	52	40	43	35
BG3	170 Old Chittaway Road, Fountaindale	59	49	60	44	55	35
BG4	139 Orchard Road, Kangy Angy	59	47	59	48	57	45

Note: Day is defined as Monday to Saturday 7.00am to 6.00pm; 8.00am to 6.00pm Sundays and Public Holidays, Evening is 6.00pm to 10.00pm and Night is the remaining periods.

Table 4-3 and Table 4-4 present the results of the short term attended noise monitoring and train passby noise measurements respectively. Measurements of train passbys were taken to provide an indication of the existing impacts from train passbys in the area.

Table 4-3 - Short term attended noise monitoring results (residential measurements)

Location	Date	Start time	$L_{eq,15min}$ dBA	$L_{90,15min}$ dBA	Comments
BG1	17/02/2016	2.05pm	52	47	The dominant ambient noise source was traffic noise from the nearby Pacific Motorway. Birds and insects contributed to the background noise levels. Industrial noise was not observed at the location.
BG1	29/02/2016	2.48pm	49	45	The dominant ambient noise source was traffic noise from the nearby Pacific Motorway. Crows and insects were occasionally audible. Industrial noise was not observed at the location.
BG1	30/03/2016	5.57pm	53	49	The acoustic environment was dominated by traffic noise from the nearby Pacific Motorway. Surrounding birds provided significant ambient noise contributions on occasions. Background contributions were made from insects and distant residential noise. Industrial noise was not observed at the location.
BG1	31/03/2016	1.46am	55	46	The noise environment was dominated by high frequency insect noise. Background noise was filled by traffic noise along the nearby Pacific Motorway. A distant pass by from a passenger train could also be heard. Industrial noise was not observed at the location.
BG2	17/02/2016	1.04pm	58	46	The acoustic environment received substantial contributions from bellbirds and insects in the general area. Other noise sources include train passbys and distant traffic noise from Enterprise Drive. Industrial noise was not observed at the location.
BG2	29/02/2016	12.46pm	58	45	The acoustic environment received significant contributions from bellbirds and insects in the general area. Other noise sources include train and distant traffic noise from Enterprise Drive. Industrial noise was not observed at the location.
BG2	30/03/2016	5.28pm	60	47	The most significant noise source was bird calls. The background noise environment consisted of insects, and traffic from the Pacific Motorway to the west. Passing road traffic on Enterprise Drive and train passbys were also present in the measurement period. Industrial noise was not observed at the location.

Location	Date	Start time	$L_{eq,15min}$ dBA	$L_{90,15min}$ dBA	Comments
BG2	31/03/2016	12.51am	50	38	Distant traffic from the Pacific Motorway and insect noise contributed to the acoustic environment. Insect noise generally the most significant noise source. Background noise contributions also came from traffic along Enterprise Drive and distant community noise. Industrial noise was not observed at the location.
BG3	17/02/2016	11.52am	59	50	Ambient noise environment was dominated by distant traffic on Enterprise Drive and intermittent train passbys. Birds and insects contributed to the background noise levels. Industrial noise was not observed at the location.
BG3	29/02/2016	10.22am	57	46	The most significant noise contribution came from distant traffic on Enterprise Drive and occasional train passbys. Background noise levels were also influenced by birds and insects. Industrial noise was not observed at the location.
BG3	30/03/2016	5.09pm	61	52	The dominant noise source was traffic along Enterprise drive. The background environment received contributions from distant Bellbirds and insects. Occasional community noise and train passbys were also present. Industrial noise was not observed at the location.
BG3	31/3/2016	1.17am	48	38	The dominant noise source was distant traffic noise from the Pacific Motorway to the west. Ambient noise levels received contributions from road traffic on Enterprise Drive with approximately one vehicle passing per minute. Background noise environment included contributions from surrounding insects. Industrial noise of approximately 35dBA could be heard from the Formit services factory to the north-west. A passing passenger train also contributed to the acoustic environment.
BG4	30/03/2016	4.16pm	52	45	The acoustic environment was dominated by industrial noise from the Sanitarium plant to the east, approximately 47dBA. Distant Bellbirds and traffic from the Pacific Motorway and Enterprise Drive formed part of the background noise environment. A train passby and occasional farm animal noise were also present.
BG4	31/03/2016	12.30am	52	45	The dominant noise source was Industrial noise from the Sanitarium factory, approximately 47dBA at the measured location. The background noise environment received contributions from the distant Pacific Motorway, Enterprise drive and insects. Passing freight and passenger trains were also present.

Table 4-4 Short term attended noise monitoring results (train measurements passbys)

Location	Distance from nearest rail (m)	Duration T (secs)	$L_{eq,T}$ dBA	L_{max} dBA	Observations
16 Turpentine Road, Kangy Angy	35m	13	72	76	V Set up direction
	35m	47	75	79	Freight up direction
	35m	5	70	73	Oscar, up direction
	35m	7	73	76	V set, down direction

The attended noise monitoring indicated that the most dominant ambient noise sources close to the proposed site was road traffic with intermittent peaks from rail passbys with birds and insects also contributing to the background noise level at all locations except BG4. At BG4 it was observed that noise from the Sanitarium factory controlled the noise environment during the day, evening and night periods.

The most dominant noise source at BG1 during the day was traffic noise from the Pacific Motorway, with bird and insect noise also contributing to the background noise environment. At night, insect noise and constant traffic noise from the Pacific Motorway contributed to background noise level. There was no audible industrial noise present during either the day or night periods.

At BG2 the acoustic environment generally consisted of distant traffic and birds during the daytime and during the night insects also contributed to the noise environment. During the day, noise was equally audible from the Pacific Motorway and Enterprise Drive. At night, traffic noise was more noticeable from Pacific Motorway than Enterprise Drive. Traffic noise made a larger contribution to the overall noise levels at night. There was no audible industrial noise measured during the day or night.

At BG3 during the day, the acoustic environment was controlled by constant traffic along Enterprise Drive, with peaks from occasional train passbys as well as birds and insects also being present. During the daytime, no industrial noise was present, and traffic noise due to Pacific Motorway was not audible.

The acoustic environment during the night at BG3 was dominated by distant traffic noise from the Pacific Motorway, with smaller traffic noise contributions coming from Enterprise Drive (approximately 1 car per minute). Background noise levels received additional low level contributions from insects and distant industrial sources. The industrial noise was a just audible, constant tonal fan noise approximately 35dBA at the measured location. The location of the noise source was identified to be the Formit services factory at 1 Co-Wyn Close, Fountaindale. Noise was observed to be originating from the open factory doors on the northern factory facade (orientated away from the receiver), approximately 200m from the measurement location.

The acoustic environment at BG4 during the day, evening and night periods was dominated by industrial noise from the Sanitarium factory, 1 Sanitarium Drive, Berkeley Vale. Other audible noise sources during the day included bellbirds, the Pacific Motorway and Enterprise Drive. Occasional peaks from train passbys also contributed to the noise environment at this location. Other audible background noise sources at night consisted of traffic noise from the Pacific Motorway and from insects, with Enterprise Drive contributing less than during the day.

The industrial noise source at BG4 consisted of two separate continuous noise sources observed to be located on the Sanitarium factory property. Pumps in a dam at the south west of the site, and fans on the western edge of the building emitted noise levels emitted industrial noise measured at 47dBA at BG4 during the day and at night period. The industrial noise source from the dams was measured 2dB higher at the boundary edge than the noise from the fans on the buildings edge. The industrial noise from the pumps was continuous and generally tonal in nature (around the 200Hz 1/3 octave band) with little shielding or attenuation and was audible outside of the Sanitarium property.

4.2 Road traffic counts

Road traffic counts were undertaken on Enterprise Drive between 30 March and 6 April 2016 at the same time as the noise monitoring undertaken at BG2 and BG4.

The average daily traffic volumes as measured by the traffic count are summarised in Table 4-5.

Table 4-5 - Traffic counting on Enterprise Drive

Direction	Day (7.00am - 10.00pm)			Night (10.00pm - 7.00am)		
	LV	HV	Speed (km/h)	LV	HV	Speed (km/h)
Northbound	6971	389	91	616	24	95
Southbound	6542	325	86	1227	47	90

Note: LV = Light vehicles, HV = Heavy vehicles, Speed is the average 85th percentile speed of all vehicles.

4.3 Prevailing meteorological conditions

The prevailing meteorological conditions were identified from long term averages collected at the BoM Gosford Automatic Weather Station (Site ID: 061087) between 1965 and 2013. The long term averages indicate that the mean maximum and minimum temperatures are 23°C and 11°C respectively. The minimum mean temperature is 5°C which would occur during the night.

The average annual rainfall is 1329 mm which classifies the area as non-arid according to Appendix C of the *NSW Industrial Noise Policy* (INP) (EPA, 2000).

It is considered that temperature inversions may occur in this area during winter nights, however drainage flows affecting the closest receivers are not expected as the height difference between the project site and receivers is not significant to warrant consideration of drainage flows.

5 Assessment Criteria

The assessment has been prepared with reference to the following guidelines, policies and standards:

- Noise
  - *Industrial Noise Policy* (INP) (EPA, 2000)
  - *Interim Construction Noise Guideline* (ICNG) (DECC, 2009)
  - *Construction Noise Strategy* (CNS) (Transport for NSW, 2013)
  - *Road Noise Policy* (RNP) (EPA, 2011)
- Vibration
  - *Assessing Vibration: A Technical Guideline* (Vibration Guideline) (DEC, 2006).
  - DIN Standard 4150-2 Part 3: Structural Vibration in Buildings: Effects on Structures (DIN Deutsches Institut für Normung, 1999).

5.1 Noise

5.1.1 Operational

Operational noise is assessed according to the *Industrial Noise Policy* (INP) (EPA, 2000). The INP is the appropriate assessment method for the proposal as the *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013) assessment method specifically excludes noise from maintenance and stabling yards.

The INP defines two criteria for the assessment of noise; the intrusive and amenity criteria. The more onerous criterion is then adopted as the project specific noise level (PSNL) which the proposal is assessed against.

The intrusive criterion is intended to protect residential receivers against intrusive noise in the short term. It is defined as $L_{eq,15min}$ dBA less than or equal to the rating background level (RBL) plus 5 dBA. The RBL is the background noise level determined in accordance with Appendix B of the INP.

The amenity criterion is intended to maintain noise amenity and limit cumulative noise increases for sensitive land uses. In Table 2.1 of the INP, recommended amenity noise levels are defined for each day, evening and night period for each sensitive land use. The recommended amenity noise levels apply to noise from industrial noise only and where existing industrial noise exceeds or approaches the recommended amenity levels, a modifying factor (INP Table 2.2) is applied to limit the cumulative increase in total industrial noise at a receiver.

The residential receivers are defined as suburban amenity receivers in a rural residential zone as defined in the INP. The suburban amenity category has been selected as the area has intermittent traffic flows and limited commerce and industry in the area and has decreasing noise levels in the evening and night. The presence of the constant background noise from the Pacific Motorway at all receivers would exclude it from being categorised as a rural amenity receiver.

Table 5-1 presents the criteria and project specific noise level for residential receivers at each of the measurement locations.

A list of receivers and the corresponding representative background noise monitoring location is provided in Appendix A.

Table 5-1 - Operational criteria for residential receivers

Noise monitoring location	Time period[1]	RBL dBA	Intrusive criteria $L_{eq,15min}$ dBA	Existing industrial noise level $L_{eq,15min}$ dBA	Acceptable noise level $L_{eq,period}$ dBA	Amenity criteria[1] $L_{eq,period}$ dBA	PSNL $L_{eq,15min}$ dBA[5]
BG1	Day	45	50	N/A	55	55	50
	Evening[2]	45	50	N/A	45	45	45
	Night	43	48	N/A	40	40	40
BG2	Day[3]	44	49	<50	55	53	49
	Evening[3]	40	45	<42	45	42	42
	Night[3]	35	40	<33	40	40	40
BG3	Day[3]	49	54	<49	55	55	54
	Evening[3]	44	49	<50	45	40	40
	Night[2]	35	40	35	40	38	38
BG4	Day[4]	47	52	47	55	55	52
	Evening[4]	48	53	47	45	37	37
	Night[4]	45	50	47	40	37	37

Note 1: Day is defined as Monday to Saturday 7.00am to 6.00pm; 8.00am to 6.00pm Sundays and Public Holidays, Evening is 6.00pm to 10.00pm and Night is the remaining periods.

Note 2: The measured RBL for evening was higher than the day. Therefore the RBL for the evening period has been set at the same as for day in accordance with the INP application notes.

Note 3: The existing industrial noise level was set at 10 dB less than the existing ambient noise level.

Note 4: The existing $L_{eq,period}$ industrial noise was set at the measured industrial noise level on site.

Note 5: The PSNL has been set as a $L_{eq,15min}$ in order to provide a conservative assessment. Where compliance is achieved over a 15 minute period is therefore implied it will occur over the day, evening or night period.

Table 5-2 presents the project specific noise level for non-residential receivers as presented in the INP.

Table 5-2 - Operational criteria for non-residential receivers

Receiver	Time period	Amenity criteria[1] $L_{eq,period}$ dBA
Industrial	When in use	70
Commercial	When in use	65
School	Noisiest 1-hour period when in use	45 (external)
Child care centre[2]	Noisiest 1-hour period when in use	35 (internal) or 45 (external)

Note 1: The PSNL has been set as a $L_{eq,15min}$ in order to provide a conservative assessment. Where compliance is achieved over a 15 minute period is therefore implied it will occur over the day, evening or night period.

Note 2: Noise criteria for the child care is considered to be similar in nature to school classroom land use and assumes a 10 dB outside to inside correction, assuming windows are partially open.

5.1.2 Construction

Noise impacts from construction noise are assessed using the *Interim Construction Noise Guideline* (ICNG) (DECCW 2009) and the Transport for NSW *Construction Noise Strategy* (CNS) (TfNSW, 2013). The ICNG defines a noise management level for residential and other sensitive land uses. Above this level, feasible and reasonable mitigation should be considered to reduce noise levels.

Table 5-3 defines noise management levels (NML) as specified in the ICNG and how they are applied for residential receivers. NMLs are the level of noise above which receivers are considered to be ‘noise affected’. They are based on the measured RBL as defined in the INP plus an additional allowance of 10 dB during standard hours and 5 dB outside of standard hours.

Where construction noise levels are above 75 dBA at residential receivers during standard hours, they are considered ‘highly noise affected’ and require additional considerations to mitigate potential impacts.

Table 5-3 - Interim Construction Noise Guideline construction noise management levels for residential receivers and working hours

Time of day	NML $L_{eq,15min}$[1,2] dBA	How to apply
Recommended standard hours: **Monday–Friday** **7 am–6 pm** **Saturday 8 am– 1 pm** **No work on Sundays or public holidays**	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. - Where the predicted or measured $L_{eq,15min}$ dBA is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. - The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: - times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) - if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

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

Note 2: The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (INP) (EPA 2000).

Table 5-4 provides a summary of the applicable NMLs based on the background noise monitoring conducted. In addition, Table 5-5 lists the NMLs that have been adopted for non-residential sensitive receivers as required by the ICNG. A list of receivers and the corresponding representative background noise monitoring location is provided in Appendix A.

Table 5-4 - Construction noise management levels for residential receivers

Noise monitoring location	NML $L_{eq,15min}$			
	Day (SH)	Day (OOHW)	Evening (OOHW)	Night (OOHW)
BG1	55	50	50	48
BG2	54	49	45	40
BG3	59	54	49	40
BG4	57	52	53	50

Note: SH = Recommended standard working hours. OOHW = outside of recommended standard hours work as defined in Table 5-3.

Table 5-5 - Noise management levels at sensitive land uses (other than residences)

Land use	NML $L_{eq,15\ min}$ dBA (applies when properties are being used)
Industrial	75 (external)
Commercial	70 (external)
Child care centre[1]	55 (external)
School	55 (external)

Note 1: Based on the maximum recommended internal noise level as specified in AS 2107 Recommended design sound levels and reverberation times for building interiors. An external noise level has been specified based on an outside to inside correction of 10 dB, assuming windows are partially open for ventilation.

5.1.3 Sleep disturbance

Operational and construction noise during the night have the potential to disturb people's sleep patterns.

Guidance in the ICNG and INP Application Notes references further information in the RNP that discusses criteria for the assessment of sleep disturbance.

The RNP and the INP application notes suggest a screening level of $L_{1,1min}$ dBA, equivalent to the RBL + 15 dB. Where this level is exceeded, further analysis should be carried out. Section 5.4 of the RNP then goes on to state that:

- Maximum internal noise levels below 50 to 55 dBA would be unlikely to result in people's sleep being disturbed
- If the noise exceeds 65 to 70 dBA once or twice each night the disturbance would be unlikely to have any notable health or wellbeing effects.

The guidance within the RNP indicates that internal noise levels of 50 to 55 dBA are unlikely to cause sleep awakenings. Therefore at levels above 55 dBA, sleep disturbance would be considered likely. Assuming that receivers may have windows partially open for ventilation, a 10 dB outside to inside correction has been adopted as indicated in the INP. Therefore sleep disturbance screening criteria of RBL+15 dB and L_{max} 65 dBA have been adopted in this report.

5.1.4 Off-site road traffic

The project requires vehicle movements on the surrounding roads in addition to the construction of a new access road from Old Chittaway Road which would also provide an additional link between Enterprise Drive and Orchard Road for potential future use by local residents (subject to agreement with Wyong City Council).

The Road Noise Policy (RNP) has been used to assess both the noise from traffic generated by the project and the impact of the new access road.

Table 5-6 presents the road traffic noise criteria from the RNP for land use developments with a potential to create additional traffic on an existing road. The external noise criteria are applied one metre from the external facades of the affected building and at a height of 1.5 metres from the most affected storey.

Table 5-6 - Road Noise Policy assessment criteria

Road category	Type of project/land use	Day (7.00am to 10.00pm)	Night (10.00pm to 7.00am)
Collector/sub-arterial/arterial/freeway	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{eq,15hr}$ 60 dBA	$L_{eq,9hr}$ 55 dBA
	New road	$L_{eq,15hr}$ 55 dBA	$L_{eq,9hr}$ 50 dBA
Local road	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{eq,1hr}$ 55 dBA	$L_{eq,1hr}$ 50 dBA

In addition, the RNP application notes state that where an existing receiver is affected by a land use development, the increase in road traffic noise above the existing road noise level should be limited to 2 dBA. This applies where the existing noise level is either above or within 2 dBA of the criteria presented in Table 5-6.

5.2 Vibration

Vibration from construction and operation can lead to:

- Cosmetic and structural building damage.
- Loss of amenity due to perceptible vibration, termed human comfort.

Importantly, cosmetic damage is regarded as minor in nature; it is readily repairable and does not affect a building's structural integrity. Damage of this nature is typically described as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks, and separation of partitions or intermediate walls from load bearing walls. If there is no significant risk of cosmetic damage then structural damage is not considered a significant risk and is not further assessed.

5.2.1 Cosmetic building damage

There is currently no guidance in NSW specifically addressing cosmetic damage to buildings from vibration. Two international standards are typically referenced for the assessment of cosmetic damage in buildings; British Standard BS 7385-2: *1993 Evaluation and measurement for vibration in buildings* and German Standard *DIN 4150-3: 1999 Structural Vibration - Part 3: Effects of vibration on structure*

The guidance in the Transport for NSW *Construction Noise Strategy* (CNS) refers to BS 7385 for safe working distances to avoid cosmetic damage of buildings. The standard provides guidance on the 'evaluation and measurement of vibration in buildings' and defines guidance for categorising building damage in terms of 'cosmetic', 'minor' and 'major'; providing limits for each (refer to Table 5-7).

Table 5-7 - BS7385 Cosmetic damage criteria, peak component particle velocity, (mm/s [1])

Group	Type of structure	4–15 Hz	15–40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial or heavy commercial buildings		50	
2	Un-reinforced or light framed structures Residential or light commercial buildings	15 - 20[2]	20 - 50	50

Note 1: Values referred to are at the base of the building, on the side of the building facing the source of vibration (where feasible).
Note 2: At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

These peak vibration limits are set so that the risk of 'cosmetic' damage in residential or commercial buildings is minimal. They have been set at the lowest level above which damage has been credibly demonstrated. The limits also assume that the equipment causing the vibration is only used intermittently, however if the equipment is used continuously, then the limits may need to be reduced by up to 50 per cent. For 'minor' or 'major' vibrational damage to occur, the standard states that vibration need to be two times and four times (respectively for group 1 and group 2) the values shown in Table 5-7.

Guidance in BS 7385 also suggests that unless structurally unsound, heritage items should not be considered to be more sensitive than dwellings for the purposes of assessment.

Vibration limits given in DIN 4150 are more conservative than BS 7385 and specifically address heritage items as being more sensitive. Table 5-8 presents a summary of the vibration limits from DIN 4150.

Table 5-8 - Guideline values for short term vibration on structures (DIN 4150-3), guideline values for velocity, (mm/s)

Type of structure	1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz
Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20
Structures that, because of their particularly sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (for example heritage listed buildings).	3	3 to 8	8 to 10

In this assessment, the DIN 4150 limits have been adopted for residential and non-residential as they represent the more conservative limits.

5.2.2 Human comfort (amenity)

Table 5-9 presents the limits (vibration dose values) above which there is considered to be a risk that the amenity and comfort of people occupying buildings would be affected by construction work. The limits are taken from *Assessing Vibration: A Technical Guideline* (DEC, 2006).

Table 5-9 - Vibration limits (human exposure), Vibration dose value, $m/s^{1.75}$

Location	Assessment period	Preferred values	Maximum values
Critical areas	Day or night time	0.10	0.20
Residences	Daytime	0.20	0.40
Residences	Night time	0.13	0.26
Offices, schools, educational institutions, and places of worship	Day or night time	0.40	0.80
Workshops	Day or night time	0.80	1.60

6 Operational noise assessment

6.1 Assessment scenarios

6.1.1 Assessed noise sources

The maintenance facility is expected to have a number of activities take place that generate noise which has the potential to impact the surrounding receivers. The operational program has been based on the information provided in the *New Intercity Fleet Maintenance Facility Business Operational Requirements Document version 3.0 document 4608829_3* (Transport for NSW, 2015) and *New Intercity Fleet project Concept of Operations V1.1 document 4889032_2* (Transport for NSW, 2016).

The following operational activities are expected:

- During the day, five trains are expected to arrive at various times to be washed inside and out and then depart, taking approximately 30 minutes each.
- In the evening and night periods, three trains would arrive between 7.00pm and 2.00am to be retained overnight. The trains would leave between 4.00am and 7.00am in the morning.
- Maintenance is expected to occur in two periods between 9.30am and 3.00pm with the second period between 6.30pm and 1.30am with the trains departing between 5.00am and 7.00am.
- A wheel lathe facility is located on an external track. It has been assumed to have walls parallel to the track and a roof, with open ends for train entry and exit.
- A train wash is located on a dedicated track alongside the access tracks south of the maintenance shed and standing tracks. It is assumed to have solid walls and a roof with open ends for train entry and exit.
- All trains entering the facility on regular maintenance would go through the train wash. It is assumed that only one train can go through the train wash in any 15 minute period.
- Trains are prepared for service at least one hour before they are due to return to service. The preparation includes all services including air conditioning, inverters and compressors being active at full capacity during this time.
- Presentation or standard mode may be used for trains when they are undergoing internal cleaning. Based on the Asset Standards Authority, T-HR-RS-00100-ST RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards documentation, this has been based on a noise level 3 dB lower than when the trains are running at full capacity.
- An external graffiti cleaning facility is located on an external track, which is assumed to use a pressure washer.
- All maintenance including internal cleaning (but excluding external cleaning) is to be carried out inside the maintenance shed. The shed has been assumed to have an acoustic performance not less than 26 dB R_w and the doors are closed when not in use.
- Horn testing, of both the country and town horns.
- Use of the yard horn to warn operators when trains are due to start moving.
- Staff vehicles to utilise the car park travel on the internal roads to and from the car park.
- Occasional heavy vehicle deliveries to the facility.
- The New Intercity Fleet has not yet been selected and detailed noise emission information is yet not available. However based on discussion with Transport for NSW, the new train sets have been assumed to have similar noise sources, noise emission levels and dimensions to existing Waratah trains sets.
- The access from the Main North railway to the maintenance facility is limited to 70 kilometres per hour and the speed limit in the maintenance facility is 8 kilometres per hour. At 70 kilometres per hour the dominant noise source from the trains is the interaction between the rail and the train. At slower speeds such as 8

kilometres per hour the dominant noise sources are from fixed mechanical services on the train including the air conditioning units, static inverters and compressors.

- Examination of the current timetable indicates that two passenger trains pass the site in a typical 15 minute period. Therefore it has been assumed that two trains may arrive or depart the site in any 15 minute period.

The assessed scenarios are summarised in Table 6-1.

Table 6-1 - Operational noise scenarios

Scenario	Name	Description	Noise sources	Descriptor	Time of day
$L_{eq,15min}$	noise scenarios				
1	Train arrival	Two (2) trains arrive into yard, and travel into the maintenance shed in a 15minute period.	One train enters at 70 km/h and stops at train wash. Travels through train wash at 3.5 km/h then travels to shed at 8 km/h. Yard horn sounded at train wash and brake release at shed.	$L_{eq,15min}$	Three scheduled arrivals between 7.00pm and 2.00am. Five arrivals between 9.30am and 3.00pm for cleaning. As required arrivals for maintenance at any time of day.
2	Train departure	Two (2) trains depart from the maintenance shed and travel out of the yard in a 15 minute period. A yard horn external to the shed is used to alert operators when the train is moving off.	Train departs shed on 8m/h section using the yard horn for one second and a brake release at shed. Then travels on departure track on 70 km/h section. Maintenance shed operating.	$L_{eq,15min}$	Three departures are scheduled between 4.00am and 7.00am/ Five departures are scheduled between 9.30am and 3.00pm. Departures at any time as required from maintenance activities.
3	Train travels within facility to wheel lathe	Train travels to wheel lathe and is pulled through lathe by shunt vehicle	Train travels at 8km/h to wheel lathe. No services on train when pulled through lathe by shunt vehicle. Wheel lathe running. Maintenance shed in-use.	$L_{eq,15min}$	Day
4	Standing on roads 6 and 7	One (1) train leaves shed and travels to standing track. Two (2) trains standing on standing tracks 6 and 7, east of shed	Train leaves shed at 8km/h and stands with all on board systems running. Yard horn for one second and brake release. Maintenance shed in-use.	$L_{eq,15min}$	Day, evening and night
5	Prepare for return to service, standing on roads 1, 3 and 4	Three (3) trains on standing tracks outside shed with all services on.	Trains stand on standing track with on board systems running. Maintenance shed in-use.	$L_{eq,15min}$	Day, evening and night
6	Standing on roads 1, 3 and 4 with pantographs down	Three (3) trains stand on tracks outside shed with no services running.	Maintenance shed operating.	$L_{eq,15min}$	Day, evening and night
7	Standing on roads 1, 3 and 4 in presentation mode	Three (3) trains stand on tracks outside shed in presentation mode	Trains stand on standing track with on board systems running in presentation mode. Maintenance shed in-use.	$L_{eq,15min}$	Day, evening and night

Scenario	Name	Description	Noise sources	Descriptor	Time of day
8	External cleaning	Train is stationary whilst being washed with gurney on wash track	Stationary train in presentation mode on external wash track and gurney. Maintenance shed in-use.	$L_{eq,15min}$	Day
9	Car park activities	Shift change over car park activities. Up to 120 cars leave and enter the car park	Cars travelling on internal roads in and to car park. Engine starts and door slams for each vehicle. Maintenance shed in-use.	$L_{eq,15min}$	Day, evening and night
10	Substation	Substation operating continuously	Substation	$L_{eq,15min}$	Day, evening and night
L_{max}	**noise scenarios**				
11	Train on 70 km/h section	Maximum noise level associated with fast moving train	Maximum noise level from train at 70 km/h	$L_{max,15min}$	Day, evening and night
12	Country horn test	Horn test outdoors on standing tracks.	Country horn	$L_{max,15min}$	Day, evening and night
13	Broadband movement alarm	Broadband movement alarm used outdoors on standing tracks	Broadband movement alarm	$L_{max,15min}$	Day, evening and night
14	Brake test	Brake test outdoors on standing track in front of shed	Brake test	$L_{max,15min}$	Day, evening and night
15	Car park	Maximum noise events associated with car parking	Door slams and engine starts	$L_{max,15min}$	Day, evening and night
16	Substation	Maximum levels from circuit breakers triggering	Circuit breakers	$L_{max,15min}$	Day, evening and night

6.1.2 Other noise sources

The project is currently in the concept phase and therefore some details and specifications of activities and equipment are not known yet and therefore the noise emission cannot be fully quantified. The sources should be designed to reduce potential impacts on surrounding receivers when they are specified in the further detailed design stages of the project.

The shunt vehicle used to pull trains through the wheel lathe has currently not been specified and has not been included in the noise modelling. It is expected that this vehicle would be electrically powered. The facilities operator should during the equipment specification stage that the vehicle is capable of the meeting the INP criteria as set out in this report in combination with the rest of the facility's noise emission.

Specifications for vehicle movement alarm systems, mechanical plant (including a backup generator) and public address (PA) systems are not yet known. During the detailed design stages, these additional systems must be designed so that the noise emission combined with all other on site noise sources meet any development approval conditions.

The backup generator is expected to be used during emergencies only. As the generator would only be used in an emergency, it has not been considered as part of the INP assessment, however it should be considered further as part of the detailed design stage to minimise any noise impacts associated with emergency use of the generator.

A PA system can be fitted to include ambient noise sensing microphones which adjusts the level of the PA relative to the ambient noise level. The PA system should be designed to minimise the potential impact on surrounding residential receivers including restrictions on use, for example use only during the daytime and for emergencies only.

During the preparation of trains to re-enter service, a number systems tests would be undertaken. These are expected to include testing of doors opening and closing, audible door warning alerts and internal PA announcements. These tests may add additional noise sources to the preparation activities of trains. However details of these tests are not available until further selection and design of the trains is undertaken. As a result it is recommended that during the subsequent design stages of operational procedures and train specification, these noise sources are assessed to ensure train preparation activities can be suitably controlled to reduce potential impacts on surrounding residential receivers.

Wheel squeal is a high frequency tonal noise that is generated by the lateral slip of a wheel against the rail surface. It is typically generated on small radius curves, however misaligned axles or bogies can also generate wheel squeal. In some cases, wheels squeal can be in excess of 100 dBA at 15 metres from the track and the tonal nature of the noise makes it easily identifiable. However, the likelihood of wheel squeal occurring in the facility is considered low due to the low travelling speeds of the trains. Should wheel squeal occur, mitigation measures such as track friction modifiers should be implemented.

6.2 Noise modelling methodology

To assist with the noise assessment of the project, a three dimensional noise model was created using SoundPLAN version 7.4. The model accounts for the following:

- Digitised ground elevation contours in two metre interval for the terrain of the area surrounding the project site.
- Receivers were modelled at 1.5 metres above ground level for single storey buildings and free field receivers locations.
- Noise emission scenarios and sources associated with the maintenance facility as detailed in Sections 6.1 and 6.3.
- Ground coverage has been assumed to be soft ground and modelled with a 0.75 absorption co-efficient. Within the site boundary, ground absorption has been assumed to be 0.25 to account for hard surfaces.
- The maintenance building is assumed to be made of material with an acoustic insulation performance of 26 dB R_w. All shed doors have been considered closed during operations occurring inside the shed.
- The trains are assumed to move at 70 kilometres per hour on part of the access tracks as they leave and enter from the Main North railway, the yard speed is 8 km/h and trains travel at 3.5km/h through the train wash.
- Trains are 205 metres for long sets and 163 for short sets. The modelling has assumed 205 metres train length to allow a conservative assessment.
- When trains are in the trains wash, wheel lathe, external cleaning road and stationary on the standing tracks, all on board systems are assumed to be on.
- The brake release is assumed to occur when a trains starts or stops.
- Topography for site taken from available architectural drawings.
- Shift change overs are assumed to occur during the day, evening and night period.

The INP also requires an assessment to consider the effects of meteorology to enhance noise levels at receivers. Meteorological conditions such as wind blowing from source to receiver and temperature inversions can increase noise levels at receivers.

A temperature inversion is when the normal temperature gradient in the atmosphere is reversed, causing sound waves to refract back towards the ground and increasing noise levels at receivers. Temperature inversions occur on calm nights during winter in situations where the air close to the ground is cooler than the air further above the ground.

The Pasquill Gifford Stability Class is a method of describing the amount of turbulence prevalent in the atmosphere. The classes range from A being very unstable or turbulent to G being highly stable and are indicative of certain meteorological conditions occurring. Wind of up to 3 metres per second typically occurs in class D and a mild temperature inversion would typically occur during a class F condition with calm to low wind conditions.

The default INP meteorological conditions have been adopted for neutral and adverse wind and temperature inversion conditions as follows:

- Neutral conditions, Pasquill Gifford stability class D, no wind during the day, evening and night.
- Adverse wind conditions, Pasquill Gifford stability class D with three metres per second source to receiver wind during the day, evening and night.
- Adverse temperature inversion conditions, Pasquill Gifford stability class F with no wind during the evening and night.

Based on a review of the potential noise sources, adjustments for modifying factors as defined in INP Chapter 4 of the INP were not considered applicable.

6.3 Noise source levels

Table 6-2 presents the sound power levels used in the assessment. The source levels were taken from previous assessment and measurements of similar facilities and Transport for NSW specifications including:

- Asset Standards Authority, T-HR-RS-00100-ST RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards
- Asset Standards Authority, T-U-EN-0002-TI TfNSW Rail Noise Database
- Linfield substation noise and vibration assessment (SLR Consulting, July 2014)
- Noise and Vibration Technical Paper for Operations and Additional Construction Works (ref: NWRL 10046 R NO 00012 v1.0 EIS2 Operational NV SLR Consulting, 2012)
- Auburn Stabling Project – Noise and vibration assessment (ref: 10083-G, Wilkinson Murray Pty Ltd October 2010)
- New Intercity Fleet Maintenance Facility Business Operational Requirements Document Version 3.0 (ref: 4608829_3 TfNSW October 2015)

The directivities associated with the sources in Table 6-2 are presented in Table 6-3.

Table 6-2 – Indicative operational noise sources sound power levels

Source	Sound Power Level dBA	Location
Train travelling at 70 km/h	110 L_E	Sound exposure level. Noise source is train's interaction with rail.
Train passby at 70 km/h	115 L_{max}	Noise source is train's interaction with rail. 107 dBA with a +6 dB correction for travelling over turnouts and crossovers
Air conditioning units	82 $L_{eq,15min}$	Two (2) units per car, located on top of the trains
Static inverter	83 $L_{eq,15min}$	Two (2) units per four car train, located on top of the train
Air compressor	87 $L_{eq,15min}$	Located underneath train
Train Wash	84 (75) $L_{eq,15min}$	Train wash facades. Number in brackets is breakout noise radiating from the sheet steel façade through wash sides. 84 dBA represents sound power level through open ends
Wheel Lathe	93 $L_{eq,15min}$	Located underneath train in housing
Brake release/test	105 L_{max}	At end of train underneath
Country Horn	133 L_{max}	At end of train underneath
Yard horn	110 L_{max}	At end of train underneath
General workshop	105 $L_{eq,15min}$	Inside maintenance shed
Car door slam	100 L_{max}	At car parking space
Car engine start	90 L_{max}	At car parking space
Car travelling at 40km/h	65 $L_{eq,15min}$	In car park
Substation[1]	85 $L_{eq,15min}$	Substation
Substation circuit breakers	118 L_{max}	Substation

Note 1: The substation includes a +5 dB penalty in accordance with Section 3 of the INP for the tonal and low frequency noise emission typical of this equipment. The noise emission of the substation is dominated by a 100Hz tone.

Table 6-3 - Source directivities, adjustment by angle (dBA)

Location of source	0°	45°	90°	135°	180°	Notes
top of train	0	0	0	-9	-15	0 degrees is defined straight up from top of train
bottom of train	-12	-5	0	-5	-12	0 degrees is defined as perpendicular to the track
Country horn[1]	0	-4.5	-8	-10	-11	0 degrees is parallel with the track
Yard horn[1]	0	-4	-8.5	-12.5	-15	0 degrees is parallel with the track

Note 1: directionalities of the country and yard horn have been taken from Asset Standards Authority, T-HR-RS-00100-ST RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards

6.4 Predicted noise levels

Predicted $L_{eq,15min}$ noise levels (scenarios 1 to 10) produced using the assumptions in Section 6.1 without mitigation are presented in Table 6-4 and Table 6-5 for neutral and adverse meteorological conditions. Predictions for all considered receivers are presented in Appendix C.

Noise contour maps of indicative predicted noise levels without mitigation under neutral conditions are presented in Appendix D. The indicative noise contour maps are predicted at a height of 1.5 metres and with a grid spacing of 20 meters.

Table 6-4 - Predicted operational noise levels for each scenario, $L_{eq,15min}$ dBA neutral meteorological conditions (without mitigation)

Receiver	Criteria												
	Day	Evening	Night	1	2	3	4	5	6	7	8	9	10
12 Ourimbah Road	49	42	40	40	**41**	40	**41**	**42**	27	39	28	28	29
19 Ourimbah Road	49	42	40	38	38	38	38	*45*	29	**42**	30	31	22
15 Schubolt Lane	49	42	40	35	32	31	29	31	20	28	28	21	20
16 Turpentine Road	49	42	40	37	31	23	24	25	<20	22	23	<20	<20
26 Turpentine Road	49	42	40	**42**	35	28	27	28	<20	25	26	<20	<20
50 Orchard Road	49	42	40	33	33	32	33	38	29	36	29	31	<20
54 Orchard Road	49	42	40	32	32	32	32	38	29	35	30	32	<20
62 Orchard Road	49	42	40	32	32	31	32	37	29	35	29	32	<20
72 Orchard Road	49	42	40	31	31	31	31	35	30	33	30	33	<20
80 Orchard Road	49	42	40	30	30	30	30	34	29	32	29	31	<20
127 Old Chittaway Road	54	40	38	34	34	34	34	35	22	32	32	23	32
130 Old Chittaway Road	54	40	38	**39**	**39**	**39**	**39**	38	24	35	33	25	**40**
141 Old Chittaway Road	54	40	38	33	33	33	35	35	23	32	32	23	30
149 Old Chittaway Road	54	40	38	33	33	33	36	37	26	35	35	26	27
150 Old Chittaway Road	54	40	38	36	36	36	**39**	**40**	27	38	37	27	32
157 Old Chittaway Road	54	40	38	31	30	30	31	31	<20	28	22	<20	27
161 Old Chittaway Road	54	40	38	28	28	28	32	32	22	30	31	22	21
165 Old Chittaway Road	54	40	38	33	33	33	38	38	28	36	38	28	20
170 Old Chittaway Road	54	40	38	36	36	36	*45*	*42*	32	**40**	48	32	21
3 Station Road	54	40	38	30	30	30	35	35	25	32	35	26	<20
7 Station Road	54	40	38	28	28	28	34	33	24	30	36	24	<20
16 Station Road	54	40	38	31	31	31	**39**	36	28	33	41	28	<20
11 Station Road	54	40	38	31	30	30	37	35	27	33	39	27	<20
11 Enterprise Drive	54	40	38	**40**	37	21	22	23	<20	20	21	<20	<20
21 Enterprise Drive	54	40	38	38	36	<20	<20	20	<20	<20	<20	<20	<20
14 Enterprise Drive	54	40	38	**40**	37	20	21	22	<20	<20	20	<20	<20
16 Enterprise Drive	54	40	38	38	36	<20	20	21	<20	<20	20	<20	<20
98 Old Chittaway Road	45	45	45	39	38	38	34	32	20	29	30	21	24
10 Catamaran Road	45	45	45	26	26	26	35	29	25	28	37	25	<20

Note: Exceedances of the night criteria only are highlighted in grey with bold text;
Exceedances of both the evening and night criteria are highlighted in blue with italic text;
Exceedances of all three day, evening and night criteria are highlighted in green with underlined text.
Scenario 8 only occurs during the daytime and has not been assessed in the evening and night period.

Table 6-5 - Predicted operational noise levels for each scenario, $L_{eq,15min}$ dBA adverse meteorological conditions (without mitigation)

Receiver	Criteria												
	Day	Evening	Night	1	2	3	4	5	6	7	8	9	10
12 Ourimbah Road	49	42	40	**42**	**42**	**42**	**42**	*44*	29	**42**	31	31	31
19 Ourimbah Road	49	42	40	40	40	40	40	*46*	30	*44*	31	33	25
15 Schubolt Lane	49	42	40	38	36	34	33	35	23	32	33	24	23
16 Turpentine Road	49	42	40	39	35	27	28	29	<20	27	28	<20	<20
26 Turpentine Road	49	42	40	*43*	38	31	31	32	21	30	31	22	<20
50 Orchard Road	49	42	40	36	36	35	36	**42**	30	39	31	34	<20
54 Orchard Road	49	42	40	34	34	34	34	**41**	30	38	31	35	<20
62 Orchard Road	49	42	40	34	34	34	34	40	30	38	31	35	<20
72 Orchard Road	49	42	40	33	33	33	33	38	30	36	31	36	<20
80 Orchard Road	49	42	40	32	32	32	32	37	29	35	30	34	<20
127 Old Chittaway Road	54	40	38	37	36	37	37	38	25	35	36	25	33
130 Old Chittaway Road	54	40	38	**40**	**40**	**40**	*41*	*41*	26	38	38	27	**40**
141 Old Chittaway Road	54	40	38	36	36	36	38	**39**	25	36	37	26	32
149 Old Chittaway Road	54	40	38	36	36	36	**39**	**40**	27	38	40	28	30
150 Old Chittaway Road	54	40	38	38	38	**39**	*41*	*43*	28	**40**	41	29	33
157 Old Chittaway Road	54	40	38	33	33	33	33	35	<20	32	26	<20	29
161 Old Chittaway Road	54	40	38	32	32	31	35	36	24	33	36	25	24
165 Old Chittaway Road	54	40	38	35	35	35	**40**	*41*	29	38	42	29	22
170 Old Chittaway Road	54	40	38	38	38	38	*47*	*45*	33	*42*	51	33	24
3 Station Road	54	40	38	33	33	33	38	38	27	36	40	27	<20
7 Station Road	54	40	38	32	32	31	37	36	26	34	40	26	21
16 Station Road	54	40	38	33	33	33	*41*	**39**	29	36	45	29	<20
11 Station Road	54	40	38	33	33	33	**39**	**39**	28	36	43	28	21
11 Enterprise Drive	54	40	38	*42*	**39**	25	27	28	<20	25	26	<20	<20
21 Enterprise Drive	54	40	38	**40**	38	22	24	25	<20	22	23	<20	<20
14 Enterprise Drive	54	40	38	*42*	**39**	24	26	27	<20	24	25	<20	<20
16 Enterprise Drive	54	40	38	*41*	38	24	25	26	<20	24	25	<20	<20
98 Old Chittaway Road	45	45	45	40	39	39	37	36	23	33	34	24	26
10 Catamaran Road	45	45	45	27	28	28	38	32	26	30	41	26	<20

Note: Exceedances of the night criteria only are highlighted in grey with bold text;
Exceedances of both the evening and night criteria are highlighted in blue with italic text;
Exceedances of all three day, evening and night criteria are highlighted in green with underlined text.
Scenario 8 only occurs during the daytime and has not been assessed in the evening and night period.

6.4.1 Maximum noise events

Predicted L_{max} noise levels (scenarios 11 to 15) using the assumptions in Section 6.1 without mitigation are presented in Table 6-6 and Table 6-7 for neutral and adverse meteorological conditions.

Noise contour maps of indicative predicted maximum noise levels without mitigation under neutral conditions are presented in Appendix D. As maximum noise levels were modelled at a number of locations across the facility, the maps present maximum extent of the noise levels modelled at all assessed locations. The indicative noise contour maps are predicted at a height of 1.5 metres and with a grid spacing of 20 meters.

Table 6-6 - Predicted operational noise levels for scenarios 9 to 13, L_{max} dBA neutral meteorological conditions (without mitigation)

Receiver	Criteria							
	RBL+15	RNP	11	12	13	14	15	16
12 Ourimbah Road	55	65	36	**71**	51	47	31	**59**
19 Ourimbah Road	55	65	41	**68**	50	46	37	52
15 Schubolt Lane	55	65	53	**63**	45	33	20	51
16 Turpentine Road	55	65	**57**	**59**	40	20	<20	44
26 Turpentine Road	55	65	**61**	**62**	45	26	23	49
50 Orchard Road	55	65	40	**61**	46	40	37	44
54 Orchard Road	55	65	38	**60**	44	38	38	47
62 Orchard Road	55	65	37	**60**	37	32	37	46
72 Orchard Road	55	65	36	**59**	35	30	37	45
80 Orchard Road	55	65	36	**58**	35	28	37	45
127 Old Chittaway Road	53	65	38	**63**	44	37	28	**58**
130 Old Chittaway Road	53	65	**54**	**66**	50	40	30	**70**
141 Old Chittaway Road	53	65	49	**62**	44	37	28	**60**
149 Old Chittaway Road	53	65	46	**63**	45	40	30	**60**
150 Old Chittaway Road	53	65	46	**65**	47	43	31	**62**
157 Old Chittaway Road	53	65	47	**61**	42	36	28	**58**
161 Old Chittaway Road	53	65	44	**59**	40	32	26	53
165 Old Chittaway Road	53	65	34	**62**	44	38	30	47
170 Old Chittaway Road	53	65	42	**65**	47	43	34	53
3 Station Road	53	65	42	**60**	43	35	29	52
7 Station Road	53	65	40	**58**	41	32	27	49
16 Station Road	53	65	38	**59**	37	36	30	45
11 Station Road	53	65	40	**59**	42	33	29	50
11 Enterprise Drive	53	65	**65**	**57**	40	<20	20	40
21 Enterprise Drive	53	65	**65**	**56**	39	<20	<20	39
14 Enterprise Drive	53	65	**64**	**55**	38	<20	<20	39
16 Enterprise Drive	53	65	**64**	**54**	36	<20	<20	37

Note: Exceedances of the RBL+15 dB criteria are highlighted in grey with bold text and exceedances of the 65 dBA criteria are highlighted in green with underlined text.

Table 6-7 - Predicted operational noise levels for scenarios 9 to 13, L_{max} dBA adverse meteorological conditions (without mitigation)

Receiver	Criteria							
	RBL+15	RNP	11	12	13	14	15	16
12 Ourimbah Road	55	65	42	**_72_**	51	49	32	**61**
19 Ourimbah Road	55	65	46	**_68_**	50	48	38	**56**
15 Schubolt Lane	55	65	**57**	**64**	46	35	21	54
16 Turpentine Road	55	65	**61**	**60**	41	22	<20	48
26 Turpentine Road	55	65	**64**	**63**	46	28	24	53
50 Orchard Road	55	65	46	**62**	47	42	38	47
54 Orchard Road	55	65	43	**61**	45	40	38	50
62 Orchard Road	55	65	43	**60**	37	34	38	50
72 Orchard Road	55	65	42	**60**	36	32	38	48
80 Orchard Road	55	65	41	**58**	36	30	38	49
127 Old Chittaway Road	53	65	42	**63**	45	39	29	**60**
130 Old Chittaway Road	53	65	**58**	**_66_**	50	42	30	**_70_**
141 Old Chittaway Road	53	65	**54**	**62**	44	39	29	**62**
149 Old Chittaway Road	53	65	51	**64**	45	42	30	**62**
150 Old Chittaway Road	53	65	51	**_66_**	47	45	32	**64**
157 Old Chittaway Road	53	65	51	**62**	43	38	28	**60**
161 Old Chittaway Road	53	65	49	**59**	41	34	27	**56**
165 Old Chittaway Road	53	65	39	**62**	45	40	31	50
170 Old Chittaway Road	53	65	47	**65**	47	45	35	**56**
3 Station Road	53	65	47	**61**	43	37	29	**55**
7 Station Road	53	65	46	**58**	41	34	28	53
16 Station Road	53	65	43	**60**	38	38	30	48
11 Station Road	53	65	45	**60**	43	35	30	**54**
11 Enterprise Drive	53	65	**_66_**	**57**	41	<20	20	44
21 Enterprise Drive	53	65	**_66_**	**57**	40	<20	<20	43
14 Enterprise Drive	53	65	**65**	**56**	38	<20	<20	43
16 Enterprise Drive	53	65	**_66_**	**54**	36	<20	<20	41

Note: Exceedances of the RBL+15 dB criteria are highlighted in grey with bold text and exceedances of the 65 dBA criteria are highlighted in green with underlined text.

6.5 Assessment of predicted noise levels

6.5.1 Operational activities

The predicted noise levels indicated that noise levels would not exceed the day time noise criteria, however a number of the closest receivers were predicted to experience noise levels in excess of the $L_{eq,15min}$ criteria during either the evening or night. These receivers are as follow:

- 12, 19 Ourimbah Road
- 26 Turpentine Road
- 50, 54 Orchard Road
- 11, 14, 16, 21 Enterprise Drive
- 96, 130, 141, 149, 150, 165, 170 Old Chittaway Road
- 11, 16 Station Road.

The predicted $L_{eq,15min}$ noise levels indicate the following:

- Scenarios 1, 4, 5 and 7 have the highest predicted impacts. Scenario 5 has the highest predicted impact with exceedances of the evening and night criteria by up to 5 dB and 7 dB respectively.
- The potentially most affected receiver is 12 Ourimbah Road where the night criteria are exceeded in scenarios 1, 2, 3, 4, 5 and 7. Both the evening and night criteria are exceeded in scenario 5 under adverse conditions. The largest exceedance was predicted to be 4 dB under adverse conditions for scenario 5.
- Other potentially affected receivers include 26 Turpentine Road, 19 Ourimbah Road, 150 and 170 Old Chittaway Road and 11 and 14 Enterprise Drive which were predicted to experience exceedances of the evening and night criteria by between 1 and 7 dB.
- Noise levels generally increase between 2 to 3 dB during adverse wind and temperature inversion conditions. The effect of adverse conditions causes additional exceedances of the evening period at 26 Turpentine Road, 11, 14 and 16 Enterprise Drive, 12 and 19 Ourimbah Road, 150, 165 and 170 Old Chittaway Road and 16 Station Road.
- The train wash facility impacts 26 Turpentine Road with a predicted exceedance during the night period and in the evening period under adverse conditions.
- Noise impacts are not expected when trains are powered down and when the maintenance shed is in-use with the doors closed.
- The substation is expected to exceed the INP criteria only at the nearest receiver 130 Old Chittaway Road during the night period.
- External cleaning only takes places during the day and is not expected to cause an exceedance of the INP criteria during the day.
- The predicted noise levels indicate that the school at 10 Catamaran Road and the child care centre at 98 Old Chittaway Road are not expected to experience noise levels in excess of the INP criteria due to the project

Analysis of the predicted noise levels indicated that the most dominant noise sources impacting at the identified receivers are:

- Standing trains on the standing tracks outside the maintenance shed and on the standing tracks to the south of the maintenance shed.
- Train wash.
- Trains entering and exiting the facility
- Rail movements on the 70 kilometres per hour section.
- Substation.

Receivers on Ourimbah Road and Orchard Road are generally impacted by the standing trains on the tracks outside of the maintenance shed during the evening and night.

Further south, receivers on Turpentine Road are impacted by the movement of trains on the 70 kilometres per hour section during the night and trains going through the train wash as well as the train wash itself.

On the other side of the Main North railway, the receivers on Old Chittaway Road opposite the maintenance facility are primarily impacted by the standing trains and external cleaning during the evening and night.

Where the predicted level of exceedances are within 2 dB or less of the criteria, the exceedance is considered marginal as typically a difference in noise level of 2 dB or less is not typically considered to be perceptible.

For receivers in the south of the project on Enterprise Drive, the noise sources from the facility are associated with trains entering and exiting the main line which are likely to be similar in nature to those already experienced due to existing rail movements on the Main North railway and are therefore considered unlikely to cause additional impacts.

As a result of the predicted exceedances, noise mitigation and management measures are recommended and further analysis of these is provided in Section 6.6.

6.5.2 Maximum noise events

The predicted noise levels of maximum noise events from horns, broadband alarms and car park activities indicate that the most dominant events are country horn testing and trains passing on the 70 kilometres per hour section.

The country horn tests exceeded the criteria at all of the closest receivers under adverse meteorological conditions by up to 22 dB above the RBL + 15 criteria. Receivers 12 and 19 Ourimbah Road, 11, 21 and 16 Enterprise Drive and 130 and 150 Old Chittaway Road were predicted to experience external noise levels of 66 dBA or above under adverse conditions.

The trains travelling on the 70 kilometres per hour section also indicated exceedances of the sleep disturbance criteria were predicted at receivers on Old Chittaway Road at the south of the project, Schubolt Lane and Turpentine Road.

For receivers in the south of the project on Enterprise Drive, the noise sources from the facility are associated with trains entering and exiting the main line and are likely to be similar in nature to those already experienced due to existing rail movements on the Main North railway and are therefore considered unlikely to cause additional impacts.

The substation is predicted to generate maximum noise levels of up to 70 dBA at 130 Old Chittaway Road and exceed the RBL + 15 dB criteria at a number of the surrounding receivers. The maximum noise events from substation are related to switches and do not occur on a regular basis. However, mitigation should be considered for this item to reduce potential noise impacts.

The maximum noise levels presented in Table 4-4 indicate that receivers are already exposed to maximum noise levels in excess of the sleep disturbance criteria. The predicted noise levels are of a similar level to those measured on site and as a result, maximum noise levels associated with train passbys are not expected to cause additional adverse impacts above those already caused by the Main North railway given that they are of a similar character and noise level.

The additional guidance contained within the RNP, indicates that sleep disturbance impacts are considered likely where external noise levels are above 65 dBA. Therefore whilst there are a number of exceedances of the RBL + 15 dBA criteria, mitigation should prioritised for those receivers where the RNP guidance level of 65 dBA is exceeded.

6.6 Noise mitigation and management

The predicted noise levels indicate exceedances of the L_{eq} and L_{max} noise levels are expected at the closest receivers to the project. As a result, mitigation measures have been investigated to reduce the potential noise impact of the project, primarily from:

- Standing of trains in the facility
- Train entry and exit from the Main North railway
- Maximum noise levels associated with horn use
- The substation
- The train wash.

The mitigation measures were investigated in the preference order of at the source, along the propagation path and finally at the receiver. The adoption of mitigation measures would be subject to further detailed design and where reasonable and feasible.

6.6.1 Operational noise and vibration management plan

An operational noise and vibration management plan would be developed for the site. It is considered that this plan would further develop reasonable and feasible mitigation strategies for the identified activities and sources that contribute to exceedances of the L_{eq} and sleep disturbance criteria.

The train supplier, operator and maintenance contractor should develop the operational noise and vibration management plan so that activities and noise sources associated with the facility are able to meet the environmental noise and vibration objectives as described in this report.

A detailed review of the operational pattern of all identified dominant noise source should be undertaken as part of the detailed design stage to determine if any operational changes can be implemented to reduce the potential noise impact.

Management measures could include:

- Management of the location, time of day and manner in which activities are carried out.
- Modifying operating procedures to reduce noise intensive activities during the evening and night at locations exposed to receivers.
- Specifying noise emission limits for certain equipment or activities.
- Developing further the mitigations strategies outlined in this report.

6.6.2 Substation

The substation noise emission was predicted to exceed the night criteria at the closest receiver and therefore requires investigation of mitigation. Mitigation for the substation would include designing a building/enclosure with an appropriate sound insulation performance so that the INP criteria are met at the nearest receiver. This will be addressed as part of the detailed design process.

6.6.3 Maintenance shed

The maintenance shed has been assumed to be constructed of panelling with an estimated performance of 26 dB R_w for the walls and the roof with all doors closed when activities are occurring inside.

The noise emission of the shed has been modelled using these specifications in order to reduce the predicted impact at sensitive receivers. An acoustic insulation performance of 26 dB R_w could be achieved by panelling such as 6mm Alucobond or a product of equivalent acoustic performance. A fast acting roller door or similar system should also be considered to allow shed doors to be closed quickly.

6.6.4 Use and testing of horns

The country horn test is the most dominant source and alternatives to testing or use of the country horn at the site project should be considered. This could include testing horns elsewhere on the network or developing alternative testing techniques. These measures should be developed as part of further stages of the development in the detailed design phase and as part of the operational noise management plan for the site.

The yard horn (train movement alarm system) was not predicted to exceed the sleep disturbance criteria at any of the assessed residences. However, experience with other maintenance facilities and stabling yards indicates that the noise produced can be a source of annoyance for nearby sensitive receivers. As a result, it is recommended that as part of the detailed design, alternative systems are investigated for vehicle movement alarms. Alternative systems similar to those implemented at other rail facilities could include visual alarms and ground based warning systems.

6.6.5 Train movements and standing activities

The sources which contribute to exceedances from train movements and standing trains are located on the access tracks, standing tracks outside the shed and on tracks 6 and 7.

Standing trains such as those preparing for service are predicted to cause exceedances at receivers both north and south of the project on Old Chittaway Road and Ourimbah Road.

Train arrivals and departures are predicted to cause exceedance of the L_{eq} and sleep disturbance criteria at receivers on Old Chittaway Road, Turpentine Road and Enterprise Drive.

The site layout is constrained by the location of the rail line relative to the receivers. The maintenance shed provides shielding to receivers to the north of the facility. Further opportunities to provide shielding from onsite buildings is not feasible due to the constraints from the location of the rail line and available land.

The final design of the New Intercity Fleet has not yet been selected, however it is expected that the new fleet would produce similar noise levels to those specified in Section 6.3, comply with the limits specified in the Asset Standards Authority, T-HR-RS-00100-ST RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards and be able to meet the environmental noise objectives at the nearest sensitive receivers at maintenance facilities.

When the new trains are selected noise emission levels should be confirmed to ensure that the noise sources, location and emission levels do not significantly differ from those presented in this report and are able to meet the environmental noise objectives outlined in this report when operating in the maintenance facility. Where significant differences occur, additional assessment should be carried out.

The impact from on board services on standing trains could be reduced by either standing trains with the pantographs down or by using trains in presentation mode. However whilst, this may reduce noise levels in some situations, it does not remove the need for trains to stand with all systems running whilst preparing to return to service or just after they come off service.

Trains cannot prepare for scheduled return to service inside the shed as this would be used for other maintenance activities. Therefore noise barriers have been considered to reduce impacts at receivers. Noise barriers are discussed further in Section 6.6.6.

6.6.6 Noise barriers

Noise barriers have been considered to reduce noise levels from train arrivals and departures in addition to standing trains.

Stationary train sources such as the air conditioning units and static inverters are elevated at approximately four metres high and therefore a barrier in excess of four metres would be required to provide a noise reduction. Barriers can typically be in the form of earth bunds, dedicated barriers or a mix of the two. The design and suitability of barriers would be determined at detailed design stage.

The effect of barriers along the access track has been considered. However barriers along the length of the access tracks are not considered feasible due to risks associated with drainage and flooding. In addition, barriers next to the rail corridor have the potential to cause reflections that are likely to increase the noise levels from existing rail movements at the receivers opposite on Enterprise Drive and Old Chittaway Road and result in relatively small noise reductions in noise from the facility at a limited number of receivers.

In addition, from discussions with Transport for NSW it is also understood that it is not feasible to locate a barrier on the eastern side of the facility near the standing tracks due to constraints from the Main North railway and therefore barriers to reduce noise levels at 130, 150 and 170 Old Chittaway Road have not been considered.

Mitigation for these receivers where barriers are not feasible should focus on operational activity management and at property treatments where necessary.

In consideration of this, barriers were investigated to reduce noise levels from standing trains and the train wash. Barriers were considered on the western side of the standing tracks outside of the shed and at the train wash. Indicative locations of the barriers are presented in Figure 6-1.

Analysis of the contributions of the predicted noise levels indicated that the air conditioning units and the north east exit of the train wash were the primary contributors to the exceedances at receivers. As a result, barriers were considered at five metres next to the standing tracks in front of the maintenance shed and at the train wash to the full height of the train wash to block line of sight from the sources to the receivers.

The barrier for the standing tracks was modelled as an earth berm at four metres high with a one metre barrier on top of the berm. Earth berms that are vegetated are typically acoustically absorbent and have the potential to reduce the effect of reflections. At locations where earth berms cannot be used, the noise barriers implemented should be acoustically absorptive on the side facing the noise sources.

Horns, brakes, compressors and rail noise are all located at the bottom of the train and the barriers can be more effective for these sources at lower height. However, under adverse meteorological conditions, the effect of barriers can be significantly reduced.

Using these barriers, noise levels were predicted for scenarios 1 and 5 which represent the highest impact for receivers on Ourimbah Road and Turpentine Road from train movements and standing trains. The predicted results of the mitigated scenarios are presented in Section 6.6.9.

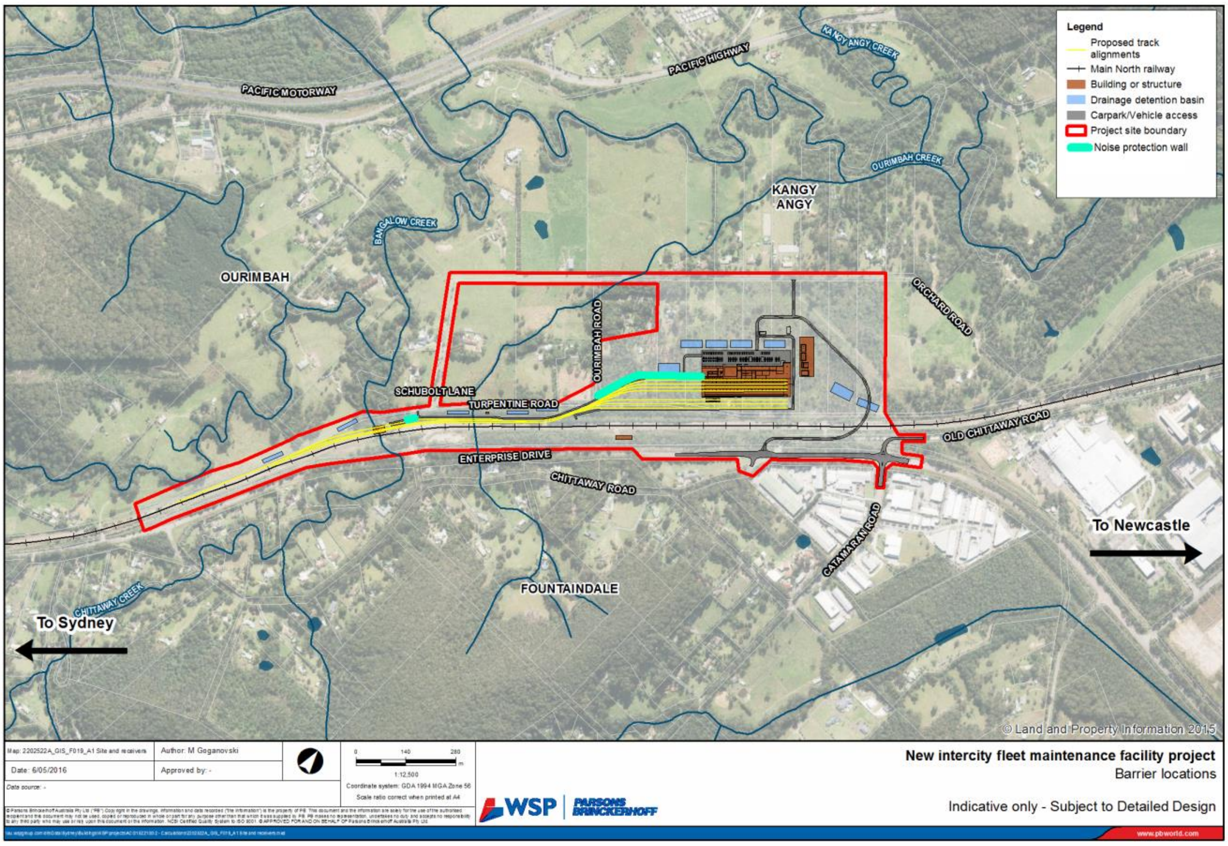

Figure 6-1 - Indicative barrier layout

6.6.7 Controls at sensitive receivers

Provision of noise control at the receiver is the least preferred option for noise mitigation. Controls at the source and the propagation path are preferable to treatments applied to individual receivers.

This type of treatment usually forms the final resolution should other mitigation options not be appropriate or sufficient in mitigating the noise impact. This typically involves providing architectural upgrades at the dwellings such as sealing windows and doors, providing mechanical ventilation and façade upgrades. However, these controls only improve amenity inside the dwelling and do not reduce noise impacts outside.

This type of mitigation can be effective where sleep disturbance impacts are predicted after noise control at the source and along the transfer path have been investigated. The adoption of treatments at residential receivers would be subject to further consideration as part of the detailed design process.

6.6.8 Mitigation summary

To conclude, the following mitigation and management measures are recommended for consideration to assist in the reduction of noise impacts from the maintenance facility where reasonable and feasible:

- Development of an operational noise and vibration to include management strategies developed by the train and maintenance facility operators contained designed to meet the environmental noise objectives for the project and include:
  - Alternative methodologies for horns, warning signals and horn testing at the facility.
  - Standing of trains outside of the shed and on tracks 6 and 7 during the evening and night period.

    - Restrictions on external cleaning during the evening and night period.
    - Strategies to control noise sources described in Section 6.1.2.
- During the detailed design stage, all mobile and fixed noise sources and activities forming the overall operation of the project should be designed to meet the environmental noise objectives of the project.
- Noise mitigation for sources discussed in Section 6.1.2 should be addressed at detailed design to ensure they meet the environmental noise objectives of the project.
- The maintenance shed should be constructed to achieve a sound insulation performance no less than 26 dB R_w.
- Design of an acoustic enclosure or insulation for the substation so that it can meet its environmental noise objectives.
- The maintenance shed doors should remain closed when activities are occurring inside the shed.
- A barrier of five metres high above the track along the standing tracks east of the maintenance shed. The side of the barrier facing the noise sources should be acoustically absorptive or the barrier should include a combination of a vegetated earth berm and barrier.
- Noise barriers should be solid and continuous with no gaps between the ground and barrier and between barrier panels. Barriers should be constructed of a material with a surface density of at least 12 kilograms per square metre.
- A barrier to the full height of the train wash which extends to fully block line of sight from the train wash exit to 26 Turpentine Road.
- Where noise levels are greater than those listed in Table 6-2 or their locations differ significantly from those assessed in this report, additional assessment should be carried out.

6.6.9 Predicted noise levels with mitigation

The scenarios with the highest potential impact on L_{eq} noise levels were used to predict noise levels with the implementation of mitigation. The noise model described in Section 6.2 was used with the described barriers for scenarios 1 and 5 which have the potentially largest impact on L_{eq} noise levels. Table 6-8 provides a summary of the predicted L_{eq} noise levels under neutral and adverse metrological conditions.

The predicted L_{eq} noise levels with mitigation indicated the following outcomes:

- The predicted noise levels indicate that noise levels could be reduced by up to 3 dB for receivers on Ourimbah Road affected by standing trains and reduced the exceedance at 19 Ourimbah Road to within 2 dB above the criteria.
- In addition, using this combination of barriers, noise levels were reduced by up to 3 dB at 26 Turpentine Road indicating that the criteria could be met at this location using a barrier to shield train wash noise.

Table 6-8 - Predicted mitigated operational noise levels for scenarios 1 and 5 for $L_{eq,15min}$ dBA neutral and adverse meteorological conditions

Receiver	Criteria			Neutral 1	Adverse 1	Neutral 5	Adverse 5
	Day	Evening	Night				
12 Ourimbah Road	49	42	40	39	40	39	**41**
19 Ourimbah Road	49	42	40	35	37	**41**	**42**
15 Schubolt Lane	49	42	40	34	36	31	34
16 Turpentine Road	49	42	40	37	38	24	28
26 Turpentine Road	49	42	40	39	40	28	31
50 Orchard Road	49	42	40	32	34	37	39
54 Orchard Road	49	42	40	31	33	36	38
62 Orchard Road	49	42	40	31	33	36	38
72 Orchard Road	49	42	40	31	32	34	36
80 Orchard Road	49	42	40	30	31	33	35
127 Old Chittaway Road	54	40	38	35	36	35	38
130 Old Chittaway Road	54	40	38	**39**	**40**	38	**40**
141 Old Chittaway Road	54	40	38	33	35	36	38
149 Old Chittaway Road	54	40	38	33	35	38	**40**
150 Old Chittaway Road	54	40	38	36	38	*41*	*43*
157 Old Chittaway Road	54	40	38	31	33	32	34
161 Old Chittaway Road	54	40	38	29	31	33	35
165 Old Chittaway Road	54	40	38	33	35	**39**	*41*
170 Old Chittaway Road	54	40	38	37	38	*43*	*45*
3 Station Road	54	40	38	31	33	35	38
7 Station Road	54	40	38	29	31	33	36
16 Station Road	54	40	38	31	33	36	38
11 Station Road	54	40	38	31	33	36	38
11 Enterprise Drive	54	40	38	**40**	*41*	23	27
21 Enterprise Drive	54	40	38	38	**39**	20	24
14 Enterprise Drive	54	40	38	**40**	*41*	22	26
16 Enterprise Drive	54	40	38	38	**40**	21	25
98 Old Chittaway Road	45	45	45	39	40	32	35
10 Catamaran Road	45	45	45	26	27	30	33

Note: Exceedances of the night criteria are highlighted in grey with bold text, exceedances of the evening criteria are highlighted in blue with italic text and exceedances of the day criteria are highlighted in green with underlined text.

6.6.10 Residual impacts

Residual impacts have been identified where there is exceedance of the criteria after the identified barriers described in Section 6.6.9 have been implemented.

