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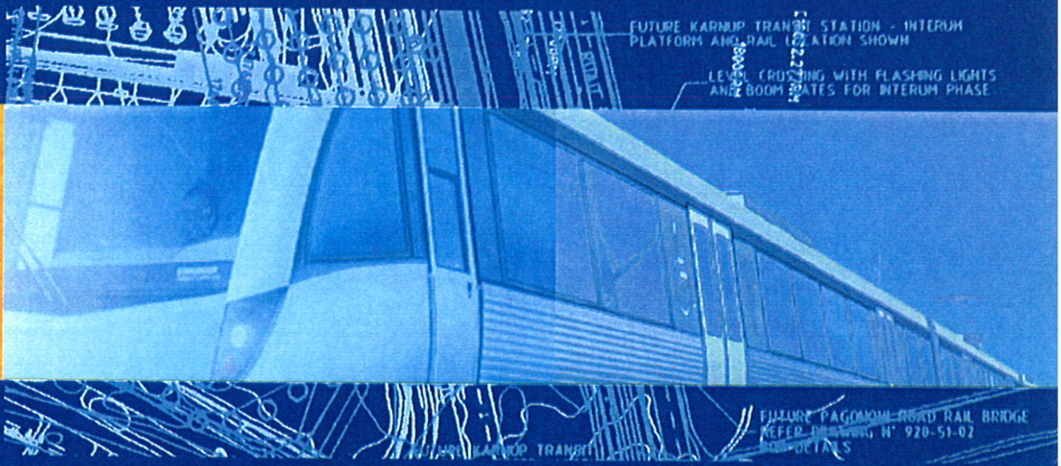
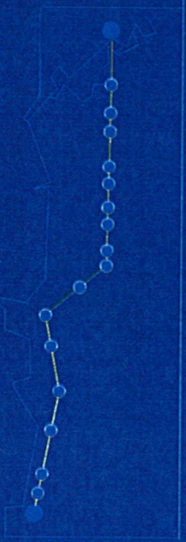
PUBLIC ENVIRONMENTAL REVIEW

SOUTH WEST METROPOLITAN RAILWAY
FROM PERTH TO MANDURAH

Volume 2

November 2002





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Government of Western Australia

PERTH URBAN RAIL DEVELOPMENT

LINKING COMMUNITIES

BOWMAN BISHAW GORHAM
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APPENDIX D

Contamination Assessment

SOUTH WEST METROPOLITAN RAILWAY
PERTH TO MANDURAH

PRELIMINARY SITE INVESTIGATION
FOR POTENTIAL CONTAMINATION

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November 2002

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF TABLES
(Compiled at Rear of Document)

LIST OF FIGURES
(Compiled at Rear of Document)

Photographs compiled at Rear of Document

1.0 INTRODUCTION

1.1 General

The Government of Western Australia is proposing to establish a rail line linking the Perth Central Business District to Mandurah via the Kwinana Freeway and Rockingham. The implementation of the South West Metropolitan Railway (SWMR) project is coordinated by the Perth Urban Rail Development (PURD) office.

The SWMR project is subject to a Public Environmental Review (PER) by the Environmental Protection Authority (EPA). The PER guidelines include the following objective for soil and groundwater contamination:

> *"Ensure that any contaminated land or groundwater that may be impacted by the proposal is managed and remediated to an acceptable standard compatible with the intended land uses."*

The guidelines indicate the works required to fulfil this objective are:

- *Identify any potentially contaminated land or groundwater that may be impacted directly or indirectly by the proposal, using the DEP Contaminated Sites Branch preliminary site assessment methodology.*

- *If potentially contaminated sites are identified, detail the procedures to be followed to assess the level and extent of contamination, and management and remediation measures, as appropriate, that will be carried out.*

A Preliminary Site Investigation (PSI) for potential contamination has been conducted for the proposed SWMR (Figure 1). The PSI included a review of the existing environment, historical site activities and site inspections for search for visible signs of contamination.

The PER describes the proposed alignment and the environmental characteristics of the route.