The mitigation suggested in this report should be confirmed during the detailed design stage of the project when further details become available and where reasonable and feasible for implementation.

The predicted L_{eq} noise level results with the mitigation summarised in Section 6.6.8 indicate that the following receivers would still be impacted by noise levels above the assessment criteria:

- 12 and 19 Ourimbah Road, especially under adverse meteorological conditions.
- 130, 150, 165 and 170 Old Chittaway Road
- 11, 14,16 and 21 Enterprise Drive

The predicted noise levels indicate the following:

- Residual impacts from standing trains and train movements in the facility are still expected during the evening and night where barriers are implemented.
- The predicted noise levels with the mitigation at the train wash indicated that a barrier at the train wash could be expected to reduce noise levels to within the INP criteria at 26 Turpentine Road.
- Maximum noise levels from trains arriving and departing were still predicted to impact receivers on Enterprise Drive and Old Chittaway Road.

There are limited options to further control arrival, departure and train standing noise events at receivers on Enterprise Drive and Old Chittaway Road due to restrictions associated with the Main North railway. It is considered that whilst exceedances of 2 to 4 dB of the INP L_{eq} criteria were predicted, these receivers are currently subject to noise of similar character and the addition of the maintenance facility may result in a moderate increase in exposure to rail noise over the day or night periods.

The arrival and departure of trains also indicated a number of predicted exceedances of the RBL + 15 dB sleep disturbance screening criteria. There is no feasible source or path treatment available at this stage to significantly reduce the occurrence and level of the maximum noise events from trains entering and departing the facility. However the overall impact is limited as receivers are already exposed to similar noise sources of equal or higher noise levels from train passbys on the Main North railway. One receiver (21 Enterprise Drive) was predicted to experience noise levels in excess of the RNP sleep disturbance guidance level of 65 dBA and this exceedance should be addressed.

Scheduled movements mean that trains would regularly arrive at the facility in the evening period and leave in the early hours of the morning and therefore there may be an increase in the number of events above the 65 dBA level. Maximum noise level measurements of existing rail passbys on site indicated that the sleep disturbance noise levels may already be exceeded at the properties on Enterprise Drive and Old Chittaway Road. Therefore whilst there may be an increase in the number of events, maximum noise events from trains passing is not a new noise source in the area and this type of noise source already forms part of the existing acoustic environment.

As sensitive receivers are predicted to be residually impacted, the following is recommended:

- Properties identified to exceed the L_{eq} and sleep disturbance criteria on Enterprise Drive, Ourimbah Road and Old Chittaway Road should be considered for additional investigation of at property treatment during subsequent stages of the design.
- The barriers as described in this report should be investigated for implementation.
- Management measures should be included in the operational noise management plan to reduce potential impacts at residually affected receivers.

The provision of any mitigation and individual property treatment is subject to further assessment as part of the detailed design stage and consideration by Transport for NSW.

It is recommended that the conditions of approval should be set no lower than the INP criteria as derived in Section 5.1 of this report.

7 Operational vibration assessment

The Transport for NSW vibration limit for rail vehicles is three millimetres per second at 15 metres as stated in Chapter 6.5 of *Transport for NSW RSU 100 Series Minimum Standards for operating rolling stock - general interface standards Version 1.0 19 Dec 2014, TfNSW T HR RS 00100 ST.* As it is expected that the rail vehicles would comply with this limit and receivers are at least 100m from the rail lines, significant operational vibration impacts are not expected.

8 Construction noise assessment

8.1 Noise modelling methodology

The noise model described in Section 6.2 has been used as the basis of the construction noise modelling and assessment for the project, along with the following considerations:

- Construction plant and equipment have been modelled to operate simultaneously for assessment of potential worst case noise impacts.
- A usage factor has been applied to each construction source to represent typical usage in a 15 minute period.
- Ground coverage has been assumed to be partially reflective and modelled with a 0.75 absorption co-efficient.
- Barriers and structures proposed as part of the operational assessment have been assumed not to have been complete during the construction stage and are not considered in the model.

The predicted noise levels at individual receivers are dependent upon the plant location and the number of plant operating during each activity. Noise impacts have been determined for a worst case 15 minute scenario where all plant are in simultaneous operation. Where fewer plant and machinery are in operation or undertaken at greater separation distance to nearest receivers, noise levels would be significantly reduced.

8.2 Assessment scenarios

Fourteen (14) construction scenarios representing each construction stage have been considered. These scenarios were based on breakdown from the early works, main works and compound works and based on the location and equipment used. This allows noise impacts from activities within one stage that occur at different locations to be determined for the nearest receivers.

The work areas have been defined by the location of the required works and the requirement for work outside of recommended standard hours, which is also dependent on the type of activity and location. Work within the rail corridor or near rail assets are required to be undertaken during a track possession. Track possessions are typically required to occur during the night and at weekends in order to minimise the potential disruption to services and to improve the safety of construction personnel within the rail corridor. As a result, some works are expected to occur during the evening and night periods and at weekends.

Table 8-1 presents the scenarios considered in the assessment. Construction works are planned during both standard hours and outside of standard hours. The time periods are defined in the ICNG as follows:

- Standard hours:
  - Monday to Friday 7.00am to 6.00pm
  - Saturday 8.00am to 1.00pm.
- Outside of Standard Hours Work (OOHW)
  - Day:
    - Saturday 7.00am to 8.00am and 1.00pm to 10.00pm.
    - Sundays and Public Holidays 7.00am to 6.00pm
  - Evening, Monday to Friday 6.00pm to 10.00pm
  - Night, Monday to Sunday 10.00pm to 7.00am

The work areas have been defined by the location of the required works and the requirement for work outside of recommended standard hours, which is also dependent on the type of activity and location. Work within the rail corridor or near rail assets are required to be undertaken during a track possession. Track possessions are typically required to occur during the night and at weekends in order to minimise the potential disruption to services and to improve the safety of construction personnel within the rail corridor. As a result, some works are expected to occur during the evening and night periods and at weekends.

Table 8-1 - Construction assessment scenarios

Scenario	Stage	Name	Duration (months)	Hours	Location
1	Enabling Works	Access Road Bridge	12 months	Standard Hours	At bridge site
1a	Enabling Works	Bridge Deck	12 months	OOHW	At bridge site
2	Enabling Works	Access Road	12 months	Standard Hours	Along access road
3	Enabling Works	Underbore	12 months	OOHW and SH	Across rail within project site on Enterprise Drive side where cables cross the rail corridor
4	Enabling Works	Relocation of services	12 months	OOHW and Standard Hours	Along rail on project site
5	Main works	Site establishment	2 months	Standard Hours	On project site
6	Main works	Bulk earthworks (and drainage)	24 months	Standard Hours	On project site
7	Main works	Main Building con-struction	24 months	Standard Hours	On project site
8	Main works	Laying of track	24 months	Standard Hours	On track areas of site
8a	Main works	Laying of turnouts	24 months	OOHW	At the joint with Main North railway
9	Main works	Auxiliary facility installations	24 months	Standard Hours	On project site
10	Main works	Substation installations	24 months	Standard Hours	On project site
11	Compound	Upside of enabling works	24 months	Standard Hours	Near road bridge
12	Compound	Downside of main works	24 months	Standard Hours	On project site

8.3 Noise source levels

Noise levels for the equipment proposed to be used is presented in Table 8-2. Noise levels were taken from published literature, including the CNS, Australian Standard AS2436 *Guide to noise and vibration control on construction, demolition and maintenance sites*, the UK's Department of Environment, Food and Rural Affairs (DEFRA) (2006) construction noise database and published reports for similar activities.

Table 8-2 - Equipment sound power levels per construction scenario

Item	SWL	Usage Factor	1	1a	2	3	4	5	6	7	8	8a	9	10	11	12
Bored piling rig	104	1	x													
Sheet piling rig	116	1	x			x										
Cranes (mobile)	104	1	x	x		x	x		x	x	x	x	x		x	x
FEL	110	0.75	x	x	x		x	x	x	x	x	x			x	x
Trucks	102	1			x			x	x		x	x				
Concrete truck	105	0.5	x	x	x	x			x	x			x	x		
Pumps	103	1	x	x		x			x	x			x			
Dozers	108	0.75			x			x	x		x	x				
Excavators	107	0.75	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Compressors	101	1	x	x		x	x			x	x	x				
Shotcrete gun	106	1	x	x		x			x	x						
Grader	110	0.75			x			x								
Vibratory roller	108	0.75	x	x	x		x	x	x	x	x	x	x	x	x	x
Drills and rock breaker	116	0.25				x				x	x	x				
Hi-rail dumper	95	1									x	x				
Tamper (rail)	111	1									x	x				
Regulator (rail)	114	1									x	x				
Rail grinder	112	0.25									x	x				
Railsaw	115	0.25									x	x				
Thermit welding	105	0.25									x	x				
Semi-trailer	102	1	x	x		x				x	x	x	x	x		
5 tonne dumper	95	0.5									x	x				
Scenario Sound Power level			**119**	**115**	**115**	**118**	**113**	**115**	**115**	**116**	**120**	**120**	**112**	**111**	**113**	**113**

8.4 Predicted noise levels

Construction noise levels at residential receivers were predicted for each scenario during the applicable time period and are presented in full in Appendix C. Noise contour maps of construction noise levels are presented in Appendix D. As the construction works were modelled at a number of worst case locations such as on the boundary of the site and the maps present the maximum extent of noise levels modelled at all assessed locations. The indicative noise contour maps are predicted at a height of 1.5 metres and with a grid spacing of 20 meters.

Table 8-3 and Table 8-4 present the noise levels predicted during standard hours, outside of standard hours and L_{max} events for the assessment of sleep disturbance for the nearest receivers respectively.

Noise contour maps of construction noise levels are presented in Appendix D. As the construction works were modelled at a number of worst case locations such as on the boundary of the site and the maps present the maximum extent of noise levels modelled at all assessed locations. The indicative noise contour maps are predicted at a height of 1.5 metres and with a grid spacing of 20 meters.

Table 8-3 - Predicted construction noise levels for scenarios 1 to 12 during standard hours, $L_{eq,15min}$ dBA

Receiver	NML (SH)	1	2	3	4	5	6	7	8	9	10	11	12
12 Ourimbah Road, Kangy Angy	54	49	47	**64**	**59**	**69**	**70**	**70**	**66**	**67**	**65**	41	**67**
19 Ourimbah Road, Kangy Angy	54	52	50	**62**	**57**	**69**	**70**	**71**	**63**	**67**	**65**	43	**67**
15 Schubolt Lane, Kangy Angy	54	45	43	**59**	53	**56**	**56**	**57**	**60**	53	52	38	54
16 Turpentine Road, Kangy Angy	54	41	38	**62**	**57**	**59**	**60**	**60**	**63**	**57**	**55**	34	**57**
26 Turpentine Road, Kangy Angy	54	43	41	**63**	**58**	**60**	**61**	**61**	**65**	**58**	**56**	36	**58**
50 Orchard Road, Kangy Angy	54	54	53	**58**	52	**60**	**60**	**61**	**59**	**57**	**56**	44	**58**
53 Orchard Road, Kangy Angy	54	54	53	**61**	**56**	**72**	**72**	**73**	**62**	**69**	**68**	45	**70**
54 Orchard Road, Kangy Angy	54	**55**	**55**	**57**	52	**61**	**62**	**62**	**59**	**59**	**57**	45	**59**
62 Orchard Road, Kangy Angy	54	**57**	**56**	**57**	52	**61**	**62**	**63**	**58**	**59**	**57**	46	**59**
72 Orchard Road, Kangy Angy	54	**58**	**59**	**56**	51	**62**	**62**	**63**	**58**	**59**	**58**	47	**60**
80 Orchard Road, Kangy Angy	54	**60**	**63**	53	48	**61**	**61**	**62**	**55**	**58**	**57**	48	**59**
127 Old Chittaway Road, Fountaindale	59	48	46	**60**	55	**60**	**61**	**61**	**61**	58	56	40	58
141 Old Chittaway Road, Fountaindale	59	49	47	58	53	58	58	59	59	55	54	40	56
149 Old Chittaway Road, Fountaindale	59	51	49	58	53	59	59	**60**	59	56	55	42	57
150 Old Chittaway Road, Fountaindale	59	51	49	**61**	56	**65**	**65**	**66**	**62**	**62**	**61**	42	**63**
157 Old Chittaway Road, Fountaindale	59	43	39	57	52	56	57	58	58	54	52	36	54
161 Old Chittaway Road, Fountaindale	59	51	48	53	48	52	52	53	55	49	48	43	50
165 Old Chittaway Road, Fountaindale	59	53	51	58	52	59	59	**60**	59	56	55	44	57
170 Old Chittaway Road, Fountaindale	59	56	56	**62**	57	**70**	**71**	**71**	**64**	**68**	**66**	46	**68**
3 Station Road, Fountaindale	59	52	50	55	50	54	55	56	56	52	50	43	52
7 Station Road, Fountaindale	59	52	50	54	48	53	53	54	55	50	49	44	51
16 Station Road, Fountaindale	59	57	55	57	51	57	57	58	58	54	53	47	55
98 Old Chittaway Road (CCC)	45	**46**	42	43	**64**	**59**	**67**	**67**	**68**	**66**	45	**64**	**63**

10 Catamaran Street (school)	45	29	29	29	29	31	33	29	30	29	29	29	29

Note: Exceedances of the 'noise affected' management level are highlighted in grey with bold text.
Exceedances of the 'highly noise affected' management level of 75 dBA are highlighted in grey with italic text.

Table 8-4 - Predicted construction noise levels for scenarios 1a, 3, 4 and 8a outside of standard hours, $L_{eq,15min}$ dBA

Receiver	NML Day (OOHW)	NML Evening (OOHW)	NML Night (OOHW)	1a	3	4	8a
12 Ourimbah Road, Kangy Angy	49	45	40	45	**64**	**59**	43
19 Ourimbah Road, Kangy Angy	49	45	40	*48*	**62**	**57**	42
15 Schubolt Lane, Kangy Angy	49	45	40	41	**59**	**53**	*46*
16 Turpentine Road, Kangy Angy	49	45	40	37	**62**	**57**	**51**
26 Turpentine Road, Kangy Angy	49	45	40	39	**63**	**58**	*48*
50 Orchard Road, Kangy Angy	49	45	40	**50**	**58**	**52**	40
53 Orchard Road, Kangy Angy	49	45	40	**50**	**61**	**56**	41
54 Orchard Road, Kangy Angy	49	45	40	**52**	**57**	**52**	40
62 Orchard Road, Kangy Angy	49	45	40	**53**	**57**	**52**	39
72 Orchard Road, Kangy Angy	49	45	40	**55**	**56**	**51**	39
80 Orchard Road, Kangy Angy	49	45	40	**57**	**53**	*48*	38
127 Old Chittaway Road, Fountaindale	54	49	40	44	**60**	**55**	45
130 Old Chittaway Road, Fountaindale	54	49	40	44	**64**	**58**	44
141 Old Chittaway Road, Fountaindale	54	49	40	45	**58**	**53**	44
149 Old Chittaway Road, Fountaindale	54	49	40	*47*	**58**	**53**	43
150 Old Chittaway Road, Fountaindale	54	49	40	*47*	**61**	**56**	43
157 Old Chittaway Road, Fountaindale	54	49	40	39	**57**	**52**	44
161 Old Chittaway Road, Fountaindale	54	49	40	*47*	**53**	*48*	43
165 Old Chittaway Road, Fountaindale	54	49	40	*49*	**58**	**52**	42
170 Old Chittaway Road, Fountaindale	54	49	40	**52**	**62**	**57**	41
3 Station Road, Fountaindale	54	49	40	*48*	**55**	**50**	42
7 Station Road, Fountaindale	54	49	40	*49*	**54**	*48*	41
16 Station Road, Fountaindale	54	49	40	**53**	**57**	**51**	40

Note: Exceedances of the OOHW 'noise affected' management level for day, evening and night time periods are highlighted in grey with bold text.
Exceedances of the OOHW 'noise affected' management level for evening and night time periods are highlighted in blue in italic text.
Exceedances of the OOHW 'noise affected' management level for night time periods are highlighted in green and underlined.

8.5 Sleep disturbance

Noise from intermittent high level noise events has the potential to cause sleep disturbance at the nearest residential receivers if conducted during the night time hours. These events were assessed assuming the L_{max} is approximately 5 dBA higher than the total sound power level of each scenario that takes place during the night period. Table 13-5 presents an assessment of the likelihood of sleep disturbance, based on guidance provided by the RNP as discussed in Section 5.1.3.

Table 8-5 - Predicted construction noise levels outside of standard hours, L_{max} dBA

Receiver	Screening criteria	1a	3	4	8a
50 Orchard Road , Kangy Angy	65	55	63	57	45
53 Orchard Road , Kangy Angy	65	55	**66**	61	46
54 Orchard Road , Kangy Angy	65	57	62	57	45
62 Orchard Road , Kangy Angy	65	58	62	57	44
72 Orchard Road , Kangy Angy	65	60	61	56	44
80 Orchard Road , Kangy Angy	65	62	58	53	43
84 Orchard Road , Kangy Angy	65	59	57	52	42
12 Ourimbah Road , Kangy Angy	65	50	**69**	64	48
19 Ourimbah Road , Kangy Angy	65	53	**67**	62	47
15 Schubolt Lane , Kangy Angy	65	46	64	58	51
16 Turpentine Road , Kangy Angy	65	42	**67**	62	56
26 Turpentine Road , Kangy Angy	65	44	**68**	63	53
127 Old Chittaway Road , Fountaindale	65	49	65	60	50
130 Old Chittaway Road , Fountaindale	65	49	**69**	63	49
141 Old Chittaway Road , Fountaindale	65	50	63	58	49
149 Old Chittaway Road , Fountaindale	65	52	63	58	48
150 Old Chittaway Road , Fountaindale	65	52	**66**	61	48
157 Old Chittaway Road , Fountaindale	65	44	62	57	49
161 Old Chittaway Road , Fountaindale	65	52	58	53	48
165 Old Chittaway Road , Fountaindale	65	54	63	57	47
170 Old Chittaway Road , Fountaindale	65	57	**67**	62	46

Note 1: Values in highlighted grey with bold text indicate exceedances of the sleep disturbance screening criteria.

8.6 Assessment of predicted noise levels

The predicted construction noise levels at the sensitive receivers indicate that:

- No receivers identified for this assessment exceed the 'highly noise affected' NML.
- A number of residential properties on Orchard Road, Schubolt Lane, Turpentine Road and Old Chittaway Road exceed the 'noise affected' NML for works conducted during the standard hours. Single properties on Catamaran Road, Enterprise Drive and Ourimbah Road were also predicted to exceed the 'noise affected' NML.
- The majority of the residential receptors exceed at least one of the NMLs for the out-of-hours construction assessment with scenarios 3 and 4 (parts of the enabling works) predicted to be the noisiest stages.
- The predicted construction noise levels at the child care centre were predicted to exceed the NMLs for works conducted during standard hours except for scenarios 1, 2 and 11.
- Noise levels at the school during construction were predicted to be within the NML for all of the assessment scenarios.

- Noise levels at the industrial land use area during construction were predicted to be within the applicable NML for any of the out-of-hours working periods. The only exceedance of the NML was identified to be at 2 Catamaran Road for the standard daytime hours for construction scenarios 1 and 2.

The residential properties have been grouped according to their proximity to the site and the surrounding noise sources. Appendix A outlines which monitoring location was used to represent each receiver.

Receivers that are represented by background noise levels at BG1 located in the vicinity of the Pacific Highway were predicted to exceed the daytime standard hours NML. In addition, properties 6, 43 and 57 Bridge Street were predicted to exceed the NML during out of hours working during the night with 57 Bridge Street also exceeding during the evening and daytime periods.

Receivers that are represented by background noise levels at BG2 located to the west of the Main North railway were all predicted to exceed the daytime standard hours NML except for 2 and 8 Orchard Road. For the out of hours construction assessment it was predicted that all residential receptors in this area would not comply with the relevant NML for at least one of the assessment scenarios.

Receivers that are represented by background noise levels at BG3 located to the west of the Mian North railway were predicted to exceed the NML at a number of properties on Old Chittaway Road during standard hours work. In this area during the out of hours working periods, the only residential property predicted to comply with the NML for all four construction scenarios is 39 Manns Road.

The receiver at 139 Orchard Road was predicted to comply with the standard daytime hours NML. However, the property is not expected to comply with the night time out-of-hours NML for the assessment of construction scenario 1a.

Predicted noise levels at the industrial land use area was predicted to be within the applicable NML for any of the out-of-hours working periods. The only exceedance of the NML was identified to be at 2 Catamaran Road for the standard daytime hours for construction scenarios 1 and 2.

As a result of the majority of receivers predicted to experience noise levels in excess of the noise management levels, it is recommended that a noise and vibration management plan is developed.

9 Construction vibration assessment

The most dominant construction vibration sources from the assessed scenarios presented in Section 8 are sheet piling rigs, vibratory rollers and rock breakers which have the potential to result in vibration impacts on nearby sensitive receivers, if appropriate mitigation measures are not implemented.

Table 3 of the CNS provides the safe working distance for dominant vibration generating equipment.

All identified sensitive receivers are located at least 75 metres or greater from the track laying and earthworks areas. The nearest commercial receiver to the proposed bridge site is approximately 100 metres and the nearest residential receiver is over 300m away.

Table 9-1 presents indicative safe working distances for the most dominant vibration generating plant. The distances are based on meeting the five millimetres per second limit for cosmetic damage from the German Standard DIN4150-3 which is considered to be a conservative limit.

Where work is required within these distances, site-specific safe working distances should be developed on-site through vibration monitoring prior to the works commencing.

Table 9-1 - Indicative vibration levels

Item	Typical PPV (mm/s)[1]	Data source	Indicative safe working distance for cosmetic damage[2]	Indicative safe working distance for human comfort[3]
Sheet piles	31 at 15m	Calculated based on the CNS safe working distances for cosmetic damage	50m	20m
Vibratory roller (300kN approx. 7-13 tonnes)	20	Calculated based on the CNS safe working distances for cosmetic damage	40m	100m
Rock breaker (1600kg, 18-34t excavator)	36	Calculated based on the CNS safe working distances for cosmetic damage	60m	73m

Note 1: Vibration levels are indicative only and may vary on site and are dependent on individual equipment, mode of operation and ground conditions.
Note 2: Indicative distance required to meet the DIN 4150-3, 5 mm/s limit.
Note 3: Taken from the CNS Table 3.

The vibration levels and associated safe working distances presented in Table 9-1 indicate that cosmetic damage is not considered be a significant risk due to the proposed construction at the nearest sensitive receivers.

Vibration may be perceptible at the nearest houses, however it is unlikely to be a significant risk for the majority of receivers. Where work requiring the use of vibratory rollers is required within 75 metres of a receiver, a roller of less than 200 kN rating should be used.

10 Construction noise and vibration management

A construction noise and vibration management plan (CNVMP) should be developed for the project, prior to commencement of works. The management plan would utilise detailed construction methodologies of the contractor. The management plan would include (but is not limited to) the following:

- Identified nearby residences and other sensitive land uses.
- Approved hours of work and what work would be undertaken.
- Dominant noise and vibration generating activities.
- Details of noise mitigation and management measures to be applied.
- Information for worker training to minimise noise impacts.
- Community consultation protocol(s).
- Complaints handling protocol(s).
- Construction works should be planned and carried out during standard construction hours wherever possible.

Table 10-1 presents the standard mitigation measured contained within the Transport for NSW *Construction Noise Strategy* (CNS) which should be considered as mitigation measures as part of the noise management plan.

Table 10-1 - Transport for NSW *Construction Noise Strategy* standard mitigation measures

Action required	Details
Management measures	
Implement any project specific mitigation measures required	In addition to the measures set out in this table, any project specific mitigation measures identified in this report.
Implement community consultation measures	Periodic notification (monthly letterbox drop or equivalent), website, project Infoline, Construction Response Line, email distribution list.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Noise Monitoring	A noise monitoring program is to be carried out for the duration of the works in accordance with the *Construction Noise and Vibration Management Plan* and any approval and licence conditions.
Source controls	
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Maximum noise levels	The noise levels of plant and equipment must have operating sound power or sound pressure levels that would meet the predicted noise levels.

Action required	Details
Rental plant and equipment	Noise emissions should be considered as part of the selection process.
Use and siting of plant	Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Plant and vehicles to be turned off when not in use. Noise-emitting plant to be directed away from sensitive receivers.
Plan works site and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out-of-hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained.
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

In addition to the standard mitigation measures identified in the Transport for NSW CNS, the following specific mitigation measures have been developed as a result of the predicted impacts associated with the proposal.

To minimise noise levels, the following work practices should be implemented:

- Work is to be scheduled during standard construction hours where feasible and reasonable.
- Provide periods of respite from noise intensive activities near receivers. Respite periods should be defined by those periods where the community is less sensitive to noise such as avoiding early morning and late afternoon.
- Orientate generators, concrete trucks and concrete pumps away from sensitive receivers.
- Utilise vehicles, obstacles and stockpiles on site to provide shielding to receivers, especially for static noise sources: generators, lighting towers, mulchers, mobile cranes and the piling rig.
- Use equipment that has noise levels equal to or less than the sound power levels in Table 8-2.
- Minimise the potential for construction vehicles to access the site prior to 7.00am along the new access road.

To minimise the risk of vibration impacts, the following is recommended:

- Where possible, the use of less vibration intensive methods of construction or equipment should be considered where possible to reduce the potential for cosmetic damage.

- All equipment should be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.
- Ensure that safe working distances provided in Table 9-1 are complied with.
- Where work requiring the use of vibratory rollers is required within 75 metres of a receiver, a roller of less than 200 kN rating should be used.
- Where work is required within the distances provided in Table 9-1, site-specific safe working distances are to be established on-site prior to the relevant vibration generating works commencing.
- If vibration intensive equipment is to be used within the safe working distances, attended vibration measurements are to be undertaken when work commences to determine site specific safe working distances.
- Vibration intensive work should not proceed within the safe working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators (via flashing light, audible alarm, SMS etc.) when vibration levels are approaching the peak particle velocity trigger levels.

To minimise the potential for sleep disturbance, where night works are proposed to be undertaken, the following controls should be implemented where feasible and reasonable:

- Avoid conducting noise intensive night works for more than two consecutive nights.
- Schedule noise intensive activities to before 10.00pm.
- Schedule activities which are likely to cause maximum noise events such as deliveries, moving material or equipment and compacting works to avoid the night time period (10.00pm to 7.00am).
- Avoid dropping tools or materials from height, striking materials, dragging materials or making metal on metal contact.
- Educate workers on the importance of minimising noise and avoid creating short duration high noise level events.
- Inform surrounding residents by mail of planned works prior to the works commencing.

Table 10-2 provides an indicative benefit of typical mitigation measures for construction activities, based on guidance in AS 2436 and experience on similar construction projects.

Table 10-2 - Indicative noise reduction from construction controls

Management and Engineering Controls	Possible Noise Benefit, dBA
Noise Management Controls	
Operate during approved hours	N/A
Undertake regular noise monitoring to determine the impact of operating plant on sensitive receivers	N/A
Appropriate training of onsite staff	N/A
Undertake community consultation and respond to complaints in accordance with established project procedures	N/A
Turning off machinery when not in use	0-5
Respite periods for pile drivers and rock breakers	N/A
Engineering Controls	
Portable temporary screens	5-10

Management and Engineering Controls	Possible Noise Benefit, dBA
Screen or enclosure for stationary equipment	10-15
Maximising the offset distance between noisy plant items and sensitive receivers.	3-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.	2-5
Orienting equipment away from sensitive receivers.	3-5
Carrying out loading and unloading away from sensitive receivers.	3-5
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks	5-10
Selecting site access points and roads as far as possible away from sensitive receivers	3-6
Using spotters, "smart" reversing alarms, or "squawker" type reversing alarms in place of traditional reversing alarms	N/A

10.1 Application of additional mitigation measures

According to the Transport for NSW CNS, where there is potential for a project's construction noise objectives to be exceeded, a number of additional measures to mitigate such exceedances should be explored. The additional mitigation measures matrix is primarily aimed at pro-active engagement with affected receivers.

Table 10-3, reproduced from the Transport for NSW CNS, outlines what measures may apply depending on the level by which the predicted noise levels exceed the measured RBLs, and the time of the day.

Additional mitigation measures that may be applicable to affected receivers include letterbox drops, noise monitoring, individual briefings, phone calls, specific notifications, proposal specific respite offers and alternate accommodation.

Specific additional mitigation measures would be identified for affected receivers at the CNVMP stage of the project.

Table 10-3 - Application of mitigation measures in addition to Transport for NSW *Construction Noise Strategy* standard mitigation measures

Time period		$L_{eq,15min}$ noise level above background (RBL) qualitative assessment of noise levels*			
		0 to 10 dBA Noticeable	10 to 20 dBA Clearly audible	20 to 30 dBA Moderately intrusive	> 30 dBA Highly intrusive
Standard	Mon-Fri (7.00am-6.00pm) Sat (8.00am-1.00pm) Sun/Pub (Nil)	-	-	Letterbox drops, monitoring	Letterbox drops, monitoring
OOHW Period 1	Mon-Fri (6.00pm-10.00pm) Sat (1.00pm-10.00pm) Sun/Pub (8.00am-6.00pm)	-	Letterbox drops	Monitoring, letterbox drops	Monitoring, individual briefings, letterbox drops, project specific respite offer, phone calls, specific notifications.
OOHW Period 2	Mon-Fri (10.00pm-7.00am) Sat (10.00pm-8.00am) Sun/Pub (6.00pm-7.00am)	Letterbox drops	Monitoring, letterbox drops	Monitoring, individual briefings, letterbox drops, phone calls, specific notifications.	Alternative accomodation, monitoring, individual briefings, letterbox drops, phone calls, specific notifications.

11 Off-site road traffic noise

11.1 Introduction

The project has the potential to increase traffic volumes on Enterprise Drive during the construction and operational phases of the project and introduce new road traffic noise when travelling on the new access road during the construction and operational phase of the project.

Vehicles are expected to access the bridge construction site via Enterprise Drive. Upon completion of the bridge construction, vehicle access to the maintenance facility construction site would be via this new access road.

Enterprise Drive is a sub-arterial road. The existing volumes were measured on site and are presented in Section 4.2. The new access road is considered a new local road for noise assessment purposes in accordance with the RNP.

During the construction stage there is expected to be approximately 600 light vehicle and 168 heavy vehicle movements in total from the project accessing construction sites on Enterprise Drive and the new access road during peak construction. For the purposes of this assessment it has been assumed that 75 percent of the construction traffic occurs in a worst case one hour period. Table 11-1 presents the total daily traffic expected for the facility during operation and construction.

Table 11-1 - Trip generation during operational and construction per 24 hour period (one way)

Stage	Daily (one way)	
	LV	HV
Construction – Standard	200	84
Construction – During Possessions	300	84
Operation – Standard	220	10

The potential impact from the operation of the project is considered to be from additional cars travelling on Enterprise Drive and accessing the project on the access road.

Operational road traffic is expected to travel from Enterprise Drive along the new access road into the facility. During a shift change during the day, evening or night period, there is potential for up to 120 vehicle movements within one hour, with 60 vehicles going in and 60 leaving.

Three eight hour shifts are proposed during normal day to day operations and include:

- 6.00am to 2.00pm
- 2.00pm to 10.00pm
- 10.00pm to 6.00am.

Heavy vehicle deliveries to the facility during the operational phase are not expected to be frequent and would occur on an as required basis from time to time.

The impacts have been assessed in terms of additional vehicles on Enterprise Drive and new road source from the access road to the maintenance facility.

11.2 Enterprise Drive

Enterprise Drive is a sub-arterial road. The existing traffic volumes were measured on site and are presented in Table 4-5. As previously discussed, it is expected that during the construction stage up to 600 light vehicles and 168 heavy vehicles per day would use Enterprise Drive to access the site at the peak of construction activities.

In the operational stage, three shifts are currently planned with each involving up to 60 employees. The total light vehicle movements per day due to staff arriving and leaving the site was estimated to be 440. There is potential for up to approximately 300 light vehicle movements associated with the site in both the day period (7.00am to 10.00pm) and night period (10.00pm to 7.00am).

Heavy vehicles are not expected to be used in large numbers for the operational phase with only occasional deliveries being required. As such, the calculations have assumed one percent heavy vehicles.

To cause a change in road traffic noise level of more than 2 dB, the traffic volume needs to increase by approximately 60 percent or higher. Based on the counted existing vehicle volumes as reported in Table 4-5, the anticipated additional vehicle movements on Enterprise Drive associated with the project are not expected to constitute an increase of more than 60 percent in either the day or night period. Therefore it is considered that the project satisfies the RNP criteria on Enterprise Drive.

11.3 New access road

The new access road has potential to cause impacts at receivers nearest to the road on Orchard Road. This access road has been assessed under the RNP as it would be a new public road (subject to agreement with Wyong City Council). The road has therefore been assessed as a local road category as it would provide local access only to residences and access to the maintenance facility.

Increases in traffic volumes are not expected on Orchard Road as this road only leads to residences and connects back to Enterprise Drive along Turpentine Road. Therefore number of additional vehicles using the road are likely to be limited to private vehicles accessing residences on Orchard Road and vehicles accessing the project. Therefore significant traffic volumes other those generated by the project are not expected on the access road.

The noise level from the road source was calculated using the Calculation of Road Traffic Noise (CRTN) method (UK Welsh office, 1988) using the following assumptions:

- Soft ground between the road and receivers with 0.75 acoustic absorptive coefficient.
- The CRTN low traffic correction was not used.
- Angle of view to the road of 160 degrees.
- Distance to 72 Orchard Road of 130 metres.
- Distance to 139 Orchard Road of 230 metres.
- Traffic speed of 50 kilometres per hour.
- Façade reflection correction of +2.5 metres.
- $L_{10,1hr}$ to $L_{eq,1hr}$ correction of 3 dB.
- 300 light vehicle with one percent heavy vehicles movements in one hour in either the day or night period during operations.
- 225 light vehicles with 28 percent heavy vehicle movements in one hour in either the day or night period during construction.

Table 11-2 presents a summary of the predicted road traffic noise levels, compared against the more stringent night criteria.

Table 11-2 - Predicted traffic road noise levels for new access road.

Receiver	Day criteria	Night criteria	Predicted operational road traffic noise level	Predicted construction road traffic noise level
72 Orchard Road	55 $L_{eq,1hr}$	50 $L_{eq,1hr}$	49 $L_{eq,1hr}$	53 $L_{eq,1hr}$
139 Orchard Road	55 $L_{eq,1hr}$	50 $L_{eq,1hr}$	45 $L_{eq,1h}$	50 $L_{eq,1hr}$

Table 11-2 indicates that the predicted noise levels are below the most stringent RNP night time criteria during operations. As a result, road traffic noise impacts above the RNP criteria are not expected during operations.

During construction, noise levels of up to 3 dBA above the night criteria may be expected where 75 percent of the construction traffic occurs in one hour before 7.00am. It is recommended that access to site be managed to avoid this occurrence as part of the construction noise and vibration management plan. During the day, the RNP criteria are expected to be complied with where up to 75 percent of the construction traffic access the site in one hour.

12 Summary of environmental impacts

The predicted impacts with the mitigation recommended in Section 6.6 as a result of the proposal have each been assigned a rating. The rating considers the likelihood of the impact occurring and the magnitude of the impact on the receiving environment. The ratings are defined where one or more of the following conditions are satisfied:

- *Negligible*: where the predicted changes are not sufficient to affect ambient noise or vibration levels beyond natural variations
- *Minor*: where there is predicted to be some level of generated noise and vibration or there is a perceptible change that would occur for less than a week during construction and is generally below the operational criteria.
- *Moderate*: where there is predicted to be a perceptible change in noise and vibration lasting more than a week, an exceedance of the ‘noise affected’ noise management levels, the potential for sleep disturbance to occur at some point or the potential for ground-borne vibration to cause cosmetic damage or to result in ‘annoyance’ at some point during construction.
- *Major*: where there is predicted to be a notable change in noise and vibration lasting more than three weeks, an exceedance of the ‘highly noise affected’ construction noise management levels, the risk of long-term sleep disturbance or an accepted certainty that ground-borne vibration would have an impact on people or buildings.

Table 12-1 - Summary of noise and vibration impacts using mitigation recommended in Section 6.6

Source	Assessed impact	Recommended mitigation
Operational noise daytime	Minor	See section 6.6
Operational noise: evening	Minor to Moderate	See section 6.6
Operational noise: night	Moderate	See section 6.6
Operational noise: sleep disturbance	Moderate	See section 6.6
Operational vibration	Minor to negligible	Not applicable
Operational road traffic	Minor	Not applicable
Construction noise: standard hours	Major	See Section 10
Construction noise: outside of standard hours	Major	See Section 10
Construction vibration: building damage	Minor to negligible	See Section 10
Construction vibration: human perception	Minor to negligible	See Section 10
Construction road traffic	Moderate	See Section 10

13 References

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International Organization for Standardization, 1996 ISO 9613 Acoustics -- Attenuation of sound during propagation outdoors.

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NSW Environment Protection Authority (formerly Department of Environment, Climate Change and Water), 2011, Road Noise Policy.

NSW RMS (formerly RTA), 2001, Environmental Noise Management Manual

Transport for NSW (Transport for NSW), 2012, Construction Noise Strategy.

Transport for NSW, October 2015, New Intercity Fleet Maintenance Facility Business Operational Requirements Document version 3.0 document 4608829_3

Transport for NSW, February 2016, New Intercity Fleet project Concept of Operations V1.1 document 4889032_2

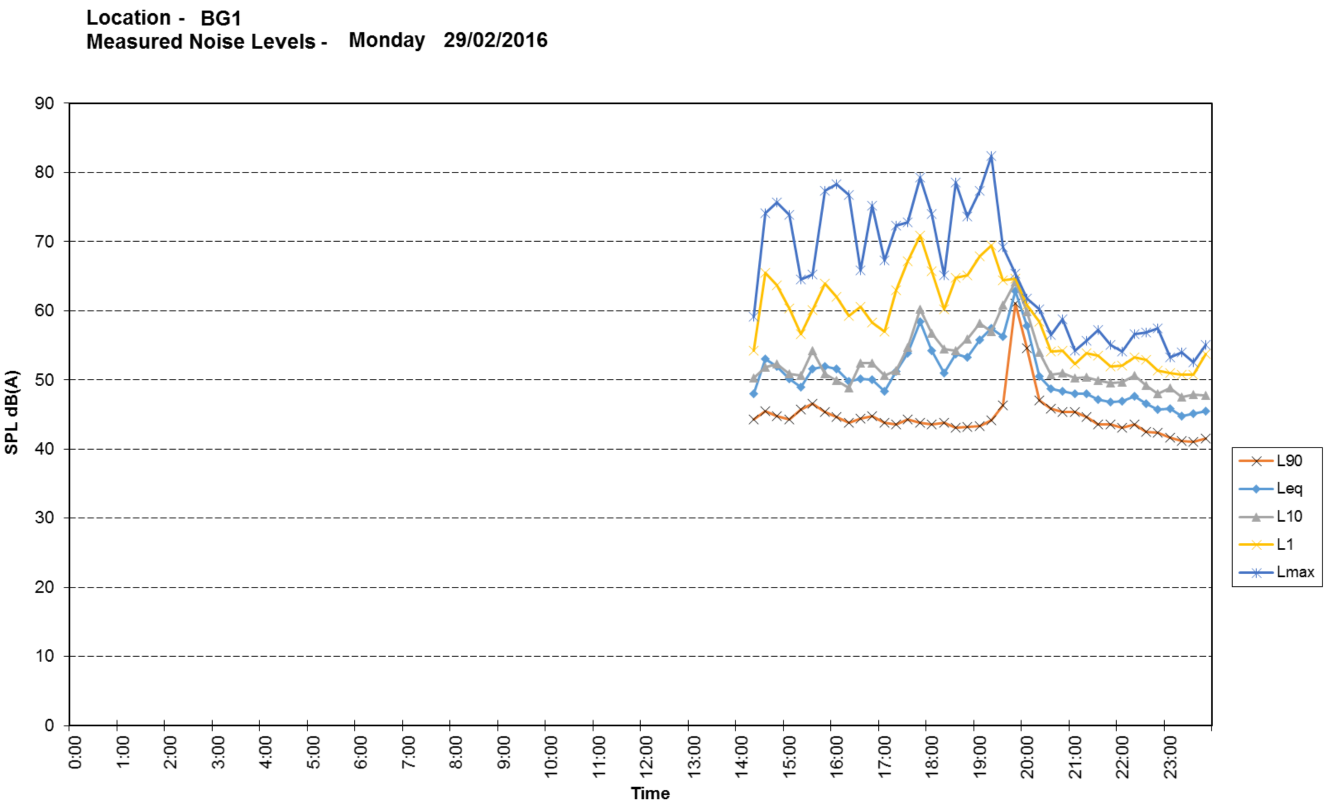
Appendix A Sensitive receivers

Assigned noise monitoring location	Address	Receiver type
BG1	2 Catamaran Road, Fountaindale	Residential
BG1	3 Bridge Street, Ourimbah	Residential
BG1	11 Bridge Street, Ourimbah	Residential
BG1	15 Bridge Street, Ourimbah	Residential
BG1	24 Bridge Street, Ourimbah	Residential
BG1	36 Bridge Street, Ourimbah	Residential
BG1	43 Bridge Street, Ourimbah	Residential
BG1	57 Bridge Street, Ourimbah	Residential
BG1	67 Pacific Highway, Kangy Angy	Residential
BG1	68 Pacific Highway, Kangy Angy	Residential
BG1	79 Pacific Highway, Kangy Angy	Residential
BG2	120 Berkeley Road, Fountaindale	Residential
BG2	56 Bridge Street, Ourimbah	Residential
BG2	52 Howes Road, Ourimbah	Residential
BG2	2 Orchard Road, Kangy Angy	Residential
BG2	8 Orchard Road, Kangy Angy	Residential
BG2	50 Orchard Road, Kangy Angy	Residential
BG2	54 Orchard Road, Kangy Angy	Residential
BG2	62 Orchard Road, Kangy Angy	Residential
BG2	72 Orchard Road, Kangy Angy	Residential
BG2	80 Orchard Road, Kangy Angy	Residential
BG2	84 Orchard Road, Kangy Angy	Residential
BG2	92 Orchard Road, Kangy Angy	Residential
BG2	106 Orchard Road, Kangy Angy	Residential
BG2	12 Ourimbah Road, Kangy Angy	Residential
BG2	19 Ourimbah Road, Kangy Angy	Residential
BG2	15 Schubolt Lane, Kangy Angy	Residential
BG2	15 Schubolt Lane, Kangy Angy	Residential
BG2	16 Schubolt Lane, Kangy Angy	Residential
BG2	16 Turpentine Road, Kangy Angy	Residential
BG2	26 Turpentine Road, Kangy Angy	Residential
BG2	26 Turpentine Road, Kangy Angy	Residential
BG3	137 Enterprise Drive, Ourimbah	Residential
BG3	11 Enterprise Drive, Fountaindale	Residential
BG3	21 Enterprise Drive, Fountaindale	Residential
BG3	14 Enterprise Drive, Fountaindale	Residential
BG3	16 Enterprise Drive, Fountaindale	Residential
BG3	28 Lillygrove Lane, Fountaindale	Residential
BG3	32 Lillygrove Lane, Fountaindale	Residential
BG3	36 Lillygrove Lane, Fountaindale	Residential
BG3	48 Lillygrove Lane, Fountaindale	Residential
BG3	6 Lorikeet Lane, Fountaindale	Residential
BG3	9 Lorikeet Lane, Fountaindale	Residential
BG3	12 Lorikeet Lane, Fountaindale	Residential
BG3	11 Manns Road, Fountaindale	Residential
BG3	22 Manns Road, Fountaindale	Residential
BG3	23 Manns Road, Fountaindale	Residential
BG3	39 Manns Road, Fountaindale	Residential
BG3	130 Old Chittaway Road, Fountaindale	Residential
BG3	86 Old Chittaway Road, Fountaindale	Residential

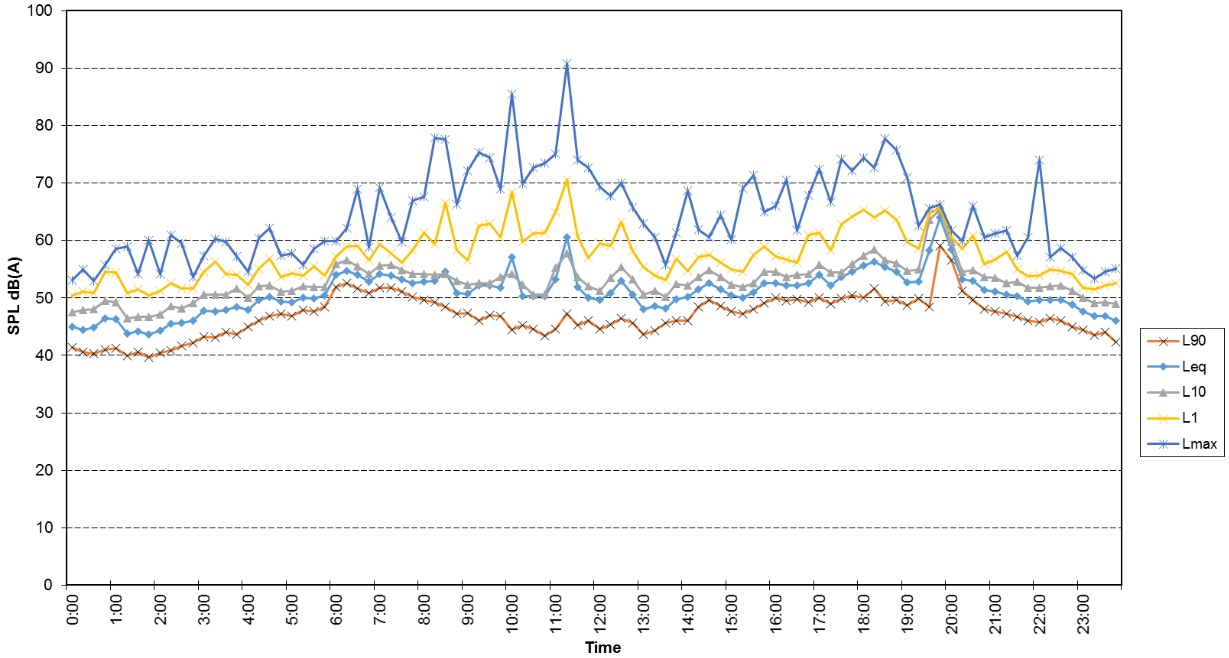
Assigned noise monitoring location	Address	Receiver type
BG3	89 Old Chittaway Road, Fountaindale	Residential
BG3	96 Old Chittaway Road, Fountaindale	Residential
BG3	96 Old Chittaway Road, Fountaindale	Residential
BG3	103 Old Chittaway Road, Fountaindale	Residential
BG3	105 Old Chittaway Road, Fountaindale	Residential
BG3	107 Old Chittaway Road, Fountaindale	Residential
BG3	121 Old Chittaway Road, Fountaindale	Residential
BG3	125 Old Chittaway Road, Fountaindale	Residential
BG3	127 Old Chittaway Road, Fountaindale	Residential
BG3	141 Old Chittaway Road, Fountaindale	Residential
BG3	149 Old Chittaway Road, Fountaindale	Residential
BG3	150 Old Chittaway Road, Fountaindale	Residential
BG3	157 Old Chittaway Road, Fountaindale	Residential
BG3	161 Old Chittaway Road, Fountaindale	Residential
BG3	165 Old Chittaway Road, Fountaindale	Residential
BG3	170 Old Chittaway Road, Fountaindale	Residential
BG3	32 Old Chittaway Road, Fountaindale	Residential
BG3	46 Old Chittaway Road, Fountaindale	Residential
BG3	58 Old Chittaway Road, Fountaindale	Residential
BG3	60 Old Chittaway Road, Fountaindale	Residential
BG3	64 Old Chittaway Road, Fountaindale	Residential
BG3	78 Old Chittaway Road, Fountaindale	Residential
BG3	33 Station Road, East Fountaindale	Residential
BG3	3 Station Road, Fountaindale	Residential
BG3	7 Station Road, Fountaindale	Residential
BG3	16 Station Road, Fountaindale	Residential
BG3	23 Station Road, Fountaindale	Residential
BG3	27 Station Road, Fountaindale	Residential
BG3	35 Station Road, Fountaindale	Residential
BG3	11 Station Road, East Fountaindale	Residential
BG4	139 Orchard Road, Kangy Angy	Residential
Receiver type ID	**Address**	**Receiver type**
CCC	98 Old Chittaway Road, Fountaindale	Child care centre
COM	3A Catamaran Road, Fountaindale	Commercial
COM	1 Catamaran Road, Fountaindale	Commercial
COM	2 Ketch Close, Fountaindale	Commercial
COM	3 Catamaran Road, Fountaindale	Commercial
COM	4 Catamaran Road, Fountaindale	Commercial
COM	5 Catamaran Road, Fountaindale	Commercial
COM	6 Catamaran Road, Fountaindale	Commercial
COM	8 Catamaran Road, Fountaindale	Commercial
COM	9 Catamaran Road, Fountaindale	Commercial
COM	11 Catamaran Road, Fountaindale	Commercial
COM	13 Catamaran Road, Fountaindale	Commercial
COM	15 Catamaran Road, Fountaindale	Commercial
COM	17 Catamaran Road, Fountaindale	Commercial
COM	1 Co-wyn Close, Fountaindale	Commercial
COM	2 Bridge Street, Ourimbah	Commercial
COM	4 Ketch Close, Fountaindale	Commercial
COM	5 Ketch Close, Fountaindale	Commercial
COM	7 Ketch Close, Fountaindale	Commercial
COM	8 Ketch Close, Fountaindale	Commercial
COM	9 Ketch Close, Fountaindale	Commercial

Assigned noise monitoring location	Address	Receiver type
COM	10 Ketch Close, Fountaindale	Commercial
COM	11 Ketch Close, Fountaindale	Commercial
COM	13 Ketch Close, Fountaindale	Commercial
COM	14 Ketch Close, Fountaindale	Commercial
COM	15 Ketch Close, Fountaindale	Commercial
COM	Sanitarium Factory	Commercial
SCH	10 Catamaran Road, Fountaindale	School

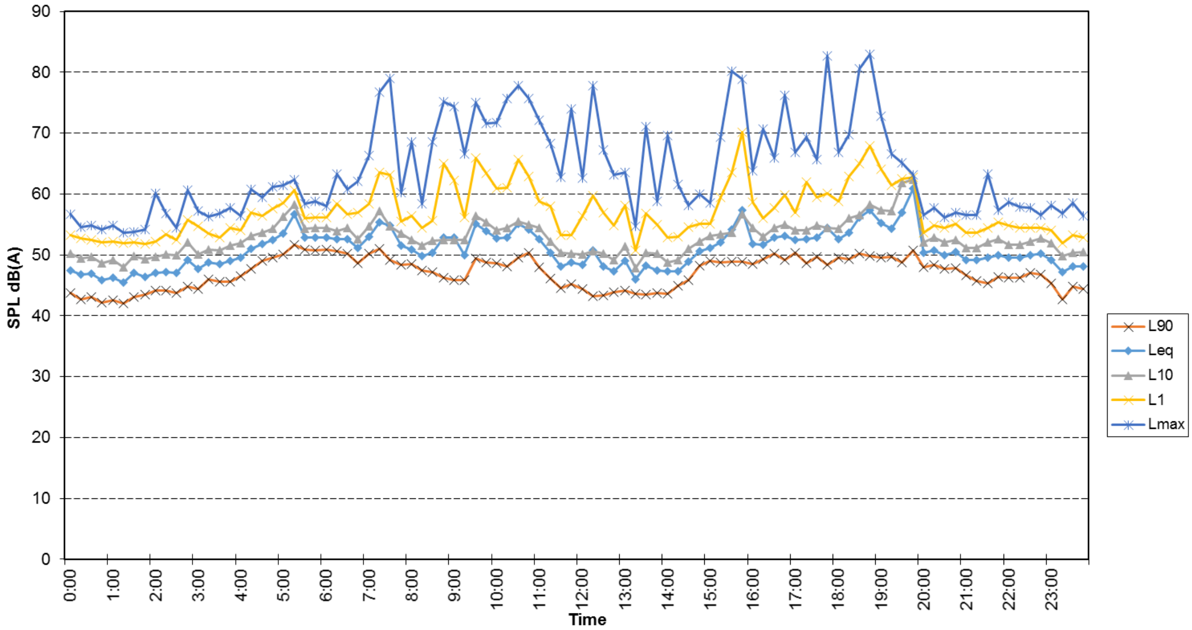
Appendix B Noise monitoring graphs



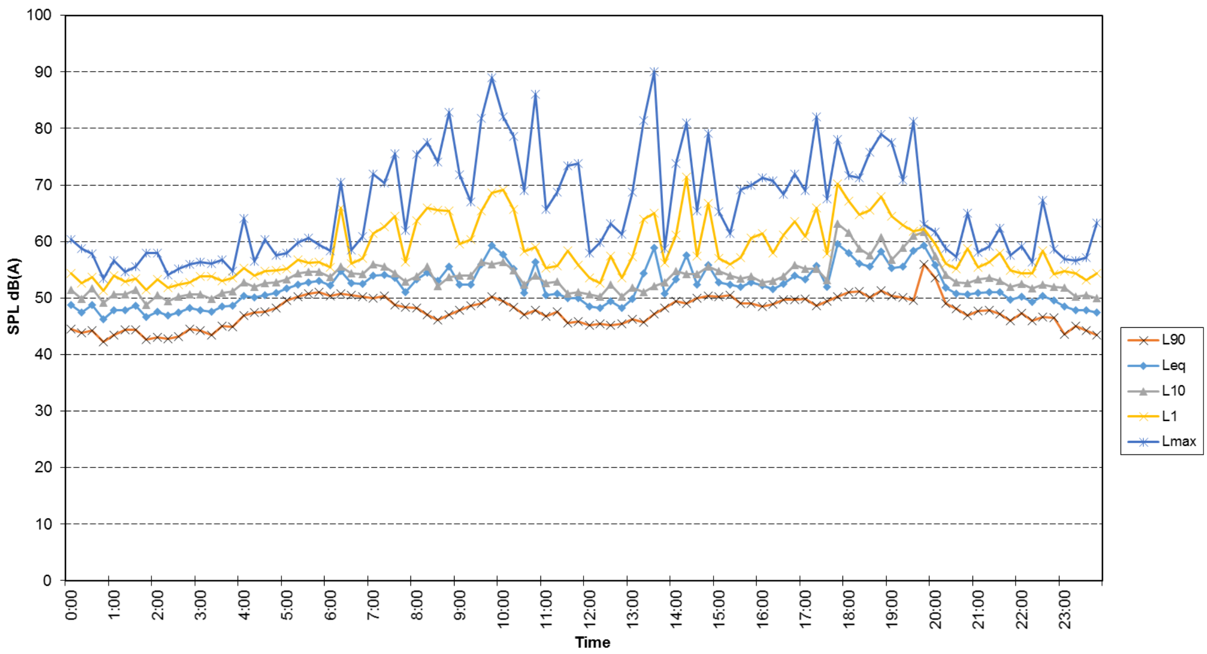
Location - BG1
Measured Noise Levels - Tuesday 01/03/2016



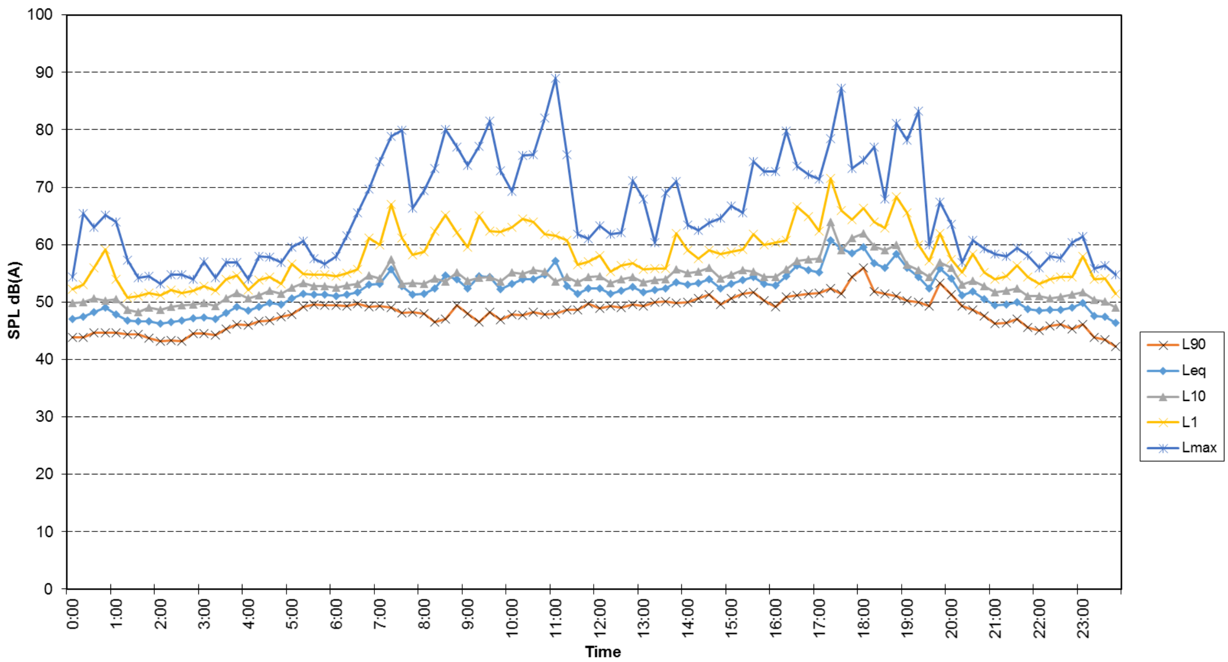
Location - BG1
Measured Noise Levels - Wednesday 02/03/2016



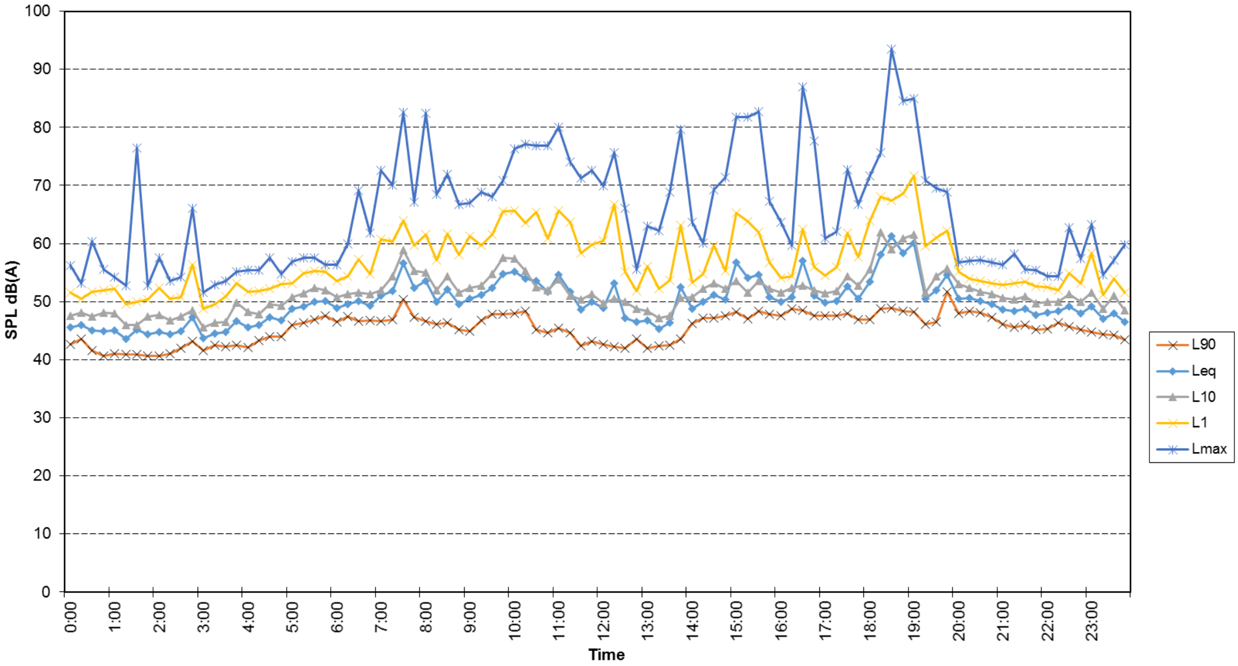
Location - BG1
Measured Noise Levels - Thursday 03/03/2016



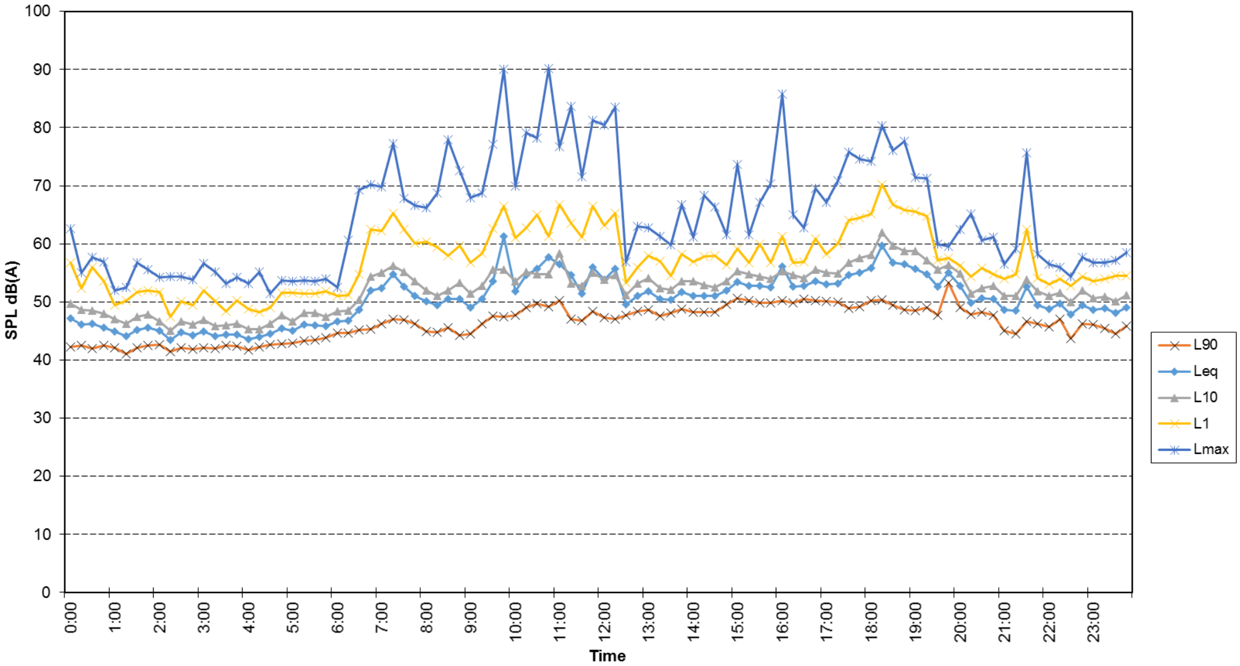
Location - BG1
Measured Noise Levels - Friday 04/03/2016



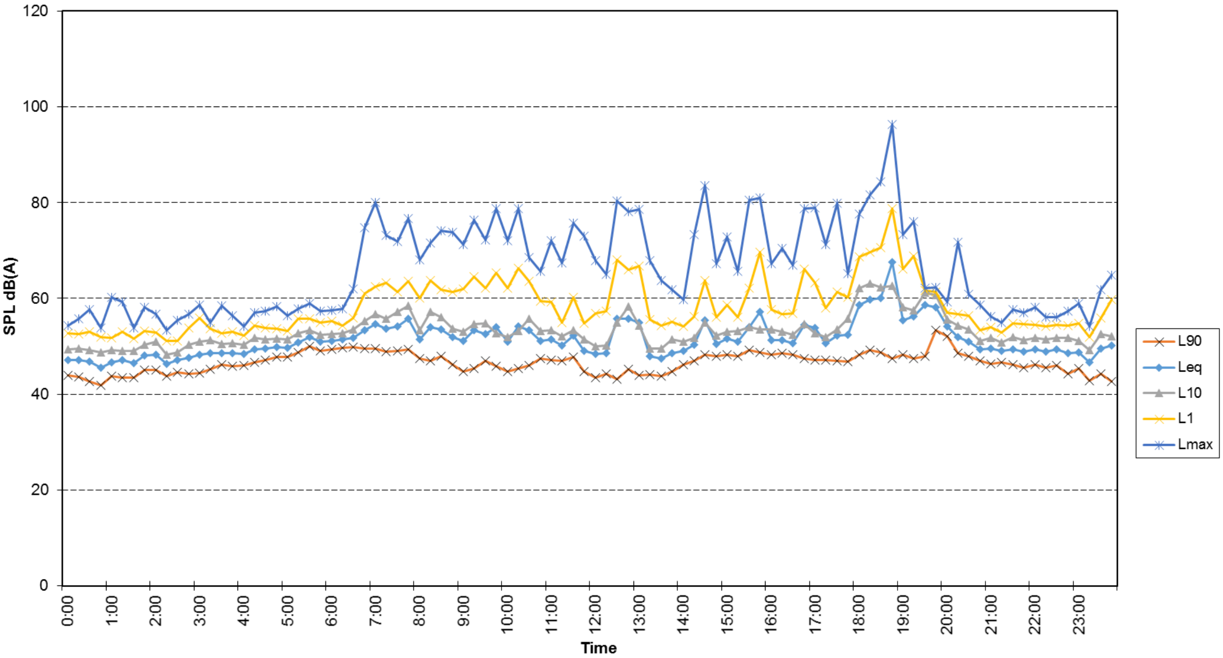
Location - BG1
Measured Noise Levels - Saturday 05/03/2016



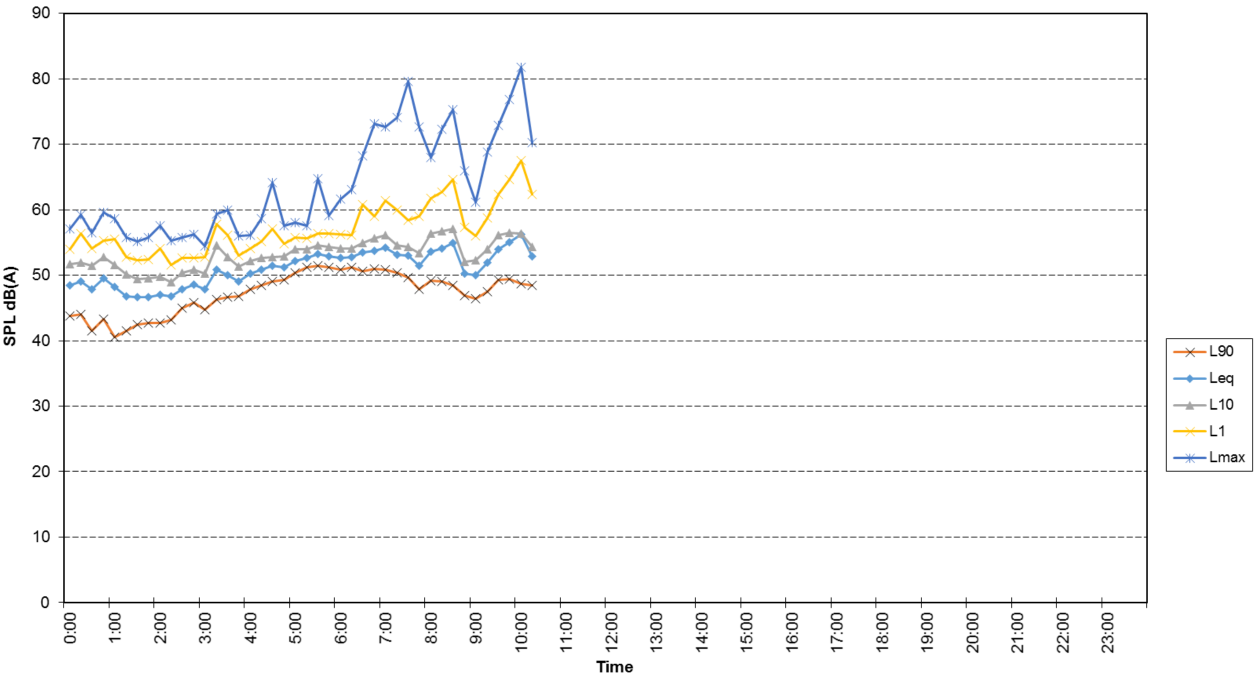
Location - BG1
Measured Noise Levels - Sunday 06/03/2016



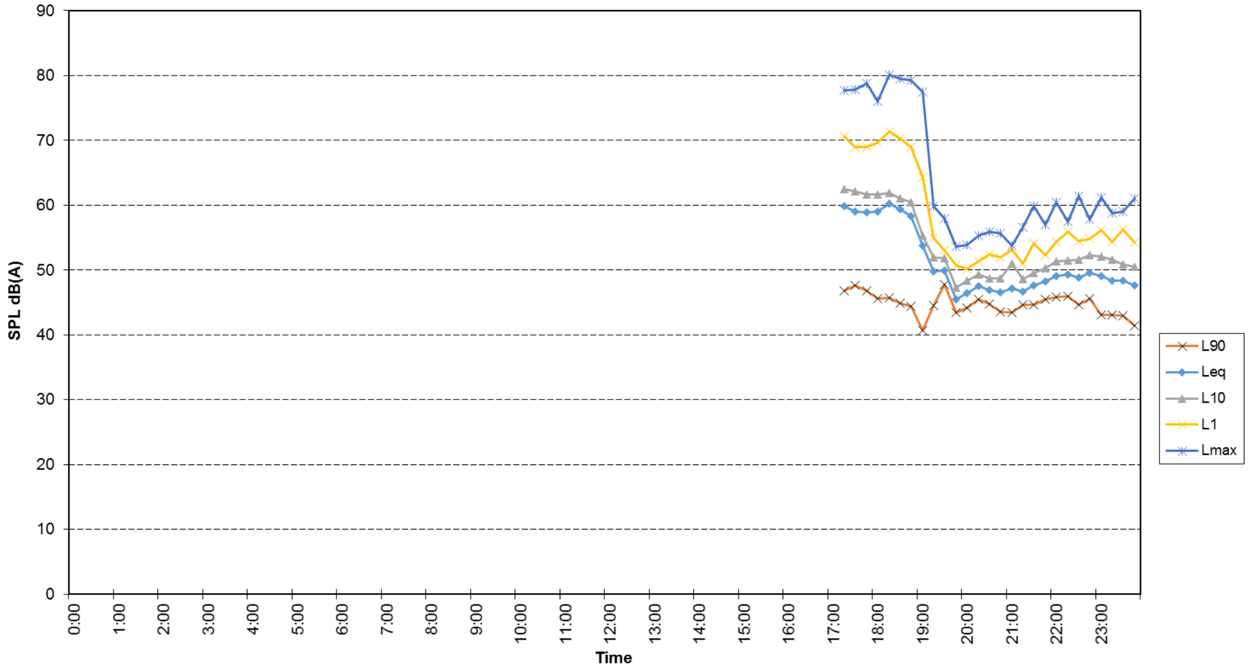
Location - BG1
Measured Noise Levels - Monday 07/03/2016



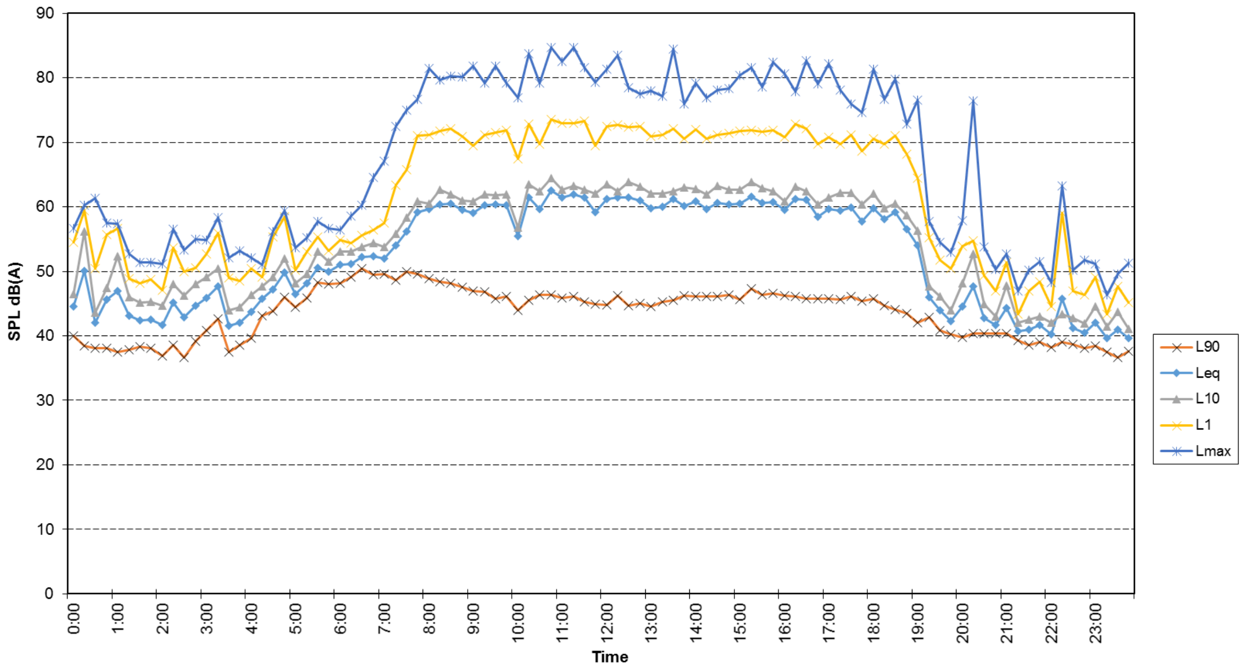
Location - BG1
Measured Noise Levels - Tuesday 08/03/2016



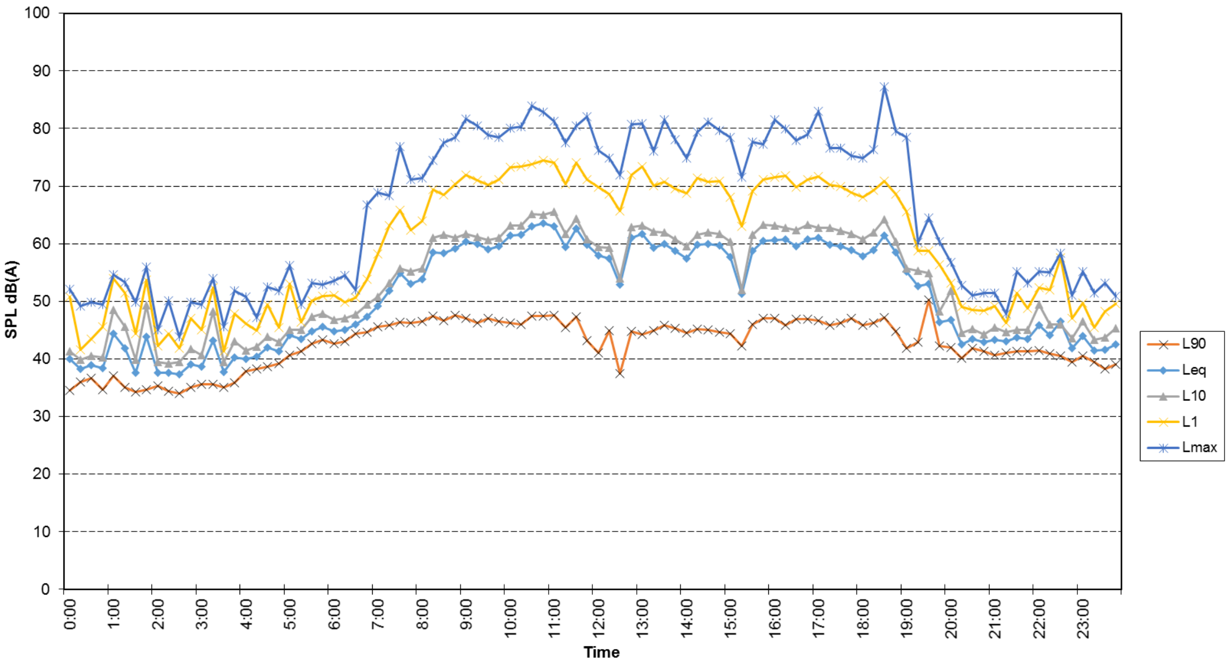
Location - BG2
Measured Noise Levels - Wednesday 30/03/2016



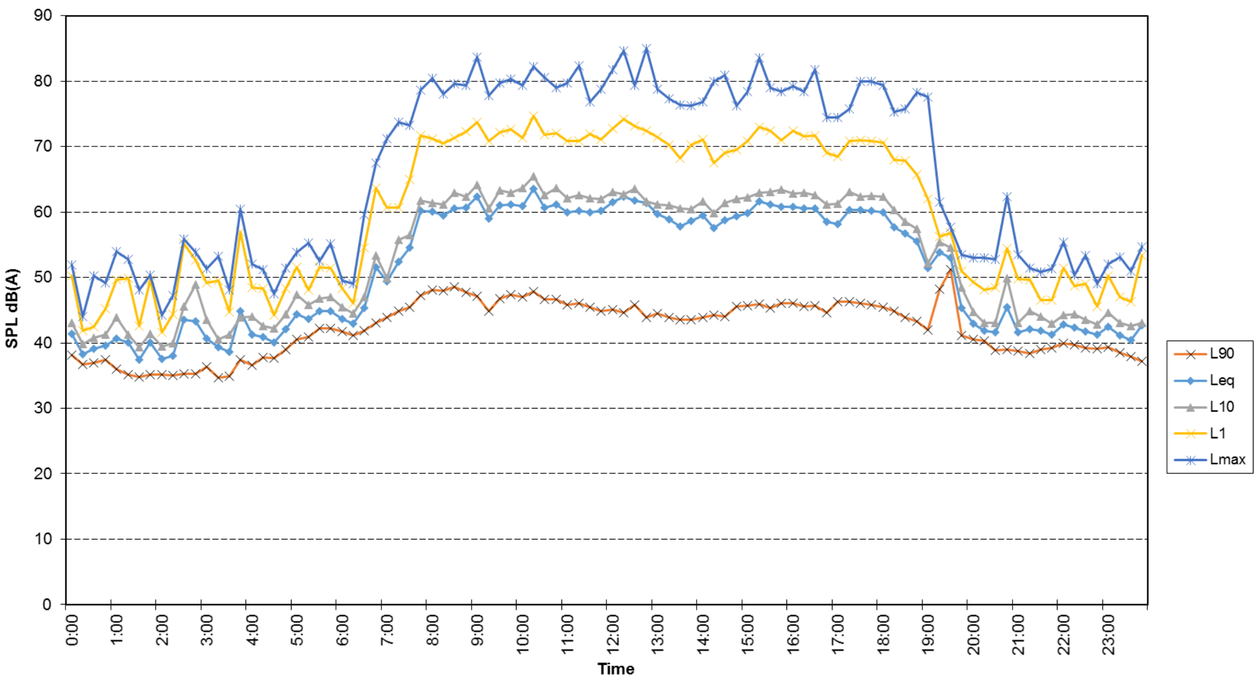
Location - BG2
Measured Noise Levels - Thursday 31/03/2016



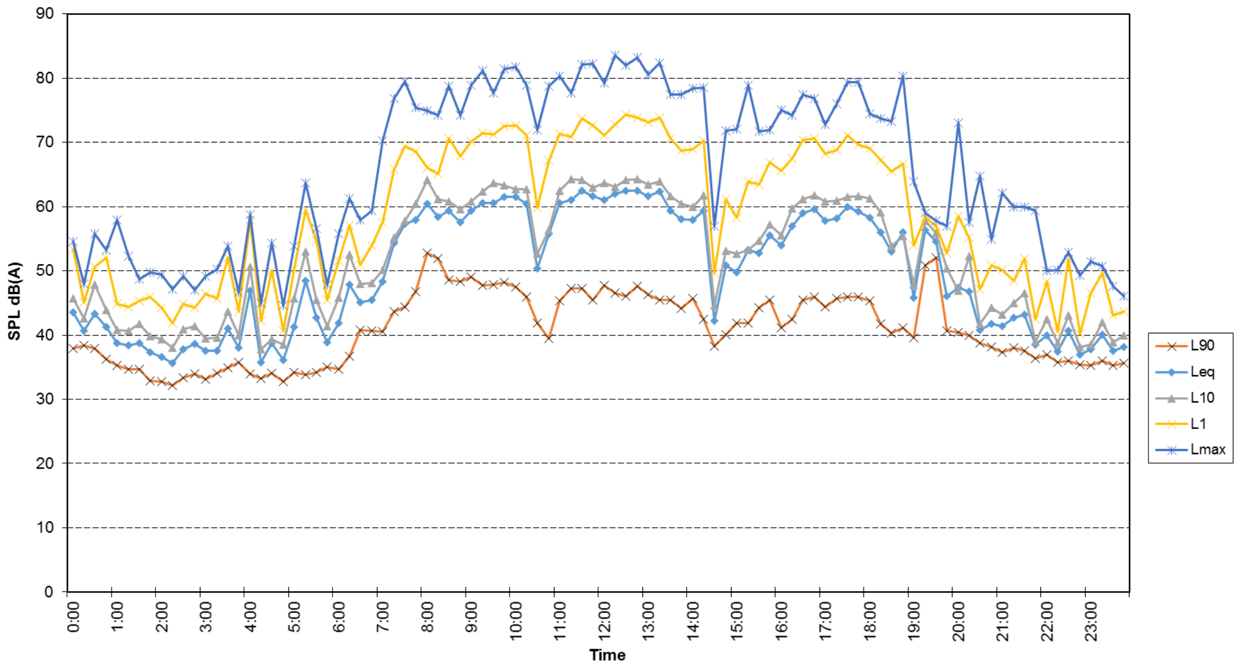
Location - BG2
Measured Noise Levels - Friday 01/04/2016



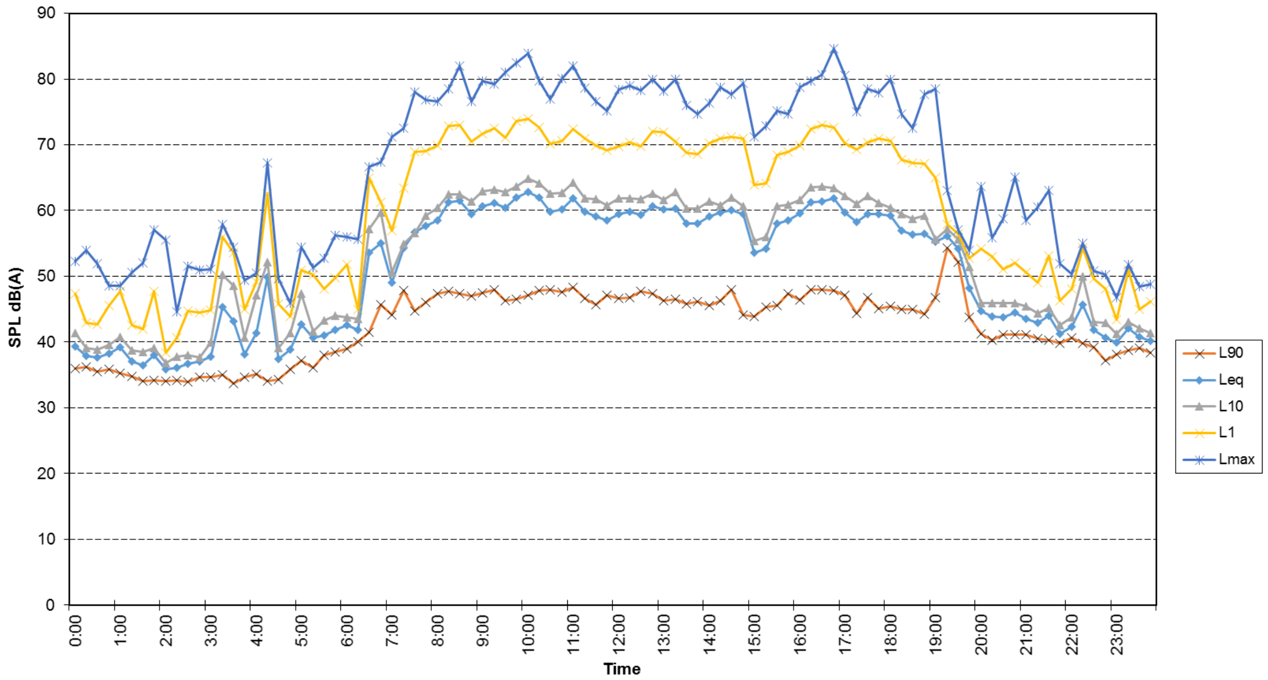
Location - BG2
Measured Noise Levels - Saturday 02/04/2016



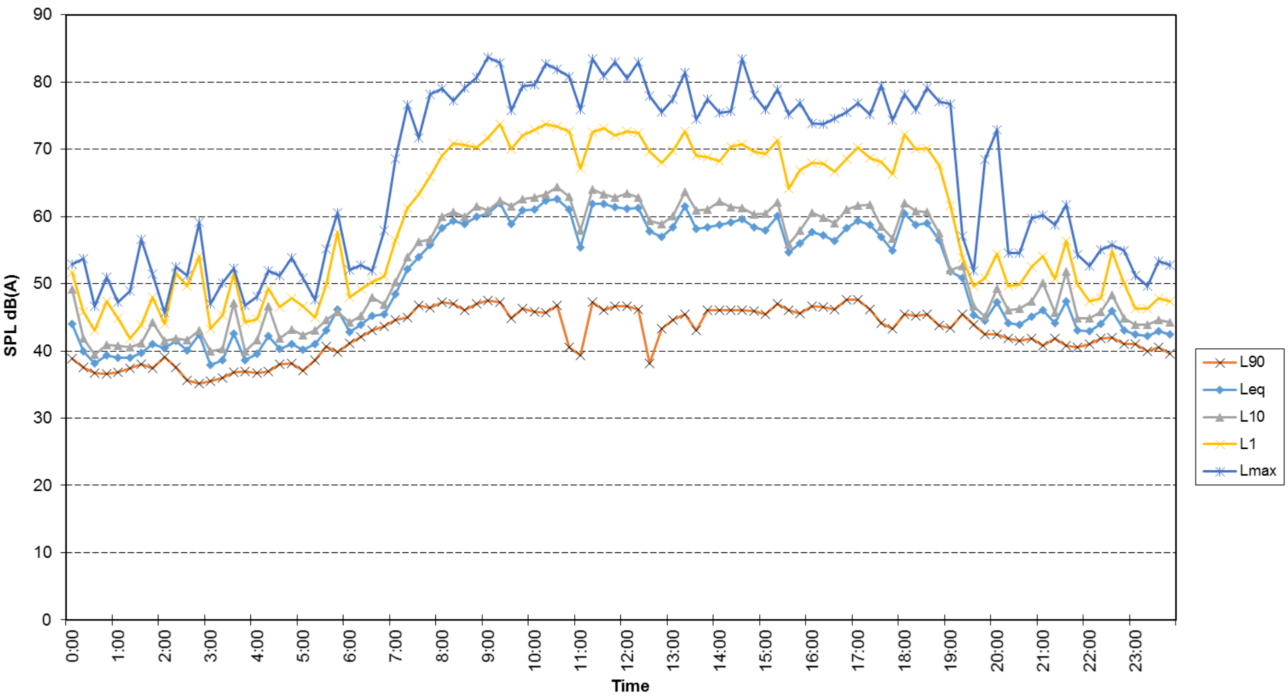
Location - BG2
Measured Noise Levels - Sunday 03/04/2016



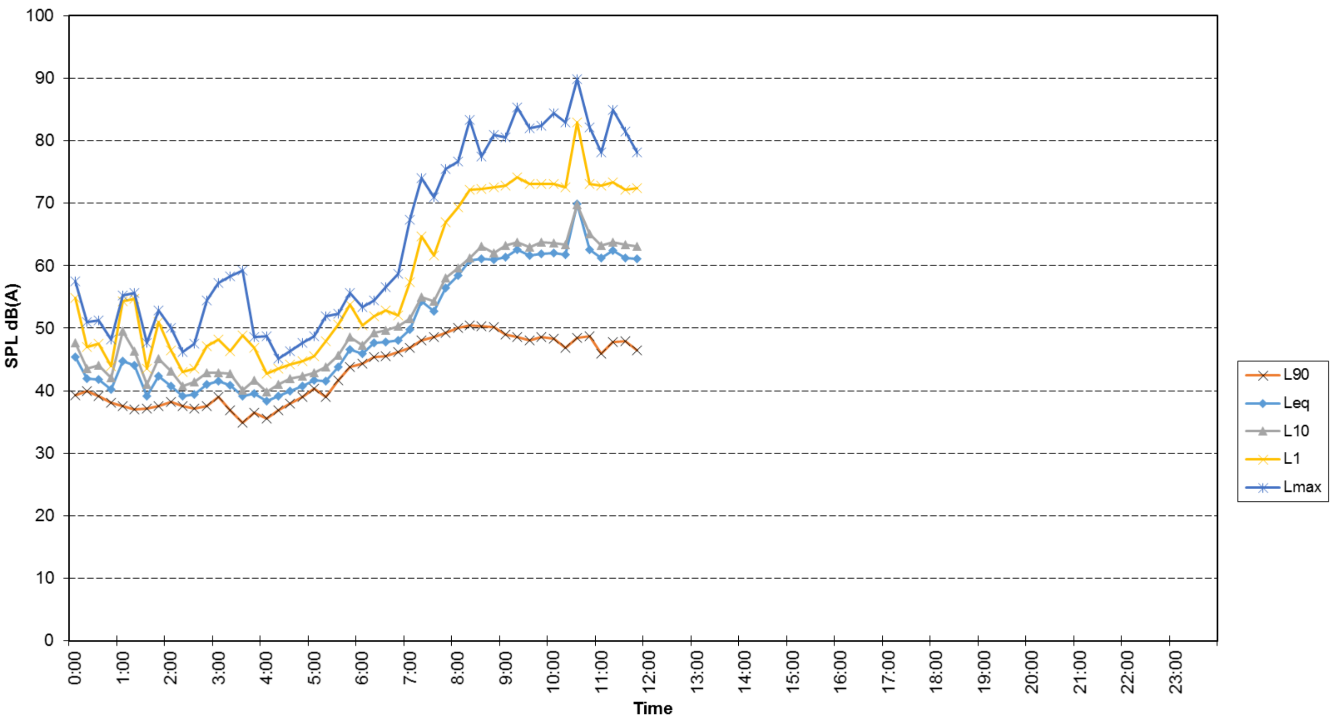
Location - BG2
Measured Noise Levels - Monday 04/04/2016



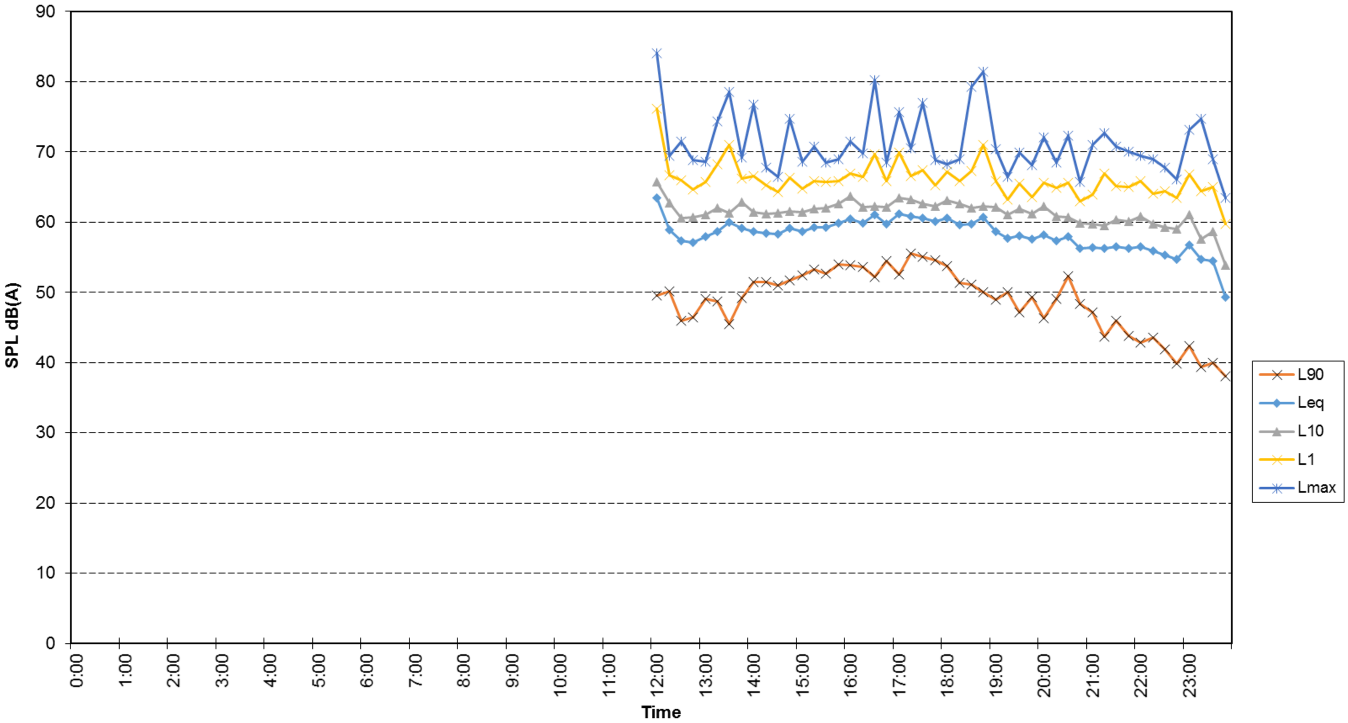
Location - BG2
Measured Noise Levels - Tuesday 05/04/2016



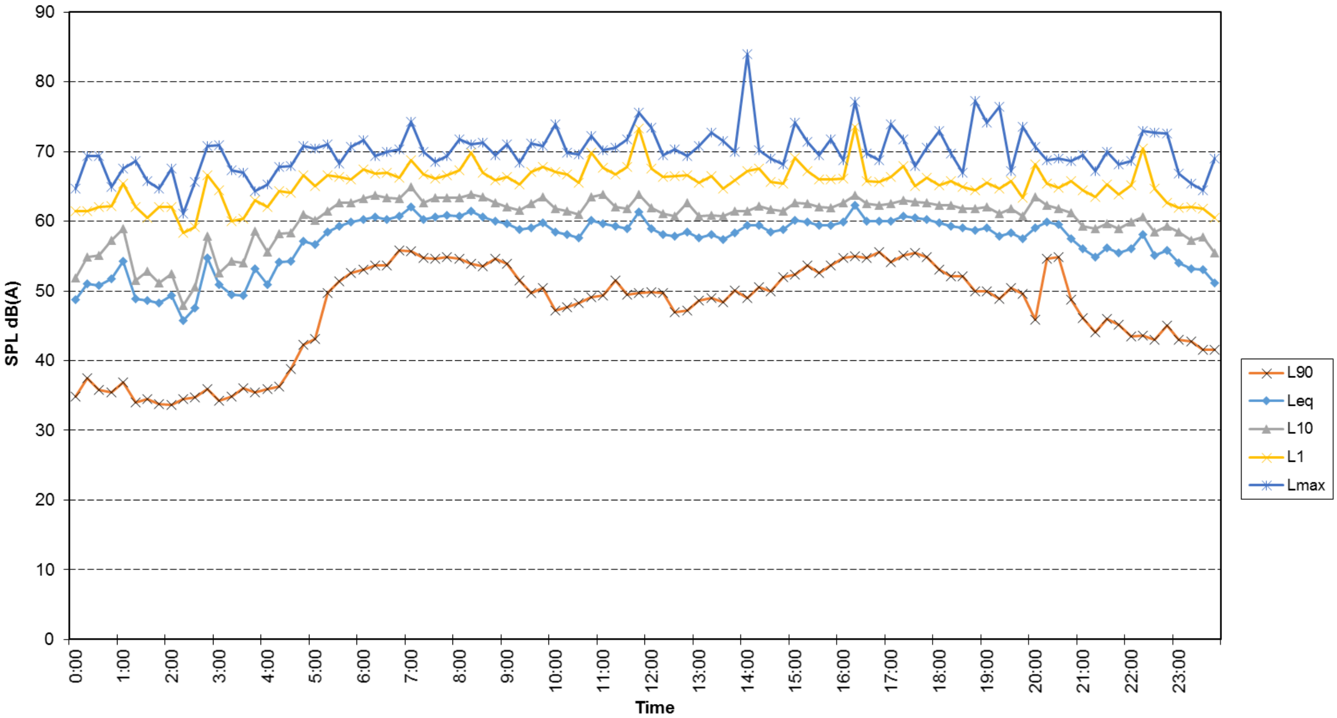
Location - BG2
Measured Noise Levels - Wednesday 06/04/2016



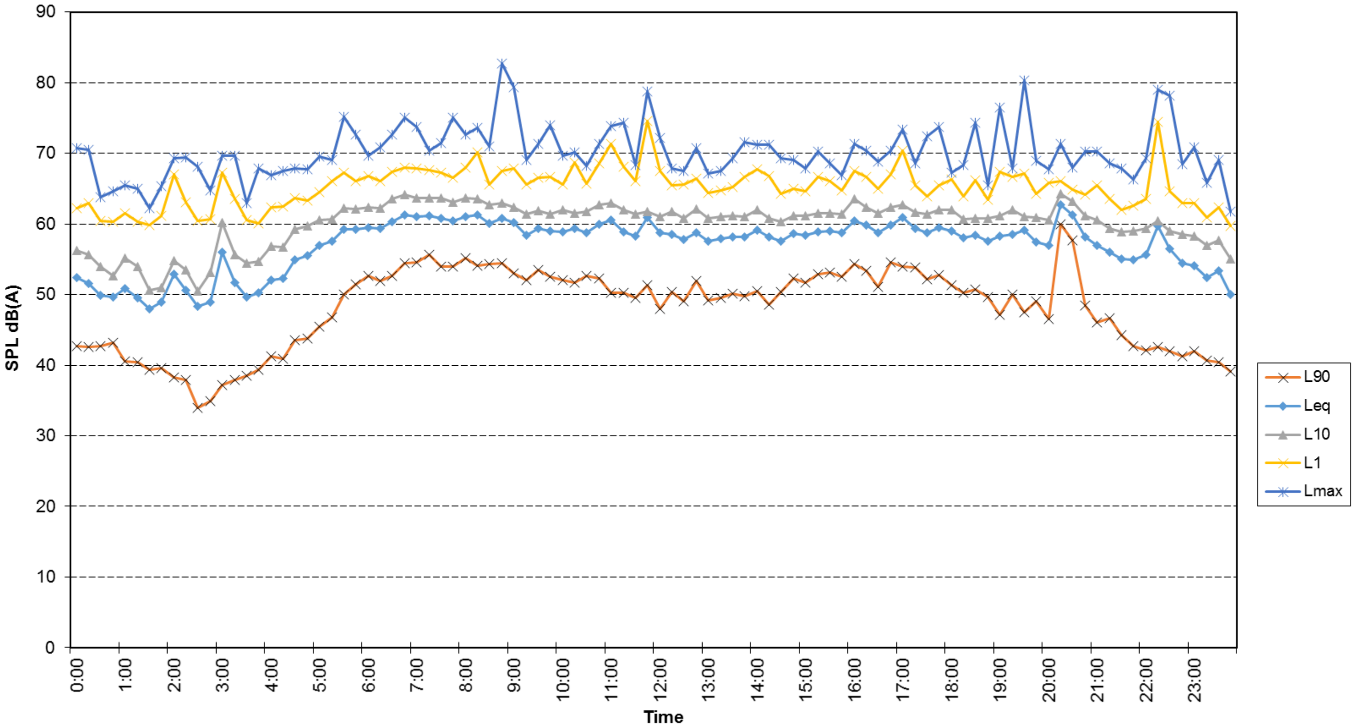
Location - BG3
Measured Noise Levels - Wednesday 17/02/2016



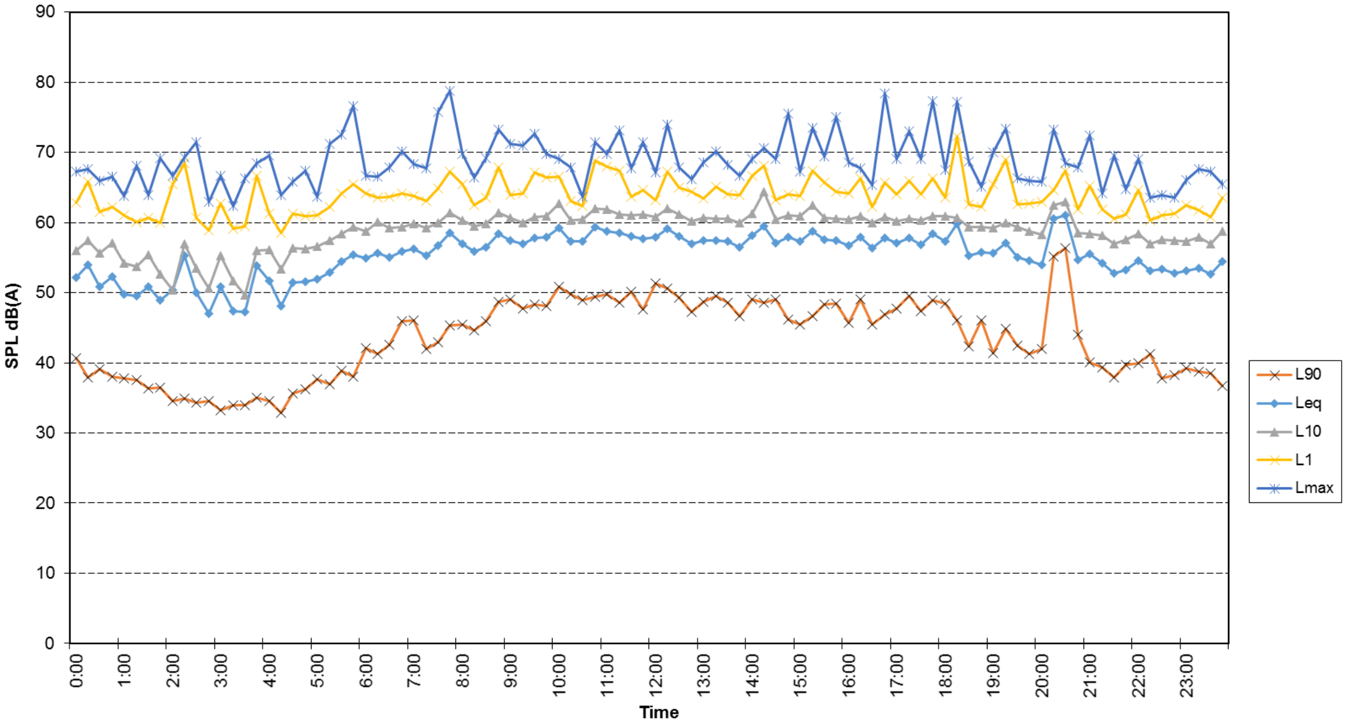
Location - BG3
Measured Noise Levels - Thursday 18/02/2016



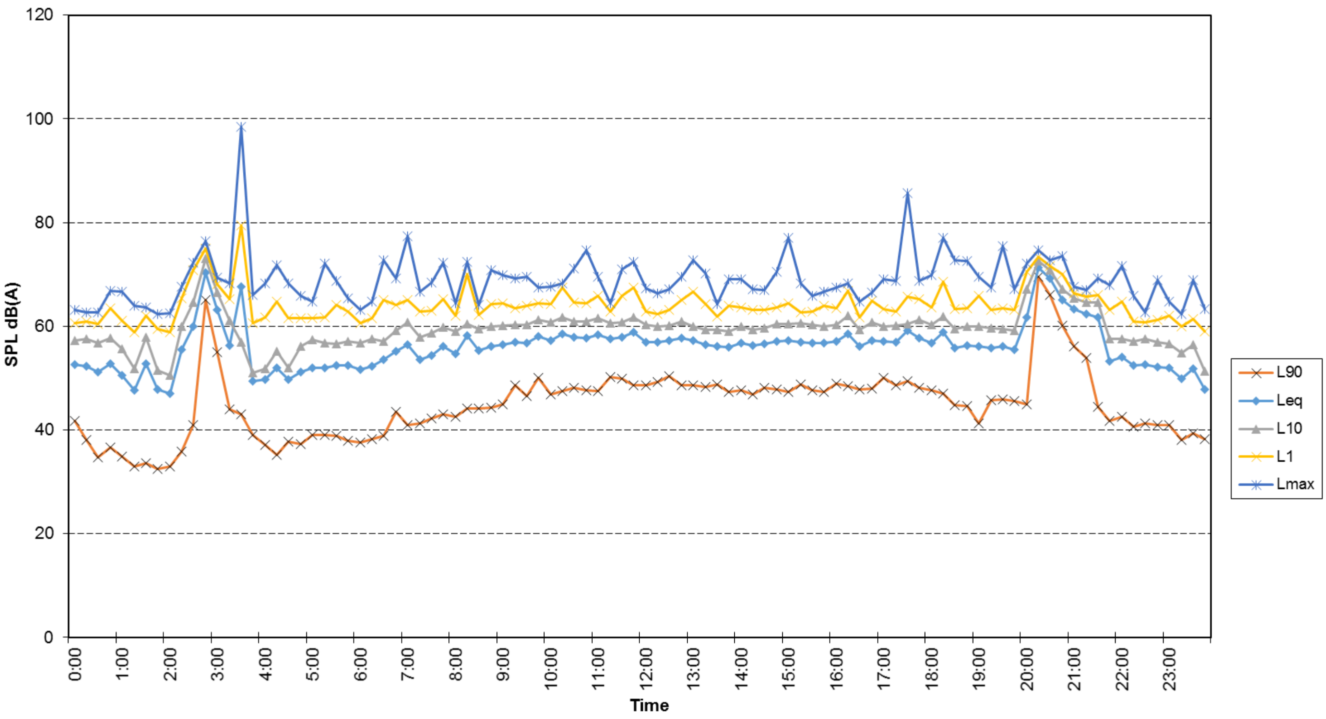
Location - BG3
Measured Noise Levels - Friday 19/02/2016



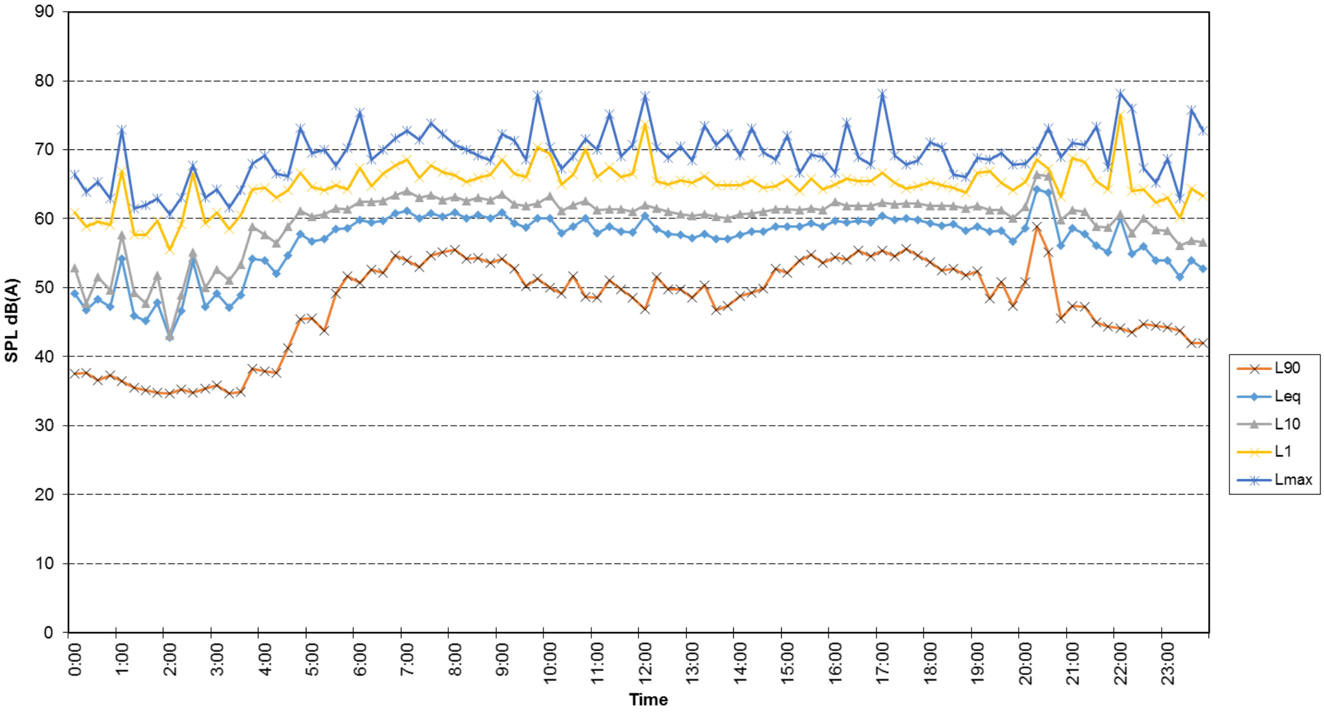
Location - BG3
Measured Noise Levels - Saturday 20/02/2016



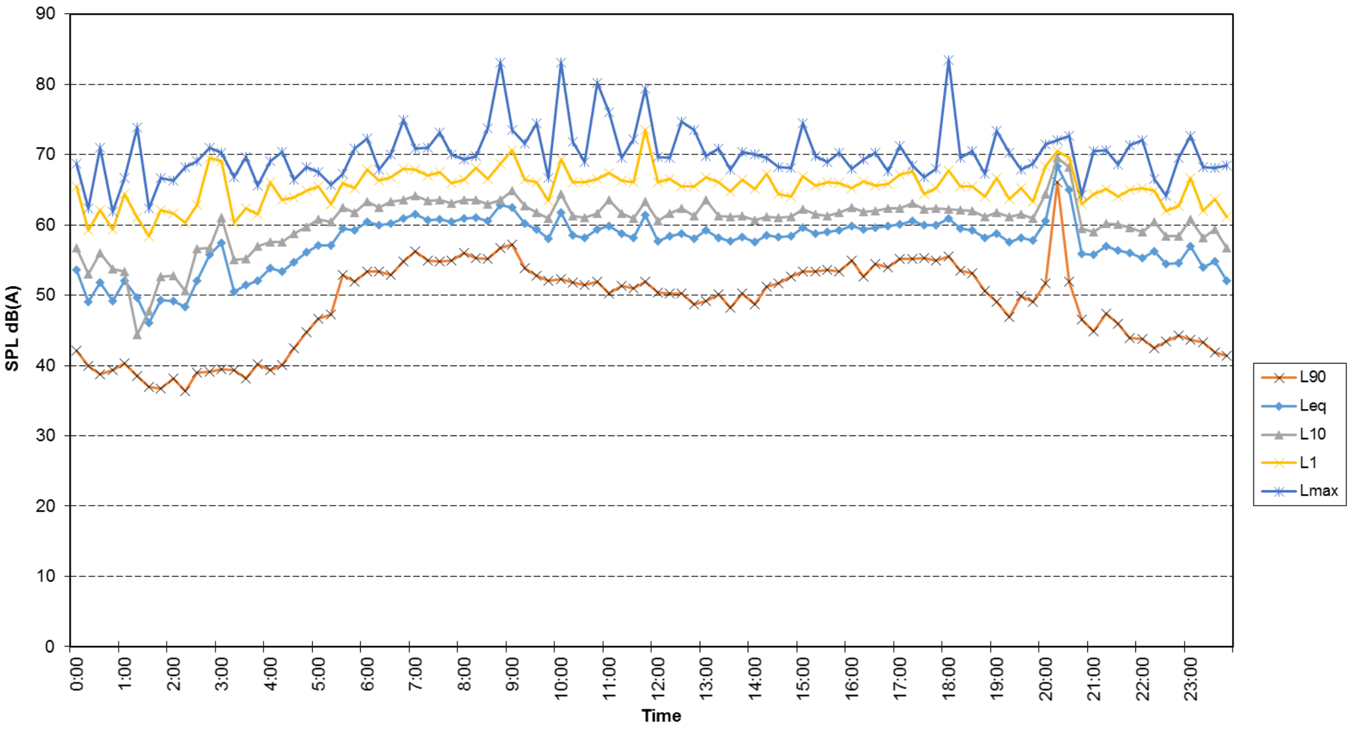
Location - BG3
Measured Noise Levels - Sunday 21/02/2016



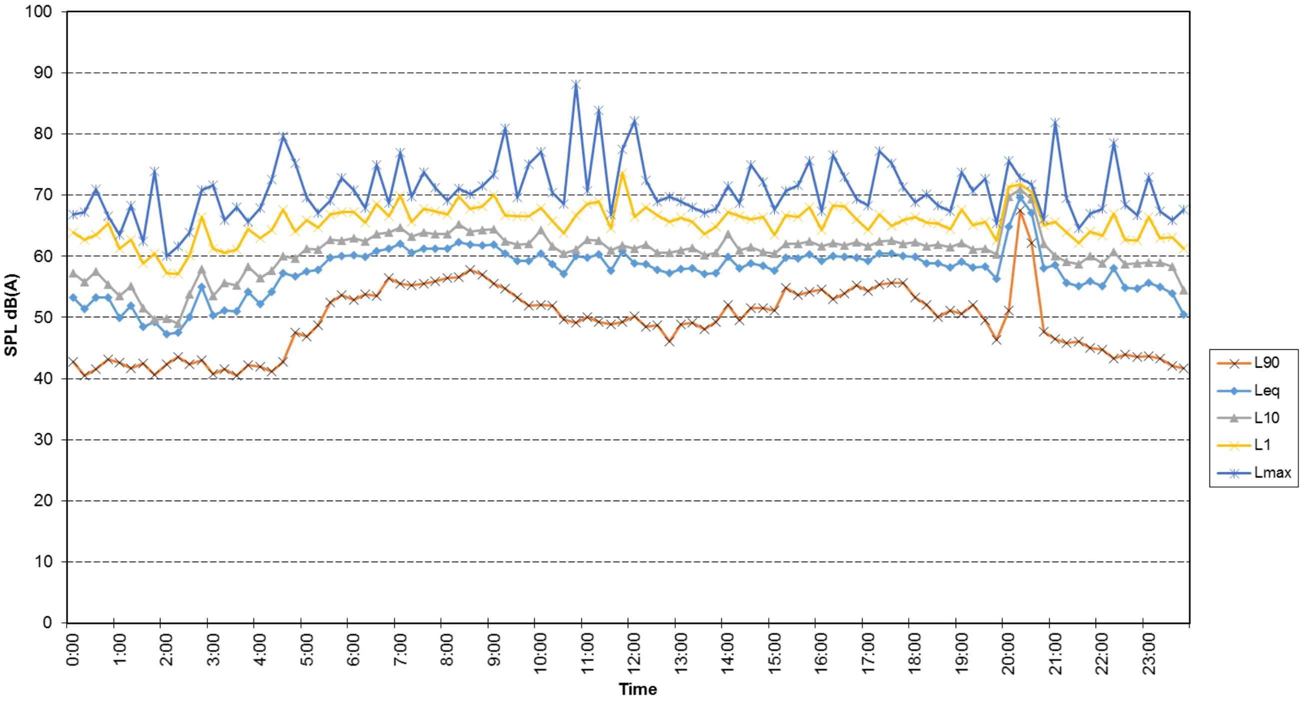
Location - BG3
Measured Noise Levels - Monday 22/02/2016



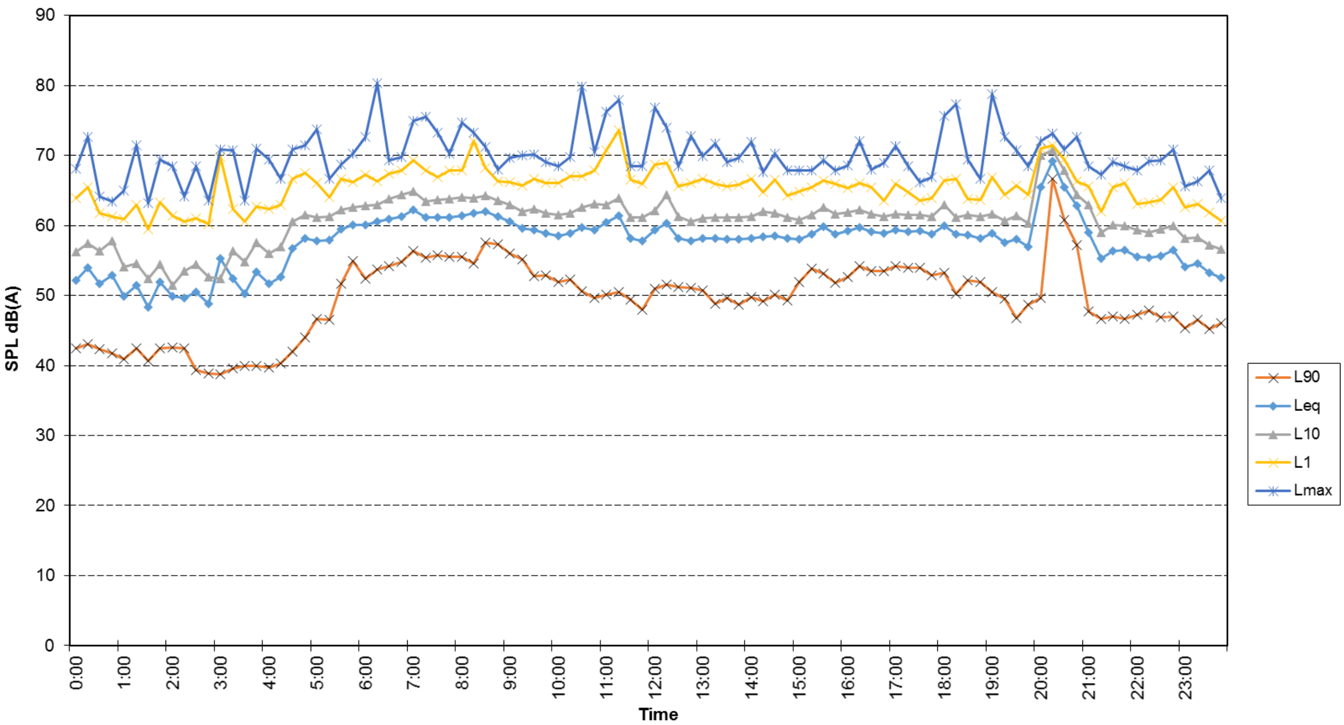
Location - BG3
Measured Noise Levels - Tuesday 23/02/2016



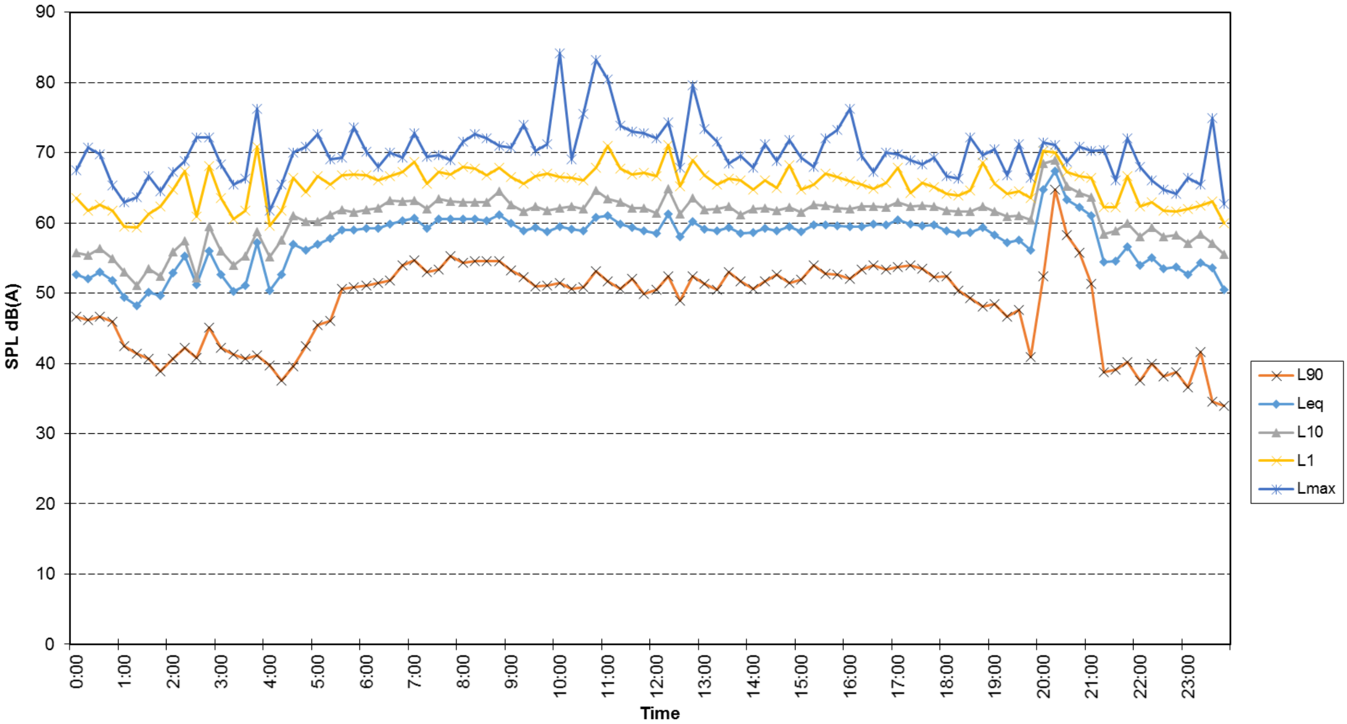
Location - BG3
Measured Noise Levels - Wednesday 24/02/2016



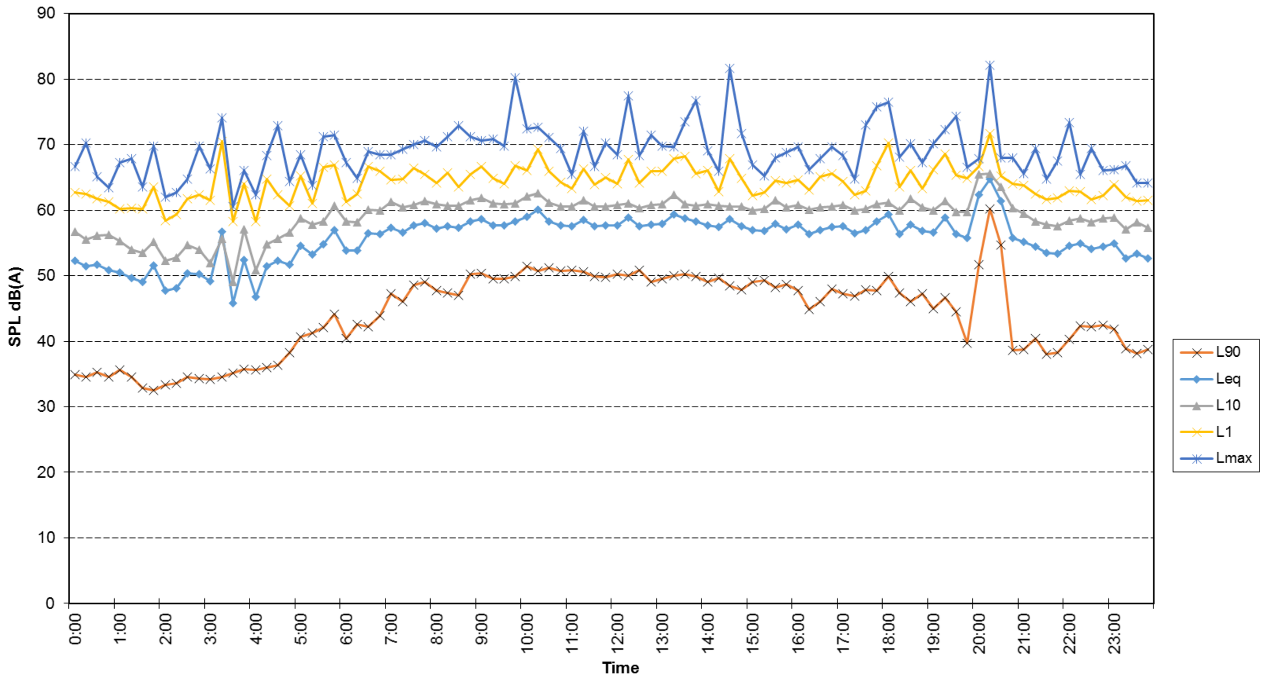
Location - BG3
Measured Noise Levels - Thursday 25/02/2016



Location - BG3
Measured Noise Levels - Friday 26/02/2016



Location - BG3
Measured Noise Levels - Saturday 27/02/2016



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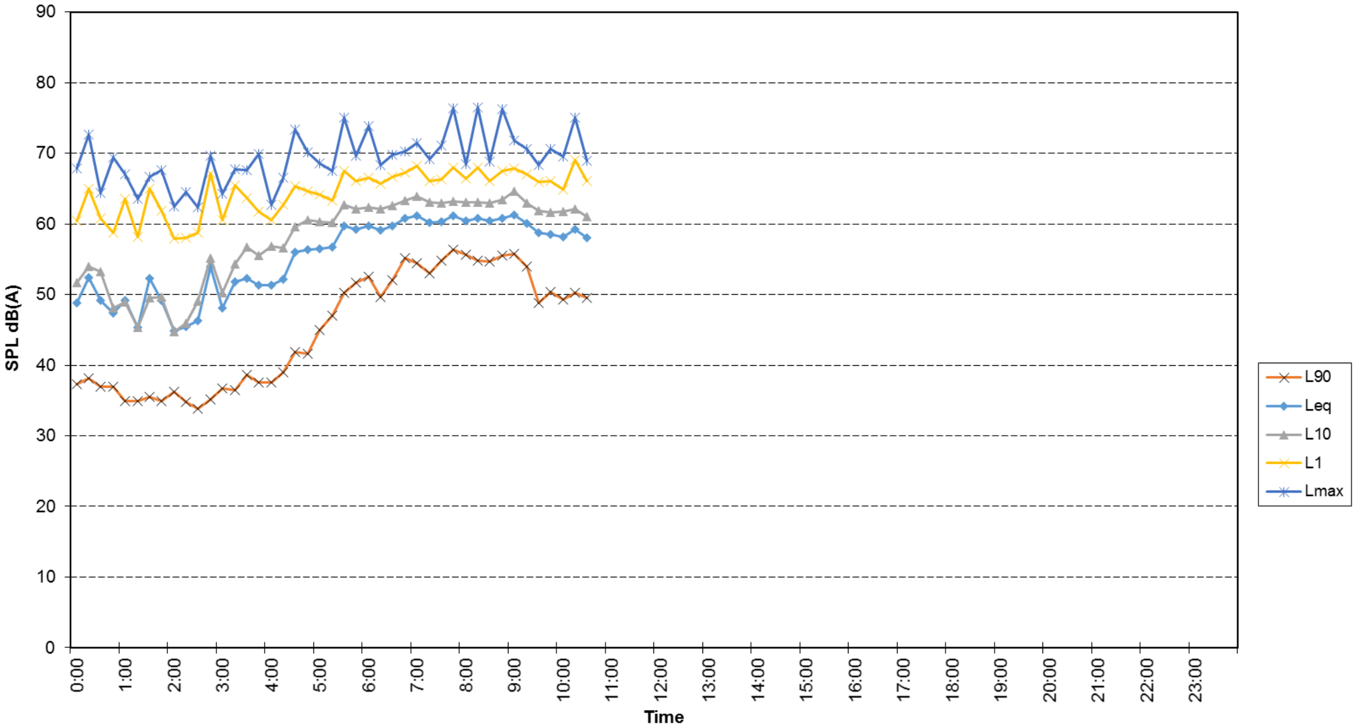
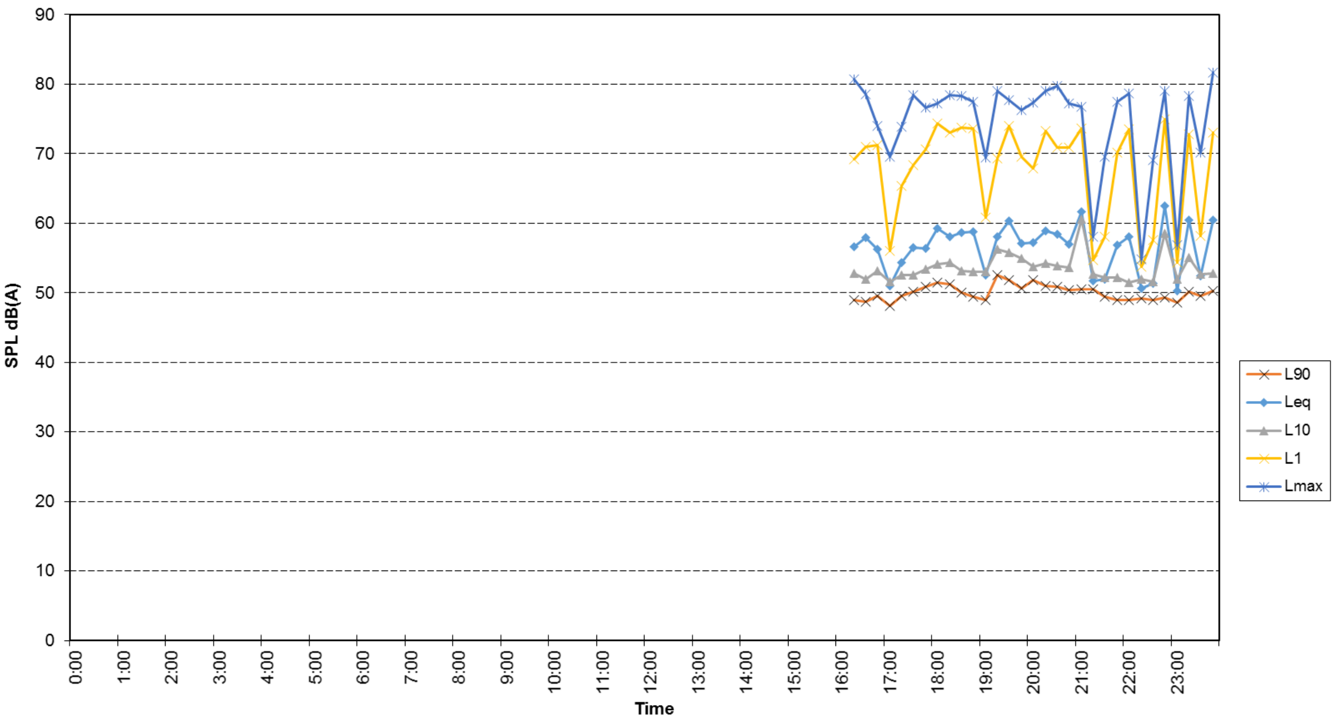
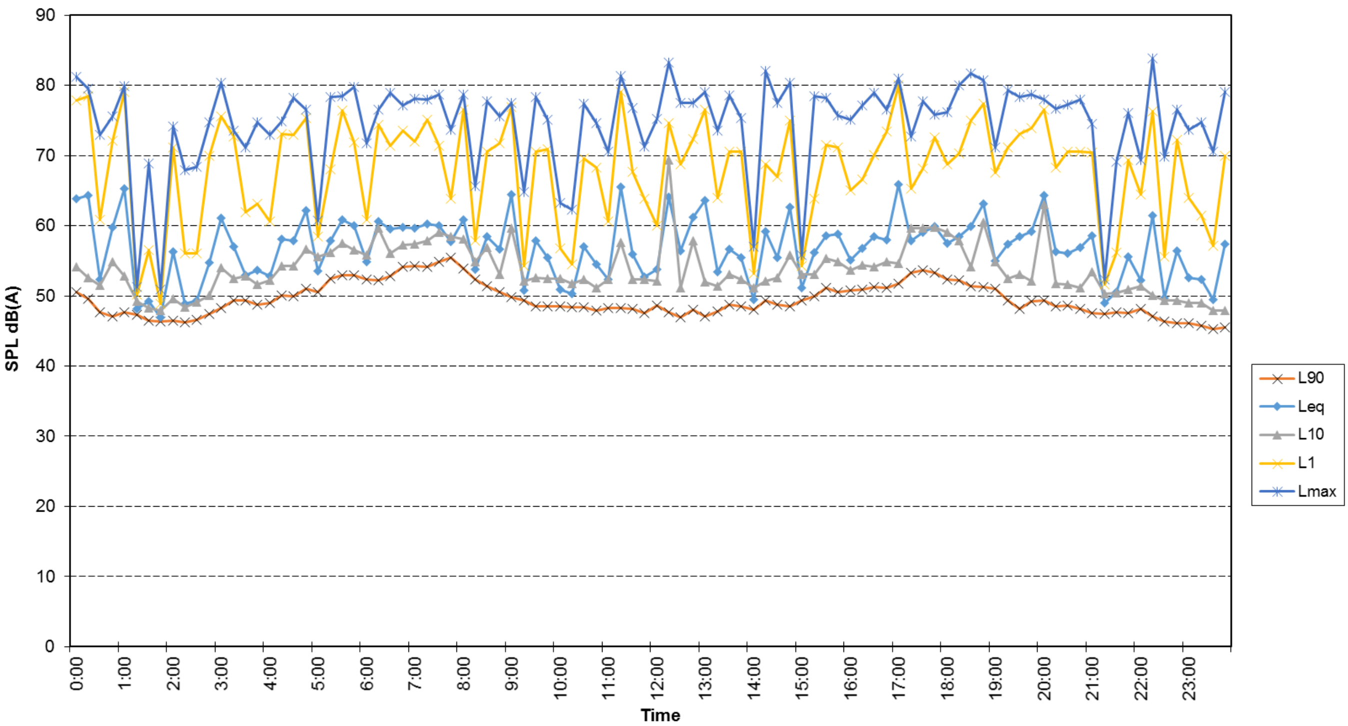
Location - BG3
Measured Noise Levels - Monday 29/02/2016



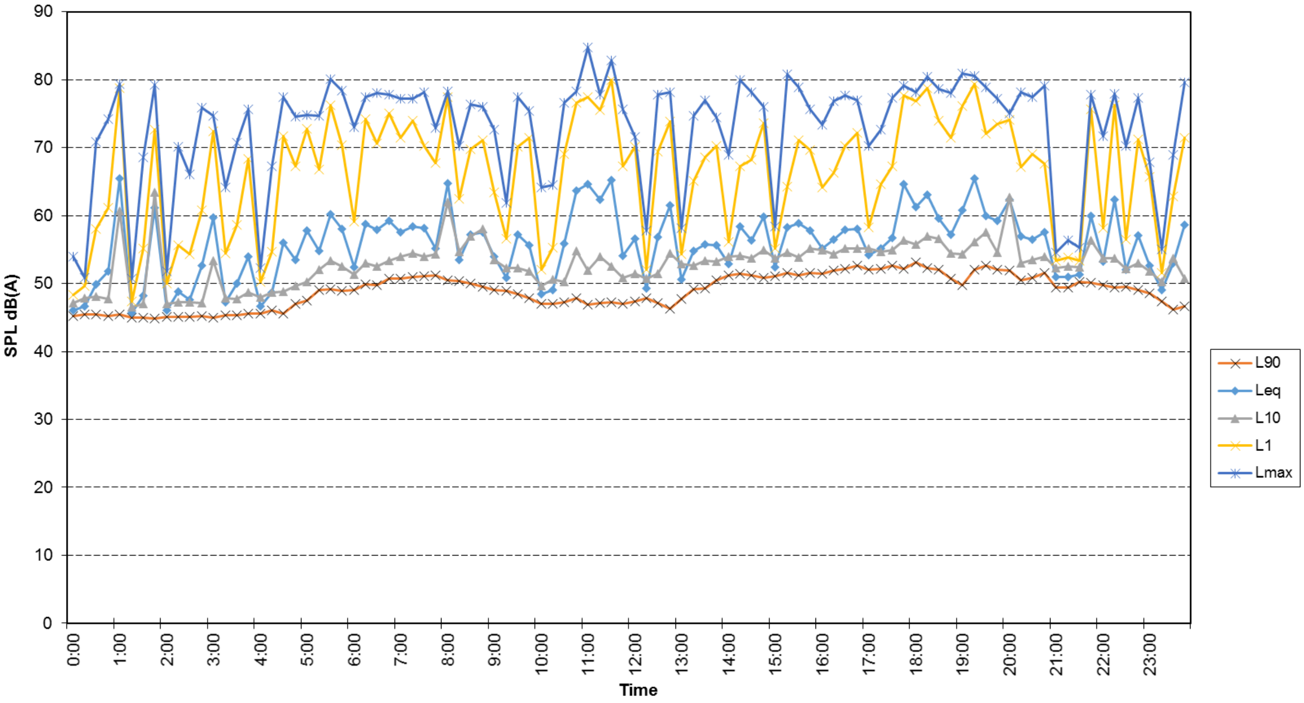
Location - BG4
Measured Noise Levels - Wednesday 30/03/2016



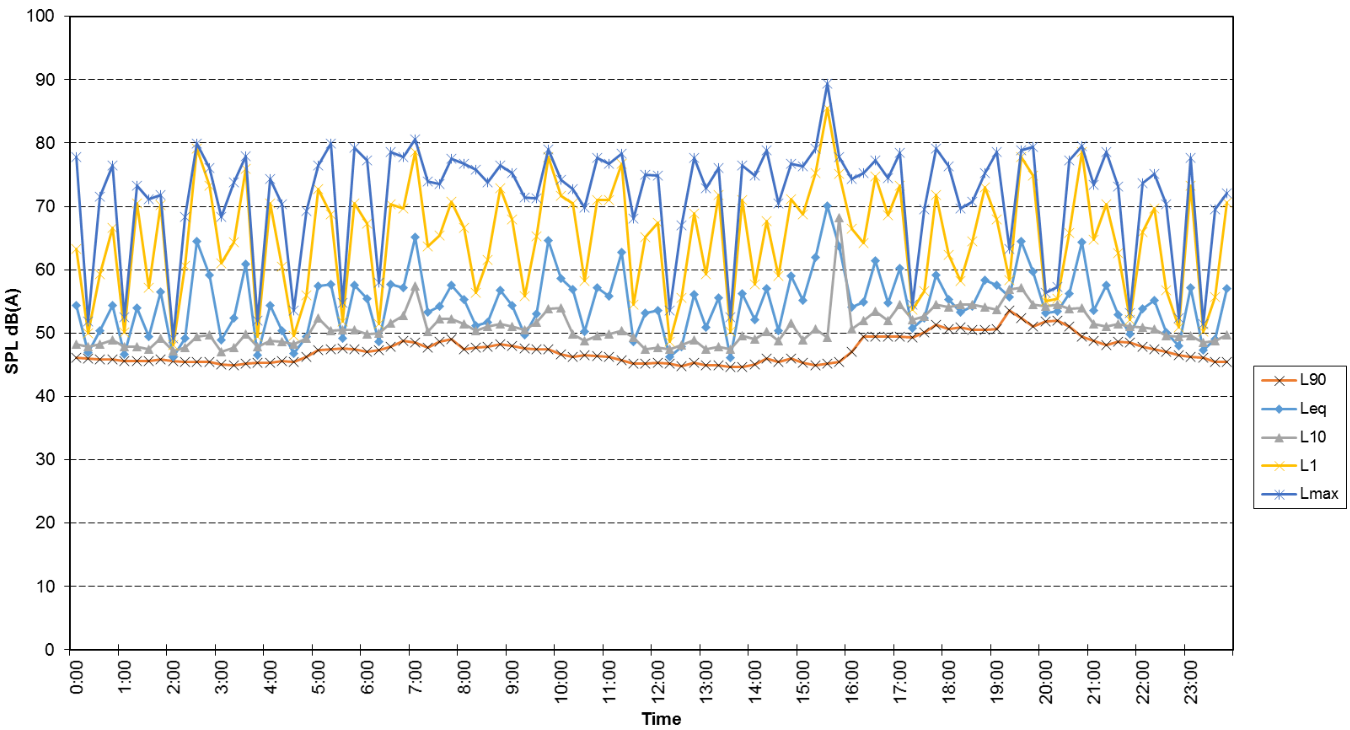
Location - BG4
Measured Noise Levels - Thursday 31/03/2016