1.2 Report Format

The remainder of the report comprises four principal sections described as follows:

- *Section 2 Objectives and Scope:* Summarises the objectives of the PSI and the tasks undertaken to achieve them.

- *Section 3 Approach:* Describes the investigations undertaken to identify and assess potential contamination at the site.

- *Section 4 Areas and Sources of Potential Contamination:* Identifies and describes areas and sources of potential contamination identified on the proposed SWMR.

- *Section 5 Further Work Requirements:* Describes the additional works that would be required to fully assess contamination and remedial requirements within the proposed SWMR reserve.

2.0 OBJECTIVES AND SCOPE

The objectives of the PSI were to fulfil the requirements of the EPA guidelines as follows:

- To identify areas and sources of potential contamination impacted by the proposed SWMR.
- To detail the procedures that will be applied to assess the identified potential contamination and the associated management requirements.

Tasks undertaken included:

- Review of existing environmental data to characterise features that may affect the transport and fate of contaminants within the proposed SWMR.
- A review of historical activities within and adjacent to the proposed SWMR to identify areas and sources of potential contamination.
- An inspection of the proposed SWMR alignment.
- Assessment of the procedures required to assess the identified potential contamination and the associated management requirements.

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3.0 APPROACH

The PSI was undertaken in accordance with procedures advocated by the Department of Environmental Protection (DEP). Details are provided below.

3.1 Information Compilation

Information on the history and conditions of the proposed route was derived via the following sources and tasks:

- Published information on soil and hydrology as follows:
  - Perth Groundwater Atlas (WRC, 1997)
  - Perth Metropolitan Region Environmental Geology Series – Perth Sheet (Gozzard, 1986), Fremantle Sheet (Gozzard, 1983a) and Rockingham Sheet (Gozzard, 1983b)
  - Urban Geology Series – Pinjarra (Geological Survey of WA, 1978)
  - Landforms and Soils of the Darling System (Churchward & McArthur, 1980)
  - Hydrogeology and groundwater resources of the Perth Region (Davidson, 1995).

- Historical aerial photographs held by the Department of Land Administration (DOLA) taken between 1947 and 2001 (Appendix A).

- Inspection of the proposed alignment to identify adjacent land uses and search for visible signs of contamination.

- Consultations with the following persons/organisations knowledgeable of area history as follows:
  - Battye Library, Perth
  - ITAL PEL Raw Hide and Skin Export, Jandakot
  - Garden Organics, Jandakot
  - Golden Bay Fruit & Veg Supplies, Karnup
  - Mr Mark Newman, Main Roads Department
  - Mr Paul Allenbrook – City of Mandurah
  - Ms Ester Cusworth – City of Mandurah

- Mr Kevin Prince – Maripana Wildlife Park, Karnup
- City of Perth Library, Perth
- Mr Don Ashby – Quarry Operator, east of Mandurah TAFE
- Shell Service Station, Bertram
- South Perth Heritage Group, South Perth
- Mr Rob Bunney – Stakehill Estate Vineyard, Stakehill
- Mr Barry Johnson – Swan River Trust
- Mr Mark MacMahon – The Great Outdoors Landscaping and Trade Centre
- Mr Richard Murton – Water Corporation, Bunbury
- Mr Mike Francina – Water Corporation, Mandurah

• Reports and documents relating to site history as follows:
  - A Short History of Planning in Perth (PCC, 1969)
  - Perth City Foreshore Urban Design Competition – Conditions and Brief (PCC & State Government of Western Australia, 1991)
  - Perth Cityscope (Cityscope, 2001)
  - The Streets of Old Perth (Austen, 1988)
  - The People of Perth: A Social History of Western Australia's Capital City (Stannage, 1979)
  - Perth – The First 100 Years (Bold, 1938)
  - Peninsula City: A Social History of the City of South Perth (Florey, 1995)
  - The History of South Perth (Crowley, 1962)
  - Cockburn: The Making of a Community (Berson, 1978)
  - Kwinana: Third Time Lucky (Russel, 1979)
  - Rockingham Looks Back (Taggart, 1984)

• Information relating to proven and inferred sources of groundwater contamination from:
  - Inventory of Proven and Inferred Groundwater Contamination Sites – Perth South 1:100,000 Map Sheets (Hirschberg, 1988)
  - Perth Groundwater Atlas (WRC, 1997)
  - LEGACI database held by the Water and Rivers Commission

• Potential contamination associated with the petrol station sites included on the DEP Contaminated Sites Database.