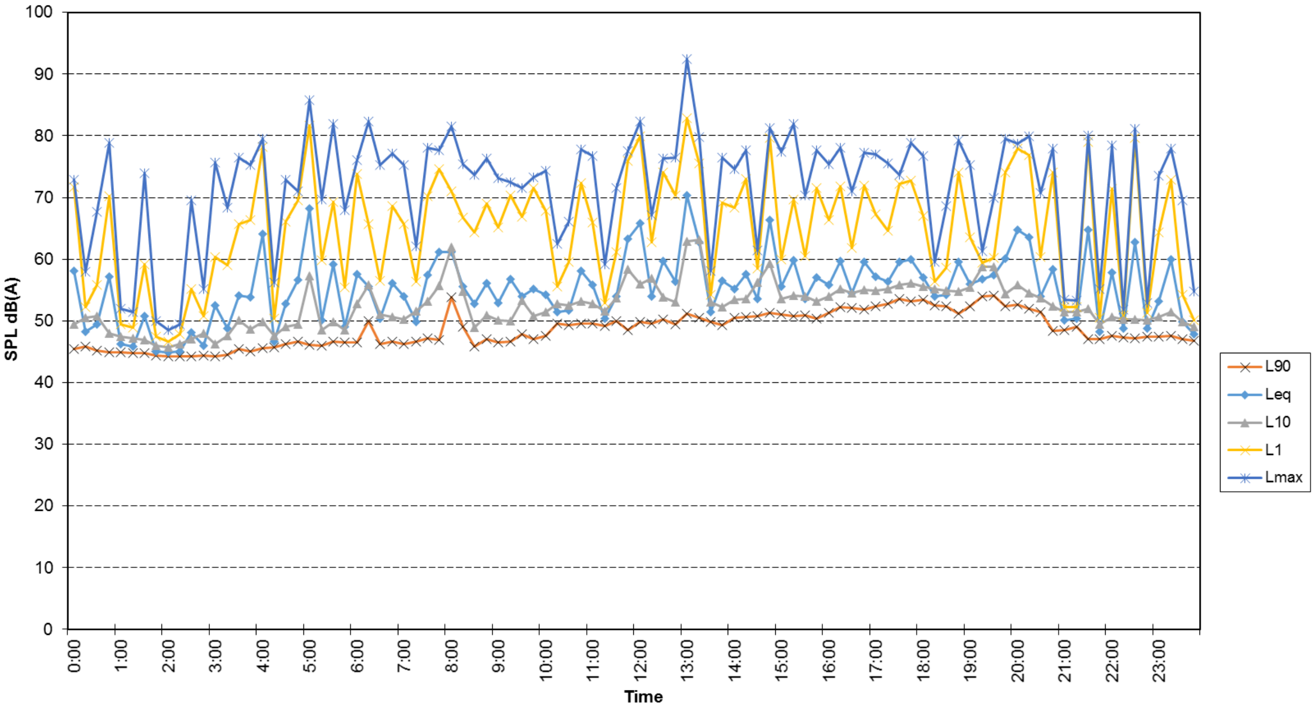
Location - BG4
Measured Noise Levels - Friday 01/04/2016



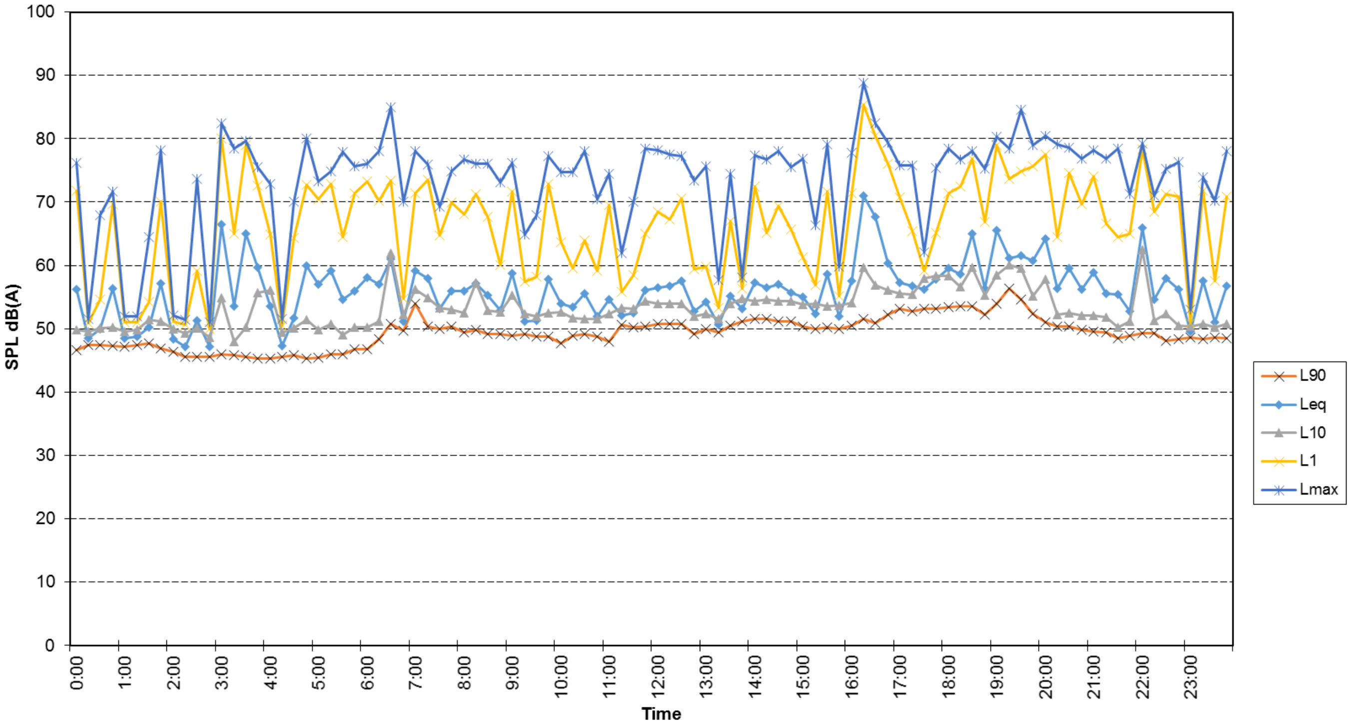
Location - BG4
Measured Noise Levels - Saturday 02/04/2016



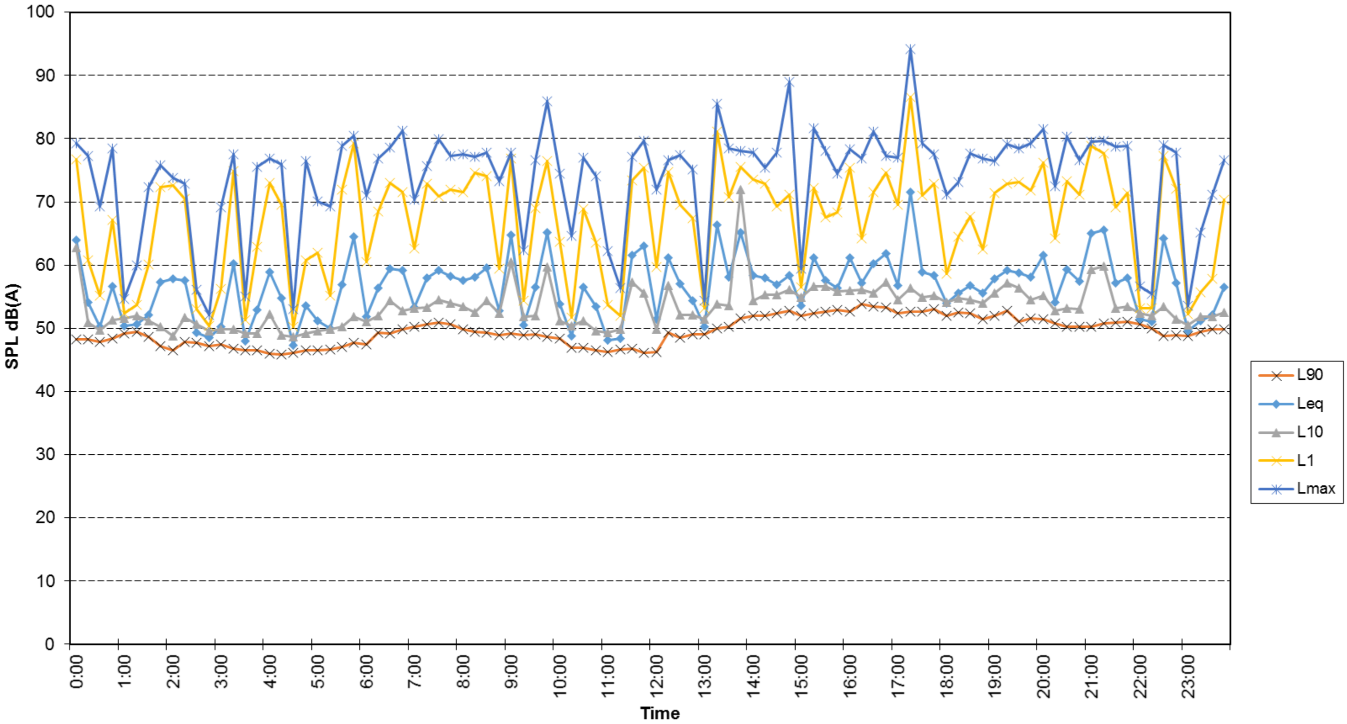
Location - BG4
Measured Noise Levels - Sunday 03/04/2016



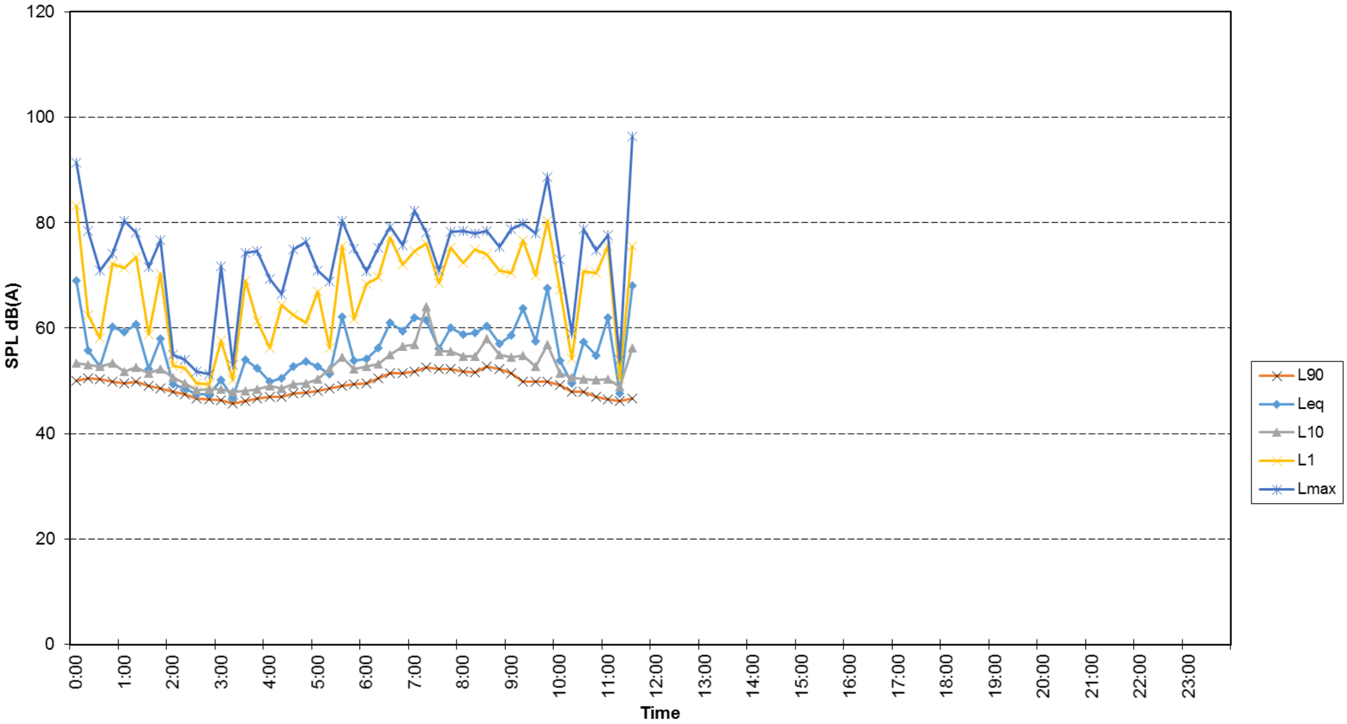
Location - BG4
Measured Noise Levels - Monday 04/04/2016



Location - BG4
Measured Noise Levels - Tuesday 05/04/2016



Location - BG4
Measured Noise Levels - Wednesday 06/04/2016



Appendix C Predicted noise levels

OPERATIONAL NOISE

Table 13-1 - Predicted operational noise levels for each $L_{eq,15min}$ scenario, $L_{eq,15min}$ dBA

Receiver	Criteria			1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
2 Bridge Street, Ourimbah	50	45	40	21	25	26	20	24	24	<20	22	23	<20	22	23	22	26	27	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
3 Bridge Street, Ourimbah	50	45	40	20	24	25	<20	23	23	<20	21	22	<20	21	22	20	25	25	<20	<20	<20	<20	22	23	<20	<20	<20	<20	<20	<20
11 Bridge Street, Ourimbah	50	45	40	21	25	26	<20	23	24	<20	21	22	<20	22	23	21	25	26	<20	<20	<20	<20	23	23	<20	<20	<20	<20	<20	<20
15 Bridge Street, Ourimbah	50	45	40	23	26	27	21	25	26	<20	23	23	<20	23	24	23	27	28	<20	<20	<20	20	24	25	<20	<20	<20	<20	<20	<20
24 Bridge Street, Ourimbah	50	45	40	23	27	28	22	26	26	20	24	25	21	25	25	24	28	29	<20	<20	<20	21	25	26	<20	<20	20	<20	<20	<20
36 Bridge Street, Ourimbah	50	45	40	25	28	29	23	27	27	21	24	25	20	24	25	23	27	28	<20	<20	<20	21	25	25	<20	<20	<20	<20	<20	<20
43 Bridge Street, Ourimbah	50	45	40	24	28	29	22	26	27	<20	23	24	<20	23	24	22	26	27	<20	<20	<20	<20	24	24	<20	<20	<20	<20	<20	<20
57 Bridge Street, Ourimbah	50	45	40	27	31	31	24	28	29	<20	22	23	<20	23	23	21	25	26	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
67 Pacific Highway, Kangy Angy	50	45	40	21	25	25	20	24	24	<20	22	23	<20	23	23	23	27	28	<20	<20	<20	21	25	25	<20	20	21	<20	<20	<20
68 Pacific Highway, Kangy Angy	50	45	40	20	24	25	20	24	24	<20	22	23	<20	23	23	23	27	28	<20	<20	<20	20	24	25	<20	<20	20	<20	<20	<20
79 Pacific Highway, Kangy Angy	50	45	40	22	26	27	22	26	26	21	25	26	22	26	26	26	30	31	<20	20	21	24	28	28	<20	23	24	<20	<20	<20
56 Bridge Street, Ourimbah	49	42	40	34	36	37	30	33	34	<20	21	22	21	25	25	20	24	25	<20	<20	<20	<20	22	23	<20	<20	<20	<20	<20	<20
52 Howes Road, Ourimbah	49	42	40	26	30	31	23	27	28	<20	<20	<20	<20	21	21	<20	22	23	<20	<20	<20	<20	20	20	<20	<20	<20	<20	<20	<20
2 Orchard Road, Kangy Angy	49	42	40	27	30	31	26	29	30	26	29	30	26	29	30	29	32	33	<20	21	22	27	30	31	20	23	24	<20	<20	<20
8 Orchard Road, Kangy Angy	49	42	40	24	28	28	23	27	28	22	26	27	23	26	27	26	30	31	<20	<20	20	24	27	28	<20	22	22	<20	<20	<20
50 Orchard Road, Kangy Angy	49	42	40	33	35	36	33	35	36	32	34	35	33	35	36	38	**41**	**42**	29	30	30	36	38	39	31	33	34	<20	<20	<20

Receiver	Criteria			1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
54 Orchard Road, Kangy Angy	49	42	40	32	34	34	32	34	34	32	33	34	32	34	34	38	40	**41**	29	30	30	35	38	38	32	34	35	<20	<20	<20
62 Orchard Road, Kangy Angy	49	42	40	32	33	34	32	34	34	31	33	34	32	34	34	37	40	40	29	30	30	35	37	38	32	34	35	<20	<20	<20
72 Orchard Road, Kangy Angy	49	42	40	31	33	33	31	33	33	31	32	33	31	33	33	35	38	38	30	30	30	33	35	36	33	35	36	<20	<20	<20
80 Orchard Road, Kangy Angy	49	42	40	30	32	32	30	32	32	30	31	32	30	32	32	34	36	37	29	29	29	32	34	35	31	33	34	<20	<20	<20
84 Orchard Road, Kangy Angy	49	42	40	27	29	30	27	29	30	27	29	30	27	29	30	31	34	35	25	27	27	29	32	33	27	30	30	<20	<20	<20
92 Orchard Road, Kangy Angy	49	42	40	27	29	29	27	29	29	26	28	29	27	29	29	30	33	33	25	26	27	28	30	31	27	29	30	<20	<20	<20
106 Orchard Road, Kangy Angy	49	42	40	28	30	30	28	30	30	27	29	30	28	30	30	30	33	34	26	27	28	29	31	32	28	30	31	<20	<20	<20
12 Ourimbah Road, Kangy Angy	49	42	40	40	**41**	**42**	**41**	**42**	**42**	40	**42**	**42**	**41**	**42**	**42**	**42**	*44*	*44*	27	28	29	39	**41**	**42**	28	30	31	29	30	31
19 Ourimbah Road, Kangy Angy	49	42	40	38	39	40	38	39	40	38	39	40	38	39	40	*45*	*46*	*46*	29	30	30	**42**	43	*44*	31	32	33	22	23	25
15 Schubolt Lane, Kangy Angy	49	42	40	35	37	38	32	35	36	31	33	34	29	32	33	31	34	35	20	22	23	28	31	32	21	24	24	20	22	23
15 Schubolt Lane, Kangy Angy	49	42	40	34	36	37	33	35	36	32	34	35	31	33	34	32	35	36	21	23	24	30	33	34	22	25	25	21	23	24
16 Schubolt Lane, Kangy Angy	49	42	40	33	35	36	30	33	34	29	32	32	28	31	32	30	33	34	<20	21	22	27	30	31	20	23	23	<20	20	21
16 Turpentine Road, Kangy Angy	49	42	40	37	38	39	31	34	35	23	26	27	24	27	28	25	29	29	<20	<20	20	22	26	27	<20	<20	20	<20	<20	<20
26 Turpentine Road, Kangy Angy	49	42	40	39	40	40	34	37	37	30	33	33	29	32	33	30	34	34	20	22	23	27	31	32	20	24	24	<20	20	21
26 Turpentine Road, Kangy Angy	49	42	40	*42*	*42*	*43*	35	37	38	28	31	31	27	30	31	28	32	32	<20	20	21	25	29	30	<20	22	22	<20	<20	20
137 Enterprise Drive, Ourimbah	54	40	38	31	34	34	28	32	32	<20	21	22	<20	23	24	20	25	25	<20	<20	<20	<20	22	23	<20	<20	<20	<20	<20	<20
11 Enterprise Drive, Fountaindale	54	40	38	**40**	*41*	*42*	37	**39**	39	21	25	25	22	26	27	23	27	28	<20	<20	<20	20	24	25	<20	<20	<20	<20	<20	<20
21 Enterprise Drive, Fountaindale	54	40	38	38	**39**	**40**	36	37	38	<20	21	22	<20	23	24	20	24	25	<20	<20	<20	<20	21	22	<20	<20	<20	<20	<20	<20
14 Enterprise Drive, Fountaindale	54	40	38	**40**	*41*	*42*	37	**39**	39	20	23	24	21	25	26	22	26	27	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20

Receiver	Cr	ite	ria	1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
16 Enterprise Drive, Fountaindale	54	40	38	38	**40**	*41*	36	38	38	<20	23	24	20	24	25	21	25	26	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
28 Lillygrove Lane, Fountaindale	54	40	38	<20	22	23	<20	22	23	<20	22	23	26	30	31	23	26	27	<20	20	21	21	24	25	<20	21	22	<20	<20	<20
32 Lillygrove Lane, Fountaindale	54	40	38	<20	22	22	<20	22	23	<20	22	22	27	30	31	23	27	27	<20	20	21	21	24	25	<20	20	21	<20	<20	<20
36 Lillygrove Lane, Fountaindale	54	40	38	<20	20	21	<20	20	21	<20	20	21	25	29	30	21	25	26	<20	<20	20	20	23	24	<20	<20	20	<20	<20	<20
48 Lillygrove Lane, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	24	28	29	<20	22	23	<20	<20	<20	<20	20	21	<20	<20	<20	<20	<20	<20
6 Lorikeet Lane, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
9 Lorikeet Lane, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
12 Lorikeet Lane, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
120 Berkeley Road, Fountaindale	54	40	38	<20	23	24	<20	23	24	<20	23	24	27	31	32	24	27	28	<20	21	22	22	25	26	<20	21	22	<20	<20	<20
11 Manns Road, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
22 Manns Road, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
23 Manns Road, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
39 Manns Road, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
130 Old Chittaway Road, Fountaindale	54	40	38	**39**	**40**	**40**	**39**	**40**	**40**	**39**	**40**	**40**	**39**	*41*	*41*	38	**40**	*41*	24	26	26	35	37	38	25	27	27	**40**	**40**	**40**
86 Old Chittaway Road, Fountaindale	54	40	38	34	36	36	30	33	34	24	27	27	23	26	27	24	28	29	<20	<20	<20	21	25	26	<20	<20	<20	<20	<20	<20
89 Old Chittaway Road, Fountaindale	54	40	38	31	34	35	29	32	33	27	30	30	27	30	31	27	31	32	<20	<20	20	25	28	29	<20	20	21	<20	<20	20
96 Old Chittaway Road, Fountaindale	54	40	38	35	37	38	32	35	36	26	29	29	25	29	29	26	29	30	<20	<20	<20	23	27	28	<20	<20	20	<20	<20	<20
96 Old Chittaway	54	40	38	37	**39**	**39**	32	35	35	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Receiver	Criteria			1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
Road, Fountaindale																														
103 Old Chittaway Road, Fountaindale	54	40	38	34	36	37	31	34	35	29	31	32	28	31	32	28	32	32	<20	20	20	25	29	30	<20	21	21	<20	<20	20
105 Old Chittaway Road, Fountaindale	54	40	38	30	32	33	28	31	32	28	30	31	28	31	32	28	32	33	<20	20	20	26	29	30	<20	20	21	<20	20	21
107 Old Chittaway Road, Fountaindale	54	40	38	32	34	35	30	32	33	29	31	32	28	31	31	23	26	27	<20	<20	<20	20	23	24	<20	<20	<20	<20	<20	<20
121 Old Chittaway Road, Fountaindale	54	40	38	34	36	36	33	35	36	33	35	35	31	33	34	31	34	35	<20	21	22	28	31	32	20	22	23	23	24	25
125 Old Chittaway Road, Fountaindale	54	40	38	27	30	30	25	28	29	24	27	27	22	24	25	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
127 Old Chittaway Road, Fountaindale	54	40	38	34	36	37	34	36	36	34	36	37	34	36	37	35	37	38	22	24	25	32	35	35	23	25	25	32	33	33
141 Old Chittaway Road, Fountaindale	54	40	38	33	35	36	33	35	36	33	35	36	35	37	38	35	38	**39**	23	25	25	32	35	36	23	25	26	30	31	32
149 Old Chittaway Road, Fountaindale	54	40	38	33	35	36	33	35	36	33	36	36	36	38	**39**	37	**39**	**40**	26	27	27	35	37	38	26	27	28	27	28	30
150 Old Chittaway Road, Fountaindale	54	40	38	36	38	38	36	38	38	36	38	39	39	***41***	***41***	**40**	***42***	***43***	27	28	28	38	39	**40**	27	29	29	32	32	33
157 Old Chittaway Road, Fountaindale	54	40	38	31	33	33	30	33	33	30	32	33	31	33	33	31	34	35	<20	<20	<20	28	31	32	<20	<20	<20	27	28	29
161 Old Chittaway Road, Fountaindale	54	40	38	28	31	32	28	31	32	28	30	31	32	35	35	32	35	36	22	24	24	30	32	33	22	24	25	21	22	24
165 Old Chittaway Road, Fountaindale	54	40	38	33	35	35	33	35	35	33	34	35	38	**40**	**40**	38	**40**	***41***	28	28	29	36	38	38	28	29	29	20	21	22
170 Old Chittaway Road, Fountaindale	54	40	38	36	38	38	36	38	38	36	37	38	***45***	***46***	***47***	***42***	***44***	***45***	32	33	33	40	41	***42***	32	33	33	21	23	24
32 Old Chittaway	54	40	38	30	34	34	28	32	32	<20	21	21	<20	23	23	<20	24	24	<20	<20	<20	<20	21	22	<20	<20	<20	<20	<20	<20

Receiver	Cr	ite	ria	1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
Road, Fountaindale																														
46 Old Chittaway Road, Fountaindale	54	40	38	30	34	35	28	32	33	<20	21	22	<20	23	24	20	24	25	<20	<20	<20	<20	22	22	<20	<20	<20	<20	<20	<20
58 Old Chittaway Road, Fountaindale	54	40	38	30	33	34	27	31	32	<20	22	23	<20	22	22	21	25	26	<20	<20	<20	<20	22	23	<20	<20	<20	<20	<20	<20
60 Old Chittaway Road, Fountaindale	54	40	38	31	34	35	28	32	33	<20	23	24	20	24	24	21	25	26	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
64 Old Chittaway Road, Fountaindale	54	40	38	31	34	35	28	32	33	20	23	24	<20	23	24	22	26	27	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
78 Old Chittaway Road, Fountaindale	54	40	38	33	36	37	30	33	34	<20	21	22	20	24	25	22	26	27	<20	<20	<20	<20	23	24	<20	<20	<20	<20	<20	<20
33 Station Road, Fountaindale	54	40	38	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
3 Station Road, Fountaindale	54	40	38	30	32	33	30	32	33	30	32	33	35	37	38	35	38	38	25	27	27	32	35	36	26	27	27	<20	<20	21
7 Station Road, Fountaindale	54	40	38	28	31	32	28	31	32	28	30	31	34	36	37	33	36	36	24	26	26	30	33	34	24	26	26	<20	20	21
16 Station Road, Fountaindale	54	40	38	31	33	33	31	33	33	31	32	33	39	*41*	*41*	36	38	**39**	28	29	29	33	36	36	28	29	29	<20	<20	<20
23 Station Road, Fountaindale	54	40	38	25	28	28	26	28	28	25	27	28	32	35	36	31	34	34	23	25	25	28	31	32	24	25	26	<20	<20	<20
27 Station Road, Fountaindale	54	40	38	23	25	26	23	26	26	23	26	26	32	35	35	29	31	32	22	24	24	26	29	30	22	24	24	<20	<20	<20
35 Station Road, Fountaindale	54	40	38	23	25	25	23	25	25	23	25	26	32	35	36	27	30	31	22	24	24	25	28	28	22	24	24	<20	<20	<20
11 Station Road, Fountaindale	54	40	38	31	33	33	30	33	33	30	32	33	37	**39**	**39**	35	38	**39**	27	28	28	33	35	36	27	28	28	<20	20	21
139 Orchard Road, Kangy Angy	52	37	37	24	26	27	23	26	26	23	25	26	28	31	32	24	26	27	23	25	25	23	25	26	24	26	27	<20	<20	<20
98 Old Chittaway Road, Fountaindale	45	45	45	39	40	40	38	39	39	38	39	39	34	36	37	32	35	36	20	22	23	29	32	33	21	23	24	24	25	26
3A Catamaran Road, Fountaindale	65	65	65	<20	22	22	<20	21	22	<20	22	23	26	30	30	21	24	25	<20	20	20	20	23	23	<20	20	21	<20	<20	<20
1 Catamaran Road, Fountaindale	65	65	65	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Receiver	Cr	ite	ria	1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
2 Ketch Close, Fountaindale	65	65	65	27	30	31	27	30	31	29	32	33	35	39	39	30	34	35	26	27	28	29	32	33	26	28	28	<20	<20	<20
3 Catamaran Road, Fountaindale	65	65	65	25	27	28	25	27	27	26	29	30	32	35	35	27	30	30	23	25	26	25	28	29	24	25	26	<20	<20	<20
4 Catamaran Road, Fountaindale	65	65	65	22	24	24	22	24	24	22	24	25	32	35	35	24	27	28	20	22	22	23	25	26	20	22	22	<20	<20	<20
5 Catamaran Road, Fountaindale	65	65	65	23	25	26	23	25	25	23	25	25	29	32	33	24	26	27	22	23	24	23	25	25	22	24	24	<20	<20	<20
6 Catamaran Road, Fountaindale	65	65	65	29	31	31	29	31	31	29	31	32	39	41	42	30	32	33	29	30	31	30	31	32	29	30	31	<20	<20	<20
8 Catamaran Road, Fountaindale	65	65	65	26	28	28	26	28	28	26	28	29	33	36	37	28	31	32	25	26	27	27	29	30	25	26	27	<20	<20	<20
9 Catamaran Road, Fountaindale	65	65	65	21	23	25	21	23	25	21	24	25	28	31	32	23	26	27	21	22	23	22	25	26	21	22	23	<20	<20	<20
11 Catamaran Road, Fountaindale	65	65	65	21	24	25	21	24	25	21	24	25	27	30	31	27	31	32	<20	<20	20	24	28	29	<20	<20	21	<20	<20	<20
13 Catamaran Road, Fountaindale	65	65	65	<20	22	23	<20	22	23	<20	22	23	27	31	32	23	26	27	<20	20	21	21	24	25	<20	20	21	<20	<20	<20
15 Catamaran Road, Fountaindale	65	65	65	24	27	28	24	27	28	24	27	28	31	34	35	30	33	34	21	23	25	27	31	32	21	23	25	<20	<20	<20
17 Catamaran Road, Fountaindale	65	65	65	25	27	28	25	27	28	25	27	28	33	36	37	28	31	32	24	26	27	26	29	30	24	26	27	<20	<20	<20
1 Co-wyn Close, Fountaindale	65	65	65	33	35	35	33	35	35	35	37	39	45	46	46	37	39	40	32	32	32	35	37	38	32	32	32	<20	<20	<20
2 Catamaran Road, Fountaindale	65	65	65	31	32	33	31	32	33	33	35	36	40	42	43	34	36	37	30	31	31	32	34	35	30	31	31	<20	<20	<20
4 Ketch Close, Fountaindale	65	65	65	23	26	27	23	26	27	23	26	27	29	33	34	27	30	31	20	23	24	25	28	29	20	23	24	<20	<20	<20
5 Ketch Close, Fountaindale	65	65	65	24	26	27	23	26	27	24	27	28	30	33	33	25	28	29	22	24	25	24	27	27	22	25	25	<20	<20	<20
7 Ketch Close, Fountaindale	65	65	65	22	25	25	22	24	25	23	26	26	28	31	32	24	27	28	21	23	23	22	25	26	21	23	24	<20	<20	<20
8 Ketch Close, Fountaindale	65	65	65	22	25	25	22	25	25	22	26	26	27	31	32	23	27	28	20	22	23	22	25	26	20	22	23	<20	<20	<20
9 Ketch Close, Fountaindale	65	65	65	<20	22	22	<20	21	22	<20	22	22	24	27	28	20	22	23	<20	21	22	<20	22	23	<20	21	22	<20	<20	<20
10 Ketch Close, Fountaindale	65	65	65	<20	21	22	<20	21	21	<20	21	22	22	25	26	<20	22	23	<20	20	21	<20	21	22	<20	20	21	<20	<20	<20
11 Ketch Close, Fountaindale	65	65	65	21	25	26	21	25	26	22	26	27	27	30	31	25	29	30	<20	21	22	23	27	28	<20	21	22	<20	<20	<20
13 Ketch Close, Fountaindale	65	65	65	22	25	27	22	25	27	23	27	28	29	33	34	25	29	30	21	23	25	23	27	28	21	24	25	<20	<20	<20

Receiver	Cr	ite	ria	1			2			3			4			5			6			7			9			10		
	D	E	N	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
14 Ketch Close, Fountaindale	65	65	65	<20	20	21	<20	20	21	<20	20	21	22	25	26	<20	23	24	<20	<20	20	<20	21	22	<20	<20	20	<20	<20	<20
15 Ketch Close, Fountaindale	65	65	65	20	24	25	<20	23	24	20	23	24	24	28	29	21	25	26	<20	<20	<20	20	23	24	<20	<20	<20	<20	<20	<20
Sanitarium Factory	65	65	65	23	26	27	23	26	27	24	27	28	30	33	34	24	27	28	22	24	25	23	26	26	22	24	25	<20	<20	<20
10 Catamaran Road, Fountaindale	45	45	45	26	27	27	26	27	28	26	27	28	35	37	38	29	32	32	25	26	26	28	30	30	25	26	26	<20	<20	<20

Note: Exceedance of the daytime criteria is highlighted in grey and bold text, exceedance of the evening criteria is highlighted in blue with italic text and exceedance of the night criteria highlighted in green and underlined.

Note: D = Day, E= Evening, Night = Night, L = Neutral conditions, T = temperature inversion conditions and W = adverse wind conditions.

Table 13-2 - Predicted maximum operational noise levels L_{max} dBA

Receiver	Criteria		11			12			13			14			15			16		
	RBL+15	RNP	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
2 Bridge Street, Ourimbah	55	65	37	42	42	47	52	53	28	33	34	<20	<20	<20	<20	<20	20	40	43	44
3 Bridge Street, Ourimbah	55	65	37	42	43	49	54	55	28	34	34	<20	<20	<20	<20	<20	20	38	42	43
11 Bridge Street, Ourimbah	55	65	38	43	43	48	53	54	28	33	34	<20	<20	<20	<20	<20	<20	37	40	41
15 Bridge Street, Ourimbah	55	65	39	44	44	49	54	55	29	34	35	<20	<20	<20	<20	<20	<20	40	43	44
24 Bridge Street, Ourimbah	55	65	39	44	45	50	55	**56**	30	35	36	<20	20	22	<20	20	21	41	44	45
36 Bridge Street, Ourimbah	55	65	42	46	47	51	**56**	**57**	31	36	37	<20	<20	20	<20	<20	20	41	45	45
43 Bridge Street, Ourimbah	55	65	42	46	47	50	55	**56**	31	36	36	<20	<20	<20	<20	<20	<20	41	44	44
57 Bridge Street, Ourimbah	55	65	47	51	52	50	55	**56**	31	36	36	<20	<20	<20	<20	<20	<20	40	43	44
67 Pacific Highway, Kangy Angy	55	65	34	39	40	46	52	52	28	33	34	<20	<20	20	<20	24	24	39	42	43
68 Pacific Highway, Kangy Angy	55	65	38	42	43	47	52	53	29	34	35	<20	<20	20	<20	23	23	40	43	44
79 Pacific Highway, Kangy Angy	55	65	34	39	40	47	52	53	30	35	35	<20	21	22	20	25	26	40	43	44
56 Bridge Street, Ourimbah	55	65	54	**57**	**58**	53	**58**	**59**	34	39	39	<20	<20	20	<20	<20	<20	39	42	43
52 Howes Road, Ourimbah	55	65	51	54	55	47	53	53	28	33	34	<20	<20	<20	<20	<20	<20	37	40	41
2 Orchard Road, Kangy Angy	55	65	43	47	48	53	**58**	**59**	34	39	40	24	28	30	22	27	27	46	49	50
8 Orchard Road, Kangy Angy	55	65	38	43	44	50	55	**56**	31	35	36	20	23	25	20	25	26	43	46	47
50 Orchard Road, Kangy Angy	55	65	40	45	46	**57**	**61**	**62**	42	46	47	37	40	42	34	37	38	44	46	47
54 Orchard Road, Kangy Angy	55	65	38	43	43	**56**	**60**	**61**	40	44	45	35	38	40	34	38	38	47	49	50
62 Orchard Road, Kangy Angy	55	65	37	42	43	55	**60**	**60**	32	37	37	28	32	34	34	37	38	46	49	50
72 Orchard Road, Kangy Angy	55	65	36	41	42	55	**59**	**60**	30	35	36	27	30	32	34	37	38	45	48	48
80 Orchard Road, Kangy Angy	55	65	36	40	41	53	**58**	**58**	30	35	36	25	28	30	35	37	38	45	48	49
84 Orchard Road, Kangy Angy	55	65	34	39	39	50	55	55	28	33	34	20	24	25	29	33	33	42	45	46
92 Orchard Road, Kangy Angy	55	65	34	39	39	50	54	55	28	33	34	20	23	25	29	33	34	43	46	47
106 Orchard Road, Kangy Angy	55	65	33	38	39	50	54	55	37	42	42	27	31	33	29	34	34	43	47	47
12 Ourimbah Road, Kangy Angy	55	65	36	40	42	68	71	72	48	51	51	46	47	49	28	31	32	**59**	**60**	**61**
19 Ourimbah Road, Kangy Angy	55	65	41	44	46	**65**	68	68	47	50	50	44	46	48	36	37	38	52	54	**56**
19 Ourimbah Road, Kangy Angy	55	65	41	44	46	**65**	68	68	47	50	50	44	46	48	36	37	38	52	54	**56**
15 Schubolt Road, Kangy Angy	55	65	53	**56**	**57**	**59**	**63**	**64**	41	45	46	29	33	35	<20	20	21	51	53	54
15 Schubolt Road, Kangy Angy	55	65	53	**56**	**57**	**59**	**63**	**64**	41	45	46	29	33	35	<20	20	21	51	53	54
16 Schubolt Road, Kangy Angy	55	65	53	**56**	**57**	**57**	**62**	**63**	40	44	44	24	27	29	<20	23	24	49	51	52

Receiver	Criteria		11			12			13			14			15			16		
	RBL+15	RNP	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
16 Turpentine Road, Kangy Angy	55	65	57	60	61	54	59	60	36	40	41	<20	20	22	<20	<20	<20	44	47	48
26 Turpentine Road, Kangy Angy	55	65	61	63	64	57	62	63	41	45	46	23	26	28	<20	23	24	49	52	53
137 Enterprise Drive, Ourimbah	53	65	52	55	56	49	55	55	30	35	36	<20	<20	<20	<20	<20	<20	39	42	43
11 Enterprise Drive, Fountaindale	53	65	65	66	66	52	57	57	35	40	41	<20	<20	20	<20	20	20	40	43	44
16 Enterprise Drive, Fountaindale	53	65	64	65	66	48	54	54	31	36	36	<20	<20	<20	<20	<20	<20	37	40	41
21 Enterprise Drive, Fountaindale	53	65	65	66	66	51	56	57	34	39	40	<20	<20	<20	<20	<20	<20	39	43	43
14 Enterprise Drive, Fountaindale	53	65	64	65	65	50	55	56	33	38	38	<20	<20	<20	<20	<20	<20	39	42	43
28 Lillygrove Lane, Fountaindale	53	65	<20	<20	<20	54	59	59	34	39	40	20	24	25	<20	23	24	26	29	30
32 Lillygrove Lane, Fountaindale	53	65	<20	<20	<20	54	59	59	34	39	40	21	24	26	<20	24	25	25	29	30
36 Lillygrove Lane, Fountaindale	53	65	<20	<20	<20	51	56	57	32	37	38	<20	22	24	<20	22	23	24	27	28
48 Lillygrove Lane, Fountaindale	53	65	<20	<20	<20	49	55	55	30	35	36	<20	20	22	<20	20	21	22	26	26
6 Lorikeet Lane, Fountaindale	53	65	<20	23	24	27	32	33	<20	<20	<20	<20	<20	<20	<20	<20	<20	22	25	26
9 Lorikeet Lane, Fountaindale	53	65	<20	23	23	31	36	37	<20	<20	<20	<20	<20	<20	<20	<20	<20	23	26	26
12 Lorikeet Lane, Fountaindale	53	65	<20	24	24	28	32	33	<20	<20	<20	<20	<20	<20	<20	<20	<20	23	26	27
120 Berkeley Road, Fountaindale	53	65	<20	<20	20	54	59	60	34	39	40	20	24	26	<20	23	24	29	32	33
11 Manns Road, Fountaindale	53	65	<20	22	23	39	44	45	<20	22	23	<20	<20	<20	<20	<20	<20	25	28	29
22 Manns Road, Fountaindale	53	65	<20	21	22	45	50	50	24	29	30	<20	20	22	<20	<20	<20	23	26	27
23 Manns Road, Fountaindale	53	65	<20	22	23	37	42	43	<20	<20	20	<20	<20	<20	<20	<20	<20	23	26	27
39 Manns Road, Fountaindale	53	65	20	25	25	27	32	33	<20	<20	<20	<20	<20	<20	<20	<20	<20	24	27	28
130 Old Chittaway Road, Fountaindale	53	65	54	57	58	61	66	66	47	50	50	38	40	42	26	30	30	70	70	70
86 Old Chittaway Road, Fountaindale	53	65	58	61	62	53	58	58	37	41	42	<20	22	24	<20	21	22	42	44	45
89 Old Chittaway Road, Fountaindale	53	65	52	56	57	53	58	59	37	41	42	21	25	27	<20	23	24	48	50	51
96 Old Chittaway Road, Fountaindale	53	65	61	64	65	54	59	59	39	43	43	20	24	25	<20	22	22	44	46	47
103 Old Chittaway Road, Fountaindale	53	65	55	58	59	55	60	60	39	43	44	23	26	28	<20	23	24	48	50	52
105 Old Chittaway Road, Fountaindale	53	65	50	54	55	53	58	59	37	41	42	23	27	29	<20	24	25	48	50	52
107 Old Chittaway Road, Fountaindale	53	65	52	56	57	55	60	61	40	44	44	26	29	31	20	25	25	50	52	53
121 Old Chittaway Road, Fountaindale	53	65	53	56	57	57	62	63	41	45	45	30	33	36	22	27	27	54	55	56
125 Old Chittaway Road, Fountaindale	53	65	46	51	51	36	40	41	35	39	40	<20	<20	<20	<20	<20	<20	46	48	49
127 Old Chittaway Road, Fountaindale	53	65	38	41	42	58	63	63	40	44	45	33	37	39	23	28	29	58	59	60
141 Old Chittaway Road, Fountaindale	53	65	49	53	54	58	62	62	40	44	44	33	37	39	24	28	29	60	61	62

Receiver	Cri	teria	11			12			13			14			15			16		
	RBL+ 15	RNP	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W	N	T	W
149 Old Chittaway Road, Fountaindale	53	65	46	50	51	**59**	**63**	**64**	41	45	45	37	40	42	26	30	30	**60**	**61**	**62**
150 Old Chittaway Road, Fountaindale	53	65	46	50	51	**61**	**65**	**66**	44	47	47	41	43	45	27	31	32	**62**	**63**	**64**
157 Old Chittaway Road, Fountaindale	53	65	47	50	51	**57**	**61**	**62**	38	42	43	32	36	38	23	28	28	**58**	**59**	**60**
161 Old Chittaway Road, Fountaindale	53	65	44	48	49	54	**59**	**59**	36	40	41	28	32	34	22	26	27	53	55	**56**
165 Old Chittaway Road, Fountaindale	53	65	34	37	39	**58**	**62**	**62**	40	44	45	34	38	40	26	30	31	47	49	50
170 Old Chittaway Road, Fountaindale	53	65	42	46	47	**61**	**65**	**65**	44	47	47	40	43	45	31	34	35	53	55	**56**
32 Old Chittaway Road, Fountaindale	53	65	54	**57**	**57**	48	53	54	30	35	36	<20	<20	<20	<20	<20	<20	36	39	40
46 Old Chittaway Road, Fountaindale	53	65	52	**56**	**57**	48	54	54	31	36	37	<20	<20	<20	<20	<20	<20	36	40	40
58 Old Chittaway Road, Fountaindale	53	65	50	54	55	49	54	55	31	36	37	<20	<20	<20	<20	<20	<20	36	40	40
60 Old Chittaway Road, Fountaindale	53	65	51	55	**56**	50	55	**56**	32	37	38	<20	<20	<20	<20	<20	<20	38	41	42
64 Old Chittaway Road, Fountaindale	53	65	51	55	**56**	50	55	**56**	32	37	37	<20	<20	<20	<20	<20	<20	38	41	42
78 Old Chittaway Road, Fountaindale	53	65	55	**58**	**59**	32	38	38	30	35	36	<20	<20	21	<20	20	20	39	42	43
33 Station Road, Fountaindale	53	65	<20	23	24	33	38	39	<20	<20	<20	<20	<20	<20	<20	<20	<20	25	28	29
3 Station Road, Fountaindale	53	65	42	46	47	**56**	**60**	**61**	38	43	43	31	35	37	24	29	29	52	54	55
7 Station Road, Fountaindale	53	65	40	45	46	53	**58**	**58**	36	41	41	28	32	34	22	27	28	49	51	53
16 Station Road, Fountaindale	53	65	38	43	43	55	**59**	**60**	33	37	38	33	36	38	25	30	30	45	47	48
23 Station Road, Fountaindale	53	65	33	38	38	51	**56**	**57**	33	37	38	24	28	30	21	26	27	42	45	46
27 Station Road, Fountaindale	53	65	20	24	25	53	**58**	**59**	30	35	36	26	29	31	21	25	26	34	37	38
35 Station Road, Fountaindale	53	65	<20	23	24	55	**60**	**60**	36	40	41	28	31	33	20	25	26	31	34	35
11 Station Road, Fountaindale	53	65	40	45	45	55	**59**	**60**	38	42	43	30	33	35	25	29	30	50	52	54
139 Orchard Road, Kangy Angy	52	65	21	27	27	49	54	55	26	31	32	<20	<20	<20	23	27	28	36	40	40

Note: Exceedance of the RBL + 15 dB criteria is highlighted in grey and bold text and exceedance of the 65 dBA criteria is highlighted in green and underlined.

Note: L = Neutral conditions, T = temperature inversion conditions and W = adverse wind conditions.

CONSTRUCTION NOISE

Table 13-3 - Predicted construction noise levels for scenarios occurring during standard hours, $L_{eq,15min}$ dBA

Receiver	Criteria Day (SH)	1	2	3	4	5	6	7	8	9	10	11	12
2 Bridge Street, Ourimbah	55	41	38	46	41	44	44	45	47	41	40	34	42
3 Bridge Street, Ourimbah	55	40	37	46	41	43	43	44	47	40	39	33	41
11 Bridge Street, Ourimbah	55	40	37	47	42	43	44	45	48	41	39	33	41
15 Bridge Street, Ourimbah	55	40	38	48	43	44	45	46	49	42	40	33	42
24 Bridge Street, Ourimbah	55	42	39	48	43	45	45	46	49	42	41	35	43
36 Bridge Street, Ourimbah	55	41	38	50	45	47	47	48	52	44	43	34	45
43 Bridge Street, Ourimbah	55	40	37	50	45	47	47	48	51	44	43	33	45
57 Bridge Street, Ourimbah	55	39	36	54	48	50	51	52	55	48	46	32	48
67 Pacific Highway, Kangy Angy	55	43	41	46	41	42	43	44	47	40	38	36	40
68 Pacific Highway, Kangy Angy	55	43	40	45	39	44	45	46	46	42	40	35	42
79 Pacific Highway, Kangy Angy	55	45	44	47	42	45	46	47	49	43	41	38	43
120 Berkeley Road, Fountaindale	54	48	45	46	41	44	45	46	47	42	40	43	42
56 Bridge Street, Ourimbah	54	40	37	**61**	**56**	**58**	**58**	**59**	**62**	**55**	54	33	**56**
2 Orchard Road, Kangy Angy	54	45	43	50	45	50	51	51	52	48	46	38	48
8 Orchard Road, Kangy Angy	54	45	42	47	42	48	48	49	49	45	44	37	46
50 Orchard Road, Kangy Angy	54	54	53	**58**	52	**60**	**60**	**61**	**59**	**57**	**56**	44	**58**
53 Orchard Road, Kangy Angy	54	54	53	**61**	**56**	**72**	**72**	**73**	**62**	**69**	**68**	45	**70**
54 Orchard Road, Kangy Angy	54	**55**	**55**	**57**	52	**61**	**62**	**62**	**59**	**59**	**57**	45	**59**
62 Orchard Road, Kangy Angy	54	**57**	**56**	**57**	52	**61**	**62**	**63**	**58**	**59**	**57**	46	**59**
72 Orchard Road, Kangy Angy	54	**58**	**59**	**56**	51	**62**	**62**	**63**	**58**	**59**	**58**	47	**60**
80 Orchard Road, Kangy Angy	54	**60**	**63**	53	48	**61**	**61**	**62**	**55**	**58**	**57**	48	**59**
84 Orchard Road, Kangy Angy	54	**58**	**57**	52	47	**55**	**56**	**56**	54	53	51	46	53
92 Orchard Road, Kangy Angy	54	**57**	**57**	51	46	**55**	**55**	**56**	52	52	51	48	53
106 Orchard Road, Kangy Angy	54	**59**	**57**	52	47	**56**	**57**	**57**	54	54	52	50	54
12 Ourimbah Road, Kangy Angy	54	49	47	**64**	**59**	**69**	**70**	**70**	**66**	**67**	**65**	41	**67**
19 Ourimbah Road, Kangy Angy	54	52	50	**62**	**57**	**69**	**70**	**71**	**63**	**67**	**65**	43	**67**

Receiver	Criteria Day (SH)	1	2	3	4	5	6	7	8	9	10	11	12
15 Schubolt Lane, Kangy Angy	54	45	43	**59**	53	**56**	**56**	**57**	**60**	53	52	38	54
16 Schubolt Lane, Kangy Angy	54	43	41	**58**	53	**55**	**56**	**56**	**60**	53	51	36	53
16 Turpentine Road, Kangy Angy	54	41	38	**62**	57	**59**	**60**	**60**	**63**	**57**	**55**	34	**57**
26 Turpentine Road, Kangy Angy	54	43	41	**63**	58	**60**	**61**	**61**	**65**	**58**	**56**	36	**58**
137 Enterprise Drive, Ourimbah	59	38	35	59	53	56	56	57	**60**	53	52	31	54
28 Lillygrove Lane, Fountaindale	59	47	44	46	40	44	44	45	47	41	40	41	42
32 Lillygrove Lane, Fountaindale	59	47	44	46	41	44	44	45	47	41	40	41	42
36 Lillygrove Lane, Fountaindale	59	47	44	45	40	43	43	44	47	40	39	41	41
48 Lillygrove Lane, Fountaindale	59	46	43	45	39	42	43	43	46	40	38	40	40
6 Lorikeet Lane, Fountaindale	59	45	42	43	38	42	42	43	44	39	38	40	40
9 Lorikeet Lane, Fountaindale	59	46	43	43	38	43	43	44	44	40	39	40	41
12 Lorikeet Lane, Fountaindale	59	46	42	40	34	42	42	43	41	39	38	40	40
11 Manns Road, Fountaindale	59	47	43	44	39	43	43	44	45	40	39	41	41
22 Manns Road, Fountaindale	59	46	43	46	40	43	43	44	47	40	39	40	41
23 Manns Road, Fountaindale	59	45	42	45	40	41	42	43	46	39	37	39	39
39 Manns Road, Fountaindale	59	29	26	27	22	25	26	26	28	23	21	23	23
86 Old Chittaway Road, Fountaindale	59	41	39	**61**	55	**60**	**60**	**61**	**62**	57	56	35	58
89 Old Chittaway Road, Fountaindale	59	44	41	56	51	55	55	56	57	52	51	36	53
96 Old Chittaway Road, Fountaindale	59	43	40	**62**	57	**63**	**63**	**64**	**64**	**60**	59	35	**61**
103 Old Chittaway Road, Fountaindale	59	44	41	59	54	58	59	**60**	**60**	56	54	36	56
105 Old Chittaway Road, Fountaindale	59	45	42	55	50	53	53	54	56	50	49	37	51
107 Old Chittaway Road, Fountaindale	59	44	42	57	52	55	56	56	58	53	51	37	53
121 Old Chittaway Road, Fountaindale	59	46	45	**60**	54	59	**60**	**60**	**61**	57	55	40	57
125 Old Chittaway Road, Fountaindale	59	39	36	54	49	52	52	53	55	49	48	29	50
127 Old Chittaway Road, Fountaindale	59	48	46	**60**	55	**60**	**61**	**61**	**61**	58	56	40	58
130 Old Chittaway Road, Fountaindale	59	48	46	**64**	58	**68**	**68**	**69**	**65**	**65**	**64**	40	**66**
141 Old Chittaway Road, Fountaindale	59	49	47	58	53	58	58	59	59	55	54	40	56
149 Old Chittaway Road, Fountaindale	59	51	49	58	53	59	59	**60**	59	56	55	42	57
150 Old Chittaway Road, Fountaindale	59	51	49	**61**	56	**65**	**65**	**66**	**62**	**62**	**61**	42	**63**

Receiver	Criteria Day (SH)	1	2	3	4	5	6	7	8	9	10	11	12
157 Old Chittaway Road, Fountaindale	59	43	39	57	52	56	57	58	58	54	52	36	54
161 Old Chittaway Road, Fountaindale	59	51	48	53	48	52	52	53	55	49	48	43	50
165 Old Chittaway Road, Fountaindale	59	53	51	58	52	59	59	**60**	59	56	55	44	57
170 Old Chittaway Road, Fountaindale	59	56	56	**62**	57	**70**	**71**	**71**	**64**	**68**	**66**	46	**68**
3 Station Road, Fountaindale	59	52	50	55	50	54	55	56	56	52	50	43	52
7 Station Road, Fountaindale	59	52	50	54	48	53	53	54	55	50	49	44	51
16 Station Road, Fountaindale	59	57	55	57	51	57	57	58	58	54	53	47	55
23 Station Road, Fountaindale	59	53	50	52	47	51	51	52	53	48	47	44	49
27 Station Road, Fountaindale	59	52	49	51	46	49	50	50	52	47	45	46	47
35 Station Road, Fountaindale	59	53	49	51	46	49	50	51	52	47	45	45	47
139 Orchard Road, Kangy Angy	57	56	53	50	45	53	53	54	51	50	49	50	51
98 Old Chittaway Road, Fountaindale	55	46	43	**64**	**59**	**67**	**67**	**68**	**66**	**64**	**63**	38	**65**
3A Catamaran Road, Fountaindale	70	57	54	51	46	52	53	54	52	50	48	43	50
1 Catamaran Road, Fountaindale	70	66	62	54	49	62	62	63	56	59	58	59	60
2 Catamaran Road, Fountaindale	70	**74**	**71**	60	54	67	67	68	61	64	63	61	65
3 Catamaran Road, Fountaindale	70	60	57	52	47	57	57	58	53	54	53	54	55
4 Catamaran Road, Fountaindale	70	68	65	51	45	63	63	64	52	60	59	49	61
5 Catamaran Road, Fountaindale	70	63	59	50	44	59	59	60	51	56	55	57	57
6 Catamaran Road, Fountaindale	70	63	60	58	53	59	59	60	59	56	55	44	57
8 Catamaran Road, Fountaindale	70	62	59	56	51	57	58	59	57	55	53	46	55
9 Catamaran Road, Fountaindale	70	57	54	49	44	53	54	54	50	51	49	51	51
11 Catamaran Road, Fountaindale	70	55	51	48	43	50	51	51	49	48	46	48	48
13 Catamaran Road, Fountaindale	70	46	51	51	46	50	50	51	52	47	46	41	48
15 Catamaran Road, Fountaindale	70	51	47	51	46	50	50	51	53	47	46	40	48
17 Catamaran Road, Fountaindale	70	55	52	52	47	51	51	52	53	48	47	45	49
1 Co-wyn Close, Fountaindale	70	69	69	62	57	67	68	68	63	65	63	52	65
2 Ketch Close, Fountaindale	70	60	57	53	47	56	56	57	54	53	52	54	54
4 Ketch Close, Fountaindale	70	56	53	51	45	52	52	53	52	49	48	47	50
5 Ketch Close, Fountaindale	70	59	56	50	45	56	56	57	52	53	52	54	54

Receiver	Criteria Day (SH)	1	2	3	4	5	6	7	8	9	10	11	12
7 Ketch Close, Fountaindale	70	58	54	49	44	54	54	55	51	51	50	51	52
8 Ketch Close, Fountaindale	70	57	53	49	44	53	53	54	50	50	49	51	51
9 Ketch Close, Fountaindale	70	54	50	48	43	50	50	51	50	47	46	48	48
10 Ketch Close, Fountaindale	70	53	49	48	43	49	49	50	49	46	45	47	47
11 Ketch Close, Fountaindale	70	53	49	47	42	49	50	50	48	47	45	47	47
13 Ketch Close, Fountaindale	70	52	49	51	45	48	48	49	52	45	44	42	46
14 Ketch Close, Fountaindale	70	54	51	47	42	50	51	52	48	48	46	48	48
15 Ketch Close, Fountaindale	70	47	44	45	40	43	44	44	47	41	39	40	41
10 Catamaran Road, Fountaindale	55	54	52	53	48	52	53	53	55	50	48	47	50

Note: Exceedance of the daytime criteria is highlighted in grey and bold text.

Table 13-4 - Predicted construction noise levels for scenarios occurring outside of standard hours, $L_{eq,15min}$ dBA

Receiver	Day (OOHW)	Evening (OOHW)	Night (OOHW)	1a	3	4	8a
2 Bridge Street, Ourimbah	50	50	48	37	46	41	43
3 Bridge Street, Ourimbah	50	50	48	36	46	41	45
11 Bridge Street, Ourimbah	50	50	48	36	47	42	45
15 Bridge Street, Ourimbah	50	50	48	37	48	43	45
24 Bridge Street, Ourimbah	50	50	48	38	48	43	45
36 Bridge Street, Ourimbah	50	50	48	37	50	45	47
43 Bridge Street, Ourimbah	50	50	48	36	50	45	48
57 Bridge Street, Ourimbah	50	50	48	35	**54**	48	52
67 Pacific Highway, Kangy Angy	50	50	48	39	46	41	40
68 Pacific Highway, Kangy Angy	50	50	48	39	45	39	41
79 Pacific Highway, Kangy Angy	50	50	48	41	47	42	39
120 Berkeley Road, Fountaindale	49	45	40	45	*46*	41	36
56 Bridge Street, Ourimbah	49	45	40	36	**61**	**56**	**52**
2 Orchard Road, Kangy Angy	49	45	40	41	**50**	45	44
8 Orchard Road, Kangy Angy	49	45	40	41	*47*	42	42
50 Orchard Road, Kangy Angy	49	45	40	**50**	**58**	**52**	40
53 Orchard Road, Kangy Angy	49	45	40	**50**	**61**	**56**	41
54 Orchard Road, Kangy Angy	49	45	40	**52**	**57**	**52**	40
62 Orchard Road, Kangy Angy	49	45	40	**53**	**57**	**52**	39
72 Orchard Road, Kangy Angy	49	45	40	**55**	**56**	**51**	39
80 Orchard Road, Kangy Angy	49	45	40	**57**	**53**	*48*	38
84 Orchard Road, Kangy Angy	49	45	40	**54**	**52**	*47*	37
92 Orchard Road, Kangy Angy	49	45	40	**54**	**51**	*46*	37

Receiver	Day (OOHW)	Evening (OOHW)	Night (OOHW)	1a	3	4	8a
106 Orchard Road, Kangy Angy	49	45	40	**56**	**52**	*47*	37
12 Ourimbah Road, Kangy Angy	49	45	40	45	**64**	**59**	43
19 Ourimbah Road, Kangy Angy	49	45	40	*48*	**62**	**57**	42
15 Schubolt Lane, Kangy Angy	49	45	40	41	**59**	**53**	*46*
16 Schubolt Lane, Kangy Angy	49	45	40	40	**58**	**53**	*47*
16 Turpentine Road, Kangy Angy	49	45	40	37	**62**	**57**	**51**
26 Turpentine Road, Kangy Angy	49	45	40	39	**63**	**58**	*48*
137 Enterprise Drive, Ourimbah	54	49	40	34	**59**	*53*	**58**
28 Lillygrove Lane, Fountaindale	54	49	40	43	46	40	33
32 Lillygrove Lane, Fountaindale	54	49	40	44	46	41	32
36 Lillygrove Lane, Fountaindale	54	49	40	43	45	40	33
48 Lillygrove Lane, Fountaindale	54	49	40	42	45	39	34
6 Lorikeet Lane, Fountaindale	54	49	40	42	43	38	23
9 Lorikeet Lane, Fountaindale	54	49	40	42	43	38	24
12 Lorikeet Lane, Fountaindale	54	49	40	42	40	34	26
11 Manns Road, Fountaindale	54	49	40	43	44	39	24
22 Manns Road, Fountaindale	54	49	40	42	46	40	25
23 Manns Road, Fountaindale	54	49	40	41	45	40	24
39 Manns Road, Fountaindale	54	49	40	25	27	22	24
86 Old Chittaway Road, Fountaindale	54	49	40	37	**61**	55	51
89 Old Chittaway Road, Fountaindale	54	49	40	40	**56**	*51*	48
96 Old Chittaway Road, Fountaindale	54	49	40	39	**62**	57	*50*
103 Old Chittaway Road, Fountaindale	54	49	40	40	**59**	*54*	48
105 Old Chittaway Road, Fountaindale	54	49	40	41	**55**	*50*	42
107 Old Chittaway Road, Fountaindale	54	49	40	40	**57**	*52*	44
121 Old Chittaway Road, Fountaindale	54	49	40	42	**60**	54	46
125 Old Chittaway Road, Fountaindale	54	49	40	35	*54*	49	44
127 Old Chittaway Road, Fountaindale	54	49	40	44	**60**	**55**	45
130 Old Chittaway Road, Fountaindale	54	49	40	44	**64**	**58**	44
141 Old Chittaway Road, Fountaindale	54	49	40	45	**58**	*53*	44
149 Old Chittaway Road, Fountaindale	54	49	40	47	**58**	*53*	43
150 Old Chittaway Road, Fountaindale	54	49	40	47	**61**	**56**	43
157 Old Chittaway Road, Fountaindale	54	49	40	39	**57**	*52*	44
161 Old Chittaway Road, Fountaindale	54	49	40	47	*53*	48	43
165 Old Chittaway Road, Fountaindale	54	49	40	49	**58**	*52*	42
170 Old Chittaway Road, Fountaindale	54	49	40	*52*	**62**	**57**	41

Receiver	Day (OOHW)	Evening (OOHW)	Night (OOHW)	1a	3	4	8a
3 Station Road, Fountaindale	54	49	40	48	**55**	*50*	42
7 Station Road, Fountaindale	54	49	40	**49**	*54*	48	41
16 Station Road, Fountaindale	54	49	40	**53**	*57*	51	40
23 Station Road, Fountaindale	54	49	40	**49**	*52*	47	39
27 Station Road, Fountaindale	54	49	40	**49**	*51*	46	28
35 Station Road, Fountaindale	54	49	40	**49**	*51*	46	34
139 Orchard Road, Kangy Angy	52	53	50	**53**	50	45	35
98 Old Chittaway Road, Fountaindale	55	55	55	42	**64**	**59**	45
3A Catamaran Road, Fountaindale	70	70	70	54	51	46	29
1 Catamaran Road, Fountaindale	70	70	70	62	54	49	37
2 Catamaran Road, Fountaindale	70	70	70	70	60	54	38
3 Catamaran Road, Fountaindale	70	70	70	56	52	47	36
4 Catamaran Road, Fountaindale	70	70	70	65	51	45	38
5 Catamaran Road, Fountaindale	70	70	70	59	50	44	40
6 Catamaran Road, Fountaindale	70	70	70	59	58	53	39
8 Catamaran Road, Fountaindale	70	70	70	58	56	51	39
9 Catamaran Road, Fountaindale	70	70	70	54	49	44	36
11 Catamaran Road, Fountaindale	70	70	70	51	48	43	32
13 Catamaran Road, Fountaindale	70	70	70	42	51	46	40
15 Catamaran Road, Fountaindale	70	70	70	47	51	46	37
17 Catamaran Road, Fountaindale	70	70	70	51	52	47	37
1 Co-wyn Close, Fountaindale	70	70	70	65	62	57	39
2 Ketch Close, Fountaindale	70	70	70	56	53	47	37
4 Ketch Close, Fountaindale	70	70	70	53	51	45	35
5 Ketch Close, Fountaindale	70	70	70	56	50	45	35
7 Ketch Close, Fountaindale	70	70	70	54	49	44	36
8 Ketch Close, Fountaindale	70	70	70	53	49	44	35
9 Ketch Close, Fountaindale	70	70	70	50	48	43	31
10 Ketch Close, Fountaindale	70	70	70	49	48	43	34
11 Ketch Close, Fountaindale	70	70	70	49	47	42	38
13 Ketch Close, Fountaindale	70	70	70	48	51	45	36
14 Ketch Close, Fountaindale	70	70	70	50	47	42	36
15 Ketch Close, Fountaindale	70	70	70	43	45	40	39

Note: Exceedance of the daytime criteria is highlighted in grey and bold text, exceedance of the evening criteria is highlighted in blue with italic text and exceedance of the night criteria highlighted in green and underlined.

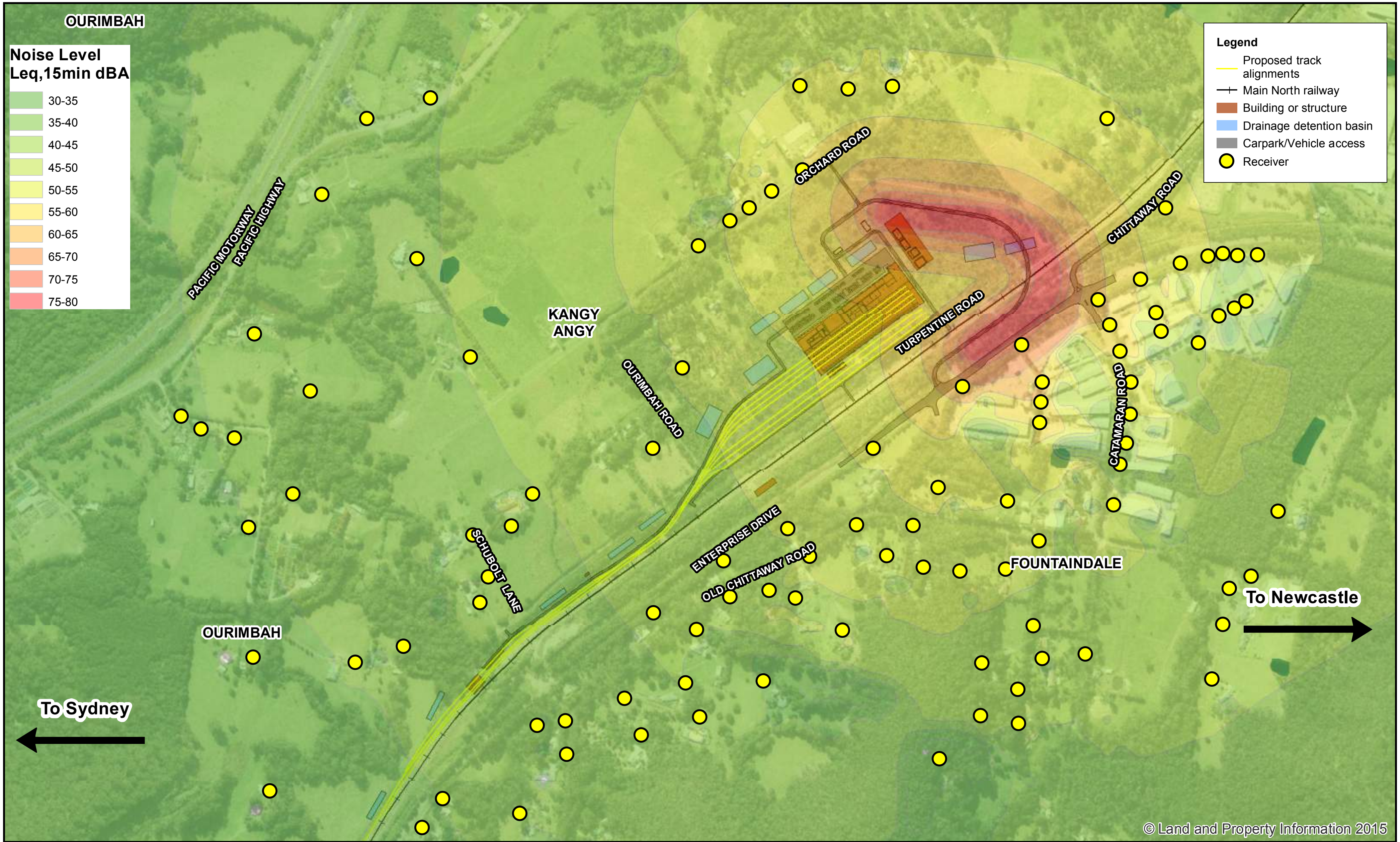
Table 13-5 - Predicted construction scenario noise levels for assessment of sleep disturbance, L_{max} dBA

Receiver	Screening criteria Lmax dBA	1a	3	4	8a
2 Bridge Street , Ourimbah	65	42	51	46	48
3 Bridge Street , Ourimbah	65	41	51	46	50
11 Bridge Street , Ourimbah	65	41	52	47	50
15 Bridge Street , Ourimbah	65	42	53	48	50
24 Bridge Street , Ourimbah	65	43	53	48	50
36 Bridge Street , Ourimbah	65	42	55	50	52
43 Bridge Street , Ourimbah	65	41	55	50	53
57 Bridge Street , Ourimbah	65	40	59	53	57
67 Pacific Highway , Kangy Angy	65	44	51	46	45
68 Pacific Highway , Kangy Angy	65	44	50	44	46
79 Pacific Highway , Kangy Angy	65	46	52	47	44
120 Berkeley Road , Fountaindale	65	50	51	46	41
56 Bridge Street , Ourimbah	65	41	**66**	61	57
2 Orchard Road , Kangy Angy	65	46	55	50	49
8 Orchard Road , Kangy Angy	65	46	52	47	47
50 Orchard Road , Kangy Angy	65	55	63	57	45
53 Orchard Road , Kangy Angy	65	55	**66**	61	46
54 Orchard Road , Kangy Angy	65	57	62	57	45
62 Orchard Road , Kangy Angy	65	58	62	57	44
72 Orchard Road , Kangy Angy	65	60	61	56	44
80 Orchard Road , Kangy Angy	65	62	58	53	43
84 Orchard Road , Kangy Angy	65	59	57	52	42
92 Orchard Road , Kangy Angy	65	59	56	51	42
106 Orchard Road , Kangy Angy	65	61	57	52	42
12 Ourimbah Road , Kangy Angy	65	50	**69**	64	48
19 Ourimbah Road , Kangy Angy	65	53	**67**	62	47
15 Schubolt Lane , Kangy Angy	65	46	64	58	51
16 Schubolt Lane , Kangy Angy	65	45	63	58	52
16 Turpentine Road , Kangy Angy	65	42	**67**	62	56
26 Turpentine Road , Kangy Angy	65	44	**68**	63	53
137 Enterprise Drive , Ourimbah	65	39	64	58	63
28 Lillygrove Lane , Fountaindale	65	48	51	45	38
32 Lillygrove Lane , Fountaindale	65	49	51	46	37
36 Lillygrove Lane , Fountaindale	65	48	50	45	38
48 Lillygrove Lane , Fountaindale	65	47	50	44	39
6 Lorikeet Lane , Fountaindale	65	47	48	43	28
9 Lorikeet Lane , Fountaindale	65	47	48	43	29
12 Lorikeet Lane , Fountaindale	65	47	45	39	31
11 Manns Road , Fountaindale	65	48	49	44	29

Receiver	Screening criteria Lmax dBA	1a	3	4	8a
22 Manns Road , Fountaindale	65	47	51	45	30
23 Manns Road , Fountaindale	65	46	50	45	29
39 Manns Road , Fountaindale	65	30	32	27	29
86 Old Chittaway Road , Fountaindale	65	42	**66**	60	56
89 Old Chittaway Road , Fountaindale	65	45	61	56	53
96 Old Chittaway Road , Fountaindale	65	44	**67**	62	55
103 Old Chittaway Road , Fountaindale	65	45	64	59	53
105 Old Chittaway Road , Fountaindale	65	46	60	55	47
107 Old Chittaway Road , Fountaindale	65	45	62	57	49
121 Old Chittaway Road , Fountaindale	65	47	65	59	51
125 Old Chittaway Road , Fountaindale	65	40	59	54	49
127 Old Chittaway Road , Fountaindale	65	49	65	60	50
130 Old Chittaway Road , Fountaindale	65	49	**69**	63	49
141 Old Chittaway Road , Fountaindale	65	50	63	58	49
149 Old Chittaway Road , Fountaindale	65	52	63	58	48
150 Old Chittaway Road , Fountaindale	65	52	**66**	61	48
157 Old Chittaway Road , Fountaindale	65	44	62	57	49
161 Old Chittaway Road , Fountaindale	65	52	58	53	48
165 Old Chittaway Road , Fountaindale	65	54	63	57	47
170 Old Chittaway Road , Fountaindale	65	57	**67**	62	46
3 Station Road , Fountaindale	65	53	60	55	47
7 Station Road , Fountaindale	65	54	59	53	46
16 Station Road , Fountaindale	65	58	62	56	45
23 Station Road , Fountaindale	65	54	57	52	44
27 Station Road , Fountaindale	65	54	56	51	33
35 Station Road , Fountaindale	65	54	56	51	39
139 Orchard Road , Kangy Angy	65	58	55	50	40

Note 1: Values in bold and highlighted in grey indicate exceedances of the sleep disturbance screening criteria.

Appendix D Noise contour maps



Map: Noise contour map	Author: -		0 110 220 m 1:10,000
Date: 11/05/2016	Approved by: -		
Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m			Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 1

Indicative only - Subject to Detailed Design

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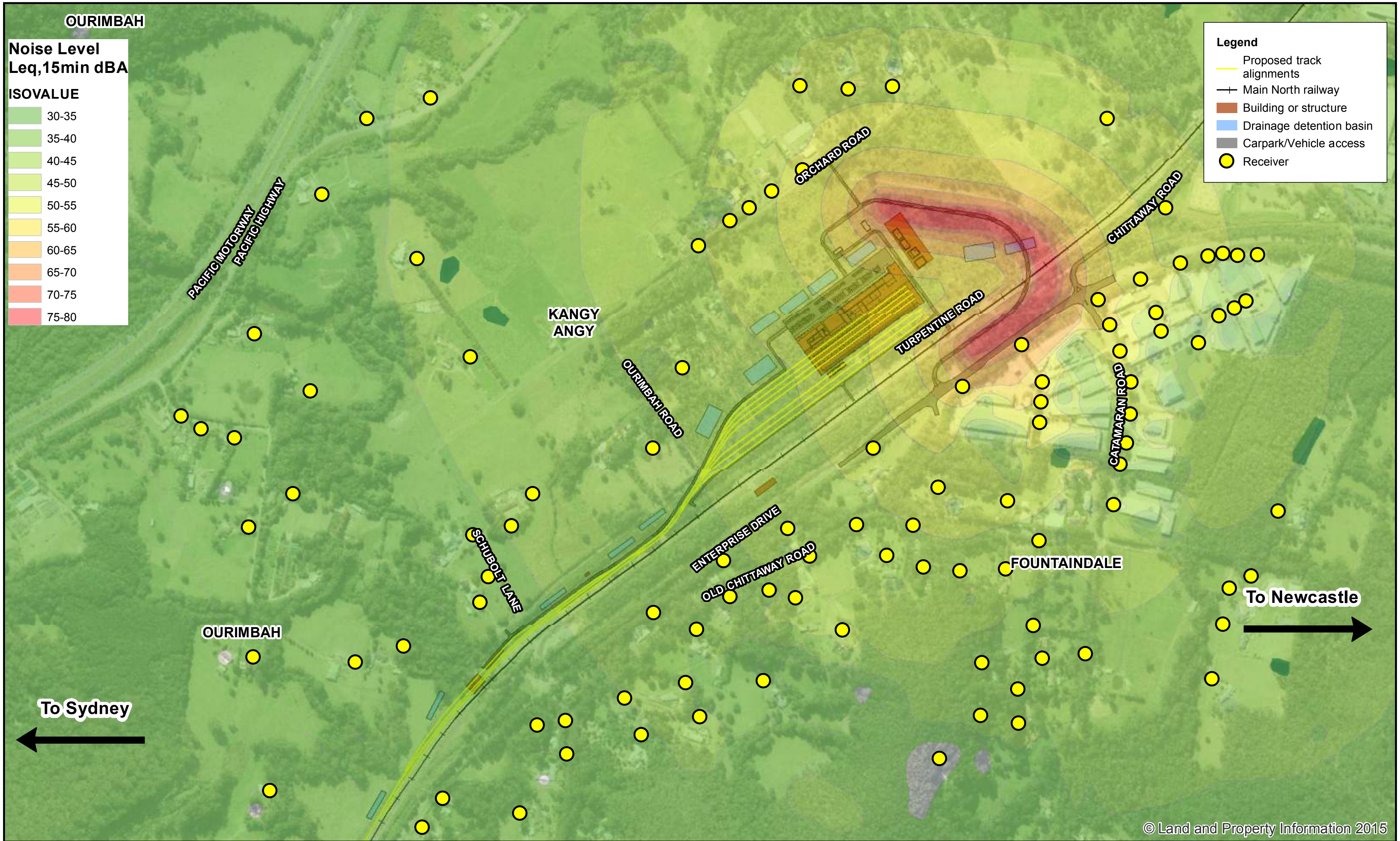

Map: Noise contour map	Author: -
Date: 11/05/2016	Approved by: -

Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m

0 110 220 m

1:10,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 1a

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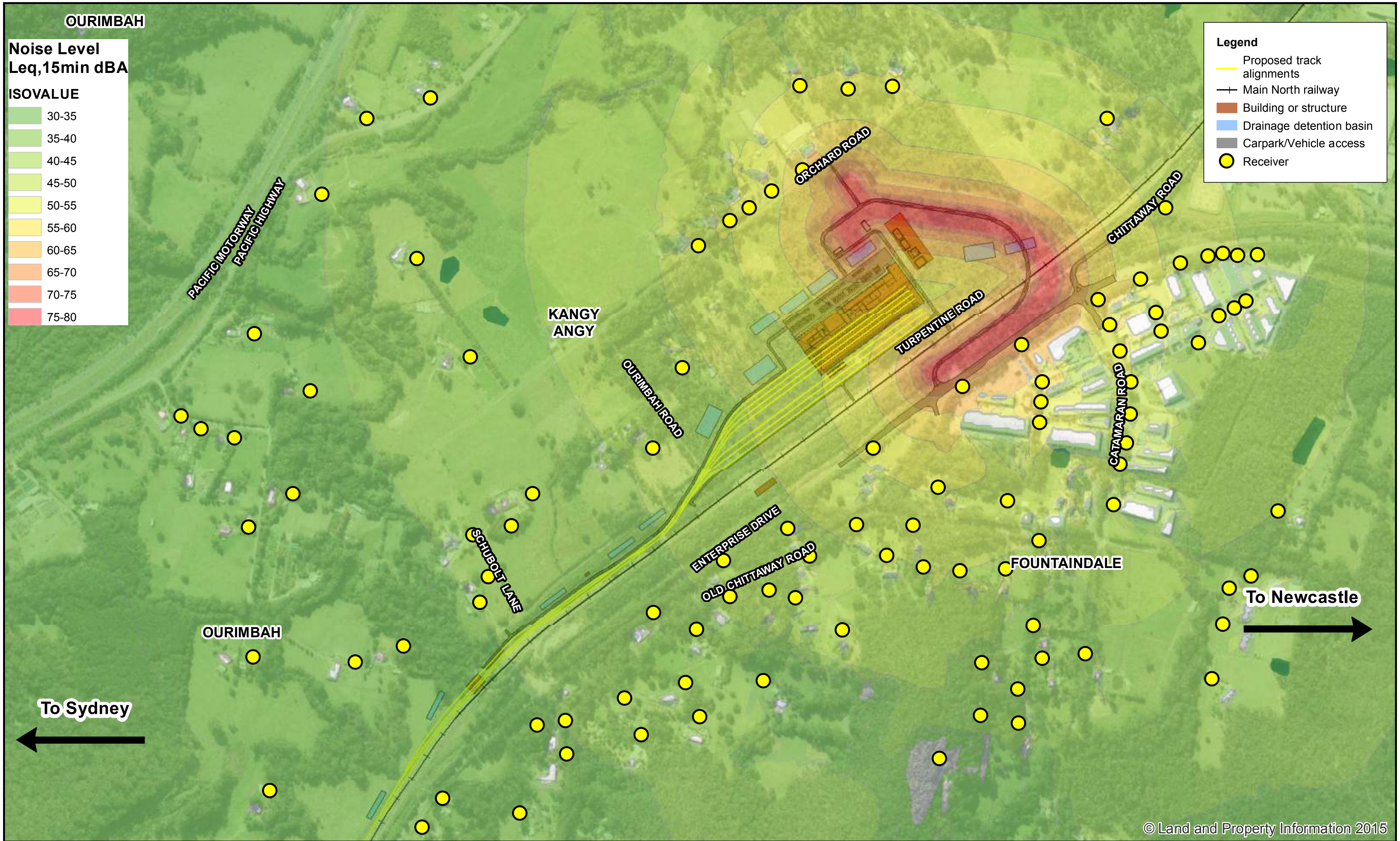

Map: Noise contour map	Author: -		0 110 220 m 1:10,000
Date: 11/05/2016	Approved by: -		
Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m			Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 2

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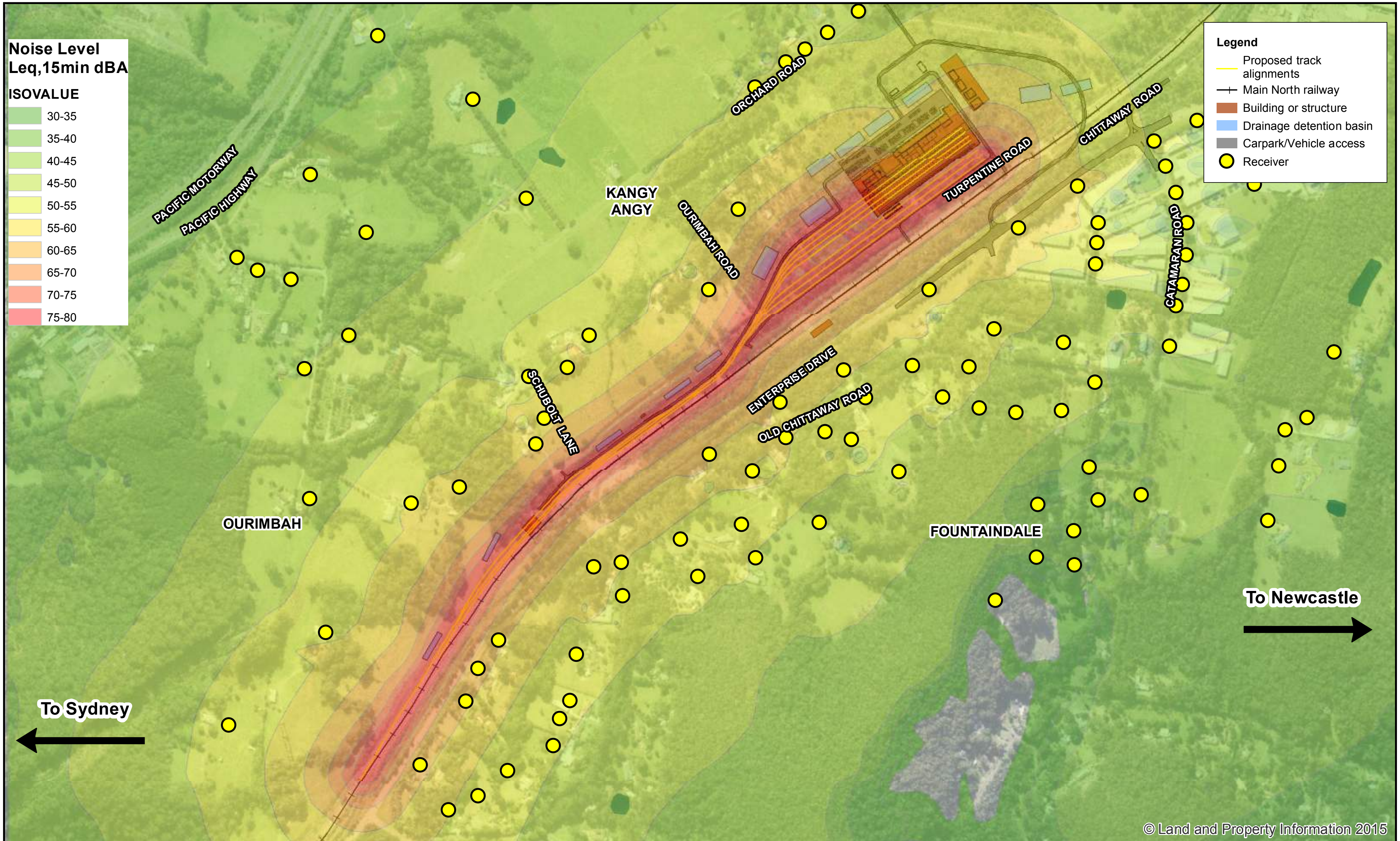

Map: Noise contour map	Author: -
Date: 11/05/2016	Approved by: -

Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m

0 110 220 m

1:10,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 3

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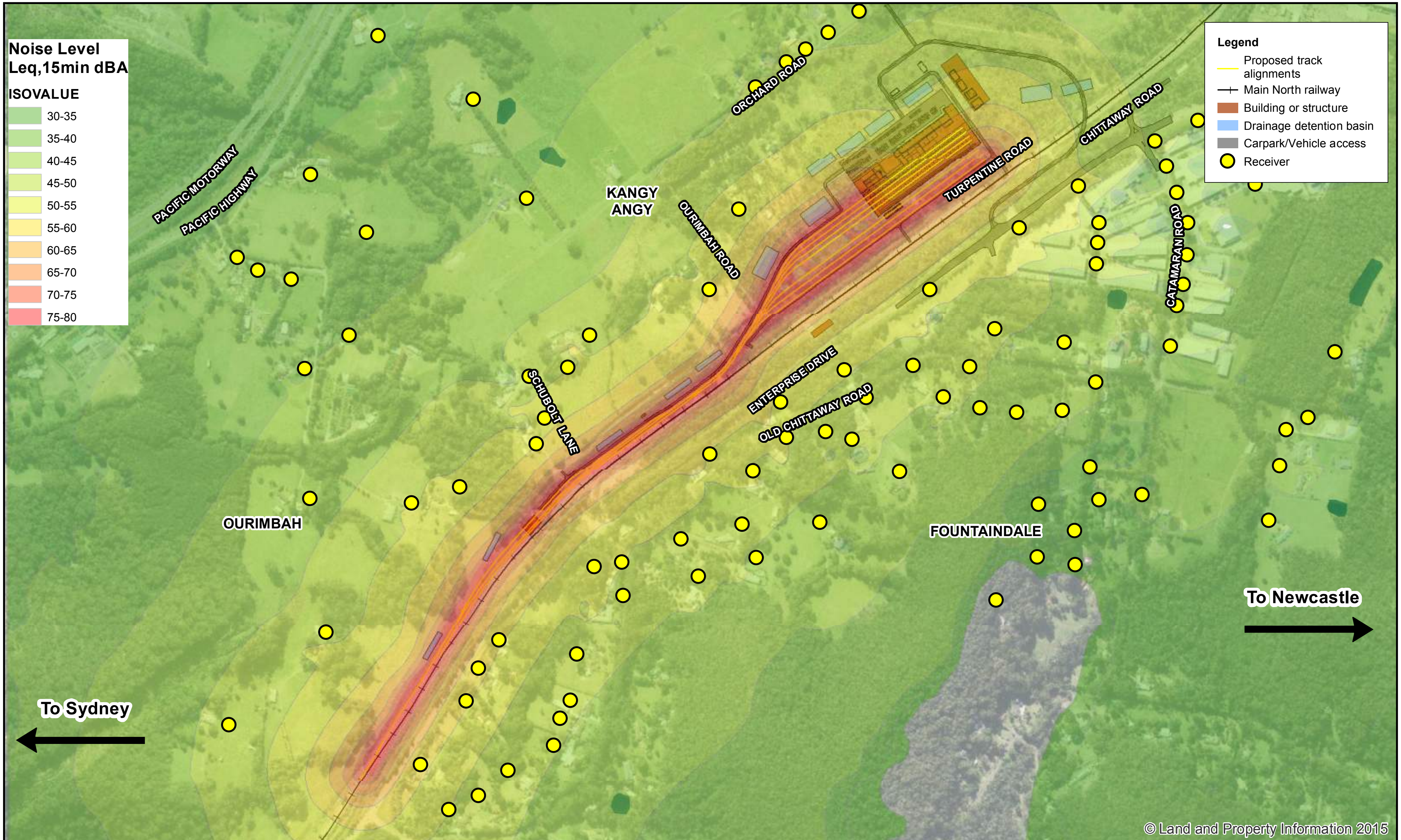

Map: Noise contour map	Author: -		0 110 220 m 1:10,000
Date: 11/05/2016	Approved by: -		
Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m			Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 4

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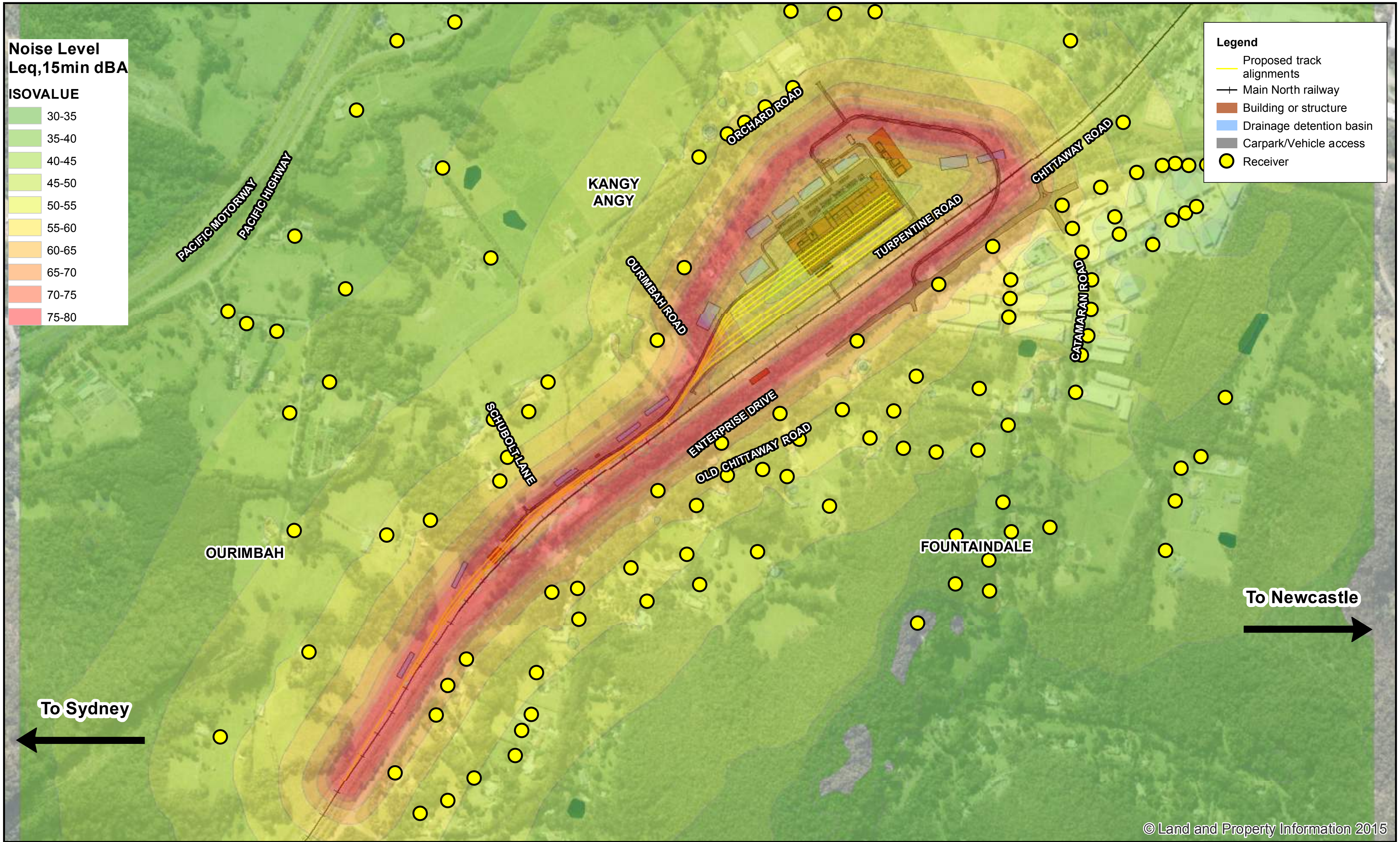

Map: Noise contour map	Author: -		0 125 250 m 1:11,000
Date: 11/05/2016	Approved by: -		
Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m			Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 5

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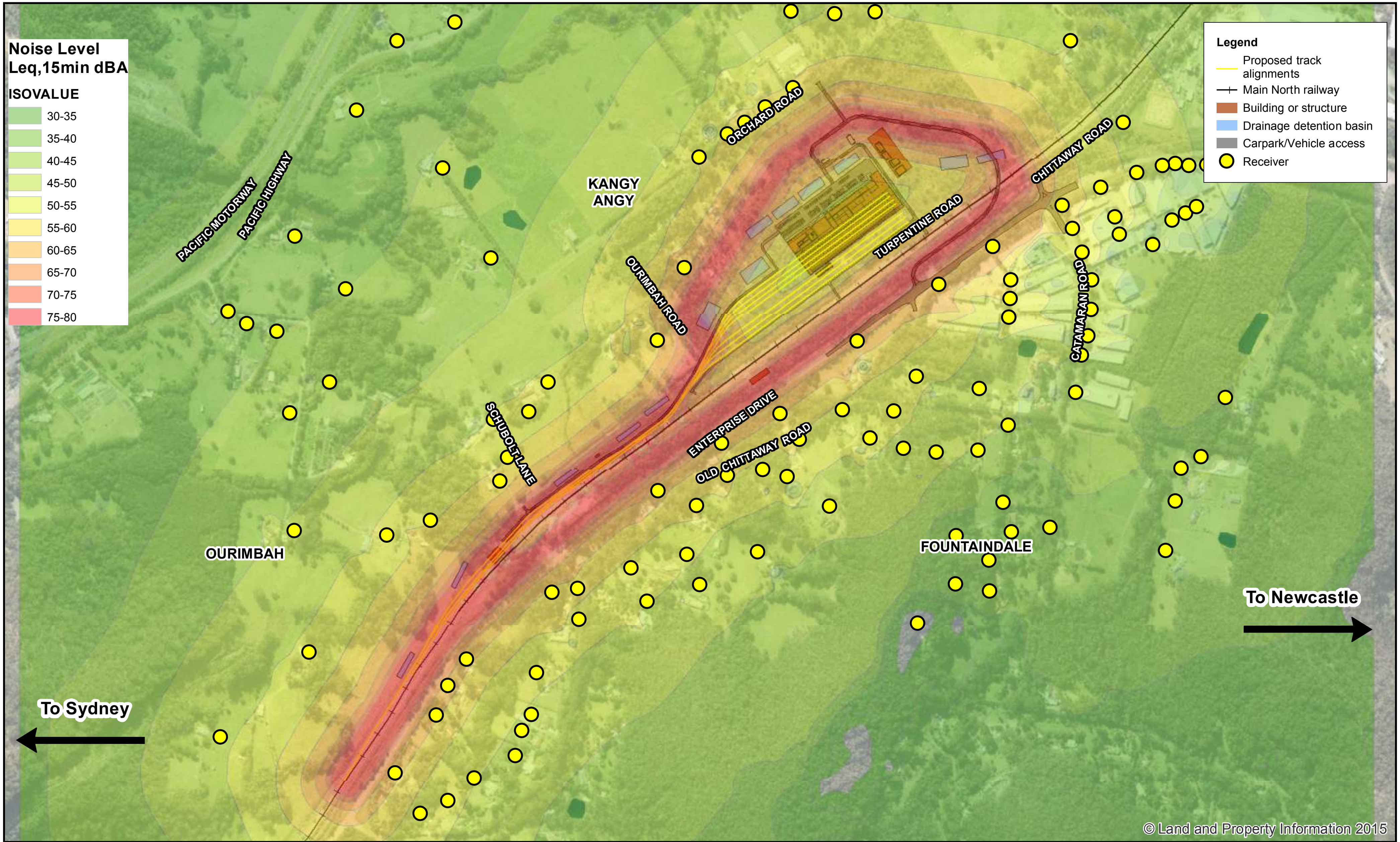

Map: Noise contour map	Author: -		0 125 250 m 1:11,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4
Date: 11/05/2016	Approved by: -		

Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m

New intercity fleet maintenance facility project

Construction scenario 6

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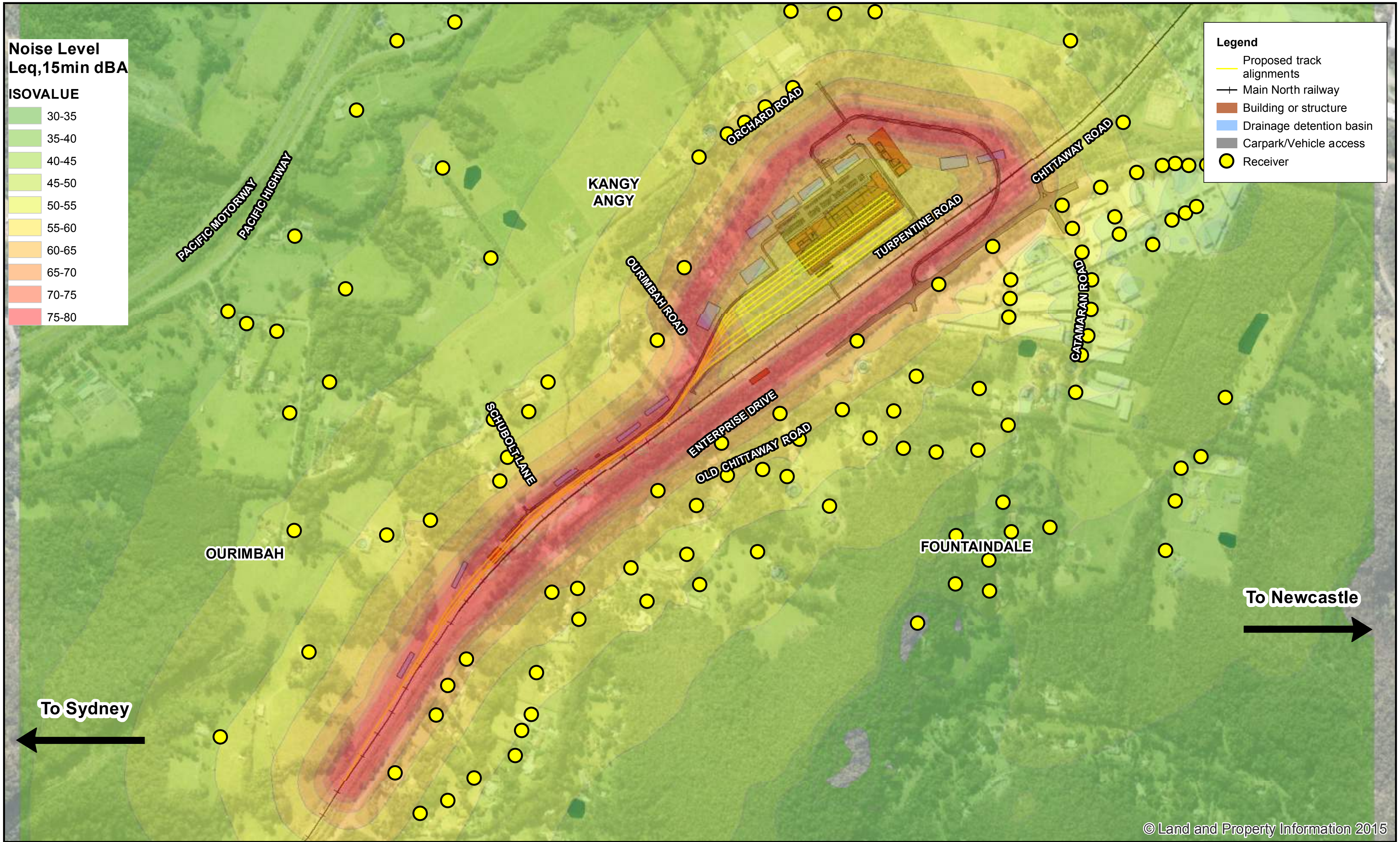

Map: Noise contour map

Author: -

Date: 11/05/2016

Approved by: -

0 125 250 m

1:11,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m

New intercity fleet maintenance facility project

Construction scenario 7

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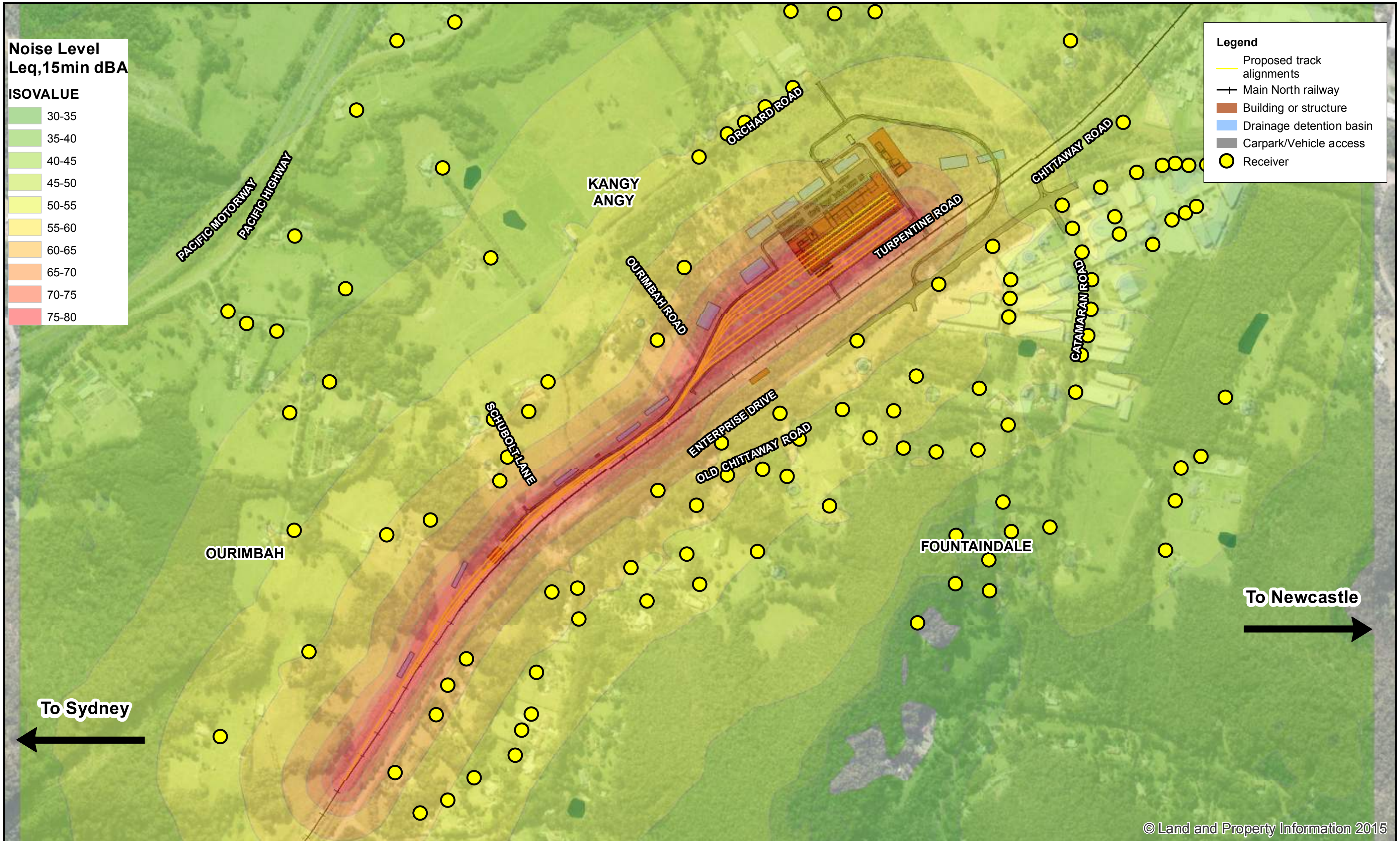

Map: Noise contour map	Author: -		0 125 250 m 1:11,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A4	**New intercity fleet maintenance facility project** Construction scenario 8
Date: 11/05/2016	Approved by: -			
Notes: Predicted using ISO9613 method implemented in SoundPlan 7.3. Reciever heights at 1.5m. Grid spacing 20m				Indicative only - Subject to Detailed Design

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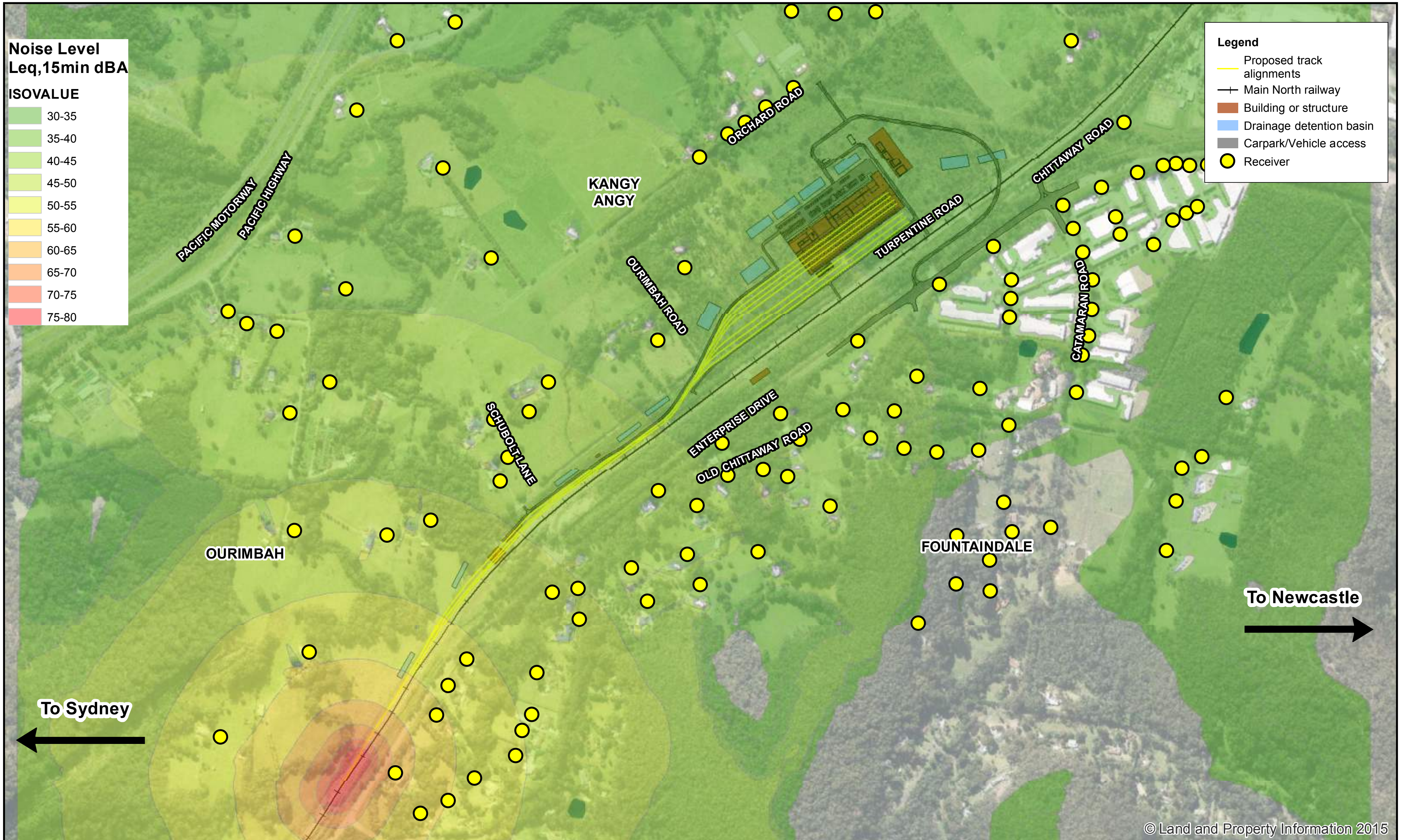

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Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 8a

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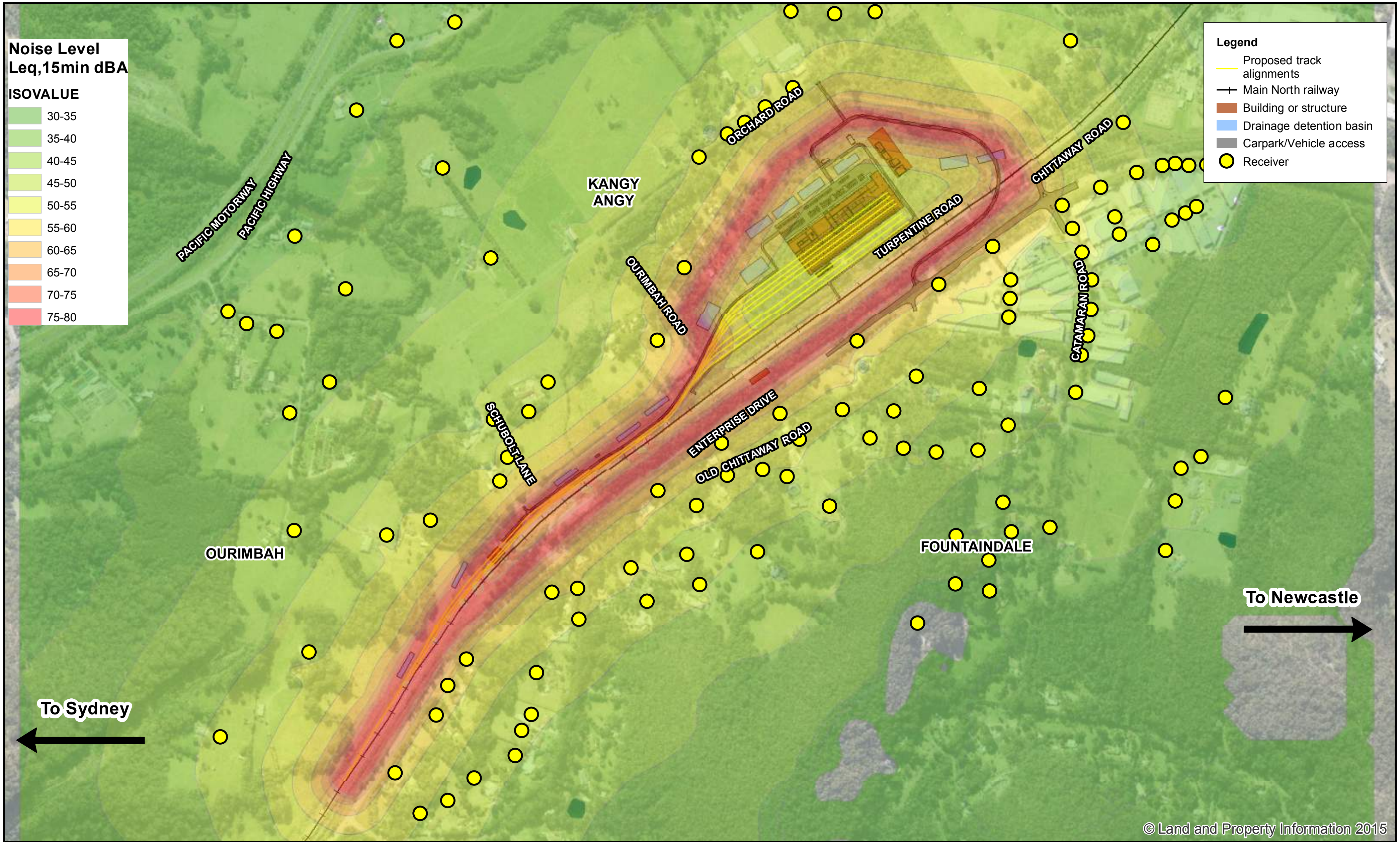

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 9

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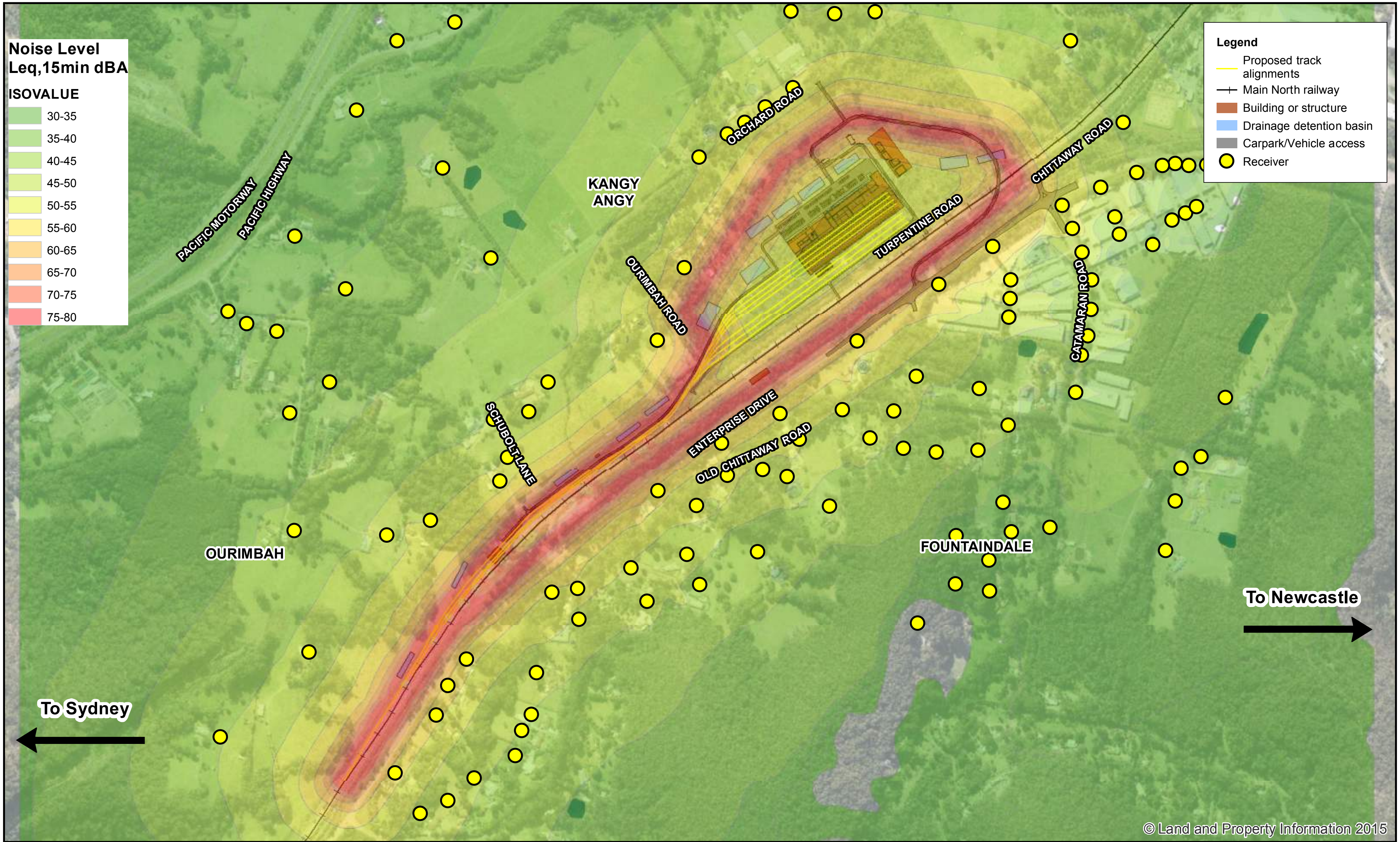

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Date: 11/05/2016	Approved by: -

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Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 10

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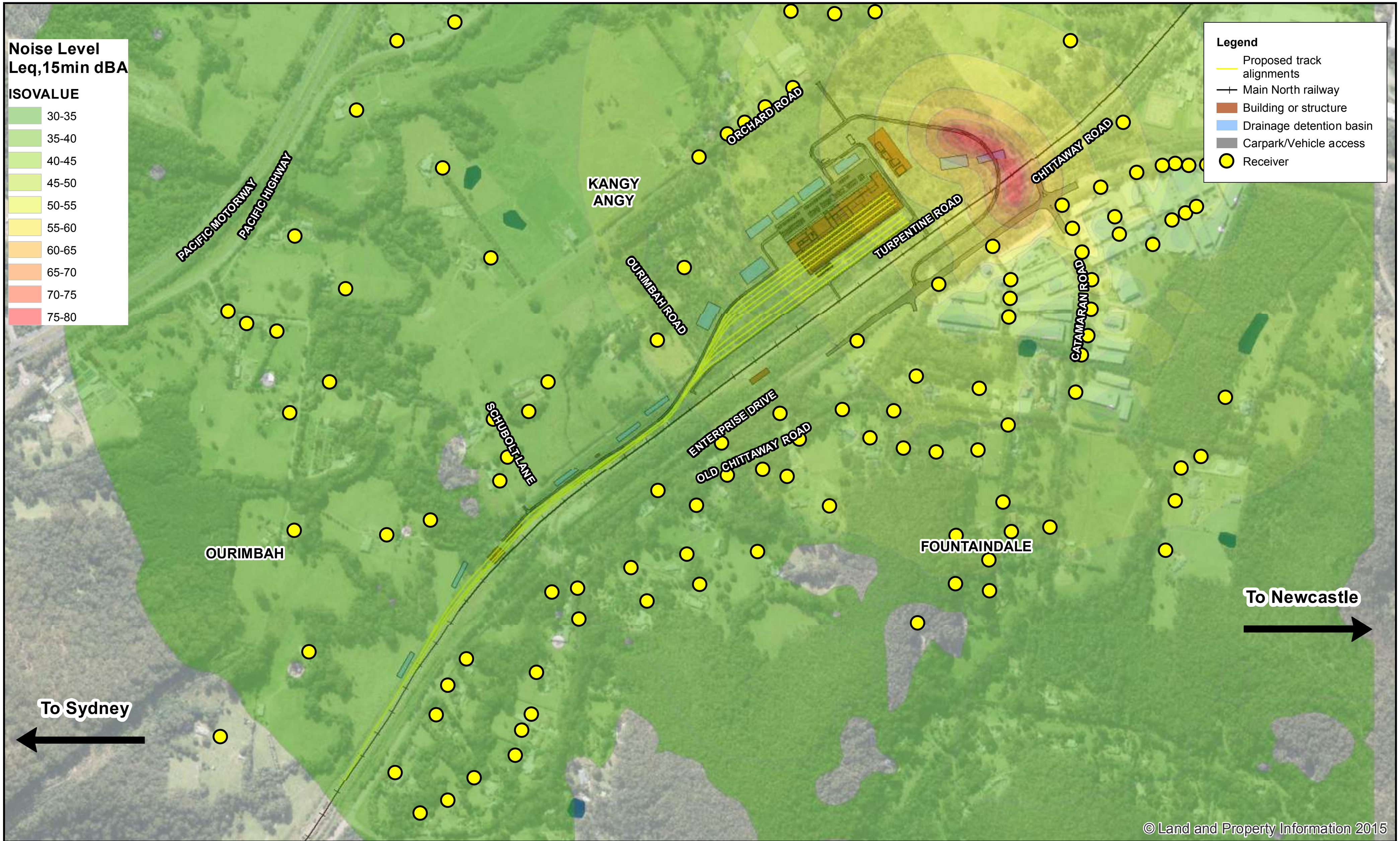

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Date: 11/05/2016	Approved by: -

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Construction scenario 11

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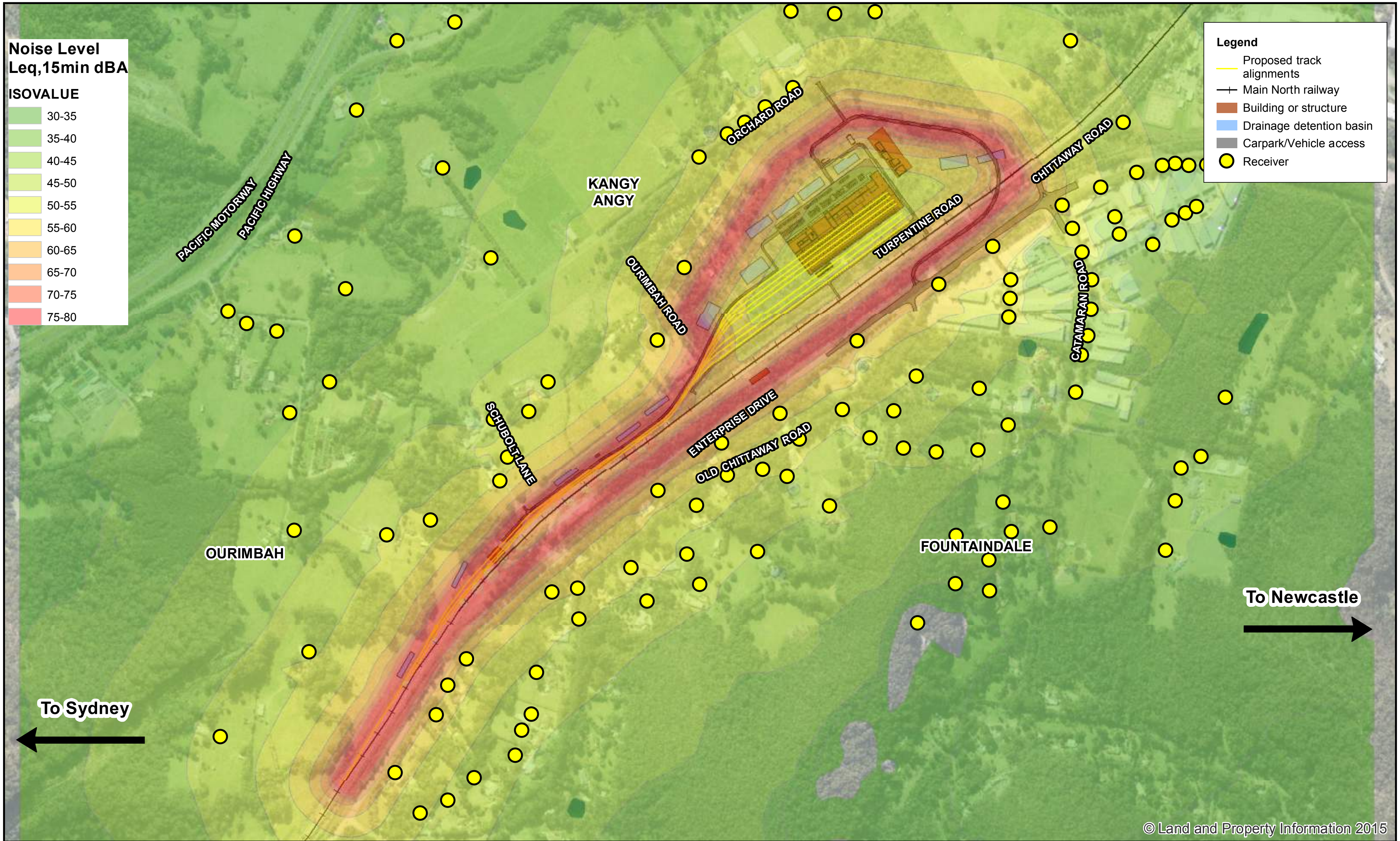

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New intercity fleet maintenance facility project

Construction scenario 12

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Date: 12/05/2016	Approved by: -	

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Scale ratio correct when printed at A4

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New intercity fleet maintenance facility project

Operational scenario 1
Neutral meteorological conditions
Indicative only - Subject to Detailed Design

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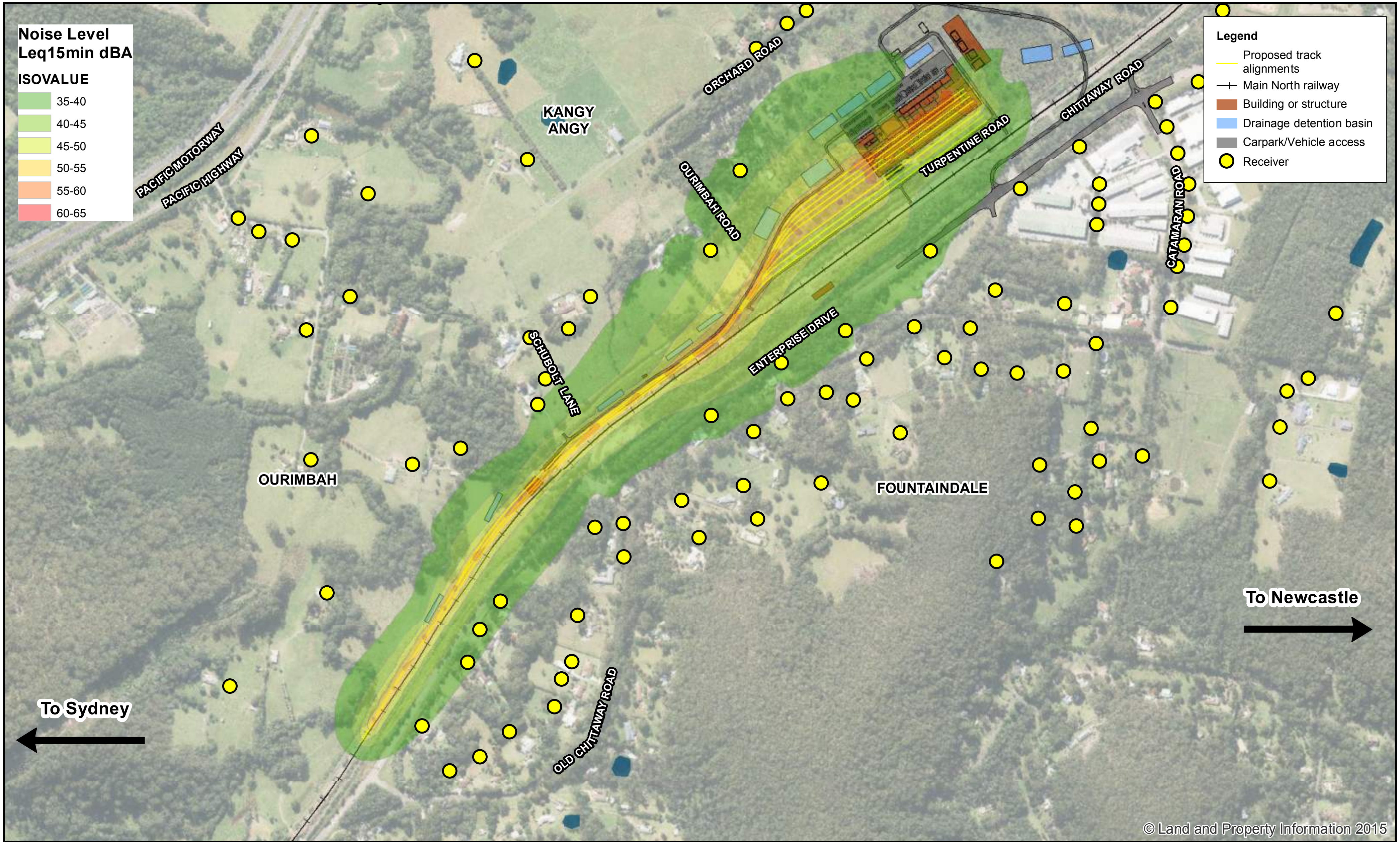

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New intercity fleet maintenance facility project

Operational scenario 2

Neutral meteorological conditions

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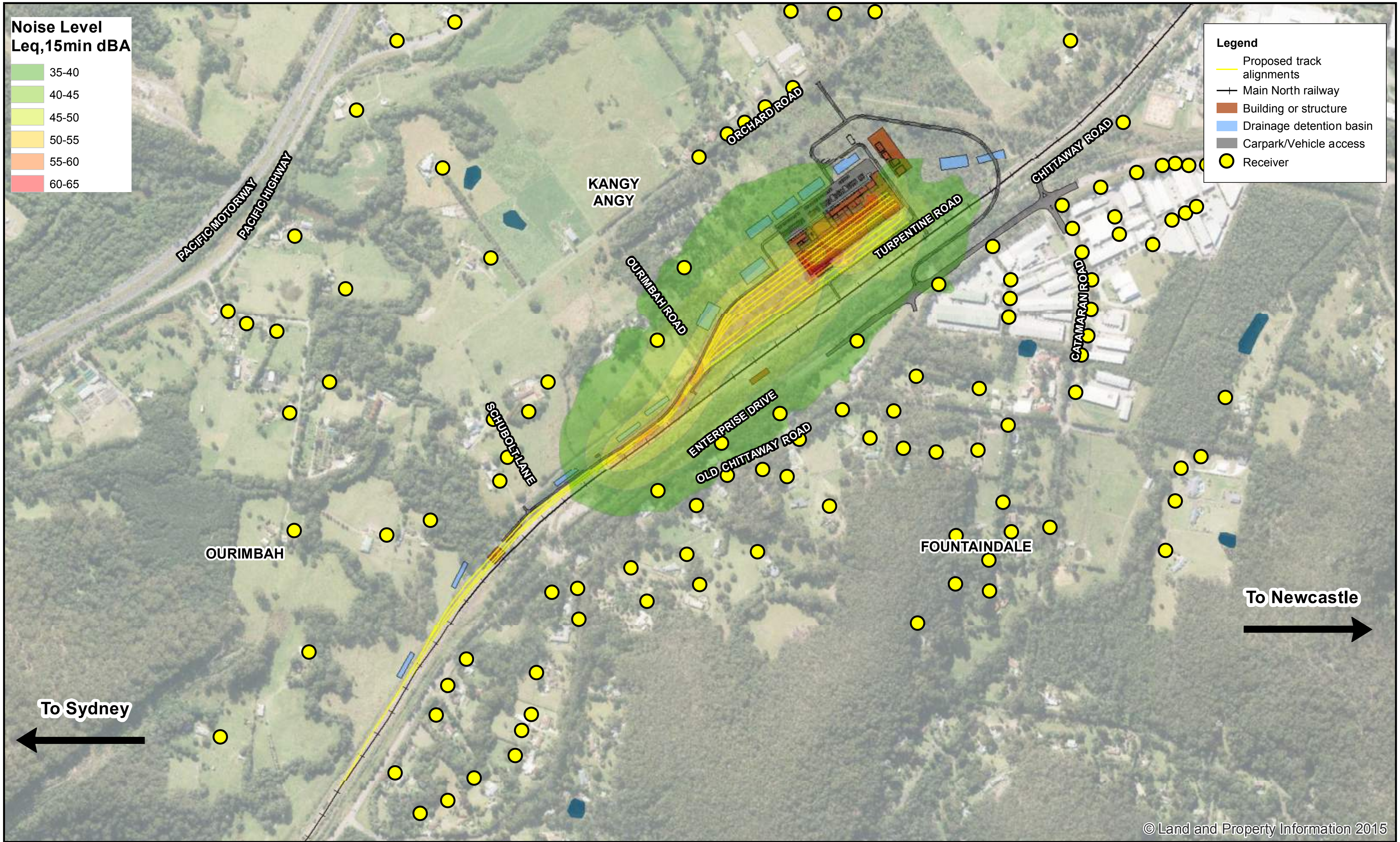

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Date: 11/05/2016	Approved by: -	

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Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Operational scenario 3
Neutral meteorological conditions
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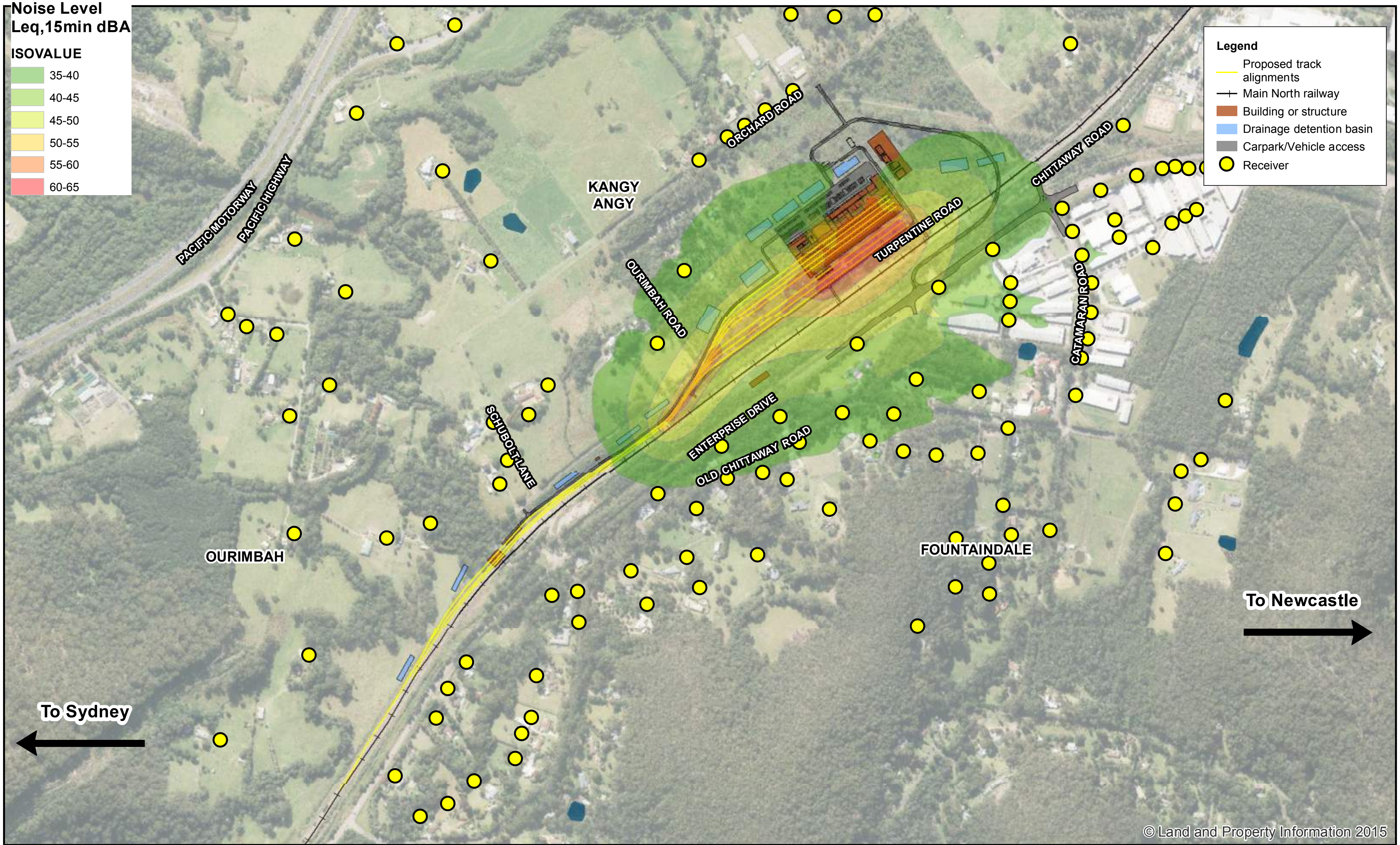

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Coordinate system: GDA 1994 MGA Zone 56

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New intercity fleet maintenance facility project

Operational scenario 4

Neutral meteorological conditions

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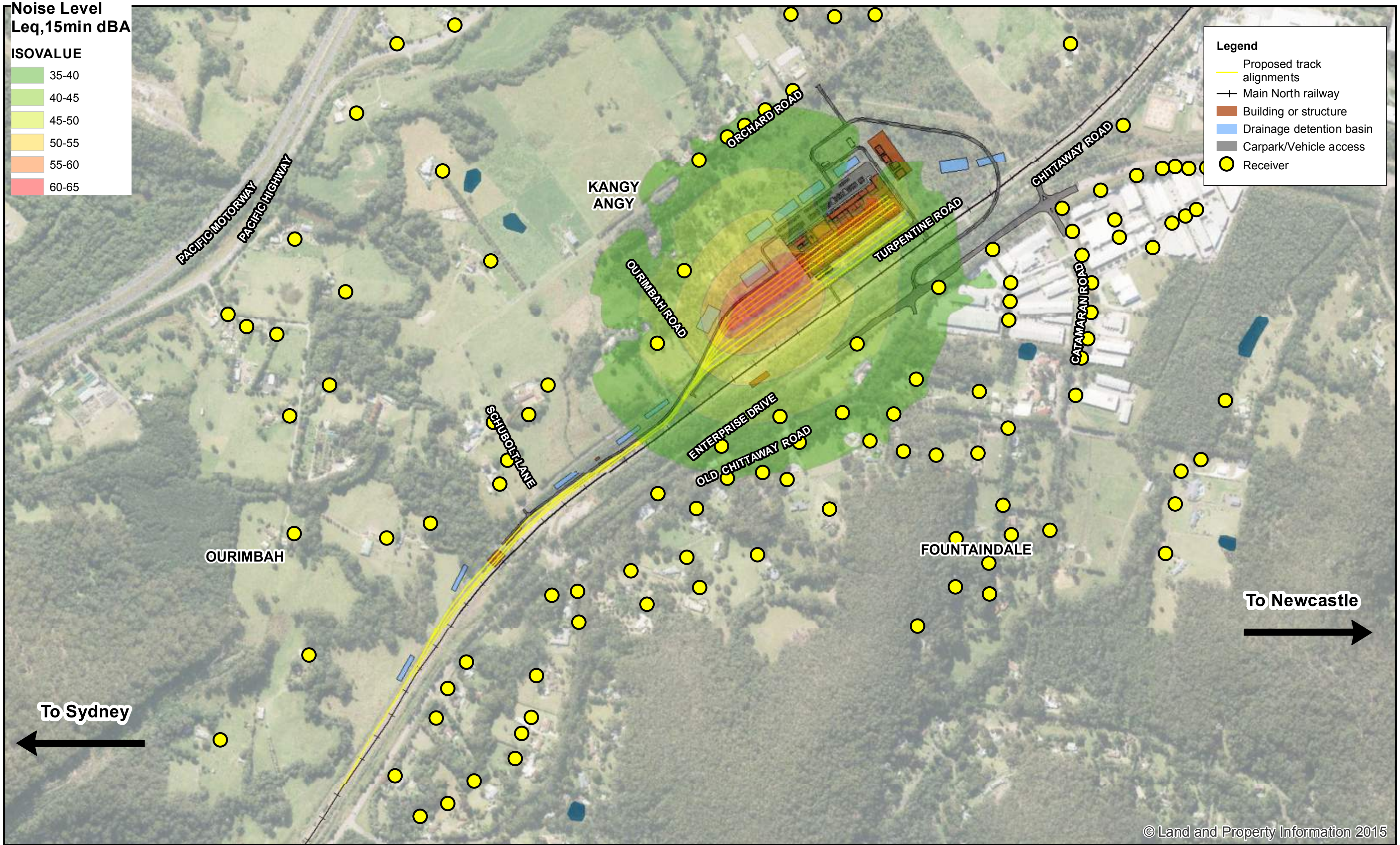