3.2 Identification of Areas of Potential Contamination

Areas of potential soil contamination were restricted to locations where an activity or source of potential contamination was located within the alignment or directly impacted the soil of the alignment (eg via spills). Potential groundwater contamination sources were restricted to those identified within the vicinity of the alignment and upgradient of the direction of groundwater flow. The distance of the source from the alignment was also noted.

A total of fifteen areas of potential contamination were identified within the proposed alignment. Section 4 describes each area in terms of:

- History
- Potential Contamination
- Further Investigation Requirements

Potential contaminants associated with areas and sources were identified using the *Contaminated Sites Management Series – Potentially Contaminating Activities, Industries and Land Uses* (DEP, 2001) as well as previous experience on similar sites.

Review of contamination databases identified nine inferred sources of potential groundwater contamination as follows:

- Garden Organics (Fertiliser Manufacturer), Jandakot
- P & Z Poultry Farm (Manure Processing), Jandakot
- ITAL PEL Raw Hide and Skin Export (Hide Processing), Jandakot
- Mandurah Integrated Waste Transfer Station (Rubbish Disposal and Recycling), Mandurah
- Former Piggery, Atwell
- Piggery and Emu Farm, Banjup
- Market Gardens, Bertram and Wellard
- Petrol Station, Bertram
- Petrol Station, Karnup

All sites are located either down-gradient or several hundred metres from the proposed alignment and development of the railway would not impede remediation if required.

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4.0 AREAS AND SOURCES OF POTENTIAL CONTAMINATION

4.1 Commercial – Perth CBD

4.1.1 General

Potential sources of contamination along the proposed alignment include reclaimed land on the Perth foreshore, historical roads and the reclaimed wetland area near Wellington Street which is currently overlain by the rail reserve. Details of these areas are summarised in Table 1 and described in the following sections.

4.1.2 Perth Foreshore Reclaimed Land

History

The Esplanade foreshore was progressively filled between 1883-1967 (Location Id 1, Photograph A). The early reclamation occurred around the Esplanade with later infilling continuing along the foreshore further east, in front of Kings Park and along the South Perth foreshore. The progression of the reclamation programs is displayed in Figure 2 (PCC and State Government of WA, 1991).

The material used for filling the area is reported to be dredge soils from the Swan River. Prior to filling of the area a number of jetties extended out from the original shoreline. Many have now been covered with fill.

Potential Contamination

Dredge spoil may contain contaminants associated with industries located upstream that discharge to the river including metals, oils and grease. The foreshore fill may also contain similar contaminants leached from the historical jetty treatments.

Further Investigation Requirements

Use of dredge spoil to reclaim this area may have resulted in contaminated fill being placed on the foreshore. Due to the uncertainty of the quality of the dredge spoil soil investigations will be required.

4.1.3 Historical Roads

History

William Street was initially constructed in the early 1830s. A macadamised (compacted broken stone) road from the jetty in William Street to its junction with St Georges Terrace was laid in the late 1850s. The remainder of William Street was macadamised in 1863. The macadamised area was only in narrow and shallow strips (Stannage, 1979).

Reconstruction of the roads in the railway station areas occurred in 1885. At this time blue metal was used for the reconstruction of Wellington Street.

Between 1898 and 1899, Hay Street was torn up and rebuilt with a jarrah block base overlaid with asphalt to assist with tram operation (Stannage, 1979). The jarrah blocks were later removed during road upgrades.

In 1912, Mounts Bay Road was rebuilt and widened. Works continued through to the 1930s. Road construction for the project was associated with land reclamation from the river (PCC & State Government of WA, 1991).