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Coordinate system: GDA 1994 MGA Zone 56

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New intercity fleet maintenance facility project

Operational scenario 5

Neutral meteorological conditions

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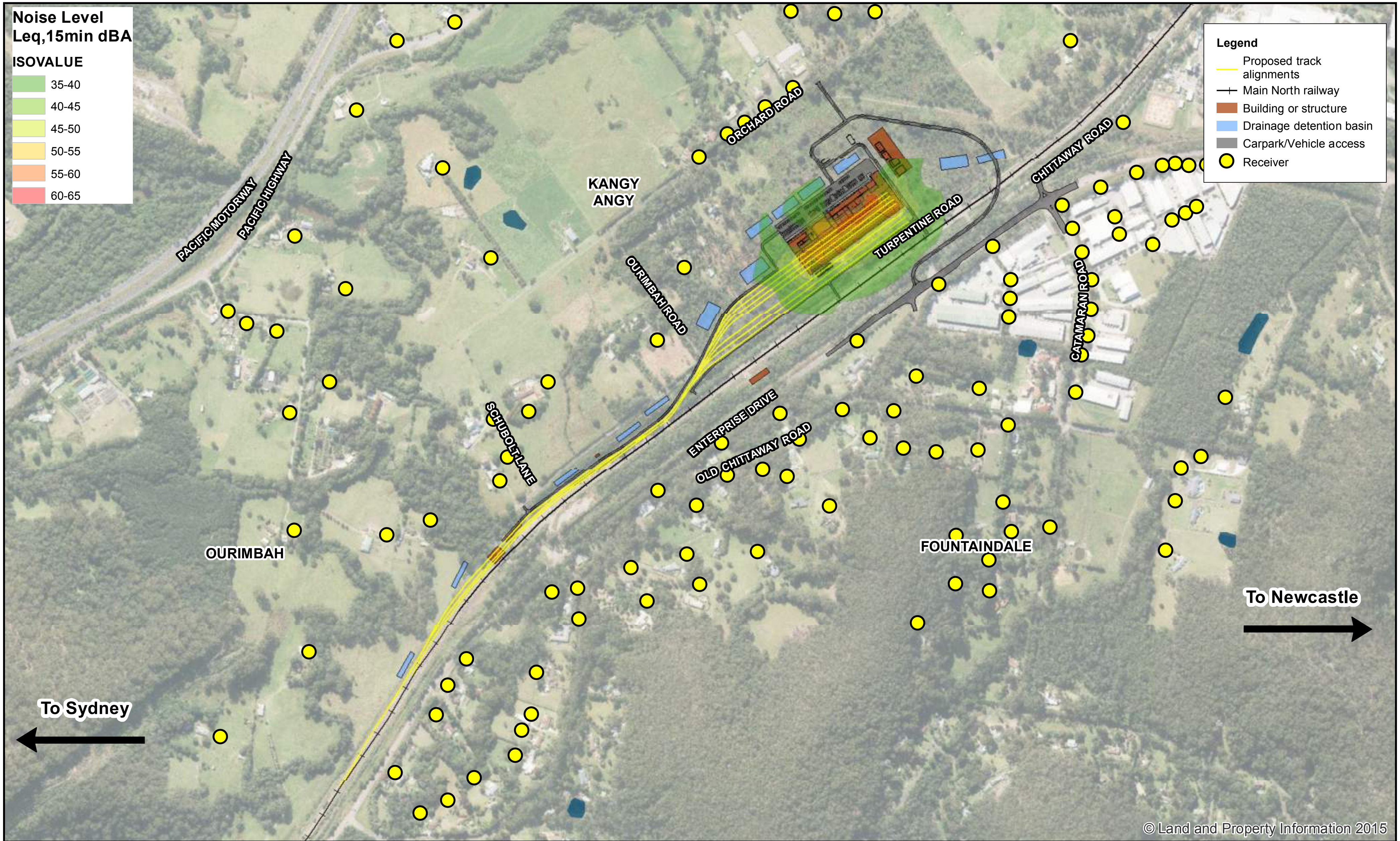

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New intercity fleet maintenance facility project

Operational scenario 6
Neutral meteorological conditions
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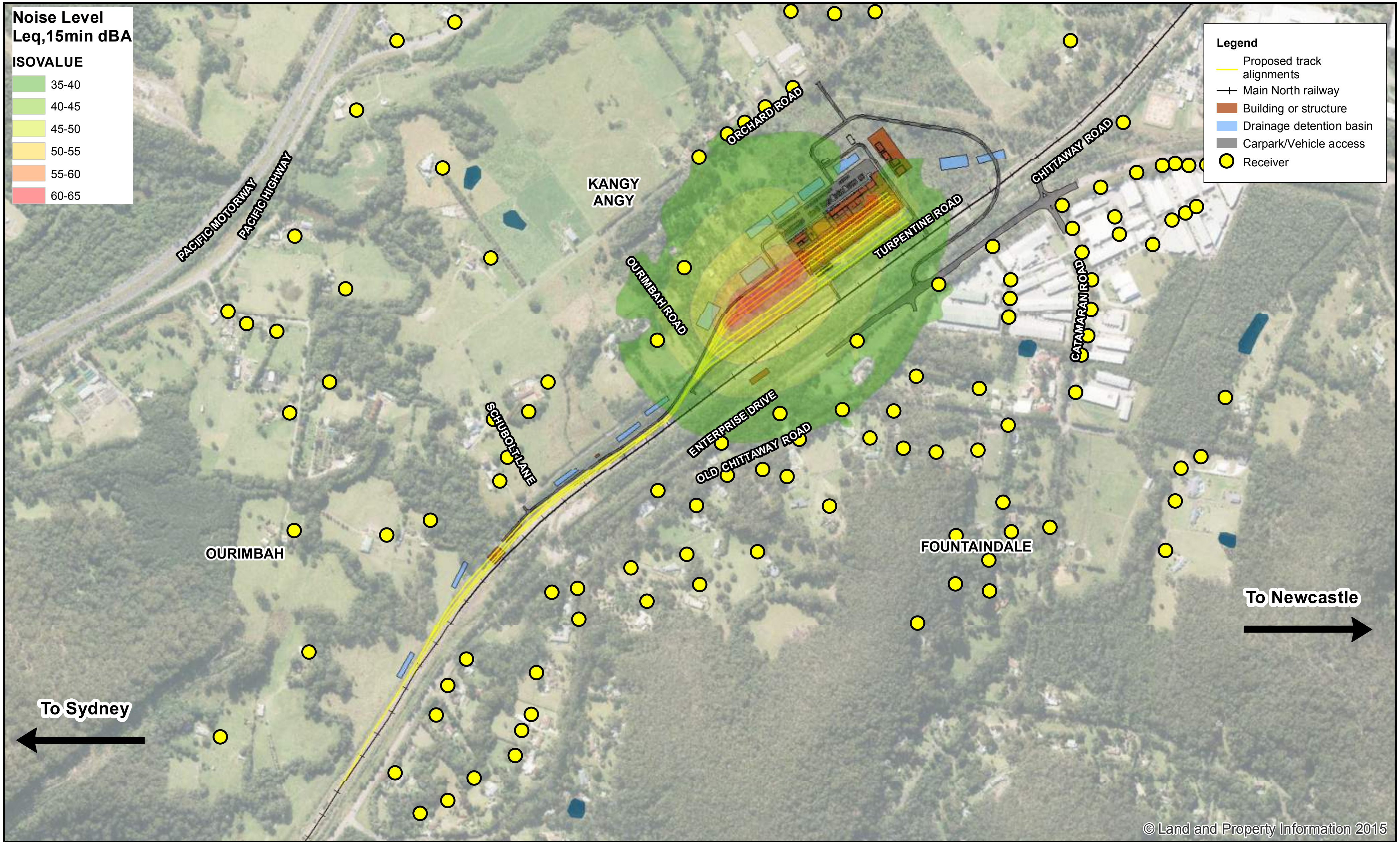

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New intercity fleet maintenance facility project

Operational scenario 7
Neutral meteorological conditions
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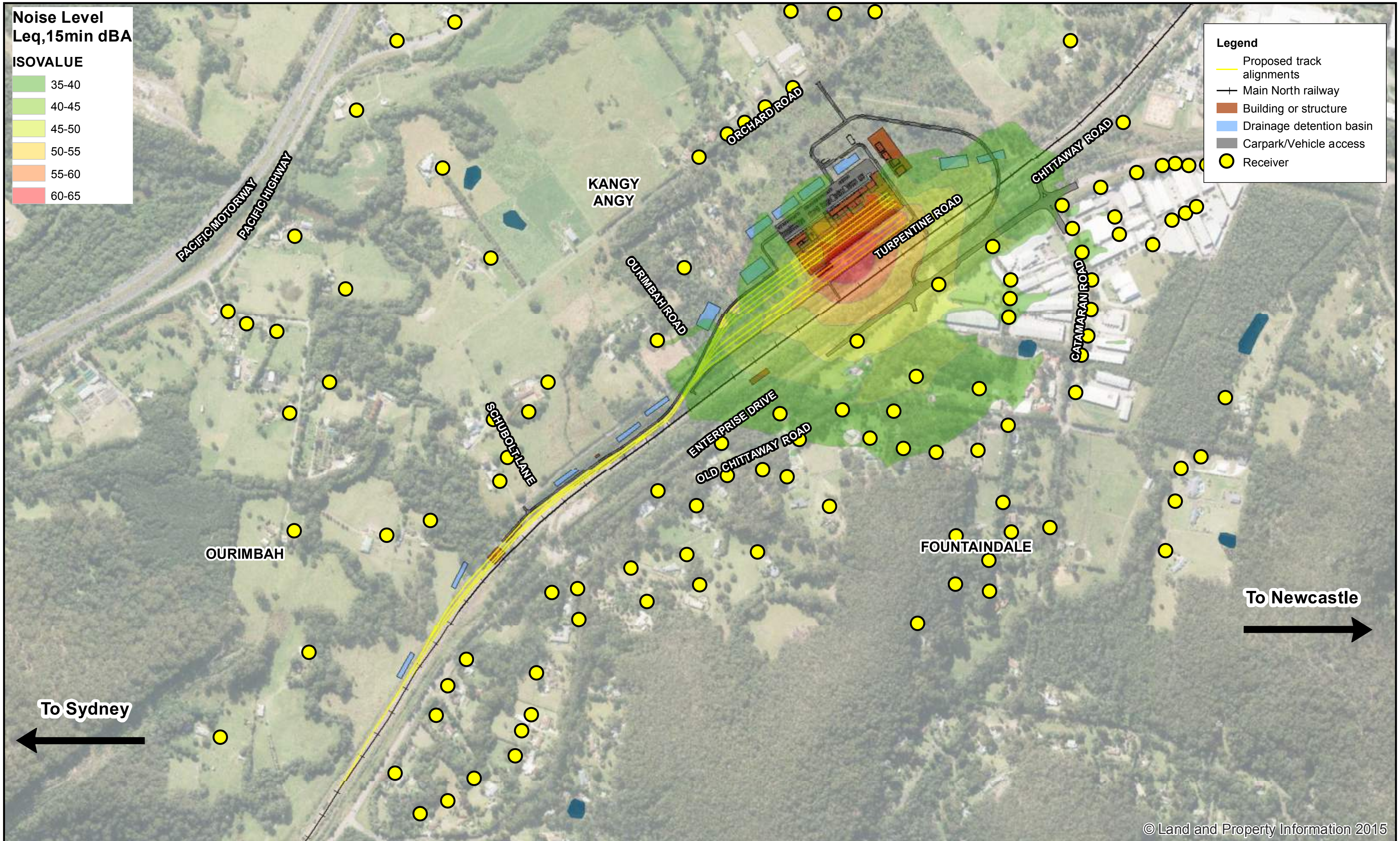

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New intercity fleet maintenance facility project

Operational scenario 8
Neutral meteorological conditions
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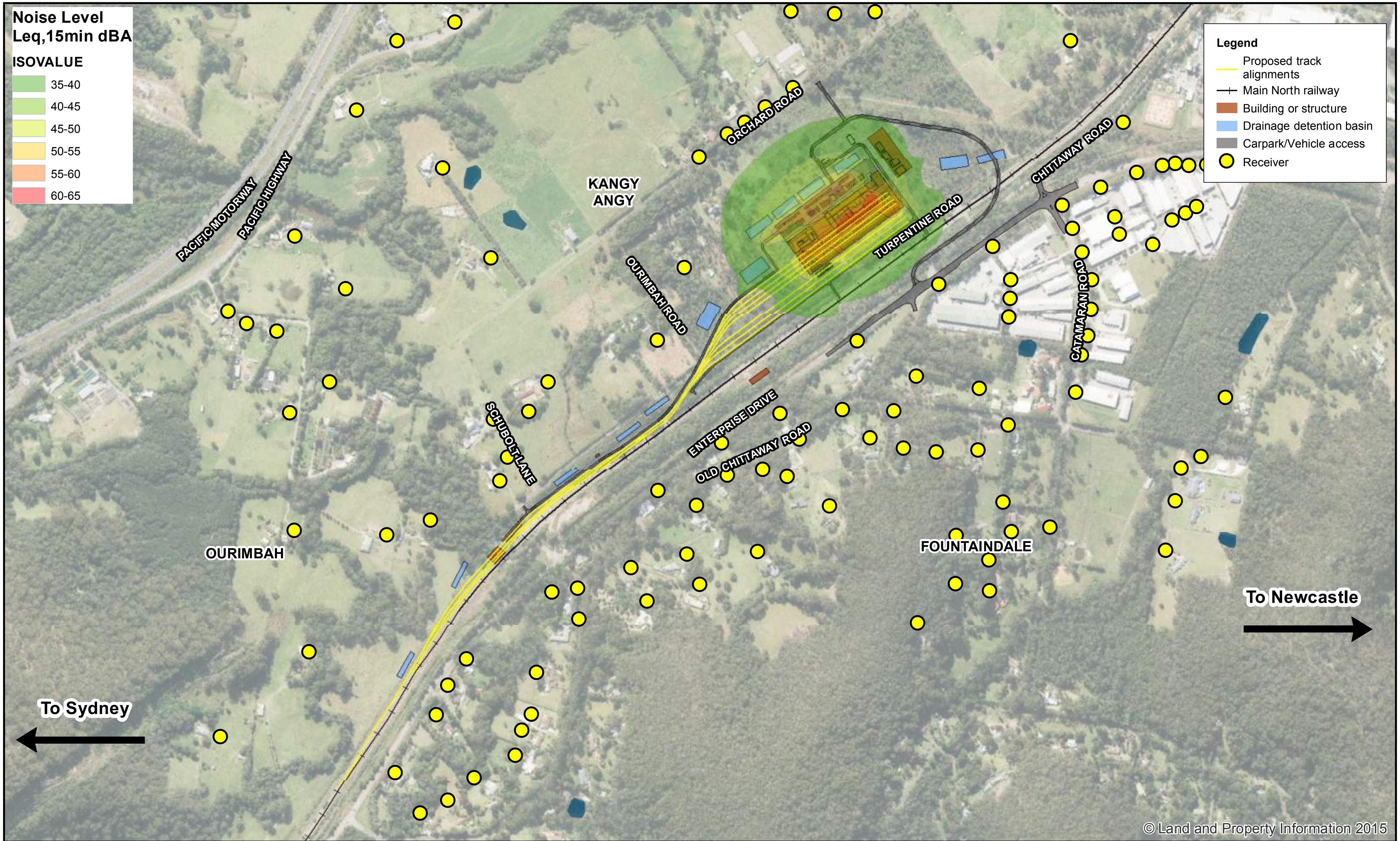

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A4

New intercity fleet maintenance facility project

Operational scenario 9

Neutral meteorological conditions

Indicative only - Subject to Detailed Design

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New intercity fleet maintenance facility project

Operational scenario 10
Neutral meteorological conditions
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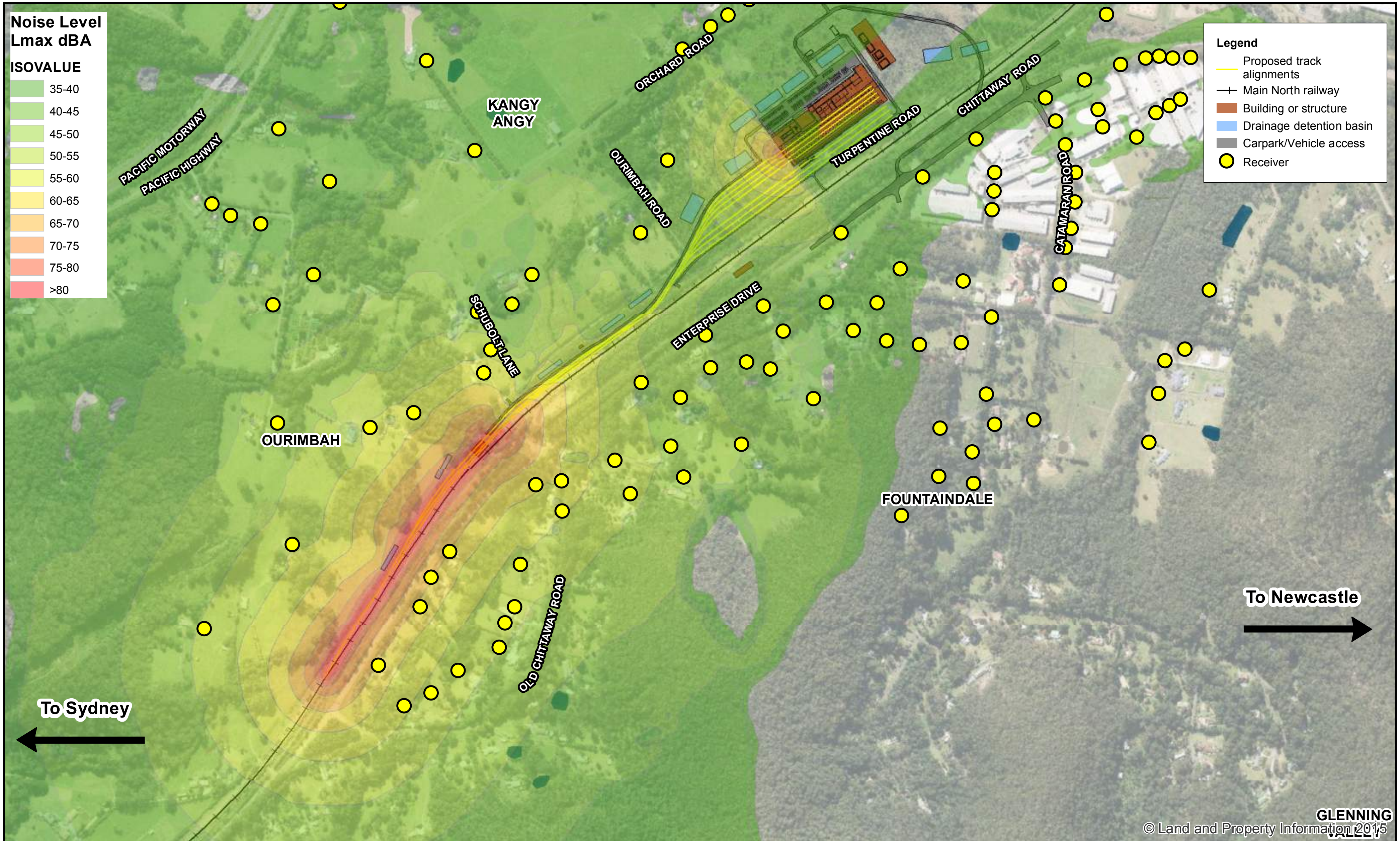

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New intercity fleet maintenance facility project

Operational scenario 11

Neutral meteorological conditions

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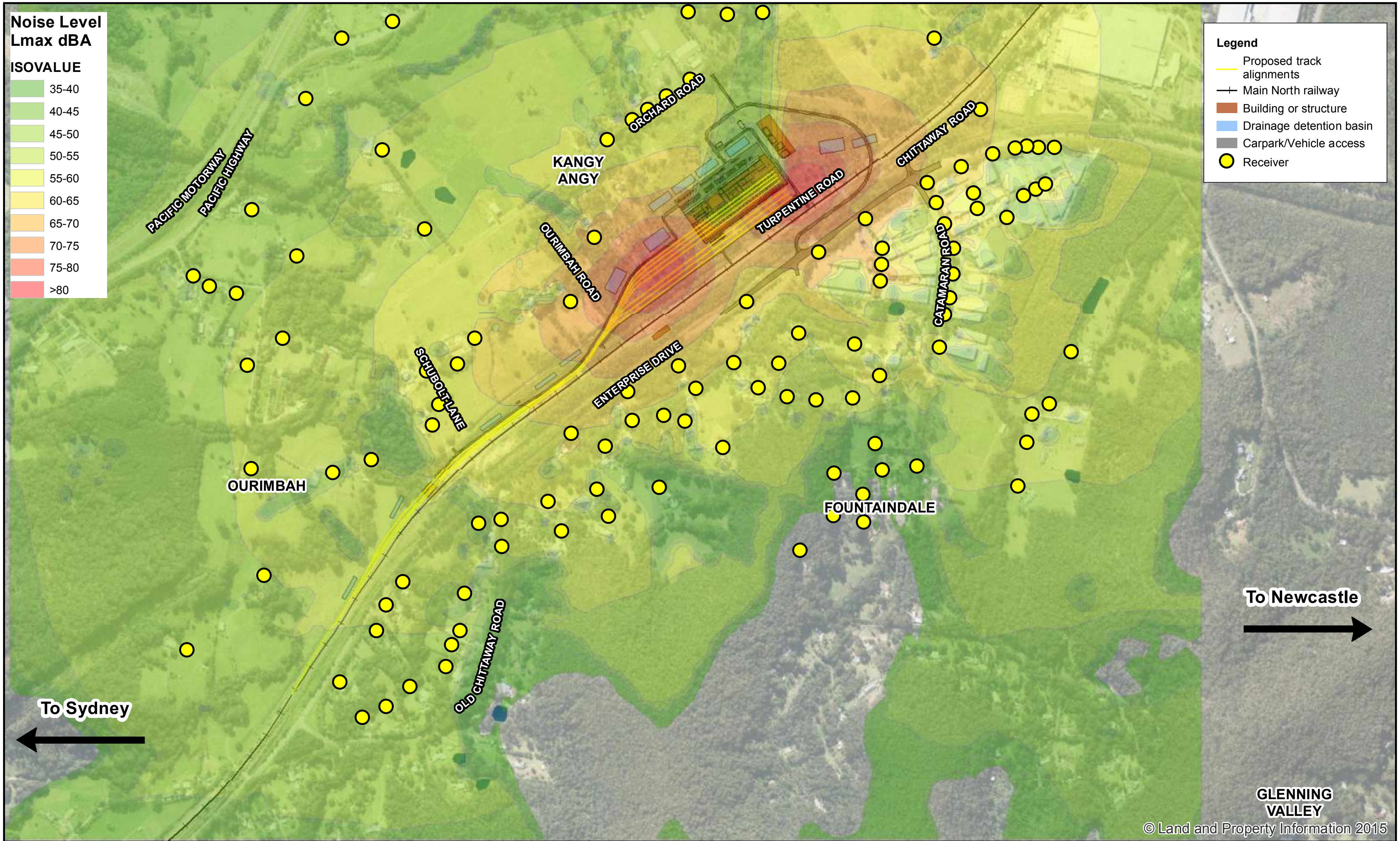

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New intercity fleet maintenance facility project

Operational scenario 12
Neutral meteorological conditions
Indicative only - Subject to Detailed Design

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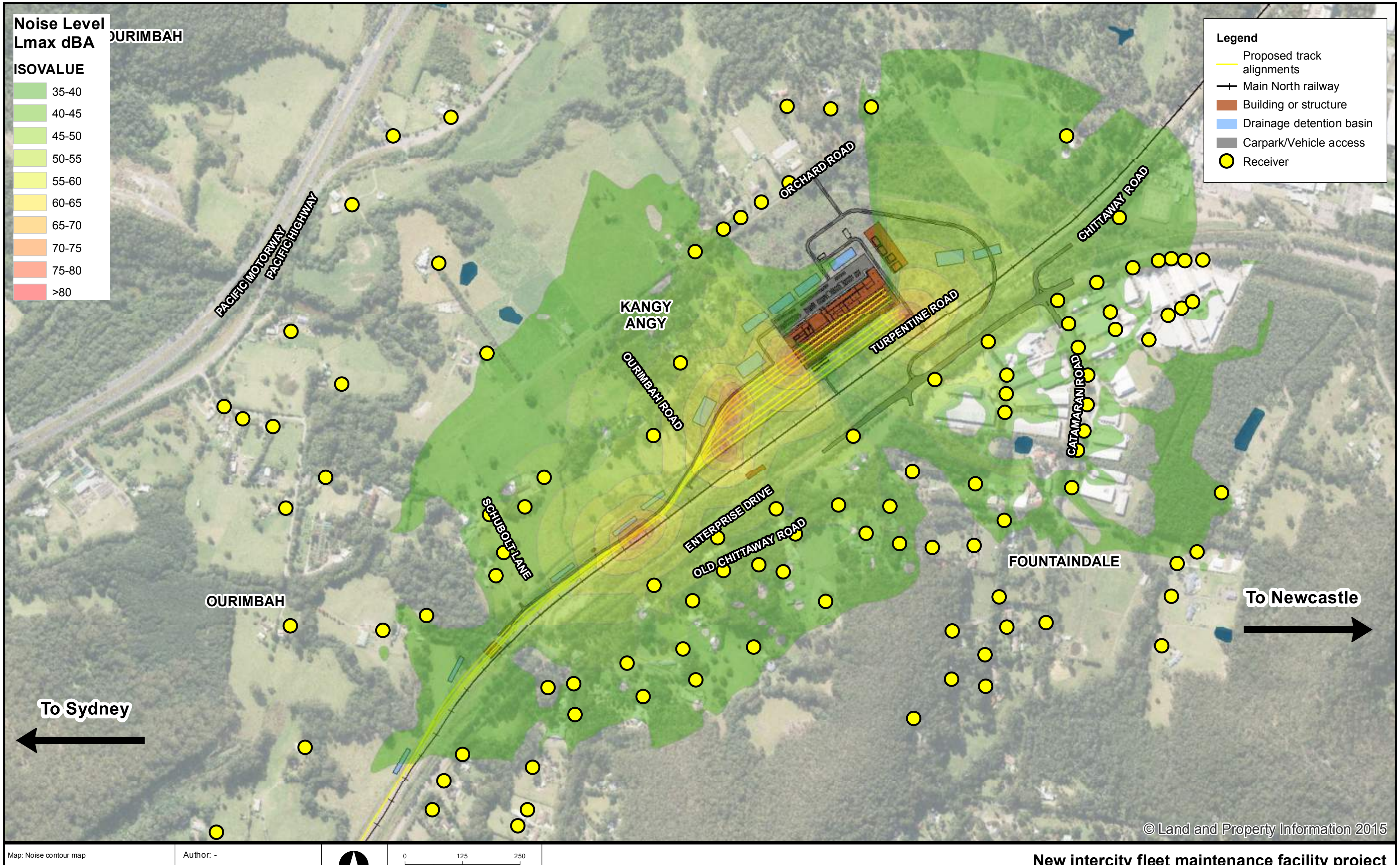

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New intercity fleet maintenance facility project

Operational scenario 13

Neutral meteorological conditions

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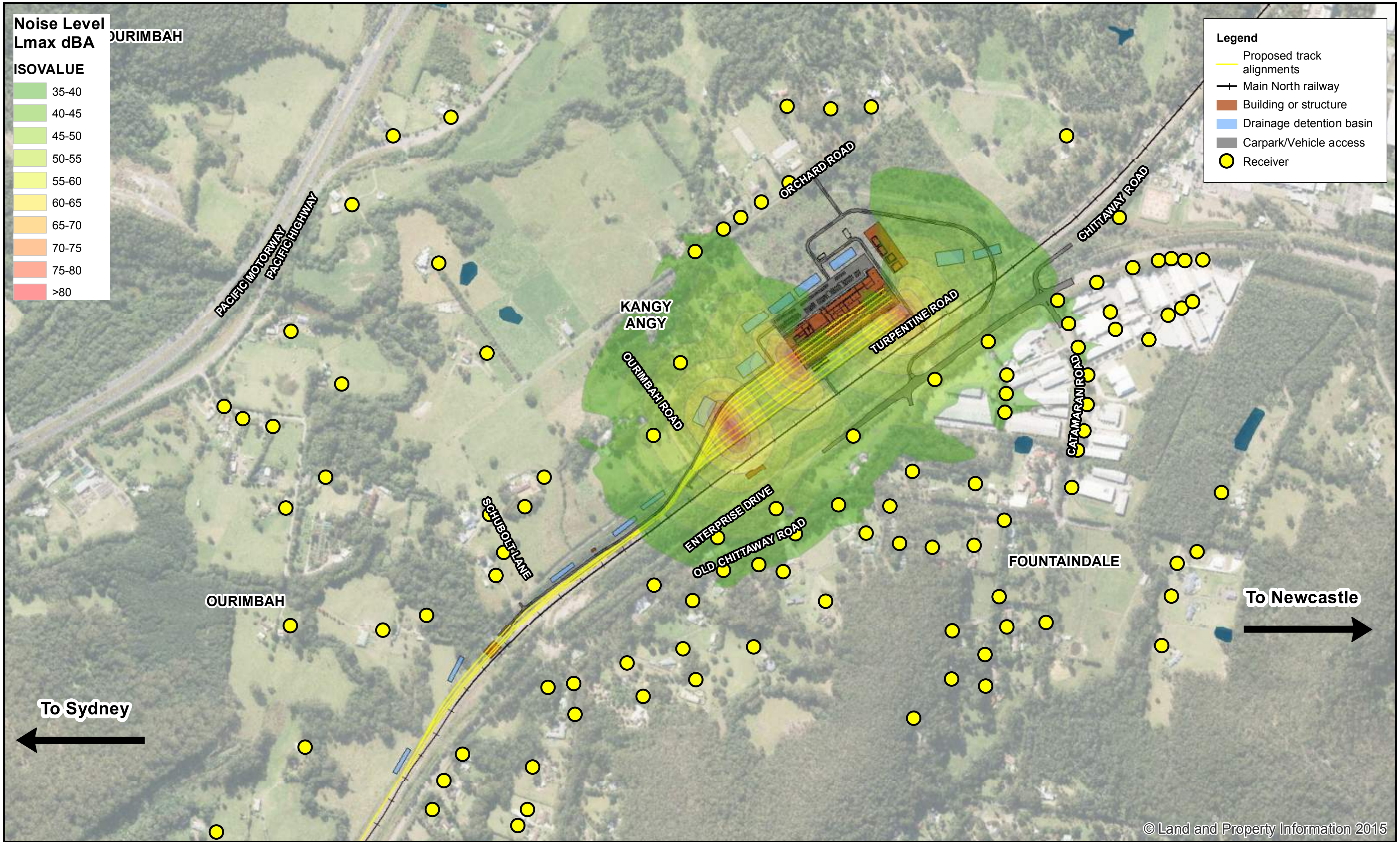

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Coordinate system: GDA 1994 MGA Zone 56

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New intercity fleet maintenance facility project

Operational scenario 14

Neutral meteorological conditions

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New intercity fleet maintenance facility project

Operational scenario 15

Neutral meteorological conditions

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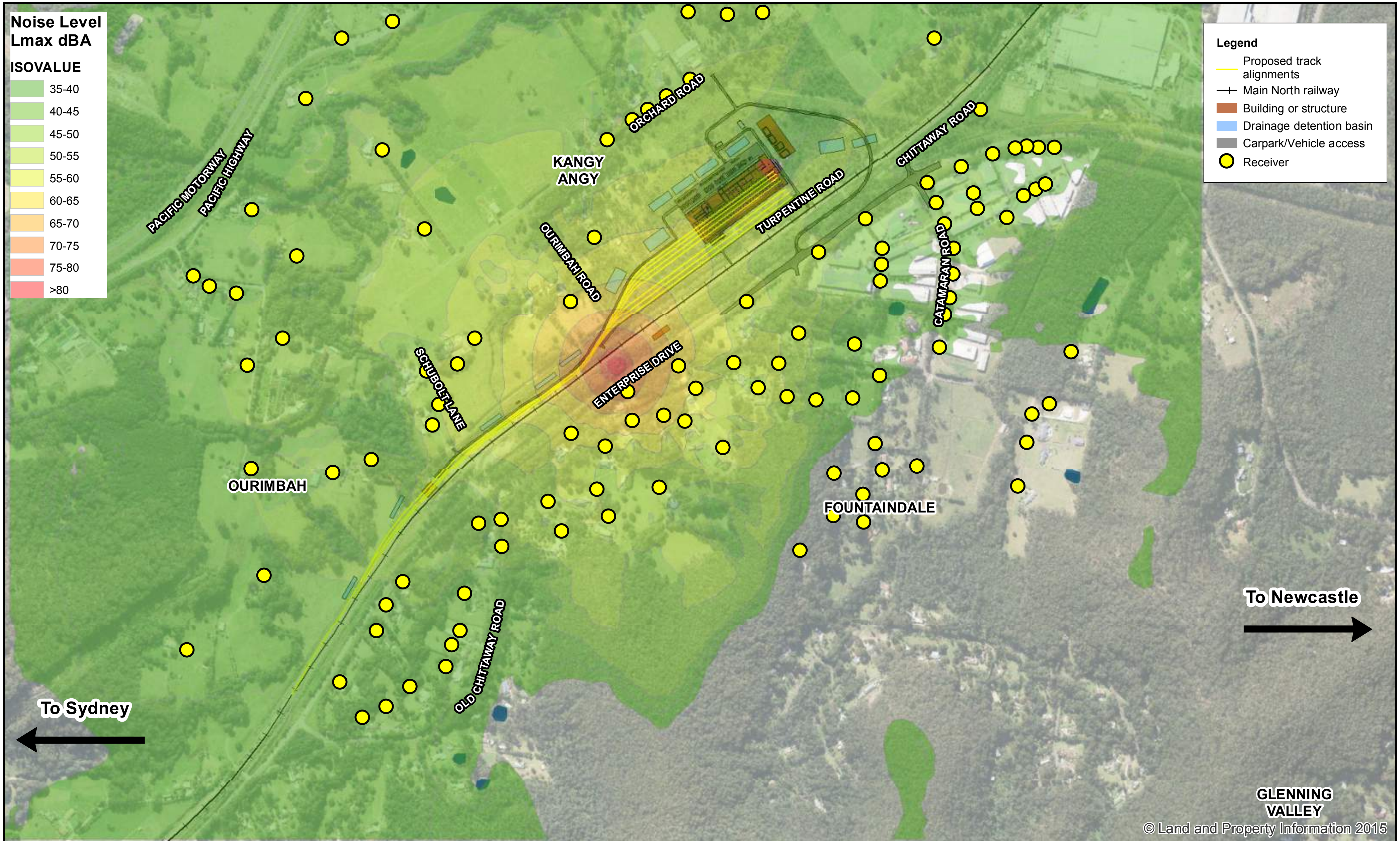

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New intercity fleet maintenance facility project

Operational scenario 16

Neutral meteorological conditions

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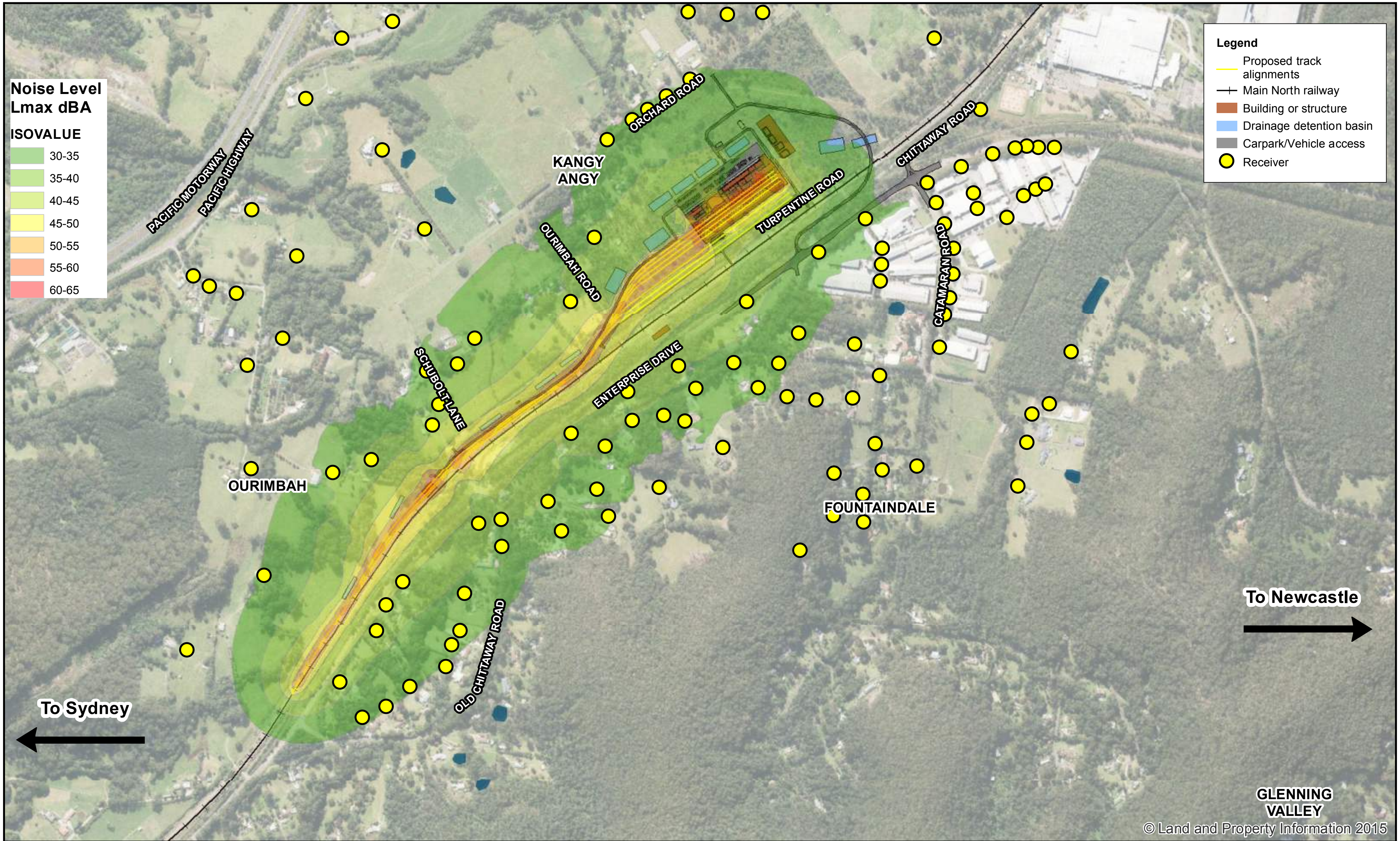

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New intercity fleet maintenance facility project

Operational scenario 1 with noise barriers
Neutral meteorological conditions
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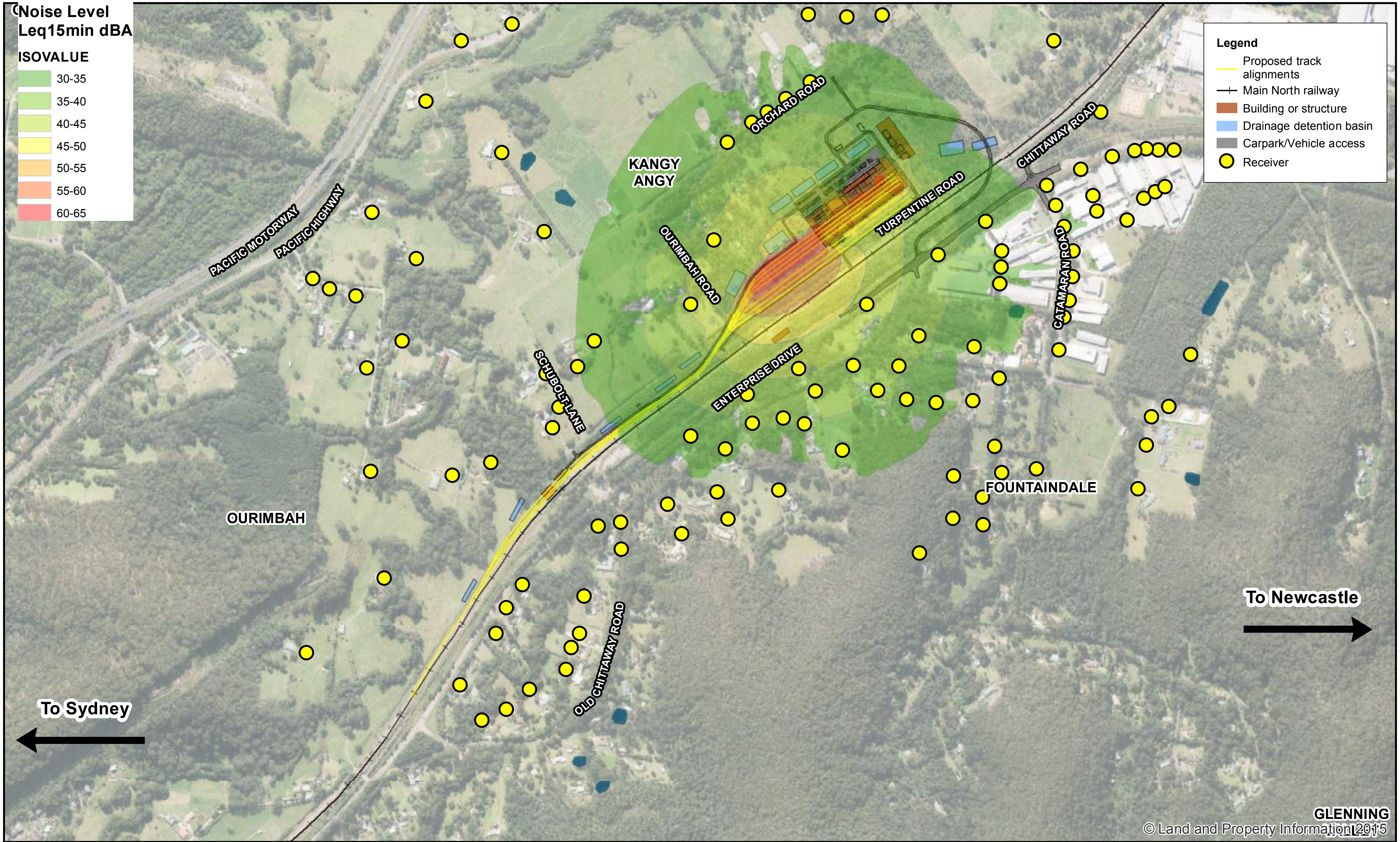

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New intercity fleet maintenance facility project

Operational scenario 5 with noise barriers
Neutral meteorological conditions
Indicative only - Subject to Detailed Design

Acoustics@WSPGroup.com

Appendix C

VISUAL AND LANDSCAPE CHARACTER ASSESSMENT

CLOUSTON associates

NEW INTERCITY FLEET MAINTENANCE FACILITY
LANDSCAPE CHARACTER AND VISUAL IMPACT ASSESSMENT

S15-0159
Issue C 04/05/2016

Cover: Vegetation near the Project site
This Page: Dense vegetation near Ourimbah creek

NEW INTERCITY FLEET MAINTENANCE FACILITY
LANDSCAPE CHARACTER AND VISUAL IMPACT ASSESSMENT

Prepared by

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Document	Issue	Date	Status	Reviewed	Verified	Validated
S15-0159	A	24/03/16	DRAFT	LC	MK	
	B	07/04/16	FINAL	LC	MK	MOD
	C	04/05/16	FINAL	LC	MK	MOD

Note: this document is preliminary unless validated.

CLOUSTON associates

TABLE OF CONTENTS

FIGURES AND TABLES


Vegetation near the Project site

1.0 INTRODUCTION

CLOUSTON associates

1.0 INTRODUCTION

1.0 INTRODUCTION

On 8th May 2014 it was announced by the NSW Premier and the Minister for Transport that Transport for New South Wales (TfNSW) is procuring a New Intercity Fleet (NIF) to serve the Central Coast and Newcastle, the Blue Mountains and the South Coast.

The New Intercity Fleet will require a Maintenance Facility for receiving, testing, commissioning and the ongoing maintenance of the new train fleet.

A site near Kangy Angy on the Central Coast, NSW has been selected as the preferred site for the facility - refer Project location.

1.1 PURPOSE OF REPORT

CLOUSTON Associates has been commissioned by WSP | Parsons Brinckerhoff (PB) on behalf of TfNSW to prepare the Landscape Character and Visual Impact Assessment (LCVIA) for the proposed New Intercity Fleet Maintenance Facility Project (hereafter, referred to as 'the Project'). The purpose of the LCVIA is to support the review of environmental factors (REF) for the Project.

This LCVIA is one of a number of technical reports supporting the REF for the Project.

1.2 METHODOLOGY

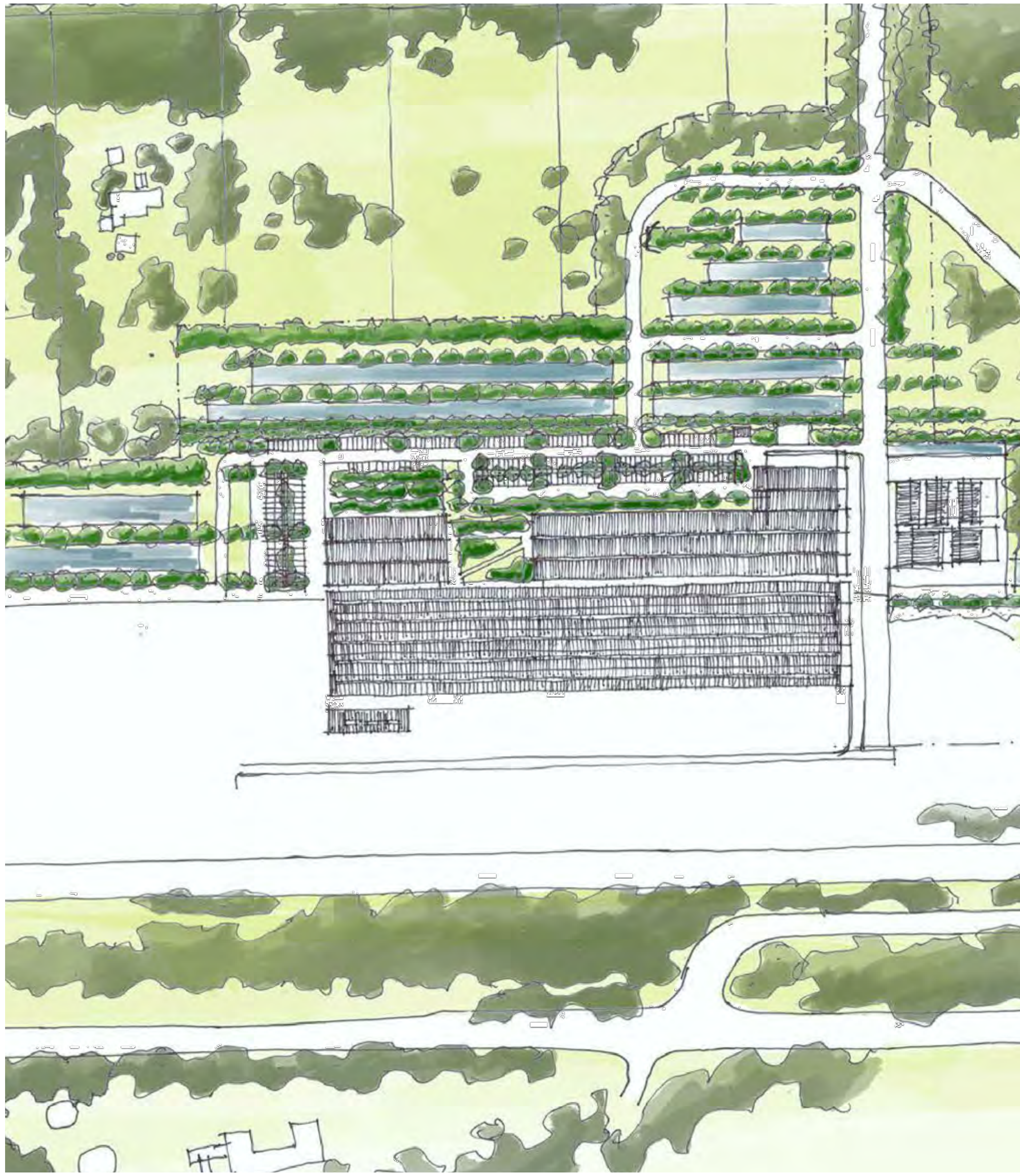
Landscape Character and Visual Impact Assessment (LCVIA) aims to ensure effects of change and development in the landscape, views and visual amenity are taken into account. It is concerned with how the surroundings of individuals or groups of people may be specifically affected by change in the landscape, both quantitatively and qualitatively.

Judgement as to the significance of the effects is arrived at by a process of reasoning, based upon analysis of the baseline conditions, identification of receptors and assessment of their sensitivity, as well as the magnitude and nature of the changes that may result from any development.

This assessment is an independent report and is based on a professional analysis of the landscape and the Project at the time of writing. The current and potential future viewers (visual receptors) have not been consulted about their perceptions. The analysis and conclusions are therefore based solely on a professional assessment of the anticipated impacts, based on a best practice methodology.

LCVIA is by its nature not an exact science and consequently is subject to varied methodologies both in Australia and overseas. Potentially subjective assessment material and differences of opinion about how to best assess visual characteristics, qualities, degrees of alteration and viewer sensitivity often arise. As a consequence, and as identified by the NSW Land and Environment Court, the key to a robust process is to explain clearly the criteria upon which an assessment is made.

This assessment has been undertaken in accordance with the structure outlined in the Roads and Maritime Services (RMS) Environmental Impact Assessment Guidance Note EIA-N04 - *Guidelines for landscape character and visual impact assessment.* Further details on the methodology employed can be found within the relevant chapters.



Extract from the concept landscape design for the Project

1.3 THE PROJECT

TfNSW proposes to deliver a new train maintenance facility at a site in Kangy Angy on the Central Coast of NSW to support the procurement of the New Intercity Fleet. The facility would undertake light and heavy train maintenance activities for the New Intercity Fleet, including but not limited to:

- regular maintenance/servicing
- repair/replacement of train components
- interior and exterior cleaning.

The proposed facility would include about six kilometres of electrified railway (in total), would be seven tracks wide at its widest point, covering an area of approximately 48 hectares, and would be bounded by a perimeter fence - refer Figure 1A, 1B and 1C. The proposed facility would include the following key elements:

Maintenance facility:

- fleet maintenance building
- four enclosed maintenance roads (tracks for undertaking maintenance on the train sets) and three external standing roads (tracks for holding trains within the maintenance facility) to accommodate the new trains within the site
- auxiliary workshops
- electronic clean room
- material storage, including flammable liquid storage
- wheel lathe
- automatic train wash
- site access roads.

Miscellaneous buildings:

- administration (including training rooms)
- facilities for presentation and train maintenance staff
- signalling buildingsecurity
- train simulator
- substation building
- power supply (traction power, bulk power, signalling power supply and backup generators).

Other infrastructure including:

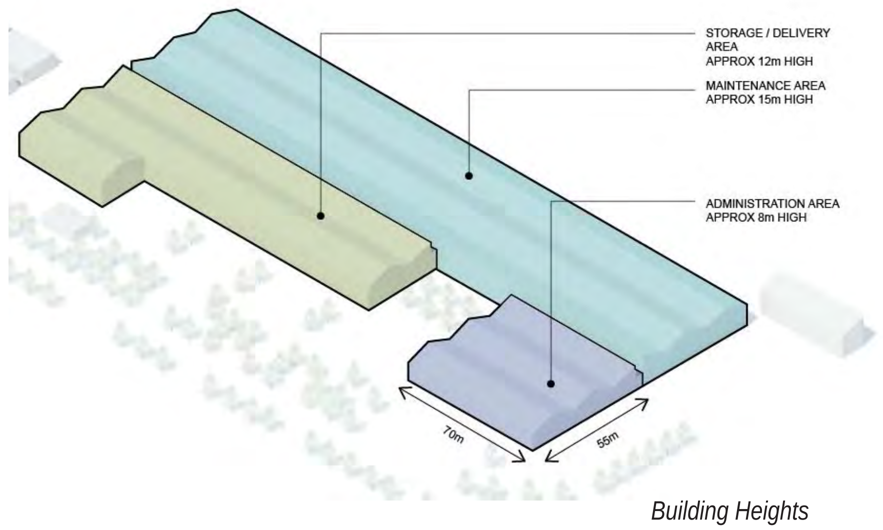
- new railway track infrastructure on the western side of the existing rail corridor to allow for trains to enter and exit the maintenance facility site from the Main North railway
- a new rail bridge over Chittaway Creek and Turpentine Road (consisting of two separate structures)
- a new access roadway and bridge to the maintenance facility site off Enterprise Drive
- a new flood access road between Orchard Road and the proposed new access roadway
- a series of drainage detention ponds
- staff car park
- relocation of the existing high voltage power transmission line and Combined Services Route.

1.3.1 Architectural Design

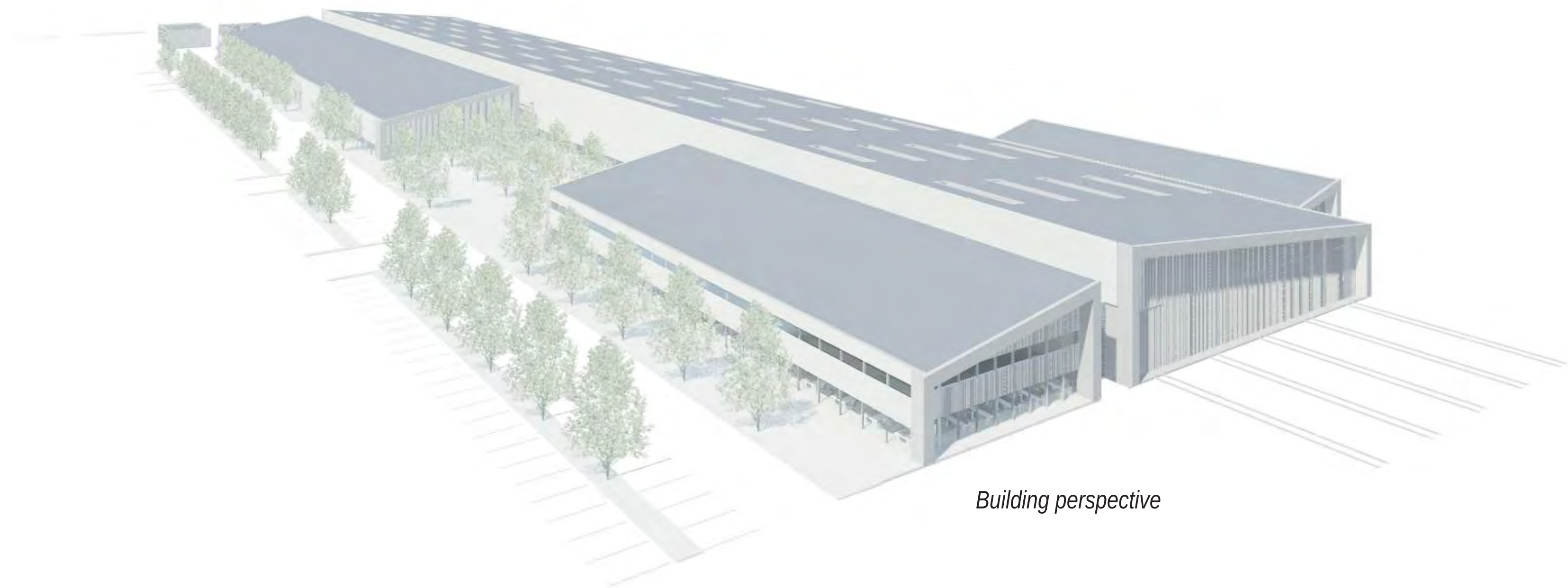
The design and layout of the maintenance facility has been generated from a site optioneering process undertaken with Aecom and TfNSW during a series of workshops and technical reviews.

The surrounding context is semi-rural and dwelling heights typically do not exceed 2 storeys. There are several large sheds and an industrial estate, the estimated maximum height of these building are approximately 12m high. The proposed design aims to minimise the apparent visual bulk of the facility by organising buildings to fit as closely as practical to create a slim profile.

The finish of buildings is likely to be a mix of steel and colourbond.



Building Heights



Building perspective

CLOUSTON associates

Project location

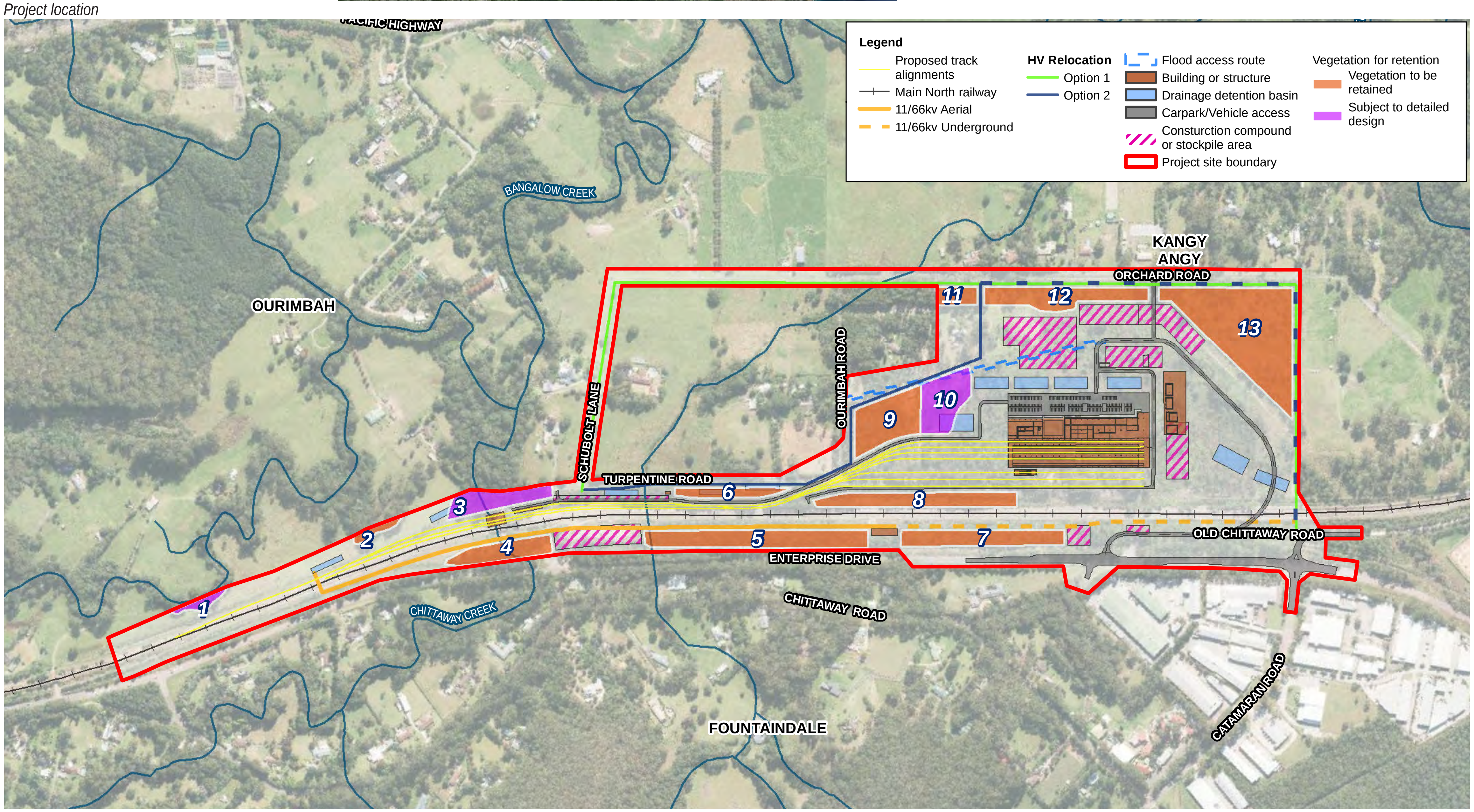


Figure 1A - Project general arrangement

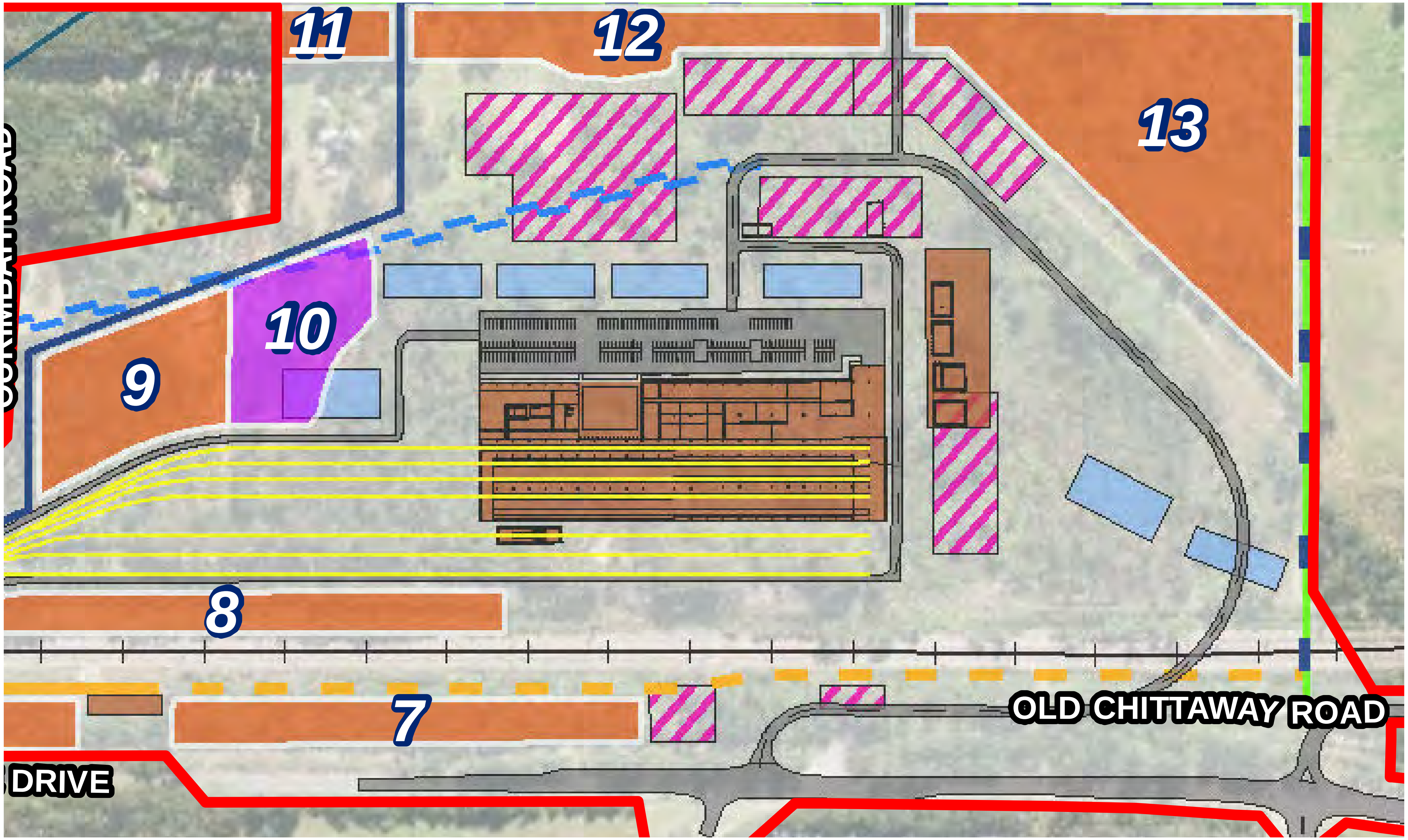
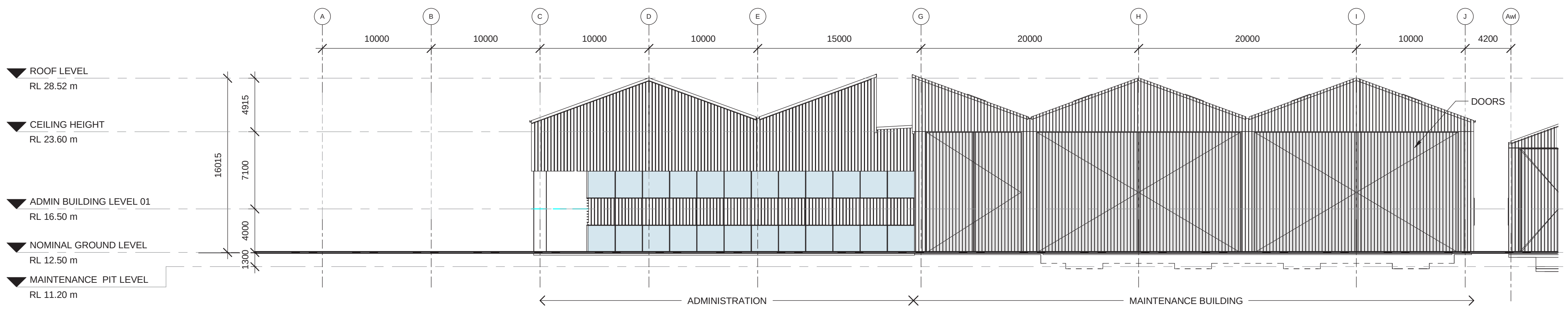


Figure 1B - Detail of main Project site



1 MAINTENANCE BUILDING West Elevation
1 : 250

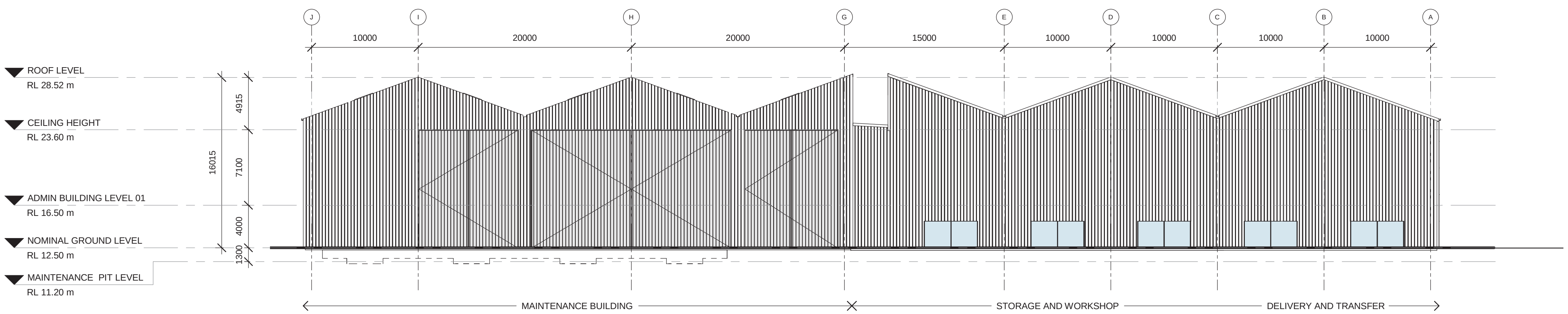


Figure 1C - Typical sections through warehouse buildings (Note: Design is indicative and subject to detailed design)

2.0
LANDSCAPE CHARACTER

CLOUSTON associates

2.0 LANDSCAPE CHARACTER ASSESSMENT

2.1 CHAPTER OVERVIEW

This section of the LCVIA provides an overview of the existing landscape character of the study area including land use, vegetation, built form and topography. The study area is then described under distinct landscape character zones before the impact of the Project on each is assessed.

2.2 STUDY AREA

The study area specific to the landscape character assessment comprises the land within and surrounding the Project site to a distance of approximately 1.5km.

2.3 SITE ANALYSIS

The site is located in the suburb of Kangy Angy, within the Wyong Shire local government area on the New South Wales Central Coast. The site is generally bordered by the Main North Rail Line rail corridor to the south, and Orchard Road to the north west - refer Figure 02.

Residential receivers on rural properties generally surround the site to the north, south and west, with industrial precincts to the south east and north-east (on the opposite side of the rail corridor to the site).

The M1 Pacific Motorway is located approximately 0.85km to the north west, and Tuggerah Lake is approximately 3.5 km to the east of the site. Chittaway Creek crosses the project at the southern end and Ourimbah Creek is to the north of the site.

2.2.2 Topography

The study area comprises undulating topography with level floodplains associated with Ourimbah Creek, rising up to wooded hillsides such as Mount Tangy Dangy in the north (140m).

2.2.3 Land use

The study area lies within what is currently a semi rural suburb within the Central Coast of NSW. The earliest parish map available for the area dates to 1924, and indicates that the area has been earmarked for subdivision for at least that long.

The pattern of subdivision has changed little since this time compared with surrounding areas, and current aerials show only a few dwellings within the study area, suggesting that it has not been as heavily impacted by residential development as the surrounding lots.

2.3.4 Flora

The study area is part of the Wyong subregion of the Sydney Basin Bioregion. This broad subregion contains a wide variety of native vegetation, typically smooth-barked apple, red bloodwood, brown stringybark, spotted gum, northern grey ironbark and grey gum on hills and hillslopes. Prickly-leaved tea-tree and other shrubs with swamp mahogany, swamp oak, sedges and common reed are typically present on swampy creek flats.

An preliminary Ecological Assessment by EMM (2015) identified two endangered ecological communities which are discussed in more detail within this chapter.

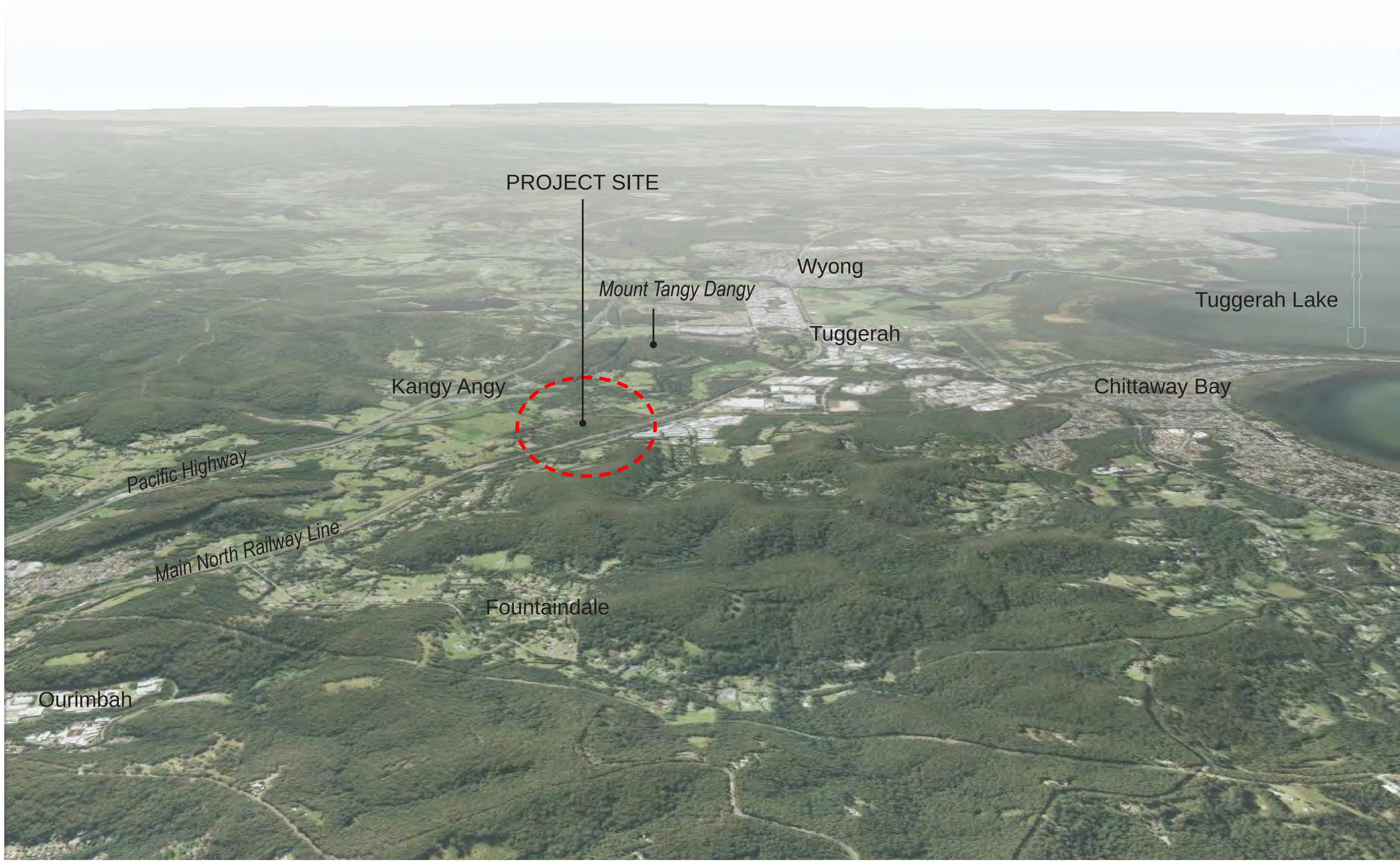


Figure 02 - Site context

2.4 LANDSCAPE CHARACTER ASSESSMENT METHODOLOGY

This report has adopted the Guidelines for Landscape Character and Visual Impact Assessment as published by the Roads and Maritime Service, RMS. To enable the assessment of impacts on landscape character, landscape character zones have been determined for the study area.

2.4.1 Landscape Character Zones

Landscape character zones are defined as areas having a distinct, recognisable and consistent pattern of elements, be they natural (soil, vegetation, landform) and/or human built form, making one landscape different from another. The study area and surrounds have been assessed and the following landscape character zones have been established (refer Figure 03):

1	Open Farmland
2	Woodland
3	Rural Residential
4	Transport Corridors
5	Industrial Development

2.3.2 Assessment

The overall impact rating of the Project on any given landscape character zone is based on themes of magnitude and sensitivity. The severity of these impacts are calculated using Table 01 - based on a combination of magnitude and sensitivity.

SENSITIVITY \ MAGNITUDE	HIGH	MODERATE	LOW	NEGLIGIBLE
HIGH	HIGH	HIGH - MODERATE	MODERATE	NEGLIGIBLE
MODERATE	HIGH - MODERATE	MODERATE	MODERATE/LOW	NEGLIGIBLE
LOW	MODERATE	MODERATE/LOW	LOW	NEGLIGIBLE
NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Table 01: Landscape Character Impact Rating as a combination of Sensitivity and Magnitude. Source: RMS Guidelines for Landscape Character and Visual Impact Assessment

Sensitivity

The degree to which a particular landscape type can accommodate change arising from a development, without detrimental effects on its character. This includes factors such as:

- existing land use
- the pattern and scale of the landscape
- visual enclosure, openness of views and distribution of visual receptors
- the value placed on the landscape.

Magnitude

The magnitude of the effects of the development within the landscape. Consideration is given to existing built form in the landscape and how closely the development matches this in bulk, scale and form. Magnitude is a study of the scale or degree of change to the landscape resource, the nature of the effect and its duration including whether it is permanent or temporary.

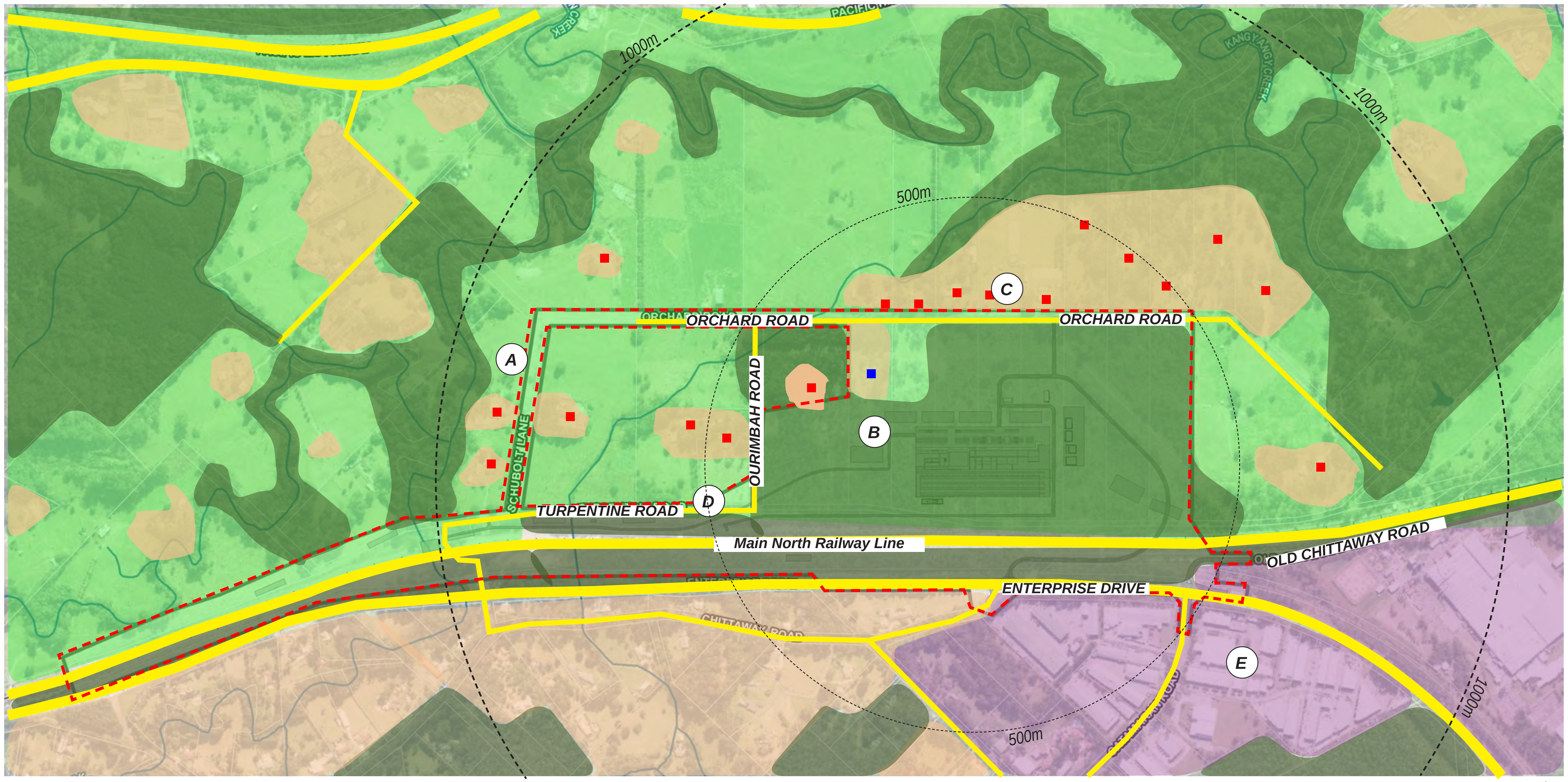
LANDSCAPE CHARACTER ZONE 1 - OPEN FARMLAND

LANDSCAPE CHARACTER ZONE 2 - WOODLAND

LANDSCAPE CHARACTER ZONE 3 - RURAL RESIDENTIAL

LANDSCAPE CHARACTER ZONE 4 - TRANSPORT CORRIDORS

LANDSCAPE CHARACTER ZONE 5 - INDUSTRIAL DEVELOPMENT



LEGEND

- zone 1 — Open Farmland
- zone 2 — Woodland
- zone 3 — Rural Residential
- zone 4 — Transport Corridors
- zone 5 — Industrial Development
- A — Landscape character photo location
- Watercourse
- Dwelling
- Dwelling (to be acquired)
- Project Boundary

Figure 03 - Landscape Character Zones - not to scale

CLOUSTON associates

LANDSCAPE ZONE 1 - OPEN FARMLAND

Photo A - Open field off Orchard Road

Element	Description
Topography	Mostly flat with some undulating topography
Hydrology	Rainfall drains to creeks and rural dams
Ecology/vegetation	Grasses and native stands of trees
Land use	Open fields/pasture/horse grazing
Built form	Rural residential dwellings and farm buildings
Spatial	Mostly open with far reaching views to surrounding hills

DESCRIPTION

This landscape character zone is of a large scale and mostly open with a gently rolling landform. The overall landscape pattern is created by a patchwork of fields with grazed grass pasture that is smooth, regular and uniform. Trees are present in groups or as isolated individuals. Denser tree plantings surround the majority of rural dwellings and can be found along driveways and riparian corridors.

ASSESSMENT

Sensitivity
There is a general absence of development throughout this landscape zone. Extensive views to ridgelines and hills are available from open areas. The structure of the landform is simple, containing few distinct features. Any new infrastructure development has the potential to be discernible within the landscape. The Project, however, is not located within this zone and within this context is rated as having a **low** sensitivity to change.

Magnitude
The main part of the Project site is not located within this character zone and will have a **low** magnitude of change.

Summary
Whilst potentially visible from this zone, the Project will have a **low** impact on the character of open farmland within the study area.

Sensitivity	LOW
Magnitude	LOW
Overall Landscape Character Impact Rating	LOW

From Table 01, using a combination of sensitivity and magnitude ratings.

CLOUSTON associates

Photo B - Swamp Sclerophyll Forest within the Project site

Element	Description
Topography	Varied topography
Hydrology	Rainfall drains to creeks and rural dams
Ecology/vegetation	The vegetation is dense consisting of a large variety of chiefly native trees, shrubs and grasses
Land use	Private Property/Easements/State land
Built form	Limited to residential dwellings and farm buildings
Spatial	Mostly enclosed with views blocked by dense vegetation

DESCRIPTION

This landscape character zone occurs in across the study area including the immediate Project site. Vegetation is predominately native and occurs in dense stands with little understory. This zone lines some road verges and riparian corridors, blocking wider views. The darker coloured foliage of wooded areas contrast against the surrounding backdrop of lighter toned pasture and cultivated areas.

ASSESSMENT

Sensitivity

A preliminary ecological assessment of the site by EMM in 2015 indicated the presence of two endangered ecological communities (EECs) listed under the NSW Threatened Species Conservation Act 1995 (TSC Act)

- Lowland Rainforest
- Swamp Sclerophyll Forest

This vegetation is rare and removal will alter its character. This zone therefor has a **high** sensitivity to change.

Magnitude

The Swamp Sclerophyll Forest EEC occurs across much of the Project site, covering approximately 30 ha. A section of moderate to good condition vegetation would be cleared within the main portion of the site, however a buffer of vegetation will be retained along Orchard and Ourimbah Road.

There is currently no development within the site and the Project will constitute an increase in the scale and bulk of built form. The magnitude of change is therefore rated as **moderate** within this character zone.

Summary

Overall, a **moderate/high** impact rating has been recorded on this character zone. The Project will require the clearance of a large area of vegetation, fragmenting the vegetation and leading to impacts on the character of this zone.

Sensitivity	HIGH
Magnitude	MODERATE
Overall Landscape Character Impact Rating	MODERATE/HIGH

From Table 01, using a combination of sensitivity and magnitude ratings.

LANDSCAPE ZONE 3 - RURAL RESIDENTIAL

Photo C - Typical rural residential housing character along Ourimbah Road

Element	Description
Topography	Flat to undulating
Hydrology	Rainfall drains to creeks and rural dams
Ecology/vegetation	Native and exotic planting within property boundaries, often planted as tall windbreaks
Land use	Residential and farm development
Built form	Houses and farm buildings
Spatial	Varies between enclosed and open depending on topography and vegetation

DESCRIPTION

This character zone is dispersed across the study area, consisting of low density residential dwellings and farm buildings. Properties are generally one or two storey and located on large blocks of land. Many properties are set back from the road and surrounded by dense vegetation, often planted as windbreaks or visual screens. Within the study area, residential development is concentrated along Orchard, Turpentine and Ourimbah Roads.

ASSESSMENT

Sensitivity
Rural residential development is widely dispersed and mostly of a low density. The isolation, large plot sizes and lack of surrounding development are important features of this character zone. Many residents value this rural character which is often an important factor in their decision to reside at this location. Any proposed large infrastructure development may alter the character of the area. The zone is described as having a **moderate** sensitivity to change.

Magnitude
The Project is of an increased scale and bulk compared to existing development within the area. Several properties in close proximity to the facility are likely to experience a **moderate** magnitude of change, especially where filtered views are available. Vegetation will block many views of the Project from more distant properties.

Summary
Overall, a **moderate** impact rating has been recorded on this character zone. Whilst the Project may not be directly visible from the majority of properties within the study area, the large nature of the facility, associated vegetation removal and lack of existing development will contribute to a **moderate** change in character to the immediate area surrounding the Project.

Sensitivity	**MODERATE**
Magnitude	**MODERATE**
Overall Landscape Character Impact Rating	**MODERATE**

From Table 01, using a combination of sensitivity and magnitude ratings.

LANDSCAPE ZONE 4 - TRANSPORT CORRIDOR

Photo D - Turpentine Road

Element	Description
Topography	The road carriageway traverses through a landscape of undulating landform
Hydrology	Rainfall drainage varies, however in most situations drains from a central pitch in the road toward the road edge
Ecology/vegetation	Undisturbed native bushland is evident throughout the study area along the perimeter of the road corridor as well as swathes of native grasses and modified pasture land
Land use	Transport Corridor
Built form	Rural road infrastructure
Spatial	Varies between linear and enclosed with some views blocked by dense roadside vegetation. Other areas are open with extensive views either side of the road corridor

DESCRIPTION

A network of lightly trafficked rural roads spread through the study area, linking rural properties to the wider road network. The quality of the road surfacing varies but is mostly sealed and lined with no permanent kerb, gutter or footpath. The roads traverse areas of open farmland as well as areas enclosed by trees and shrubs. Where the roadside is clear of trees, far reaching views are available across the surrounding landscape.

The Sydney to Newcastle Main North Rail Line also passes through the study area with similar rural views from the train where not restricted by vegetation and embankments.

ASSESSMENT

Sensitivity
The roads are lightly trafficked and mainly used by local residents to access properties. Although highly scenic (with views over the surrounding rural landscape) the roads predominately serve the local community and are not used as scenic drives. Receptors move through this zone relatively quickly, with rail passengers only viewing the Project site in a transient manner. The sensitivity of this landscape zone to change is rated as **low**.

Magnitude
The Project is in close proximity to the Orchard, Ourimbah and Turpentine Road corridors, however the main change will be the construction of a new access road from Enterprise Drive. This is to reduce the impact of increased vehicles on the existing local roads as well as providing flood free access. Alterations to the road layout are likely to have a **moderate** impact on this character zone.

Summary
Overall, a **moderate/low** impact rating has been recorded on this landscape zone. Alterations to the road layout, views of ancillary Project elements and increases in traffic/vehicle size will lead to a **moderate/low** impact to the character of this zone.

Sensitivity	LOW
Magnitude	MODERATE
Overall Landscape Character Impact Rating	MODERATE/LOW

From Table 01, using a combination of sensitivity and magnitude ratings.

LANDSCAPE ZONE 5 - INDUSTRIAL DEVELOPMENT

Photo E - Warehousing off Enterprise Drive

Element	Description
Topography	Mostly flat landform
Hydrology	Rainfall drainage falls to an urban drainage system
Ecology/vegetation	Fragmented native and exotic vegetation
Land use	Commercial and light industrial
Built form	Low rise warehousing
Spatial	Linear pattern formed by streetscape. Varies between enclosed and open depending on vegetation and built form

DESCRIPTION

Light industrial and commercial development is found to the south of the Project site, concentrated along Enterprise Drive. Development consists primarily of larger buildings including warehouses and storage facilities up to 12m in height. Sparse and fragmented vegetation is scattered through this character zone.

ASSESSMENT

Sensitivity

This landscape zone constitutes a medium density of urban development with associated infrastructure and large commercial and industrial buildings. This landscape character has few sensitive receptors and a high ability to absorb change, leading to a **low** sensitivity rating.

Magnitude

The Project is of a similar scale and bulk to this industrial development and will not adversely impact the character of the zone. A vegetation buffer also exists between the two areas leading to a **low** magnitude of change.

Summary

Overall, a **low** impact rating has been recorded on this landscape zone. Although parts of the Project, including the elevated access road may be visible, the low sensitivity of this zone to change ensures there will be very limited impacts.

Sensitivity	LOW
Magnitude	LOW
Overall Landscape Character Impact Rating	LOW

From Table 01, using a combination of sensitivity and magnitude ratings.

2.5 LANDSCAPE CHARACTER SUMMARY

The landscape character surrounding the Project is typical of this region of the Central Coast with large swathes of pasture, pockets of native vegetation and transport corridors. The low density of development, patchwork of fields and stands of remnant vegetation contribute strongly to the spatial quality of the area and its scenic nature.

The overall impact of the Project on landscape character is rated as (refer Table 02)

- low across two character zones - Industrial Development and Open Farmland
- moderate/low across one character zone - Transport Corridors
- moderate across one character zone - Rural Residential
- moderate/high across one character zone - Woodland

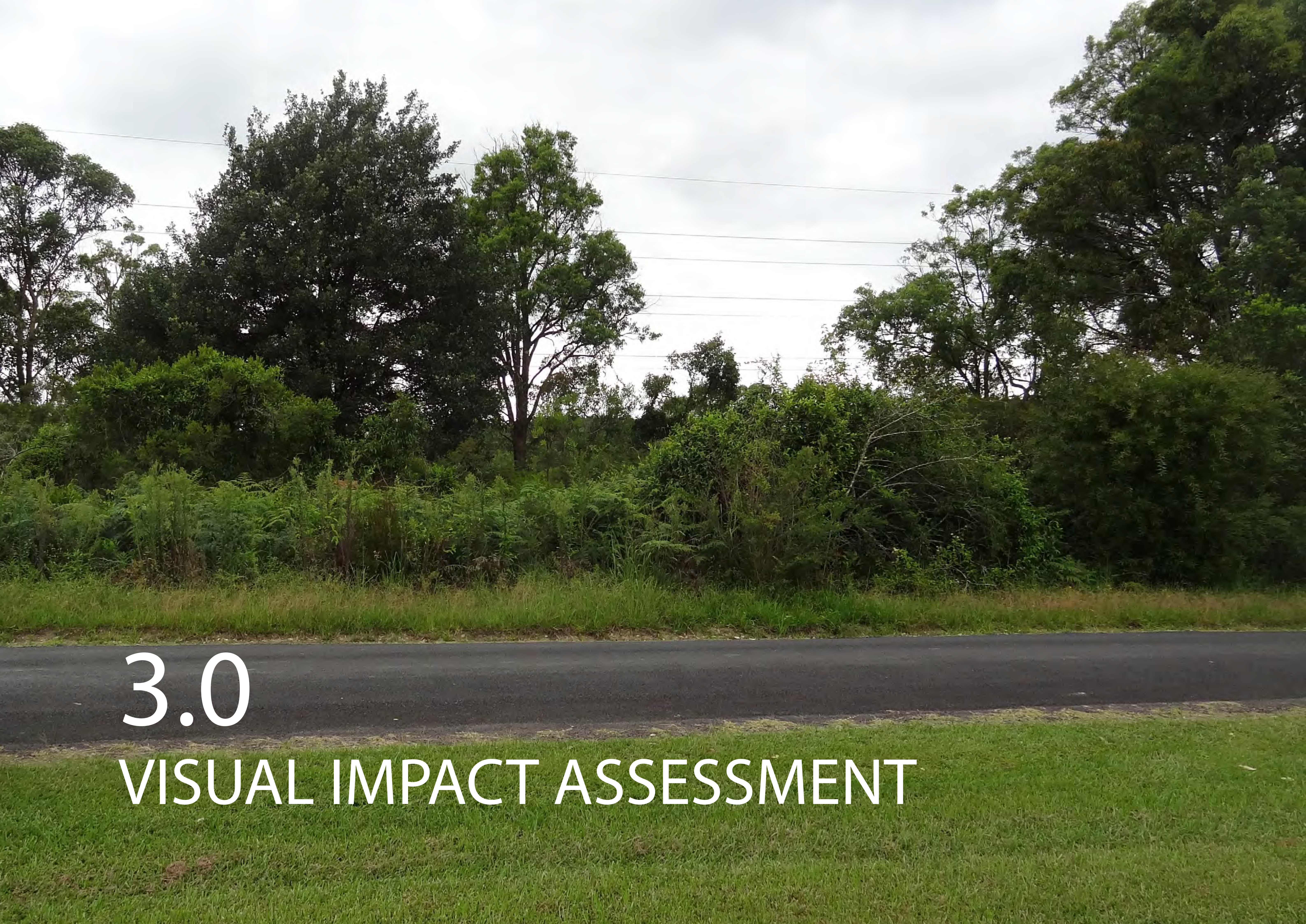
The Project will have the highest impact on the endangered woodland found within the immediate vicinity of the Project site. Removal of this vegetation will reduce the quality of the woodland and fragment habitat.

Offsetting this removed vegetation with planting from the same ecological community will assist with reducing the visual and landscape character impacts recorded on this zone. Landscape strategies are further discussed within the Mitigation section of this report and should be incorporated into the concept design.

SUMMARY OF LANDSCAPE CHARACTER IMPACTS

	OPEN FARMLAND	WOODLAND	RURAL RESIDENTIAL	TRANSPORT CORRIDOR	INDUSTRIAL DEVELOPMENT
Sensitivity	LOW	HIGH	MODERATE	LOW	LOW
Magnitude	LOW	MODERATE	MODERATE	MODERATE	LOW
Overall Rating	LOW	MODERATE/HIGH	MODERATE	MODERATE/LOW	LOW

Table 02 - Summary of Landscape Character Impacts



3.0

VISUAL IMPACT ASSESSMENT

3.0 VISUAL IMPACT ASSESSMENT

3.1 CHAPTER OVERVIEW

This section of the report provides an overview of the existing visual environment of the study area and the subsequent expected visual impacts of the Project.

3.2 VISUAL ENVIRONMENT

3.2.1 Study Area

The study area specific to the visual impact assessment comprises the area of land within and beyond the Project site that could be potentially visually affected by the Project and its ancillary facilities. Through a desktop analysis and rigorous site visit, a study area of approximately 1.5km offset from the Project site was identified based on topography, vegetation, receptor location and viewing distance.

It is important to note that some elements of the Project may be visible from areas of the landscape beyond the nominated study area such as elevated ground to the north (Mount Tangy Dangy) and west. These areas, however, are not generally publicly accessible and contain no residential receptors. They have therefor been excluded from the study.

3.2.2 Private Domain

A low density of residential receptors is spread throughout the study area. Vegetation obscures many longer distance views although where open in nature, expansive views are available over the surrounding landscape.

The majority of sensitive receptors are located to the northern side of the rail line along Orchard, Ourimbah and Turpentine Roads. Dense vegetation screens views towards the Project site from south of the rail line.

A large industrial park is located along Enterprise Drive with very limited views towards the Project site.

3.2.3 Public Domain

There is no publicly accessible land or open space within the study area apart from the local road network. This passes close to the Project site and would require modifications to ensure access to the facility.

3.3 REPRESENTATIVE VIEWPOINTS

The following representative viewpoints have been chosen for further analysis - refer Figure 04. The visual receptors encompassed by these viewpoints all have the potential to be visually impacted by some element of the Project.

53 Orchard Road is proposed to be acquired for the Project and has been excluded from the VIA as it will no longer be a residential property.

The locations identified are:

Public Viewpoints

- PU1 - Enterprise Drive
- PU2 - Turpentine Road
- PU3 - Turpentine Road

Private Viewpoints

- PR1 - 15 and 16 Schubolt Lane
- PR2 - 50, 54 and Lot 20 Orchard Road
- PR3 - 72 and 80 Orchard Road
- PR4 - Lot 8660 and Lot 24 Orchard Road
- PR5 - 139 Orchard Road
- PR6 - Lot 31 Orchard Road
- PR7 - Lot 121 Ourimbah Road

3.4 METHODOLOGY

This report has adopted the Guidelines for Landscape Character and Visual Impact Assessment as published by the Roads and Maritime Service, RMS. The overall impact rating of the Project on any given receptor is based on factors of magnitude and sensitivity.

Sensitivity

Each visual receptor type has an inherent and varied sensitivity to change in the visual scene based on their personal context in which the view is being experienced. This would have a direct bearing on the perception of visual impact experienced by the receptor and qualifies the quantitative impacts. Appendix A describes the levels of sensitivity for each receptor type.

Magnitude

The magnitude of the visual effects of the development within the landscape. A series of quantitative assessments are studied, including distance from development, quantum of view, duration of view and scale of change. Appendix A describes the ratings assigned to these quantitative assessments.

Overall impact rating

The severity of these impacts is calculated using matrix Table 03 - based on a combination of magnitude and sensitivity.

SENSITIVITY \ MAGNITUDE	HIGH	MODERATE	LOW	NEGLIGIBLE
HIGH	HIGH	HIGH - MODERATE	MODERATE	NEGLIGIBLE
MODERATE	HIGH - MODERATE	MODERATE	MODERATE/LOW	NEGLIGIBLE
LOW	MODERATE	MODERATE/LOW	LOW	NEGLIGIBLE
NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Table 03: Visual Impact Rating as a combination of Sensitivity and Magnitude. Source: RMS Guidelines for Landscape Character and Visual Impact Assessment

CLOUSTON associates

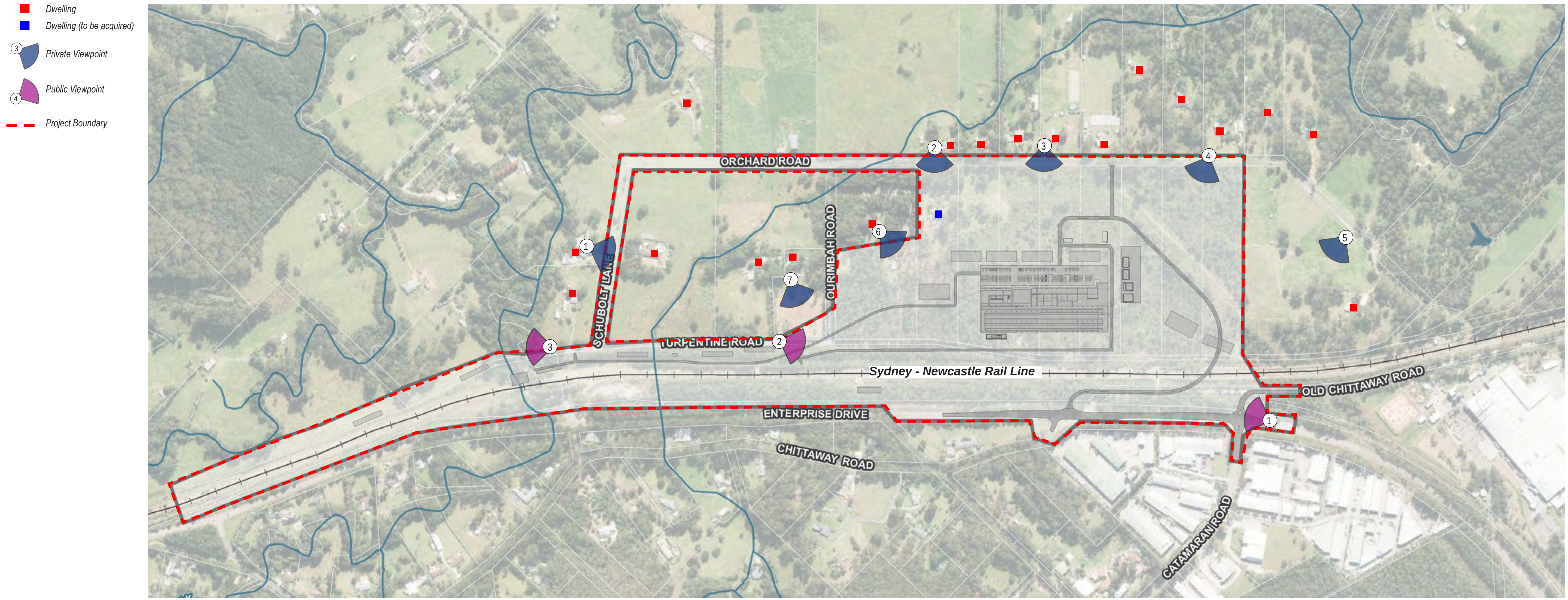


Figure 04 - Viewpoint location map - not to scale

3.5 VISUAL ANALYSIS

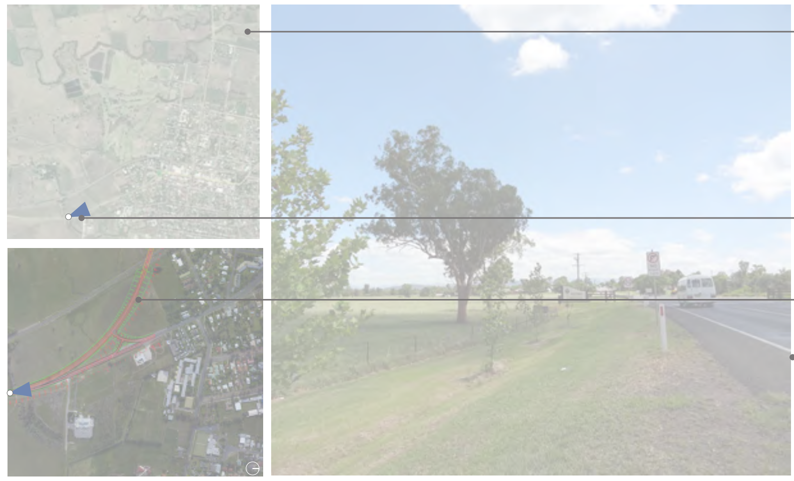
The following section assesses the visual impact of the Project on each of the selected viewpoints. This includes a description of the current view from each viewpoint followed by a discussion of the potential visual impacts of the Project on that view. Each viewpoint is accompanied by a location map and photograph of the current view.

For residential receptors, access was not always possible to the property itself and so a photograph was taken at the closest publicly accessible point. The description of visual impact is estimated from the property's main dwelling area.

For a detailed description of the assessment factors and impact ratings used see Appendix A.

EXAMPLE

VIEWPOINT X — Viewpoint number



Location map

Photo location and direction marker

Proposed works

View photo

VISUAL IMPACT — Description of expected visual impact

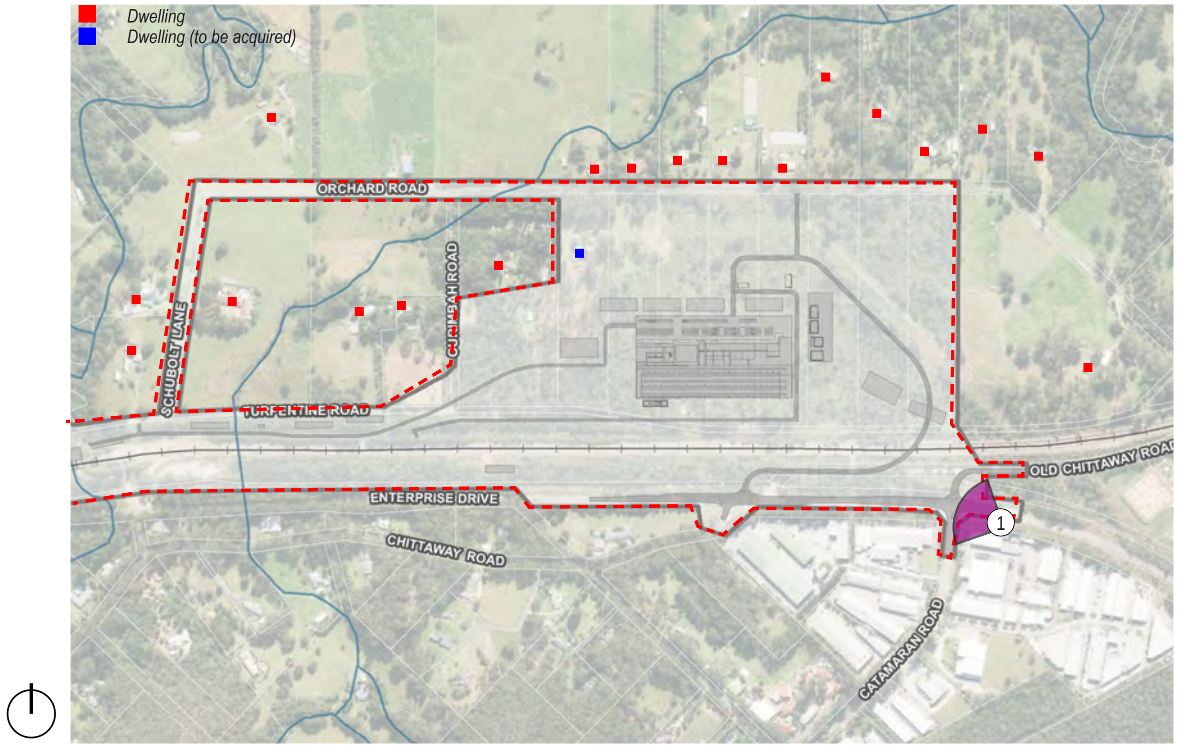
XXXX

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Public	X	L	H	M	L	L	M
Visual Impact Rating		MODERATE/LOW					

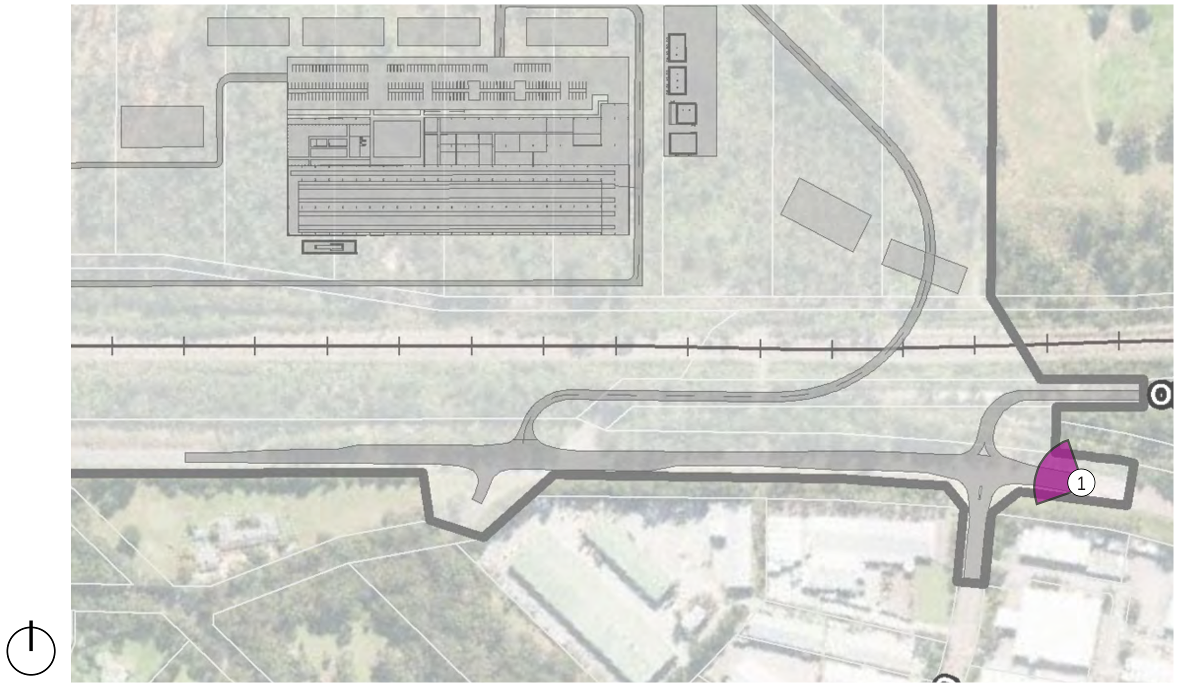
Assessment matrix table

Overall visual impact rating

PUBLIC VIEWPOINT 1 (PU1)



Viewpoint location



Proposed works

Public Viewpoint 1 - Photo A (source: google earth)

CLOUSTON associates

LOCATION
Enterprise Drive, looking north.

Distance to nearest Project element
70 metres

Receptors
Users of Enterprise Drive, travelling in both directions.

Current View
As shown in viewpoint photo A, the road has a densely vegetated northern verge that screens the majority of views to the north. An industrial park is located to the south of the road, consisting of large warehouse units and a planted streetscape.

VISUAL IMPACT

The elevated access road connecting the Project site to Enterprise Drive will be visible from this location, partially screened by foreground vegetation. The presence of existing transport infrastructure, low sensitivity of receptors and short duration of view have lead to an overall visual impact rating of low.

			MAGNITUDE				
RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Public	PU1	L	H	M	L	L	L
Visual Impact Rating		LOW					

From Table 03, using a combination of sensitivity and magnitude ratings.

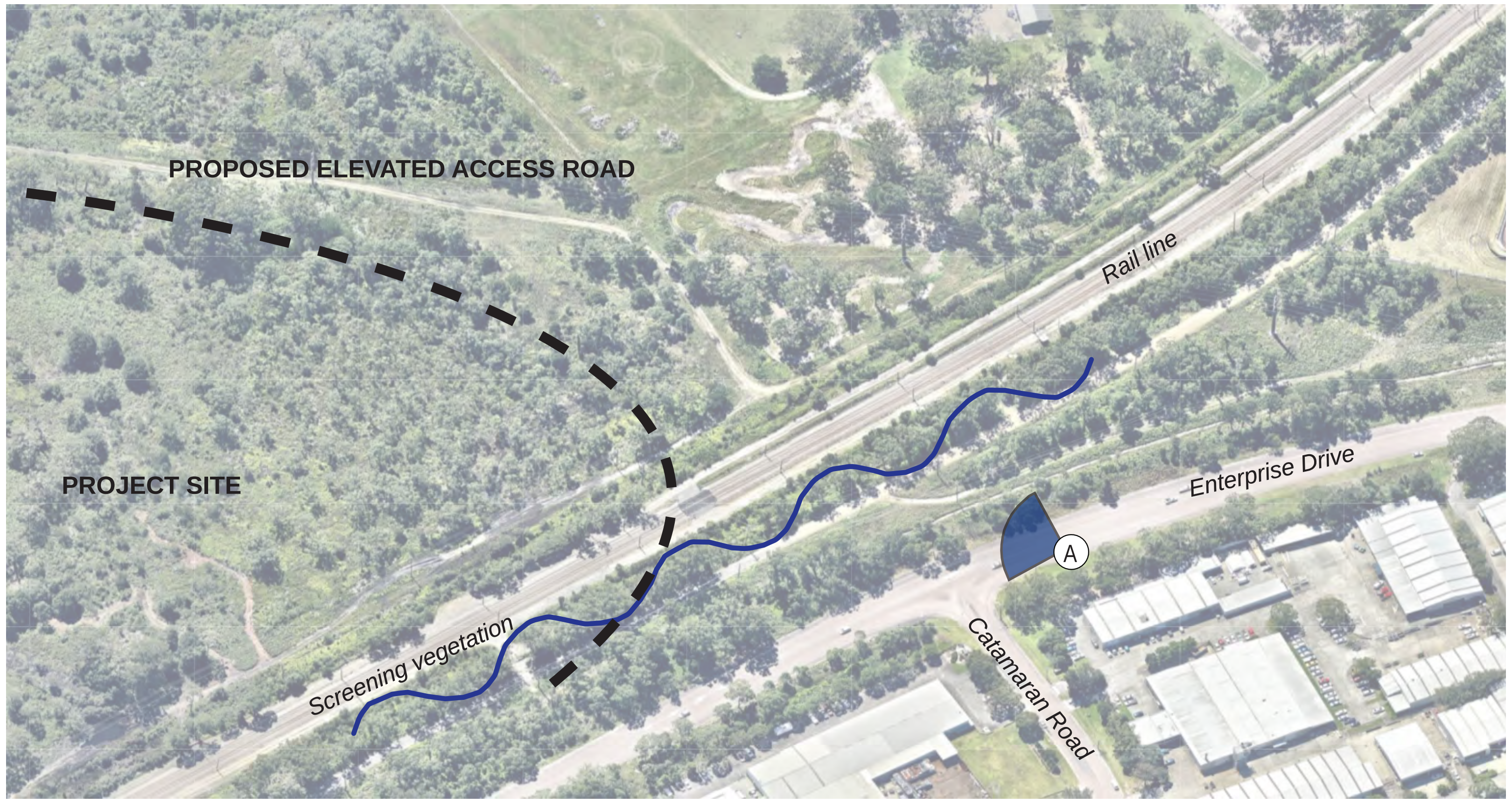
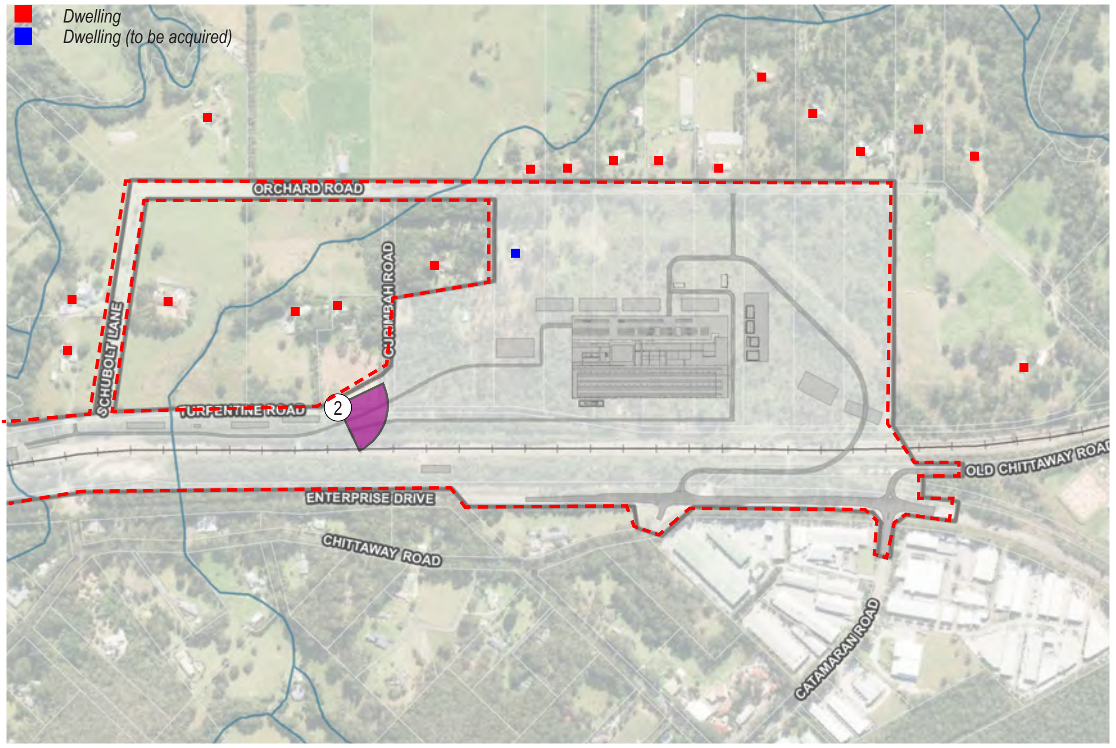


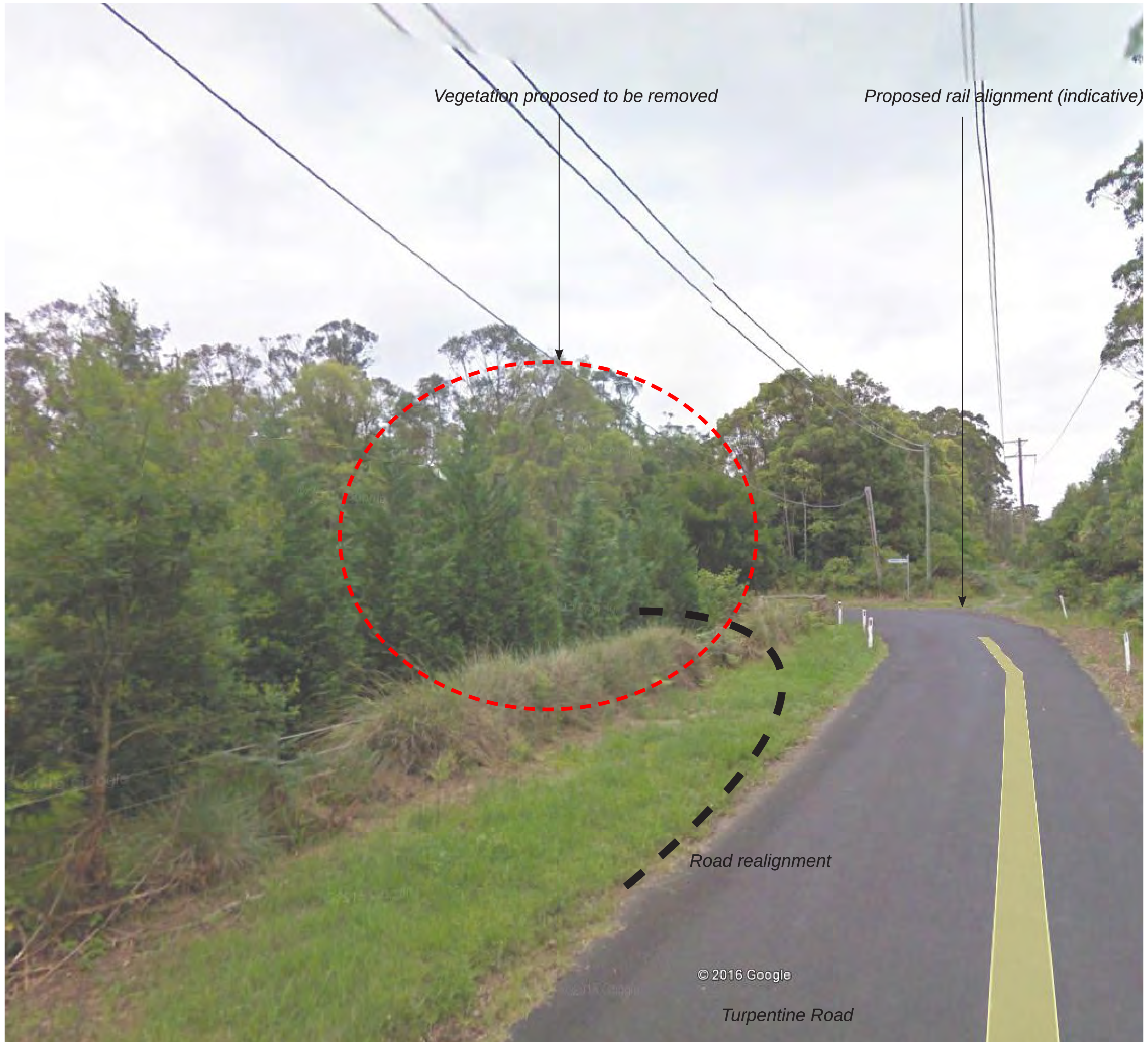
Figure 5A - Viewpoint context

PUBLIC VIEWPOINT 2 (PU2)



Viewpoint location

Proposed works



Public Viewpoint 2 - Photo A (source: google earth)

CLOUSTON associates

LOCATION
Turpentine Road, looking east.

Distance to nearest Project element
10 metres

Receptors
Users of Turpentine Road, travelling in both directions.

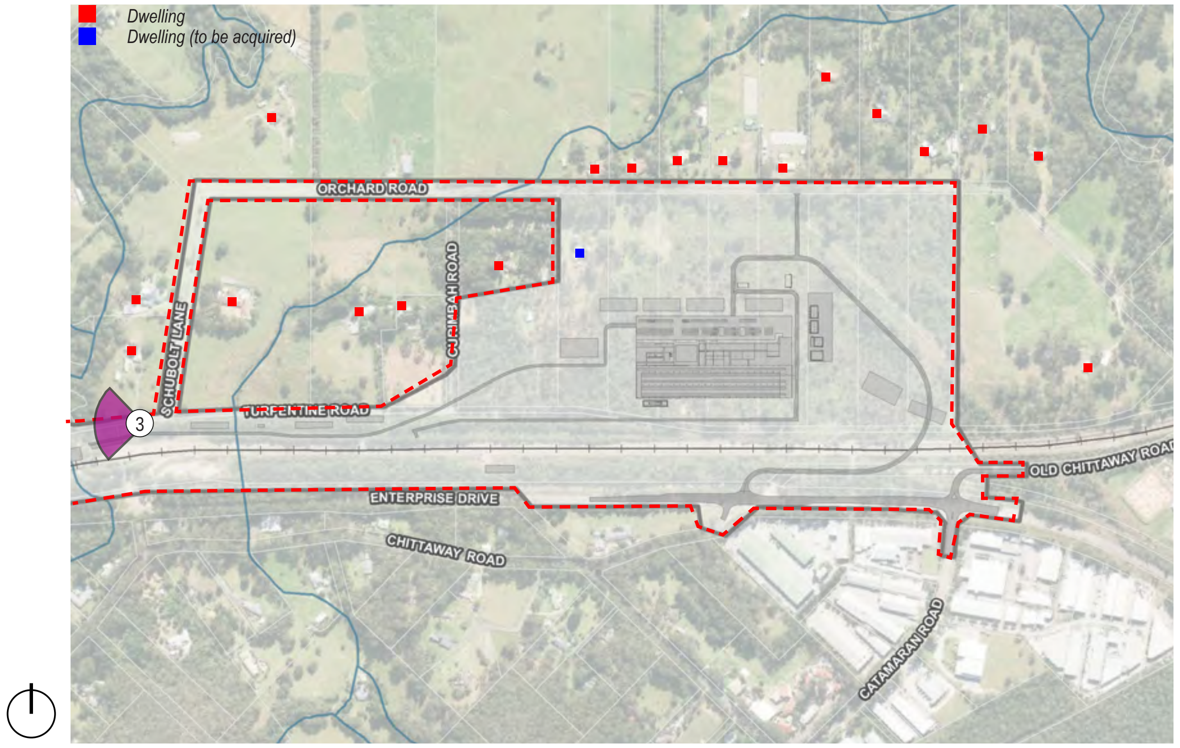
Current View
As shown in viewpoint photo A, the existing view from the narrow road is dominated by dense vegetation on either side of the road corridor.

VISUAL IMPACT
Vegetation removal will be required in this location, associated with the realignment of Turpentine Road further north. The proposed rail alignment, moving trains and security fence will be visible to the southern side of the road leading to a moderate/low visual impact on road users.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Public	PU2	L	H	M	L	M	M
Visual Impact Rating		MODERATE/LOW					

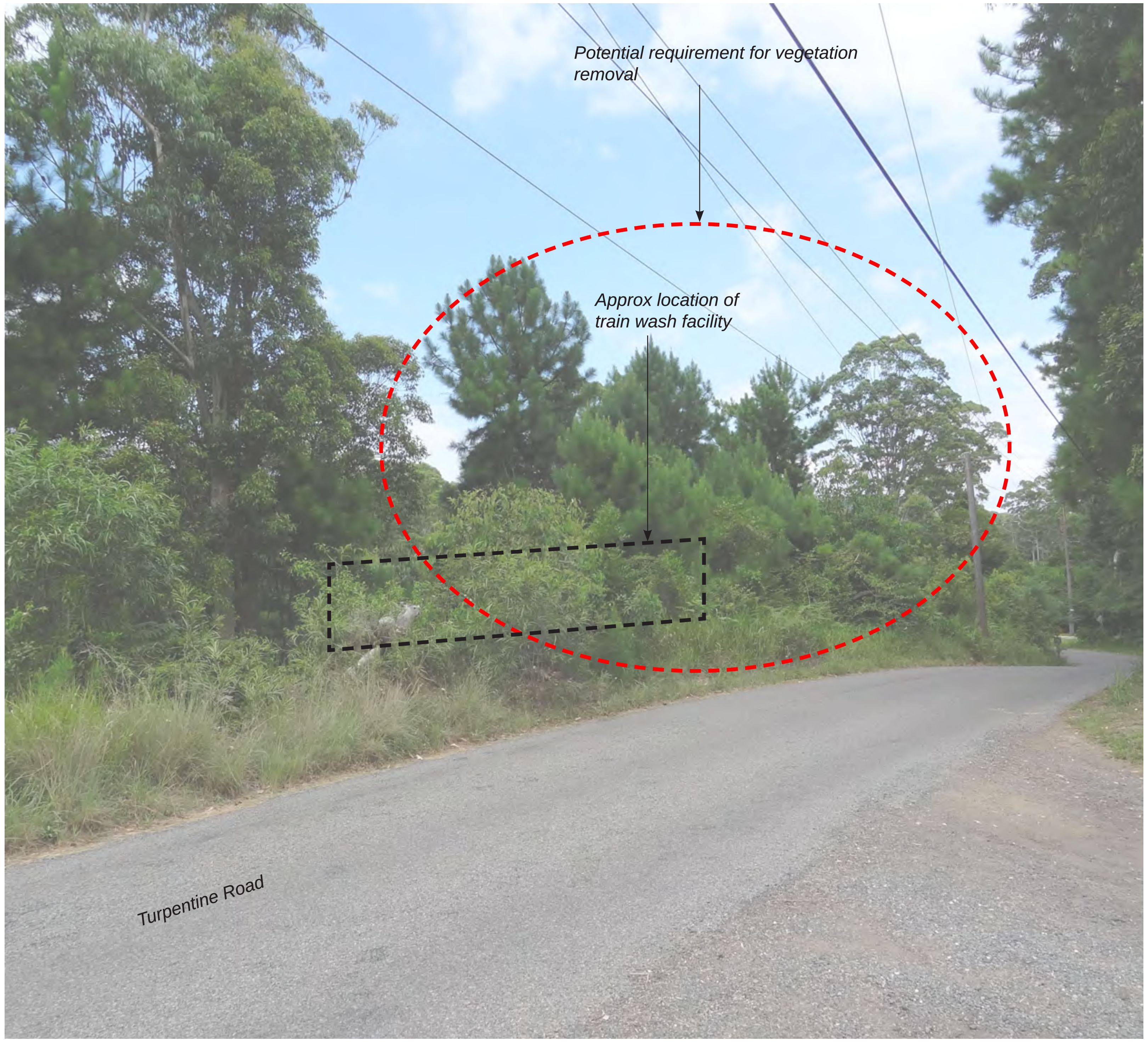
From Table 03, using a combination of sensitivity and magnitude ratings.

PUBLIC VIEWPOINT 3 (PU3)



Viewpoint location

Proposed works



Public Viewpoint 3 - Photo A

CLOUSTON associates

LOCATION
Turpentine Road, looking west.

Distance to nearest Project element
10 metres

Receptors
Users of Turpentine Road, travelling in both directions.

Current View
As shown in viewpoint photo A, the existing view from the narrow road is dominated by dense vegetation on either side of the road corridor.

VISUAL IMPACT

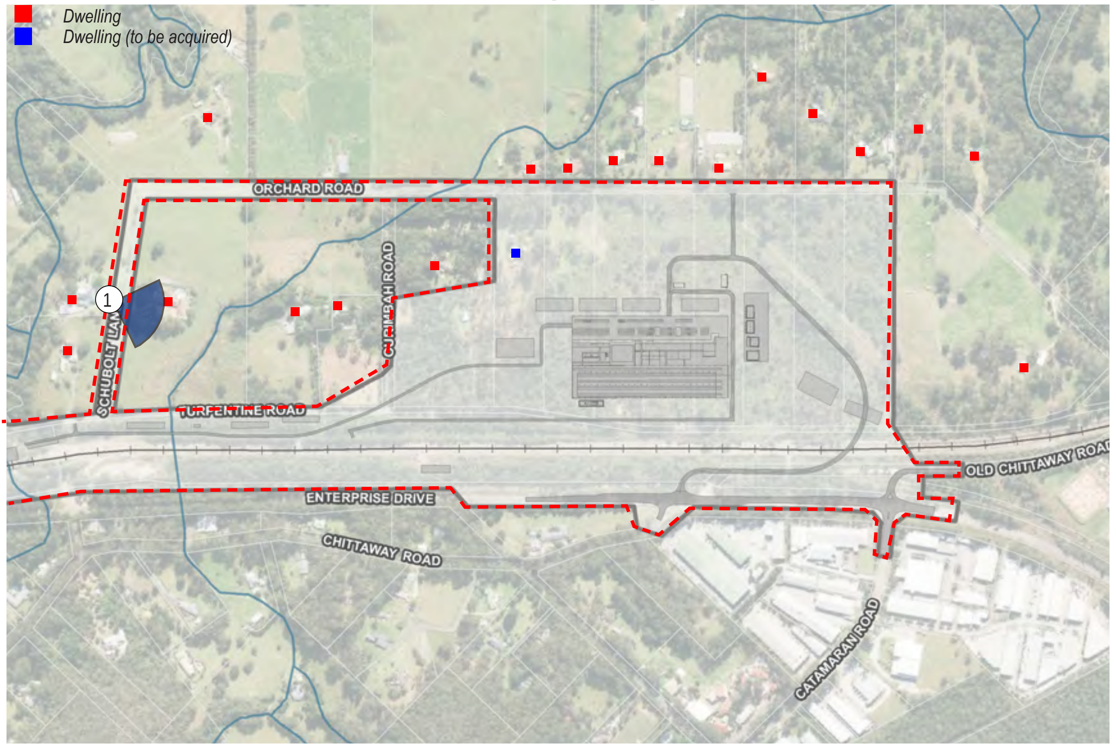
Vegetation removal will be required in this location, associated with the construction of the new track alignment, train wash facility and security fence.

These elements may be visible from the road corridor leading to a moderate/low visual impact on road users.

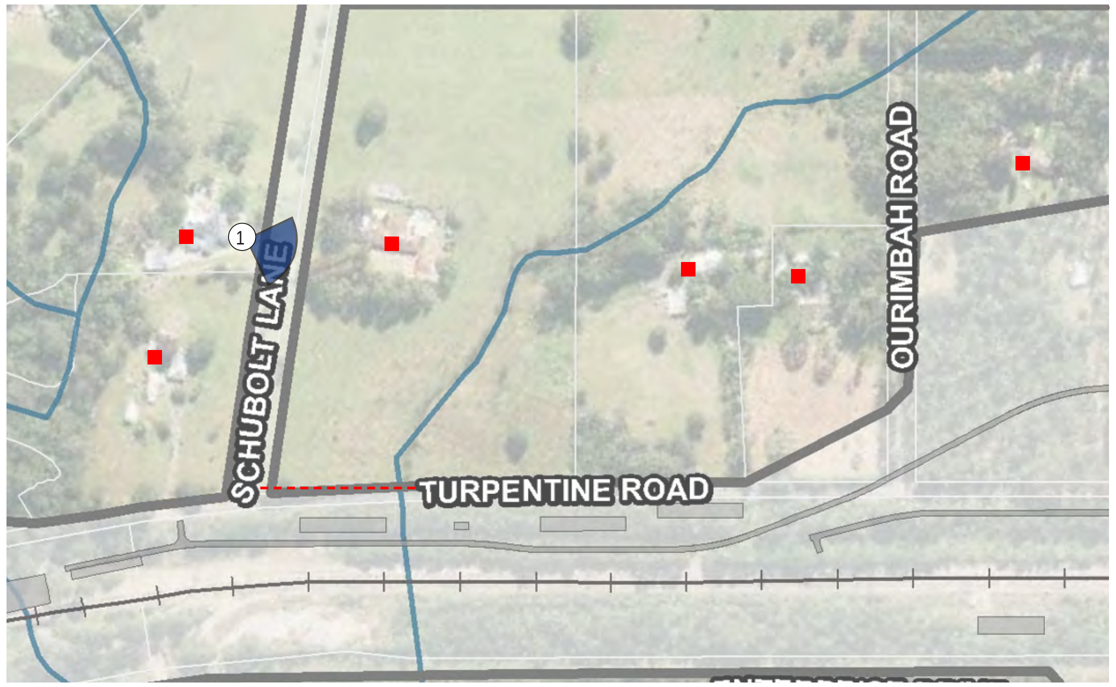
RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Public	PU3	L	H	M	L	M	M
Visual Impact Rating		MODERATE/LOW					

From Table 03, using a combination of sensitivity and magnitude ratings.

PRIVATE VIEWPOINT 1 (PR1)



Viewpoint location



Proposed works

Private Viewpoint 1 - Photo A

Private Viewpoint 1 - Photo B

CLOUSTON associates

LOCATION
16 Schubolt Lane, looking east.

Distance to nearest Project element
400 metres

Receptors
Residents of 15 and 16 Schubolt Lane.

Current View
These two properties are located on slightly elevated land above the floodplain to the west of the Project site. The main parts of the dwellings have extensive views over open farmland to the north, although as shown in the viewpoint photo A, screening vegetation filters views west towards the Project site. The foreground is currently dominated by tree and shrub planting with views available through gaps to vegetated hill sides in the middle distance. Clear views towards the 132kV stanchions and wires are available parts of the dwellings and wider property.

VISUAL IMPACT

Despite the relatively close proximity to the Project site, it is highly unlikely that the main portion of the maintenance facility will be visible from these dwellings.

From the field to the north of 16 Schubolt Lane there are clear views east to a row of trees, along Ourimbah Road (viewpoint photo B). These trees are taller than 15m and should screen the Project site.

A small quantum of vegetation removal may be noticeable from the land to the north of these properties although overall, a high impact on visual amenity is not expected.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE: DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR1	H	L	L	L	L	L
Visual Impact Rating		MODERATE					

From Table 03, using a combination of sensitivity and magnitude ratings.

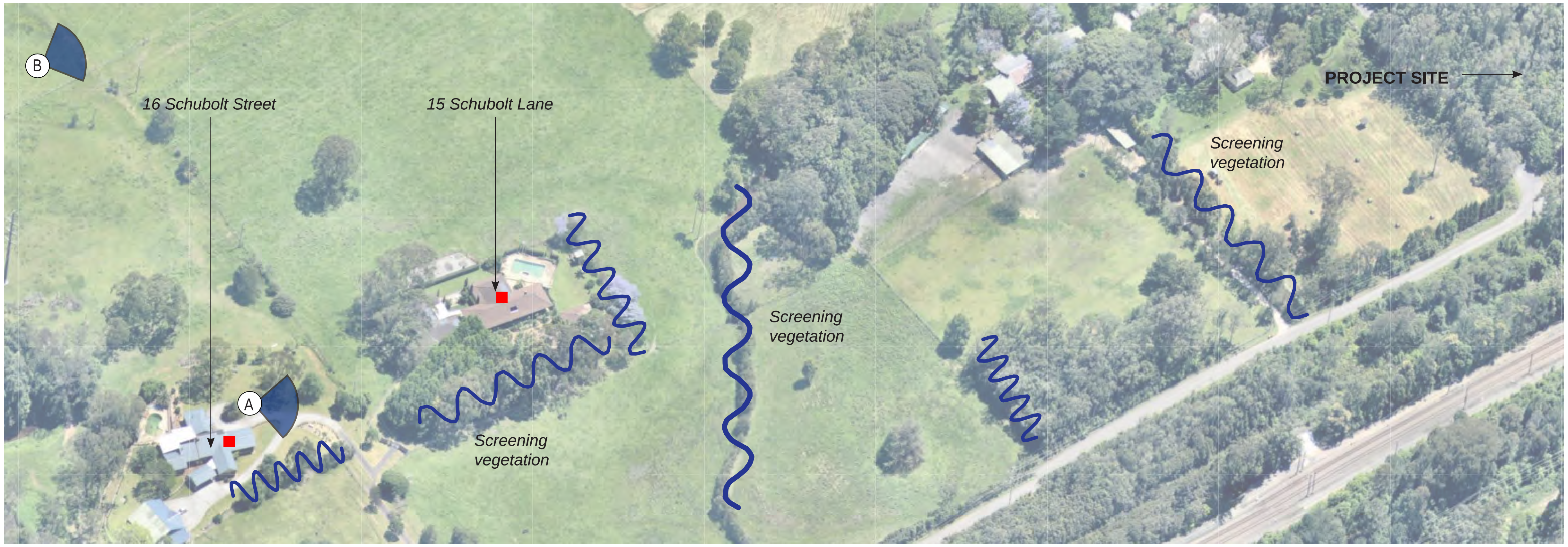
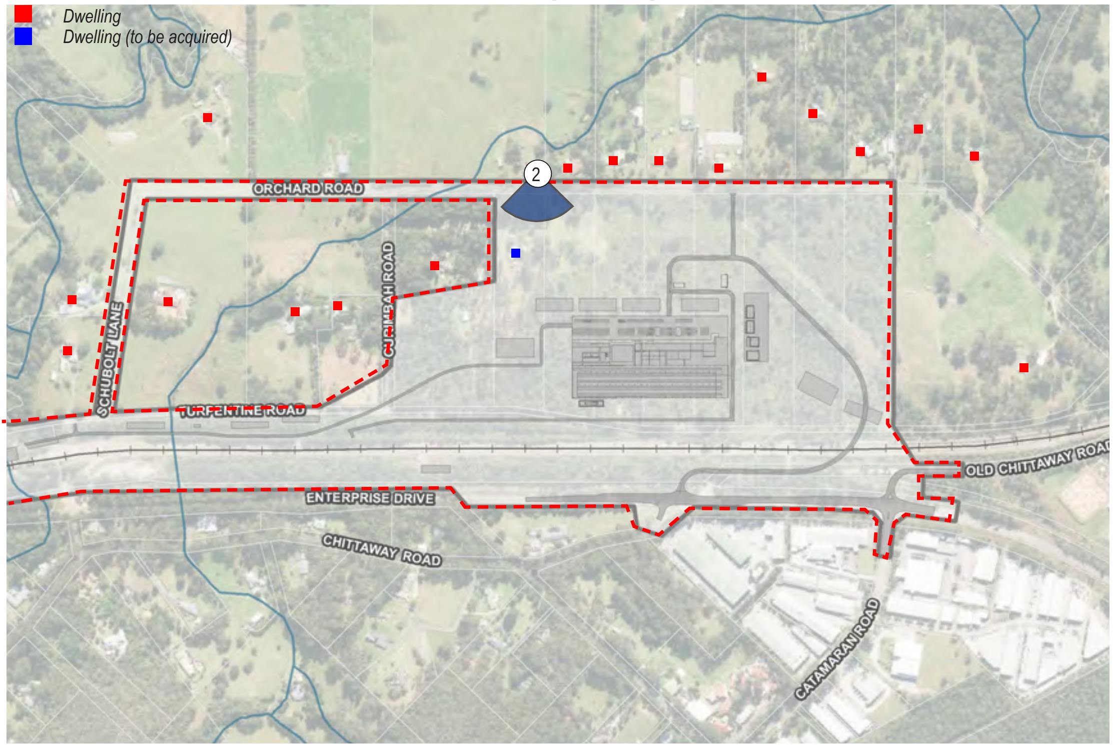


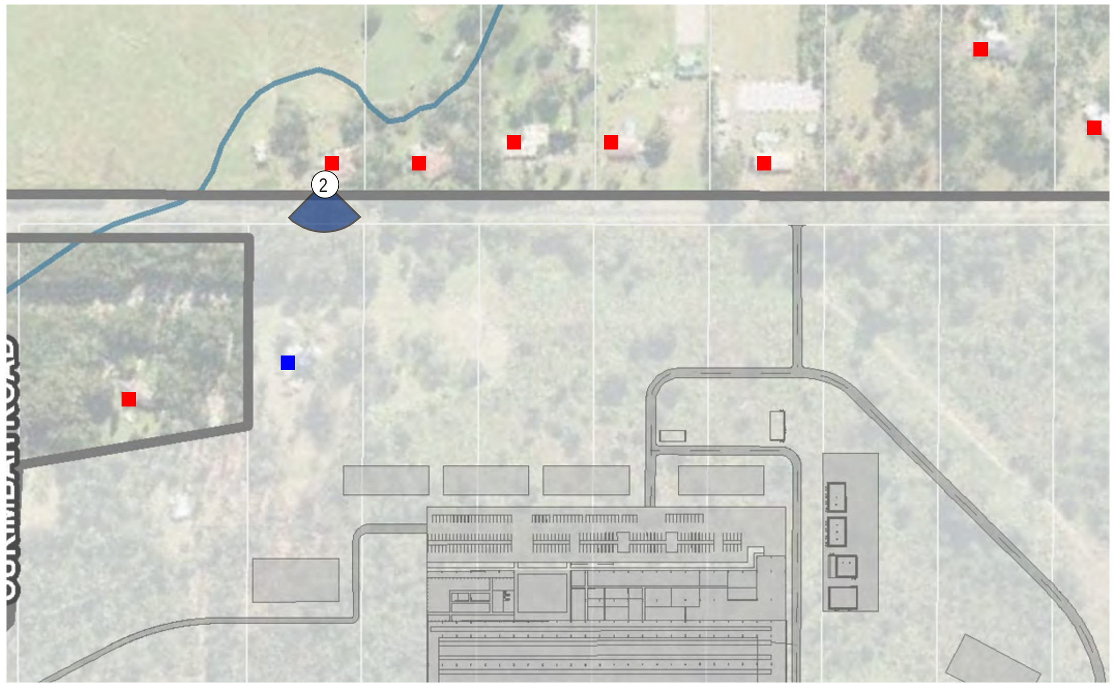
Figure 5B - Viewpoint context

PRIVATE VIEWPOINT 2 (PR2)



Viewpoint location

Private Viewpoint 2 - Photo A



Proposed works

50 Orchard Road

Private Viewpoint 2 - Photo B

CLOUSTON associates

LOCATION
Orchard Road, looking south.

Distance to nearest Project element
200 metres

Receptors
Residents of 50, 54 and Lot 20 Orchard Road.

Current View
These three properties are located along Orchard Road. The dwellings are set back from the road and the foreground is dominated by vegetation planted within the property boundary and alongside the road verge - refer viewpoint photo A. Some filtered views through gaps in the vegetation are available to the south

54 Orchard Road has a very tall hedge along the property boundary which blocks all views in a southerly direction - refer viewpoint photo B.

VISUAL IMPACT

Although screening vegetation will block the majority of views towards the Project site, glimpses of some elements of the Project will be available through gaps in the vegetation. These might include the tops of the warehouse buildings, light poles and the security fence. There may also be the noticeable increase in traffic volumes associated with workers accessing the site.

A moderate impact on visual amenity is expected from these properties.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR2	H	M	L	M	L	L
Visual Impact Rating		MODERATE*					

From Table 03, using a combination of sensitivity and magnitude ratings.

*Individual access to properties was not possible so a general impact rating has been given for these dwellings. Some properties may have a lower visual impact rating where local vegetation blocks views of the Project.

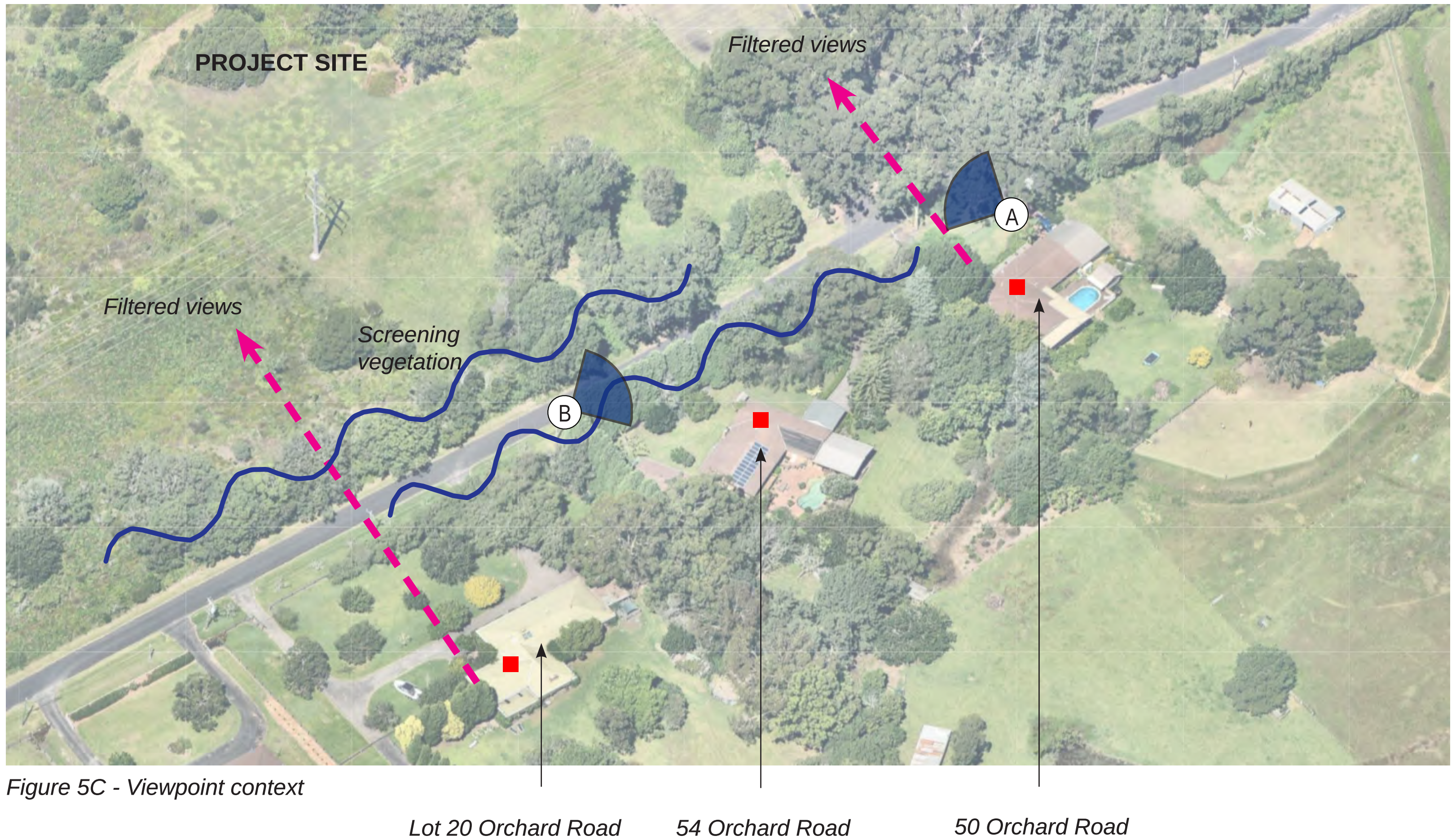
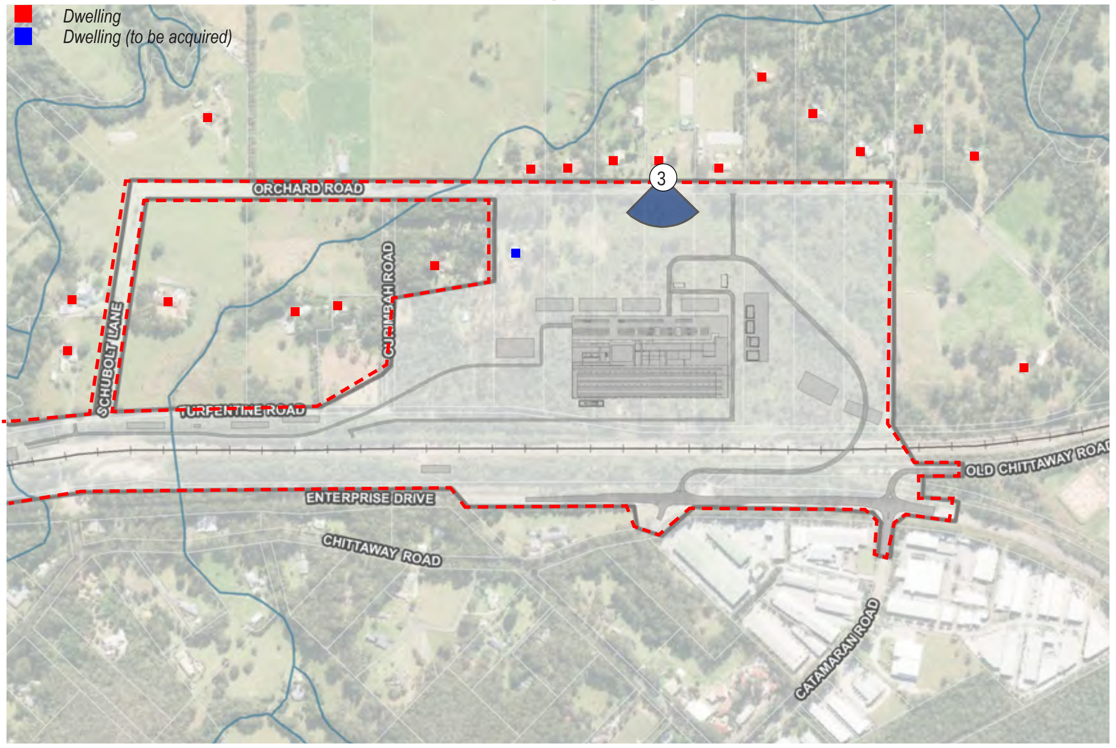
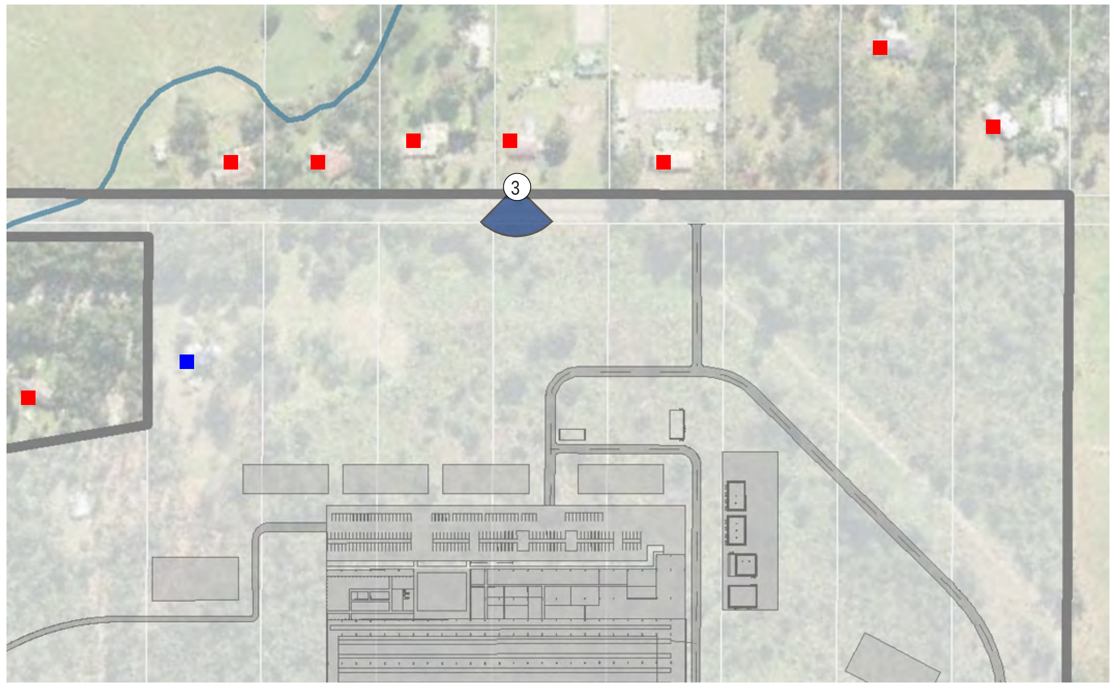


Figure 5C - Viewpoint context

PRIVATE VIEWPOINT 3 (PR3)



Viewpoint location



Proposed works

Private Viewpoint 3 - Photo A


Private Viewpoint 3 - Photo B

Filtered views towards Project site between gaps in vegetation

CLOUSTON associates

LOCATION
Orchard Road, looking south.

Distance to nearest Project element
200 metres

Receptors
Residents of 72 and 80 Orchard Road.

Current View
These properties are located along Orchard Road, set back slightly from the road corridor. The foreground is dominated by stands of native vegetation with filtered views through gaps to the Project site beyond - refer viewpoint photo A and B. Views towards the Ausgrid 132kV stanchions and wires are available behind the vegetation.

VISUAL IMPACT

Screening vegetation will block some Project elements although filtered views of the warehouse buildings, light poles and the security fence are likely through gaps in the trees. There may also be the noticeable increase in traffic volumes associated with workers accessing the site. The realigned high voltage transmission line is likely to be visible running parallel to Orchard Road.

A moderate impact on visual amenity is expected from this location.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE					
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR3	H	M	L	L	M	L
Visual Impact Rating		MODERATE					

From Table 03, using a combination of sensitivity and magnitude ratings.

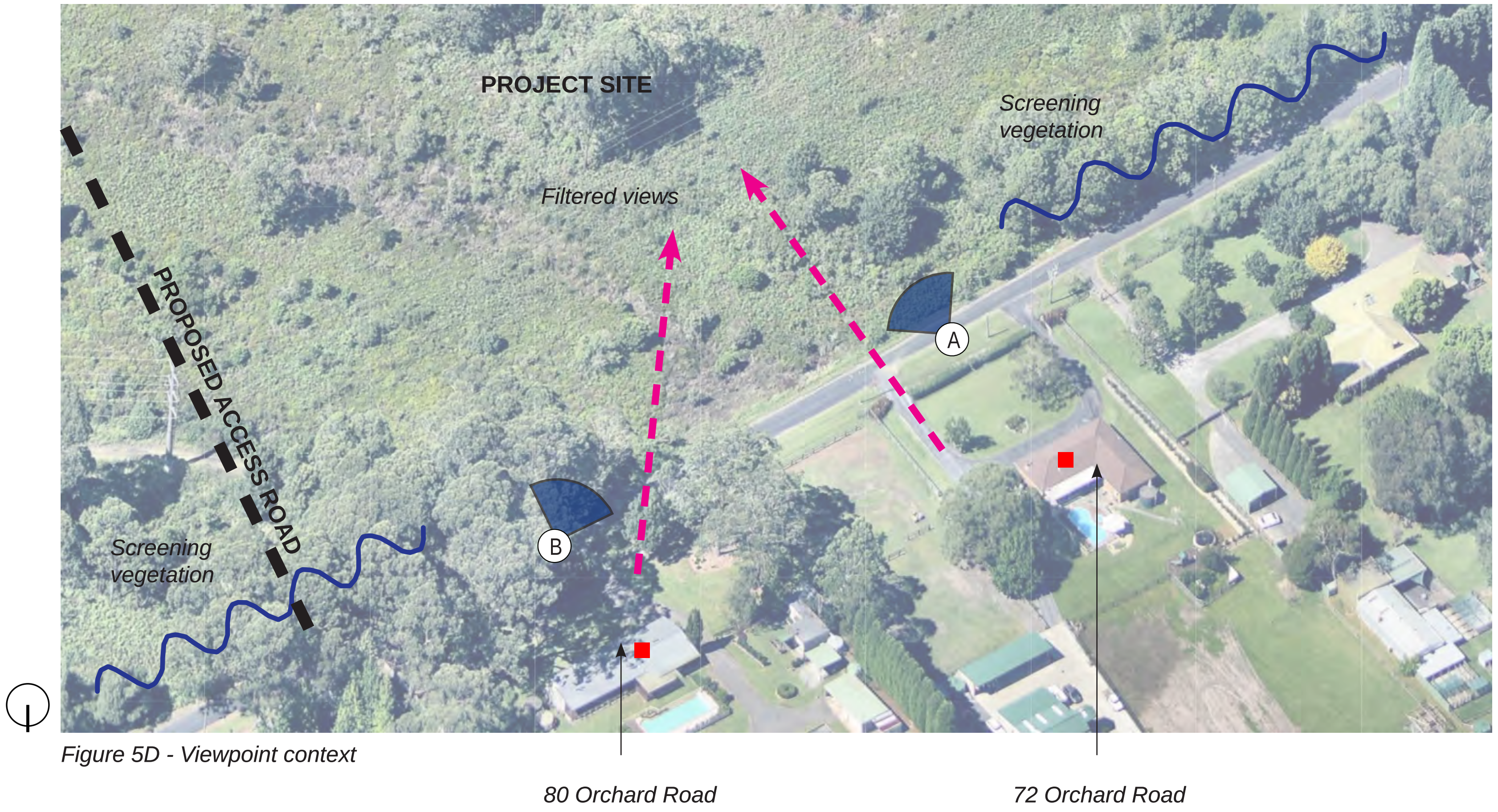
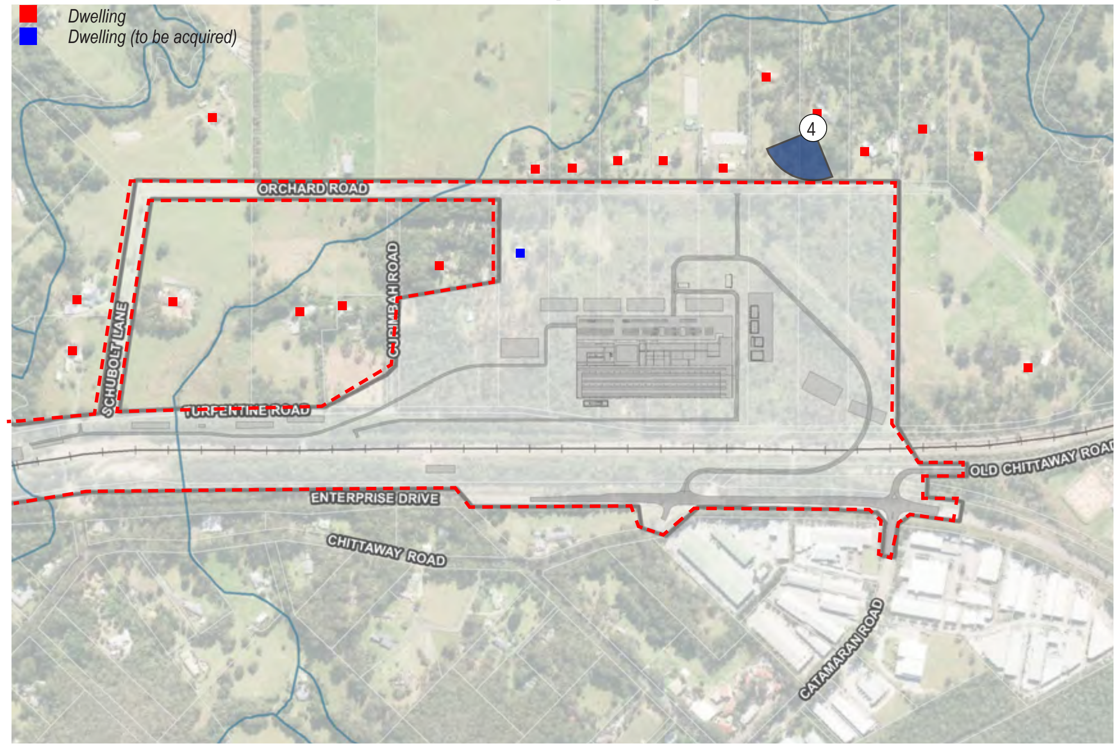


Figure 5D - Viewpoint context

PRIVATE VIEWPOINT 4 (PR4)



Viewpoint location

Proposed works

Lot 8660 Orchard Road (behind trees)

Private Viewpoint 4 - Photo A

Private Viewpoint 4 - Photo B

CLOUSTON associates

LOCATION
Orchard Road, looking south.

Distance to nearest Project element
400 metres

Receptors
Residents of Lot 8660 and Lot 24 Orchard Road.

Current View
These properties are located along Orchard Road, set back over 60m from the road road corridor (refer viewpoint photo A). The foreground is dominated by stands of native vegetation within the property boundary with filtered views to a denser band of vegetation along the southern verge of Orchard Road (photo B).

VISUAL IMPACT

Screening vegetation along Orchard Road will block the majority of views towards the Project site. It is unlikely that the main Project site will be visible from these two properties, however access was not possible to the dwelling itself and so a moderate rating has been recorded.

The realigned high voltage transmission line is likely to be visible running parallel to Orchard Road.

			MAGNITUDE				
RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR4	H	M	L	L	L	L
Visual Impact Rating		MODERATE*					

From Table 03, using a combination of sensitivity and magnitude ratings.

*Individual access to properties was not possible so a general impact rating has been given for these dwellings. These properties may well have a lower visual impact rating as vegetation is likely to screen the Project.

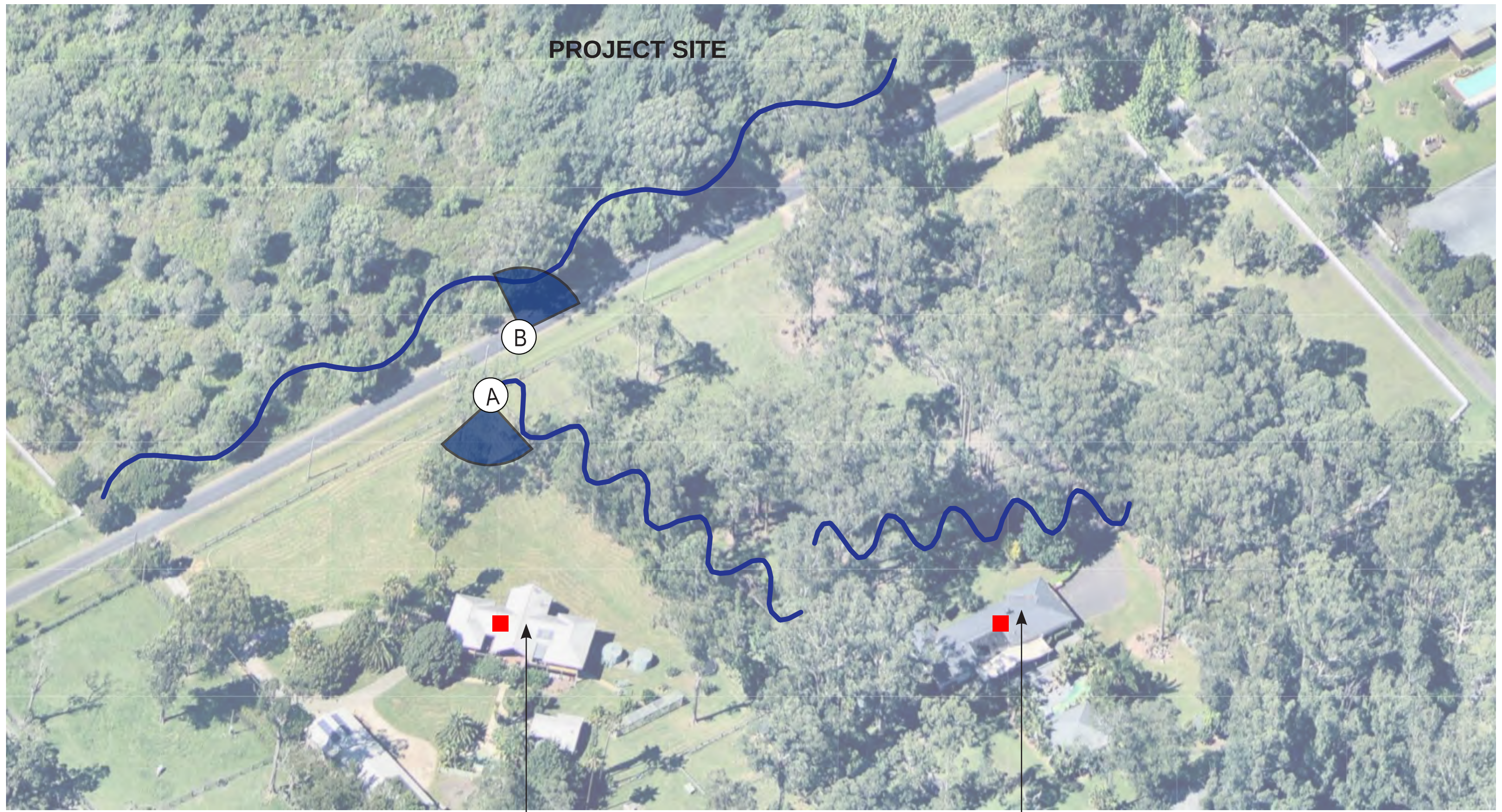


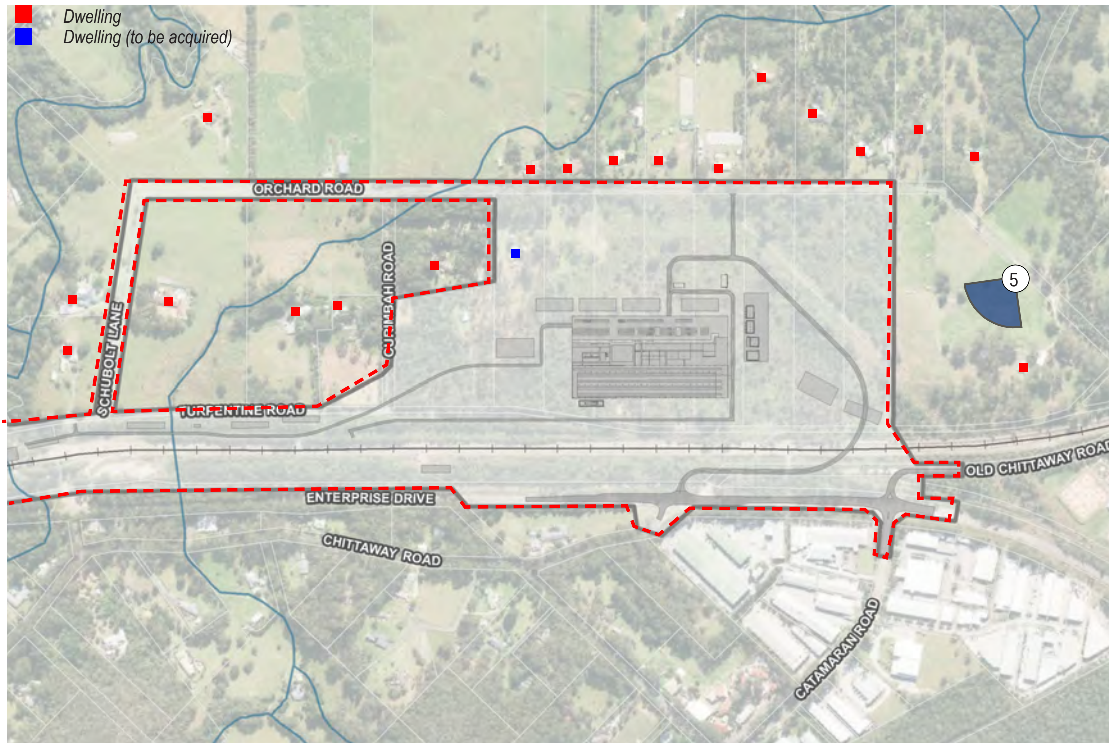
Figure 5E - Viewpoint context

8660 Orchard Road

Lot 24 Orchard Road

CLOUSTON associates

PRIVATE VIEWPOINT 5 (PR5)



Viewpoint location

Proposed works

Private Viewpoint 5 - Photo A

CLOUSTON associates

LOCATION
Orchard Road, looking south west.

Distance to nearest Project element
350 metres

Receptors
Residents of 139 Orchard Road.

Current View
This property is located at the end of Orchard Road surrounded by stands of native tree planting. Views from the dwelling are highly constrained by this planting although the surrounding fields have expansive views south and west towards a tree line in the middle distance. Glimpses towards the Ausgrid 132kV stanchions and wires are available through gaps in the vegetation.

VISUAL IMPACT

Screening vegetation will block views of the majority of elements associated with the Project from the main part of this dwelling.

Filtered views of the elevated access road will be available from the fields to the west of the property. The elevated road will be up to 14m high - greater in scale and bulk than existing elements within the visual scene. Removal of some vegetation may be noticeable, as will the proposed 132kV transmission line along the boundary of the site.

A moderate overall impact on visual amenity is expected from this location. Screening vegetation around the dwelling itself has reduced the sensitivity and magnitude of change ratings from the main habitable area of this property.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE					
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS	
Private	PR5	M	M	M	M	M	M	
Visual Impact Rating		MODERATE						

From Table 03, using a combination of sensitivity and magnitude ratings.

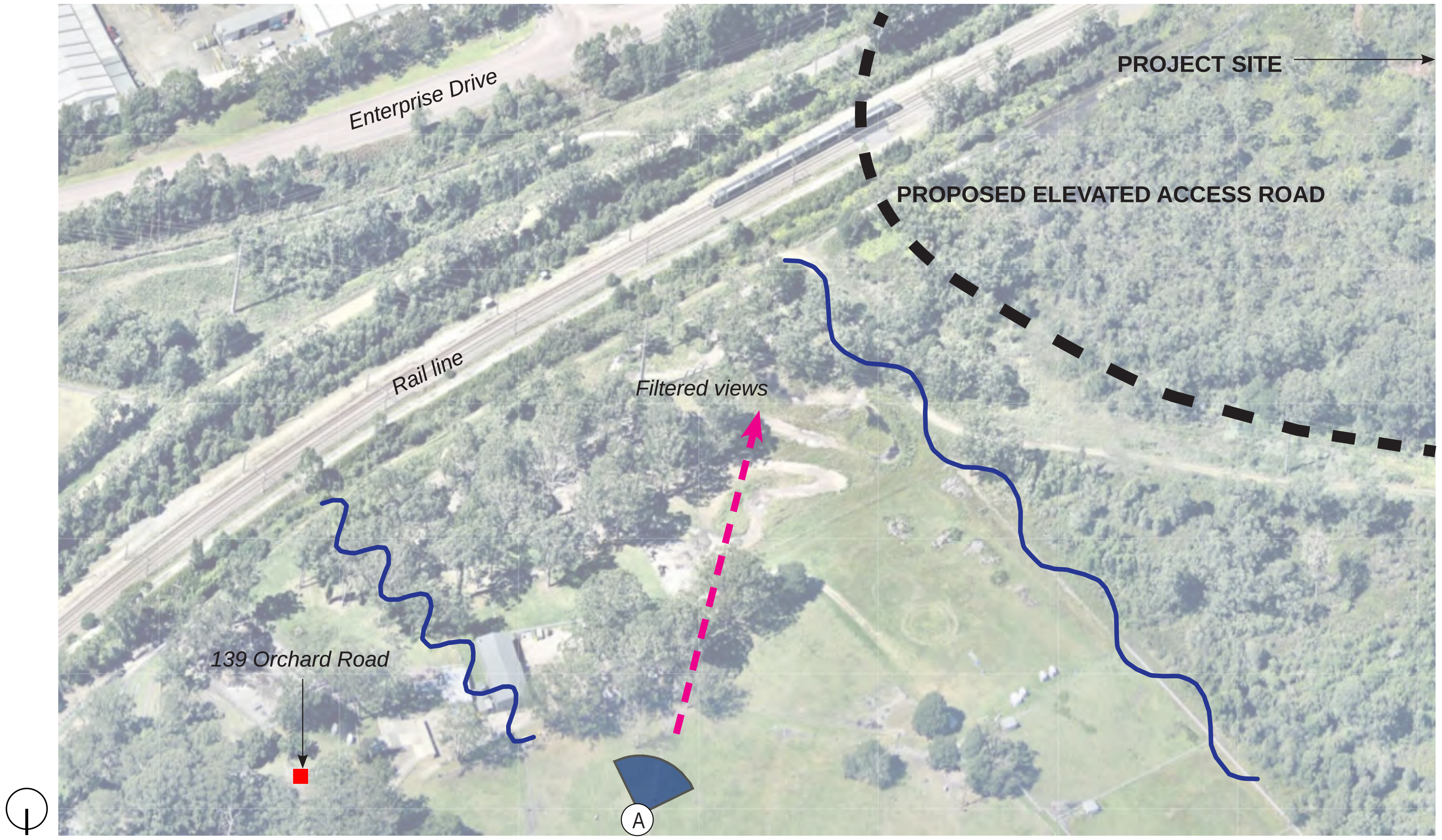
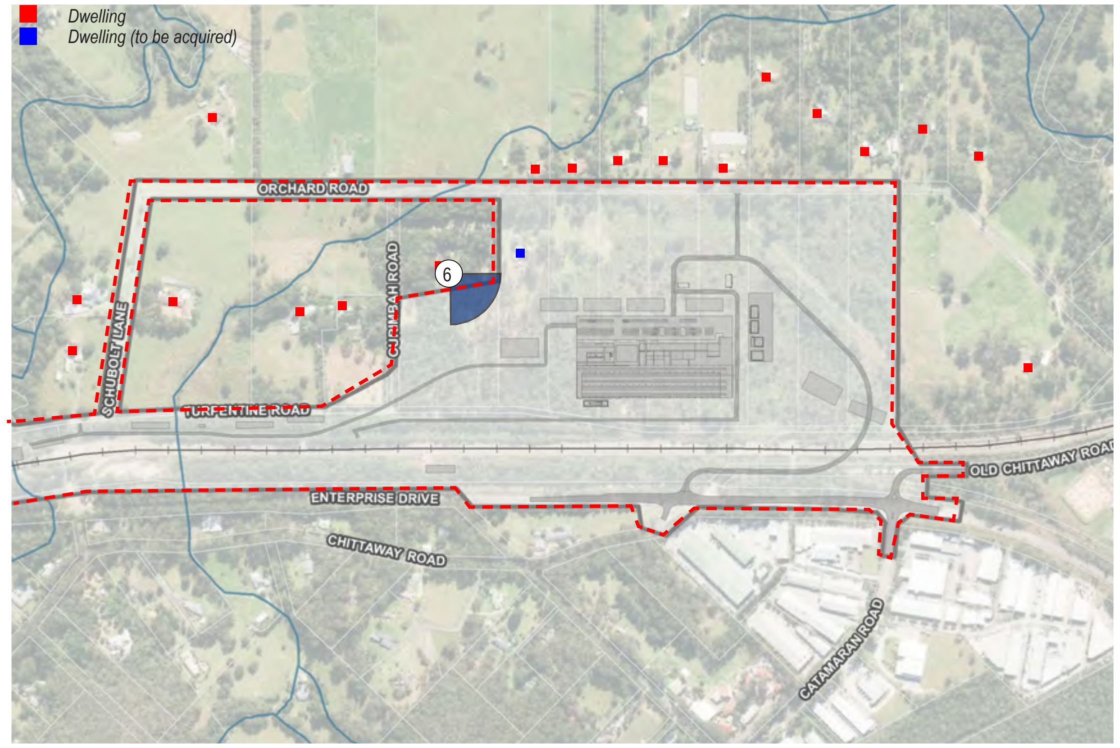


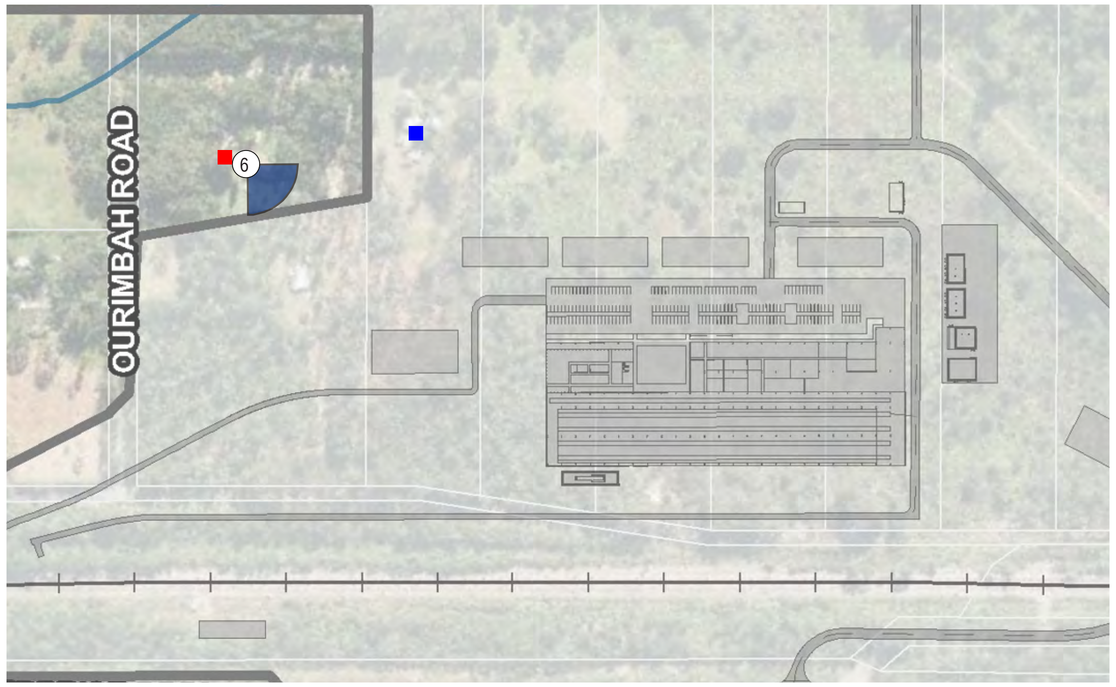
Figure 5F - Viewpoint context

Potential filtered views of Project elements and associated vegetation removal

PRIVATE VIEWPOINT 6 (PR6)



Viewpoint location



Proposed works

Private Viewpoint 6 - Photo A

Private Viewpoint 6 - Photo B

Potential highly filtered views of Project elements through trees

CLOUSTON associates

LOCATION
Off Ourimbah Road, looking south.

Distance to nearest Project element
110 metres

Receptors
Residents of Lot 31 Orchard Road.

Current View
This property is located off Ourimbah Road and is set back from the road down a long driveway. The dwelling is surround by tall and dramatic native tree planting with grass lawns to the front and rear of the property. Very little built form is visible from the property with the viewframe being dominated by a layer of trees and shrubs in the foreground. Filtered views are available through gaps in the trees to the surrounding bush land from the back (viewpoint photo A) and front (viewpoint photo B) of the property.

VISUAL IMPACT

This property is in close proximity to the Project site although dense screening vegetation may filter the majority of views of the Project. Filtered views of elements such as the warehousing, light poles and security fence may be visible from the front and back of the house.

The level of visual impact will depend on the quantum of vegetation removal associated with the Project. A moderate to moderate/high impact on visual amenity is expected in this location.

*The overall impact rating will depend on amount of vegetation removal required. If a screening buffer remains between the property and Project site, the visual impact rating is likely to be lower than recorded. Greater vegetation removal will lead to a greater level of Project visibility and a higher visual impact to the dwelling.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR6	H	M	M	H	M	M
Visual Impact Rating		MODERATE/HIGH*					

From Table 03, using a combination of sensitivity and magnitude ratings.

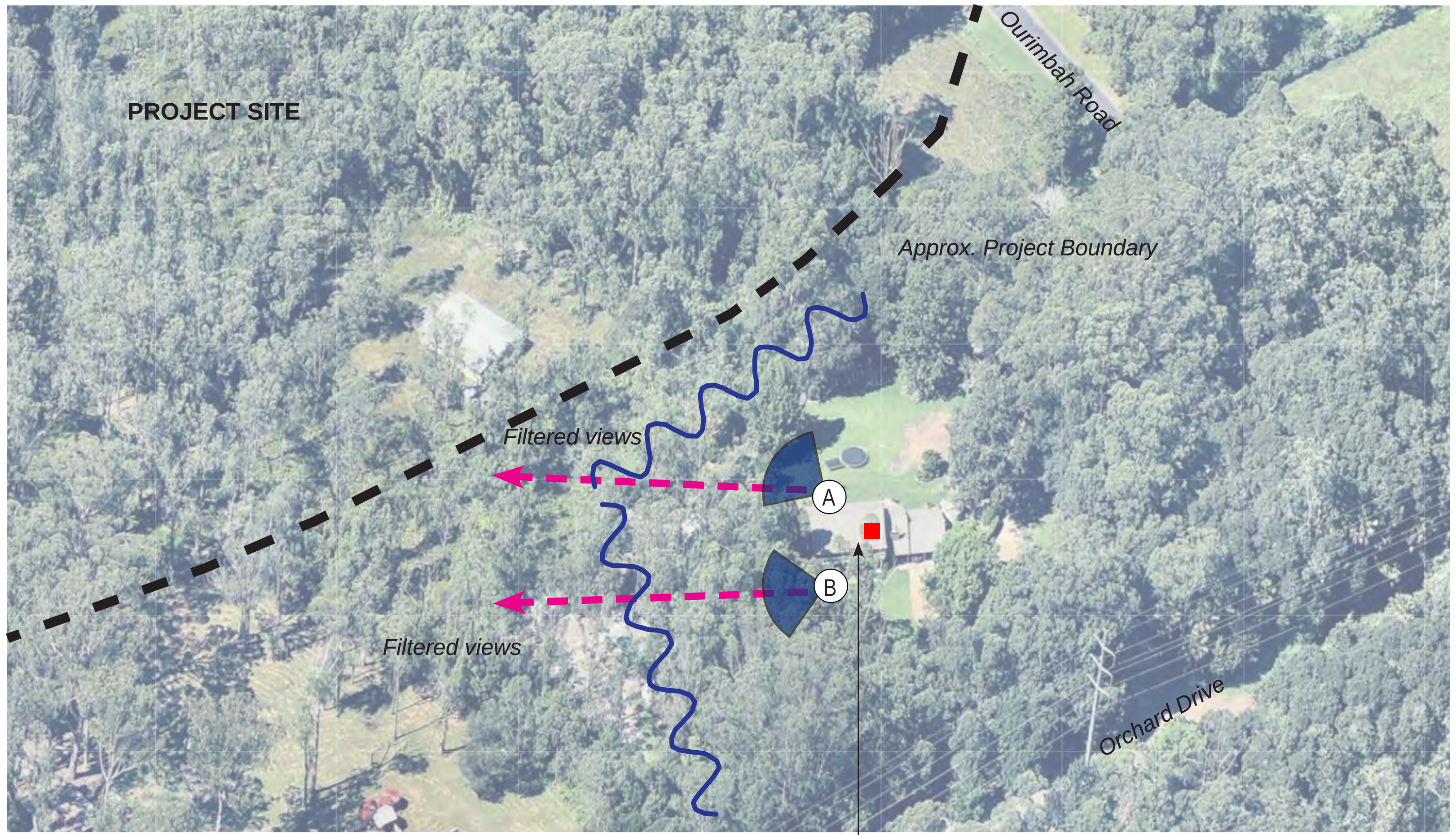
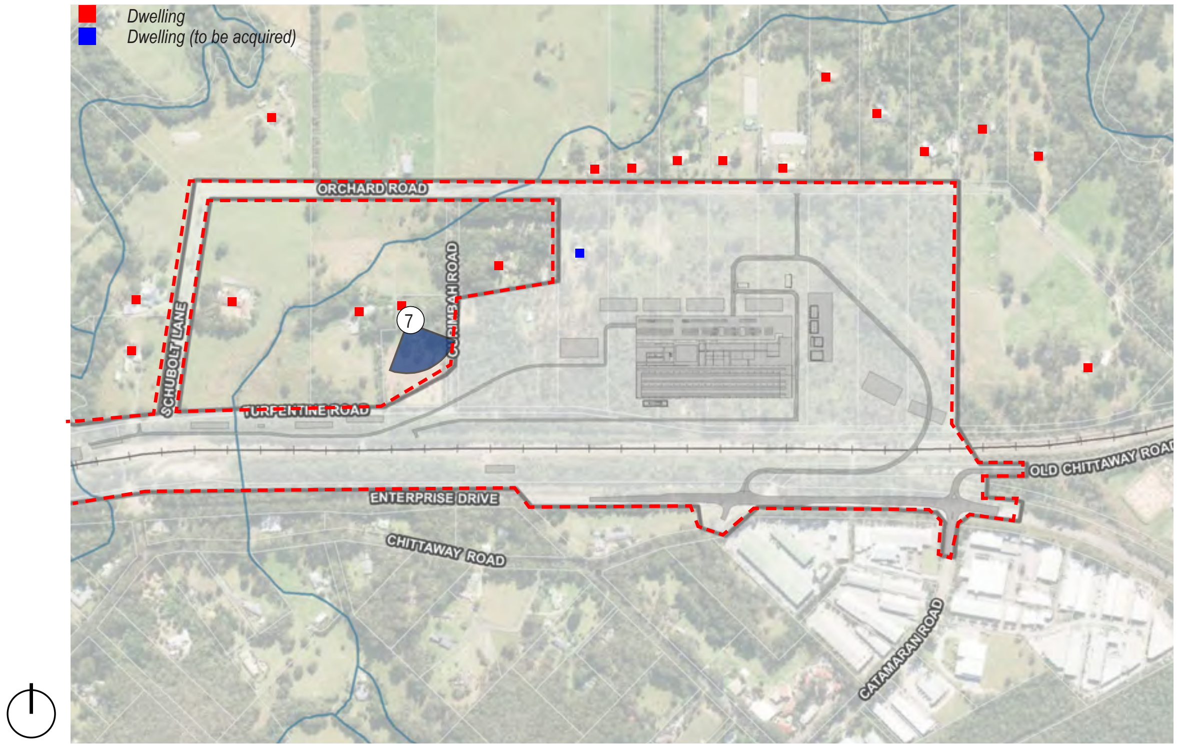


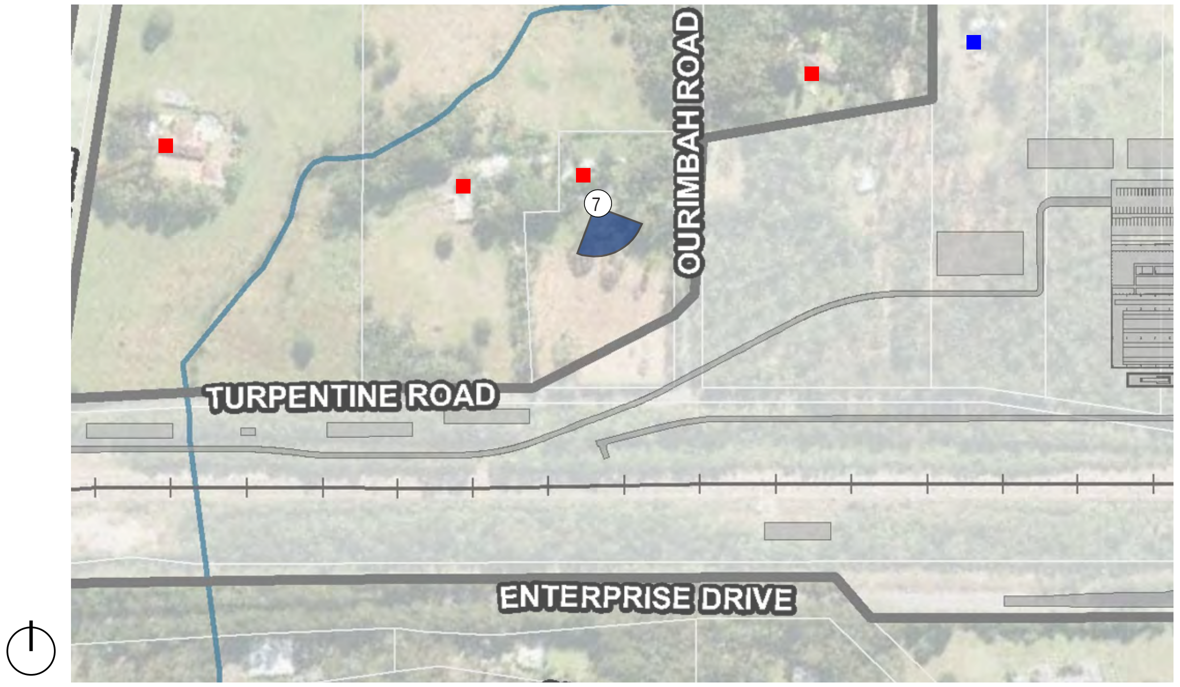
Figure 5G - Viewpoint context

Lot 31 Orchard Road

PRIVATE VIEWPOINT 7 (PR7)



Viewpoint location



Proposed works

Private Viewpoint 7 - Photo A - Lot 121 as viewed from Turpentine Road

CLOUSTON associates

LOCATION
Orchard Road, looking south.

Distance to nearest Project element
150 metres

Receptors
Residents of Lot 121 Ourimbah Road.

Current View
This property is located off Ourimbah Road, set back from the road corridor. The dwelling is surround by tree planting with a large field to the south - refer viewpoint photo A. Although access to this property was not possible to take a photograph, the dwelling is likely to have filtered views across this field to the boundary with Turpentine Road.

VISUAL IMPACT

It is proposed to widen Turpentine Road in this location requiring the acquisition of a large corner of this property. This will bring the road into closer proximity to the dwelling and require the removal of some vegetation. Filtered views will be available to the realigned road, rail tracks, trains and security fence.

A moderate/high impact on visual amenity is expected from this location. This rating would be reduced with the planting of screening vegetation to block views of the Project elements.

RECEPTOR TYPE	RECEPTOR IDENTIFICATION	RECEPTOR SENSITIVITY	MAGNITUDE				
			DISTANCE	QUANTUM OF VIEW	PERIOD OF VIEW	SCALE OF CHANGE	SUMMARY OF RATINGS
Private	PR7	H	M	M	M	M	M
Visual Impact Rating		MODERATE/HIGH*					

From Table 03, using a combination of sensitivity and magnitude ratings.

*Access to this property was not possible so a general impact rating has been given for this dwelling. The property may have a lower visual impact rating if vegetation screens Project elements.

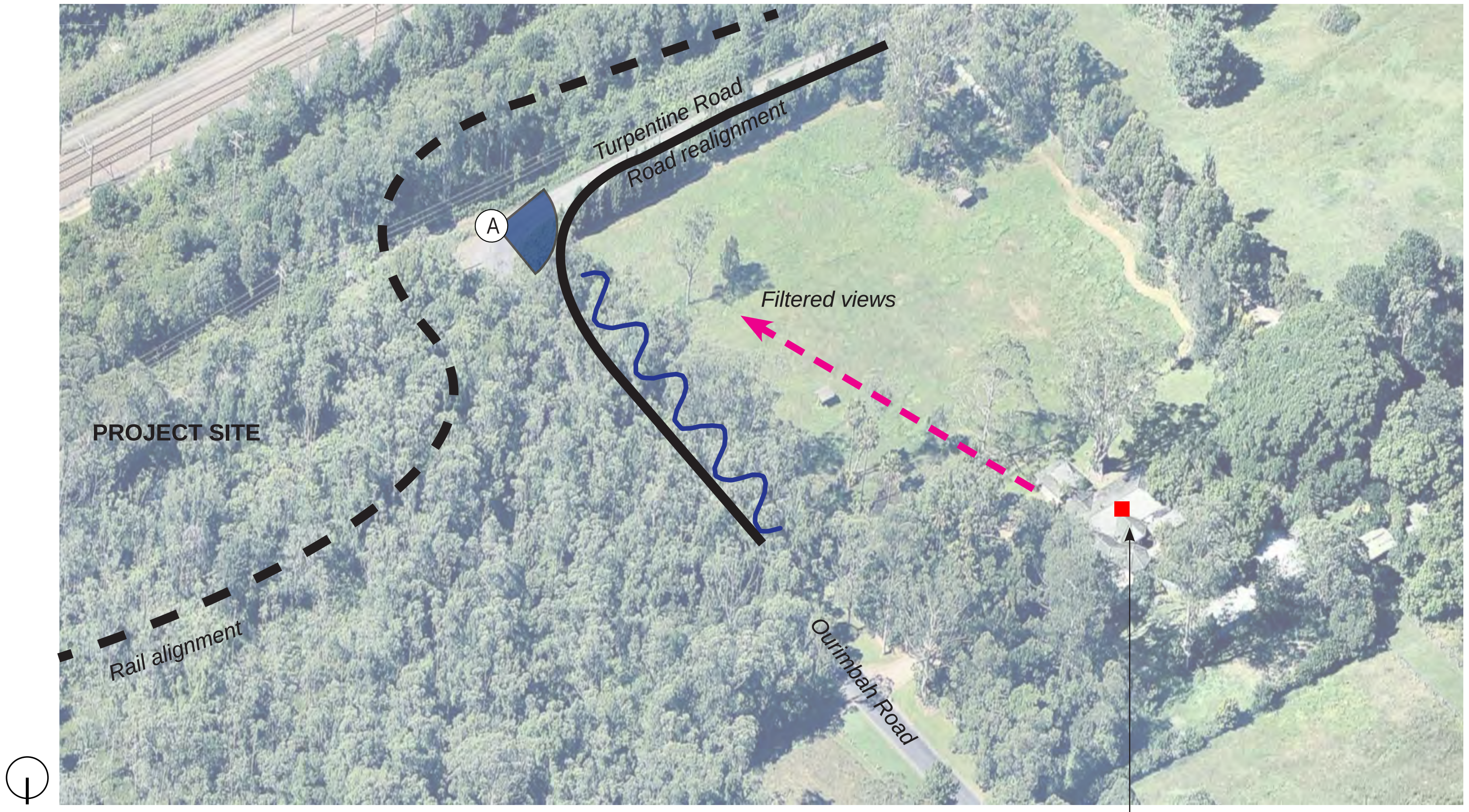


Figure 5H - Viewpoint context

3.5 VISUAL IMPACT SUMMARY

3.5.1 Operational Phase

The visual impacts of the Project on the studied viewpoints range from low to moderate/high (refer Table 04 and Figure 06).

- One viewpoint received an impact rating of low
- Two viewpoints received an impact rating of moderate/low
- Five viewpoints received an impact rating of moderate
- Two viewpoints received an impact rating of moderate/high

Moderate/high visual impacts associated with the Project are limited to properties in close proximity to the Project site - two dwellings along Ourimbah and Orchard Roads. These dwellings may have filtered views of the most visually prominent elements of the Project including the warehouse buildings, light poles, fences and potentially, moving trains.

Although there will be some noticeable changes in the visual scene from public roads that pass close to the Project site, the low sensitivity of these receptors and short duration of view have lead to low to moderate/low impacts.

The Project site is surrounded by dense and tall tree planting that screens or blocks many views of the Project from surrounding roads and dwellings. The retention and enhancement of this visual buffer is crucial in limiting visual impacts. Some dwellings that recorded a moderate and moderate/high visual impact are likely to have a lower rating if a sufficient buffer of screen planting is retained.

Visual impacts related to increases in traffic (associated with workers and equipment accessing the site) are harder to quantify. It is assumed that the majority of site access will be via the new elevated road off Enterprise Drive, limiting the impacts to dwellings west of the Project site.

To the south of the rail line, visual impacts are likely to be low to negligible due to the low sensitivity of receptors and presence of dense screening vegetation. The most visible element of the Project from Enterprise Drive will be the new elevated access road at up to 14m high.

3.5.2 Construction Phase

The construction period is likely to last approximately 33 months involving the following activities:

- clearing of vegetation
- setting up of site compounds
- stockpiling
- earthworks
- site fencing
- increased site traffic including heavy vehicles
- building construction including the use of large cranes

During the construction period, all viewpoints studied within this report are likely to have increased visual impacts - refer Table 04. Views of tall construction cranes, site compounds, storage areas and increased site traffic (including trucks) will lead to a reduction in visual amenity. These impacts will be the highest for properties in close proximity to the Project site, reducing as distance and screening vegetation increases. These visual impacts will be of a temporary nature and the impact will reduce for many viewpoints during the operational phase.

CLOUSTON associates

RECEPTOR TYPE	Receptor Identification	Receptor Sensitivity	OPERATIONAL PHASE – MAGNITUDE: Distance	Quantum of View	Period of View	Scale of change	Summary of Ratings	OPERATIONAL PHASE: Impact Rating	CONSTRUCTION PHASE: Impact Rating	RESIDUAL IMPACTS POST MITIGATION (INDICATIVE ONLY): Impact Rating
Enterprise Drive	PU1	L	H	M	L	L	L	LOW	MODERATE	LOW
Turpentine Road	PU2	L	H	M	L	M	M	MODERATE/LOW	MODERATE	MODERATE/LOW
Turpentine Road	PU3	L	H	M	L	M	M	MODERATE/LOW	MODERATE	MODERATE/LOW
15 and 16 Schubolt Lane	PR1	H	L	L	L	L	L	MODERATE	MODERATE	MODERATE
50, 54 and Lot 20 Orchard Road	PR2	H	M	L	M	L	L	MODERATE*	MODERATE	MODERATE
72 and 80 Orchard Road	PR3	H	M	L	L	M	L	MODERATE	MODERATE/HIGH	MODERATE
Lot 8660 and Lot 24 Orchard Road	PR4	H	M	L	L	L	L	MODERATE*	MODERATE	MODERATE
139 Orchard Road	PR5	M	M	M	L	M	M	MODERATE	MODERATE	MODERATE
Lot 31 Orchard Road	PR6	H	M	M	H	M	M	MODERATE/HIGH*	MODERATE/HIGH	MODERATE
Lot 121 Ourimbah Road	PR7	H	M	M	M	M	M	MODERATE/HIGH*	MODERATE/HIGH	LOW

Table 04 - Summary of visual impacts of the Project across the study area

**Worse case scenario - see individual viewpoint for more information*

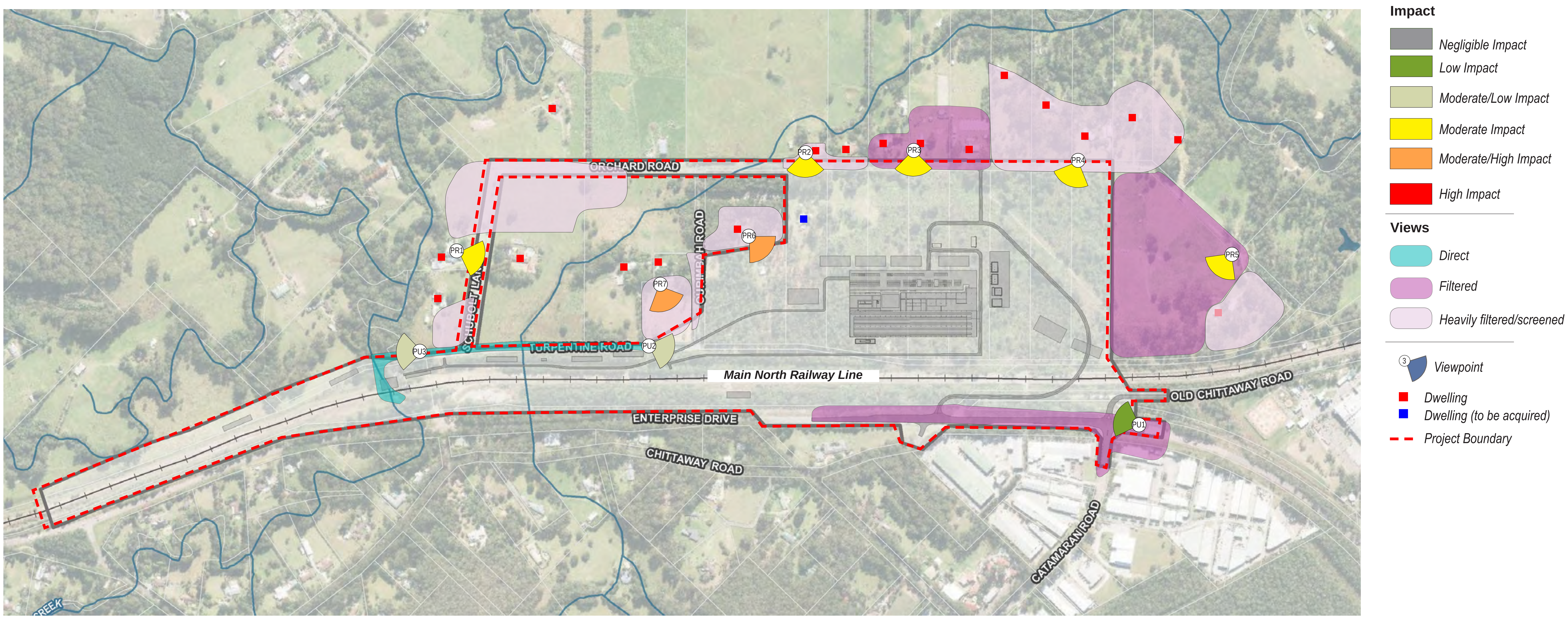


Figure 06 - Summary of visual impacts across the study area

4.0 MITIGATION MEASURES AND CONCLUSION

4.1 TYPES OF MITIGATION

Effective mitigation measures for any form of potential visual impact are those that entail:

- Avoidance
- Reduction
- Alleviation

4.2 AVOIDANCE

A thorough site selection process has been undertaken. Once set, the ability to avoid impact is reduced. Location is key to the functioning of the facility. Avoidance measures have not been considered applicable in this report.

4.3 REDUCTION

The principal forms of reduction are associated with refinements and modifications that address the siting and scale of built form. Measures to be considered include:

- restrict vegetation clearing to those areas where it is necessary. Opportunities to minimise clearing should be part of the developed concept design
- ensure a vegetation buffer of existing planting is left between within or outside the Project boundary to provide visual screening of the facility
- locate storage areas and associated works in cleared or otherwise disturbed areas away from sensitive native vegetation
- avoid stockpiling materials in areas supporting vegetation where possible
- trim rather than removal of trees to be undertaken where possible and to be conducted by a qualified arborist
- rehabilitate vegetated areas where ground is disturbed

4.4 ALLEVIATION

Options to alleviate impacts are usually associated with detailed design features such as materials, finishes, reflectivity, planting character and the like. Measures to be considered include:

4.4.1 Vegetation

- plant native trees and shrubs to screen built form and reduce the scale of the infrastructure
- reinforce the local semi-rural landscape character through the use of appropriate native vegetation, including that from the identified endangered vegetation communities
- plant a graded screen of vegetation at varied heights that includes groundcover, shrub and tree layers to form an effective visual screen
- consider the use of advanced size trees for instant effect
- restore areas disturbed by construction to match existing condition

4.4.2 Finishes

The aesthetic quality of the facility is key to ensuring the Project fits with the local context. The buildings should as simple and elegant as possible.

- All elements including lighting columns, roof lines, cladding etc. to be considered as a whole to simplify the structure and reduce clutter
- avoid reflective surfaces.

4.5 OFF SITE MITIGATION

Tree planting outside the works boundary may assist in visually screening the facility and should be considered further during the design. Offset planting for the removed ECC vegetation will be required and should be undertaken with specialist ecological advice.

4.6 RESIDUAL IMPACTS

A full planting scheme within the Project site will greatly assist in reducing the visual impact for properties located close to the Project boundary. Combined with off site screen planting at specific property locations (such as PR5 and PR7), visual impacts may reduce further - refer Table 04.,

5.0 CONCLUSION

Overall, the following conclusion can be drawn on the Project's impacts to landscape character and visual amenity within the study area:

- Moderate/high impacts on landscape character are limited to the immediate Project site, associated with clearing sensitive vegetation.
- Moderate/high visual impacts are limited to two residential receptors in close proximity to the main part of the Project site.
- The most visually prominent elements of the Project are expected to be warehouse buildings, light poles, security fence and elevated access road. Moving trains and additional road traffic will have an additional visual impact.
- Dense screening vegetation surrounding the Project site filters views to the Project and limits the severity of visual impacts.
- No direct views of the main Project site are available from sensitive residential receptors within the study area - all views are filtered by vegetation to some extent.
- Moderate/low visual impacts are expected for users of the local road network.
- Construction impacts are likely to be moderate to high but for a limited period of time.
- Retention and bolstering of the vegetation surrounding the Project site is likely to reduce some of the impact ratings recorded within this report.

APPENDIX A

An explanation of the rating categories used within this report to determine the level of visual impact on each viewpoint/receptor studied. These rating categories have been developed by CLOUSTON Associates and follow national and international best practice.

SENSITIVITY **Qualitative Assessment Definitions**		
Receptor sensitivity		Each visual receptor type has an inherent and varied sensitivity to change in the visual scene based on their personal context in which the view is being experienced. This would have a direct bearing on the perception of visual impact experienced by the receptor and qualifies the quantitative impacts:
	H	**Public Reserve, Parks, Reserves, Public walkways:** the purpose of visiting and using reserves largely relates to an enhanced sense of wellbeing. Receptor is more sensitive to both positive and negative visual experiences, especially where the reserve is the destination for leisure and relaxation.
		Residential: view from dwelling or garden may be experienced regularly over extended periods of time; residents may have chosen the location specifically for the view and/or develop a strong familiarity and association with the view and have high sensitivity to change
		Public Roads/Transport: the view experienced can be important to the driver/passenger but is sometimes a brief experience and the driver is usually focused on the road.
		Commercial Property - Work: view can enhance the work or education experience but focus of activity is not principally on the view.
	L	**Semi-Private property - Work/Education/Service provider:** view can enhance the work or education experience but focus of activity is not principally on the view.

MAGNITUDE **Quantitative assessment definitions**		
Distance		The effect the Project has on the view relating to the distance between the Project and the visual receptor. The distances are from the approximate boundary of the site and categorised as:
	H	Within 0 - 100 metres- high impact.
	M	100 to 500 metres - high to moderate impact.
	L	Further than 500 metres - low impact.
Quantum of view		The Quantum of view relates to the openness of the view and the angle of the view to the visual receptor. A development located in the direct line of sight has a higher impact than if it were located obliquely at the edge of the view. Whether the view of the Project is filtered by vegetation etc. also affects the impact, as does the nature of the view (panoramic, restricted etc.). A small element within a panoramic view has less impact than the same element within a restricted or narrow view. The effects can be categorised as:
	H	A direct view of the Project or its presence (sometimes in a very narrow or highly framed view), where the Project occupies the greater proportion of the view cone.
		A direct view of the Project within a panoramic view where the Project occupies a large proportion of the view cone.
		A direct view of the Project or its presence in a broader view where the Project occupies a moderate proportion of the view cone.
		A direct or slightly oblique view of the Project within a broad or panoramic view cone
	L	An oblique, highly filtered or largely obscured view of the Project.
	N	No view of the Project from this location.
Period of view		The length of time the visual receptor is exposed to the view. The duration of view affects the impact of the Project on the viewer - the longer the exposure the more detailed the impression of the proposed change in terms of visual impact:
	H	Significant part of the day - high impact: usually residential property.
		5 minutes to several hours - high to moderate impact: often from a garden or park or commercial property and work places.
		10 seconds to 1 minute - moderate impact: usually from a road/driveway entrance, walking past or entrance to commercial property.
		5 to 10 seconds - moderate to low impact: often from a road or walking past.
	L	1 to 5 seconds - low impact: usually from a road or railway

Scale of change		Scale of change is a quantitative assessment of the change in compositional elements of the view. If the proposed development is largely similar in nature and scale to that of existing elements in the vicinity, the scale of change is low. If the development radically changes the nature or composition of the elements in the view, the scale of change is high. Distance from the development would accentuate or moderate the scale and variety of visible elements in the overall view and hence influence this rating:
	H	Elements within the view would be greatly at odds with existing features in the landscape
		Elements within the view would be largely at odds with existing features in the landscape
		Elements within the view would be at odds with existing features in the landscape
		Elements within the view would be partly at odds with existing features in the landscape
	L	Elements and composition of the view would remain largely unaltered .
	N	No view of the Project from this location.
Summary of Magnitude Ratings	**From H to N**	A summary rating that combines all of the quantitative ratings. This is rated either high, moderate to high, moderate, moderate to low, low or none, where none implies no visible change based on the above criteria and high implies significant visible change in terms of the combined quantitative criteria

SUMMARY		
Combined Rating		The nature of the visual impact may be **beneficial** or **adverse**, based on a transparent professional assessment of the combined totals of qualitative and quantitative ratings and comments as outlined above. The final rating is derived using the RMS matrix table - 01:
	H	Highly adverse.
	M/H	Moderately to Highly adverse.
	M	Moderately adverse.
	M/L	Slightly adverse.
	L	Neutral or Beneficial.

INTENTIONALLY BLANK

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