The construction of Riverside Drive between the Causeway and Barrack Street began in 1913. In 1937, Riverside Drive was connected to Mounts Bay Road (PCC & State Government of WA, 1991).

Potential Contamination

The alignment will travel along William Street crossing St Georges Tce, Hay St, Murray St and Wellington Street before continuing along the existing rail reserve (Location Id 2, Photograph A).

A variety of materials have historically used for road base and road surface construction in Perth including clay, crushed rock, bitumen, wood blocks, blue metal and asphalt. Wood blocks may have been treated with creosote and oils prior to being laid to prevent pest attack and may have potentially contaminated the underlying soil and groundwater.

Albeit unlikely industrial waste may have been used as road base. Contaminants that may be present include metals, oils and grease as well as other industry specific substances.

Further Investigation Requirements

Boring will be used for tunnel construction along William Street section of the alignment. The tunnel will be a diameter height below the road surface. Construction workers are unlikely to be exposed to the historical road base or any remaining surface materials. Soil investigations do appear to be required.

Groundwater quality requires investigation to confirm it is not a health risk to construction workers and that dewatering discharge is suitable for disposal to the receiving environment.

4.1.4 Lake Kingsford

History

A linear chain of lakes was historically located at the northern end of the city (Figure 2). Lake Kingsford was at the site of the present railway station, and the railway goods yard was located over Lake Irwin (Location Id 3, Photograph A) (Bold, 1938).

The lakes were drained in 1854 using a brick drain which opened from Lake Kingsford in Wellington Street and discharged to Claise Brook. Lakes Irwin and Sutherland, being at higher level, were linked with Kingsford. Drainage opened at 5 feet above the bottom of the lake and the ground was filled to two feet above winter level (PCC, 1969). Anecdotal evidence suggests fill used in this area during railway construction was from cut areas of the alignment near Subiaco and Leederville.

Potential Contamination

Although anecdotal evidence suggests soil from railway cuts was used to fill the lakes area it cannot be discounted that some of the fill may have come from other sources such as industrial waste.

If uncontrolled fill used to reclaim land was associated with historical industrial sites (ie wastes disposed as fill) there is the potential it may be contaminated.

Further Investigation Requirements

Due to the uncertainty of the quality of fill used in this area investigations will be required to assess the contamination status of the soil. The requirement for groundwater investigations will depend upon the findings of the soil investigation program.

4.1.5 Railway Reserve

History

The railway to Fremantle was opened in 1881 (PCC and State Government of WA, 1991). Diesel locomotives replaced steam trains on the suburban line in the mid 1960s. In the early 1990s electric trains were introduced.

The area west of the train station historically contained marshalling yards, a carriage shed, parcel sheds, water tank and small worker's sheds likely to have been used as lunchrooms. The carriage shed was used for cleaning the inside of suburban carriages and was located in the northern section of the yard, close to Roe Street. The parcel sheds were located close to Wellington Street, where goods were loaded and unloaded. The site did not contain maintenance areas for carriages or locomotives, boiler shops or re-fueling facilities.

Wooden sleepers have historically been used for track construction. For a seven year period in the 1960s sleepers were treated with creosote. For a few years after this time a limited amount of sleepers were treated with a creosote/light oil/aldrin mix for termite protection. In the 1970s and early 1980s pressure treated creosote sleepers were purchased for use on the line.

The portion of railway reserve under consideration in this investigation is located between the Horseshoe Bridge and Milligan Street (Location Id 4, Photograph A).

Potential Contamination

The Department of Environmental Protection identifies railway yards as a potentially contaminating landuse (DEP, 2001). Common contaminant types associated with railway yards include:

- Total petroleum hydrocarbons
- Monocyclic aromatic hydrocarbons
- Phenols
- Metals
- Creosote
- Nutrients
- Carbamates
- Organochlorine pesticides
- Organophosphate Pesticides
- Herbicides

Since World War II (WWII), the Western Australian Government Railways (WAGR) has chemically controlled weeds within the rail reserve. Prior to WWII, weeds were removed manually or by burning. The herbicides historically used by WAGR are summarised as follows:

• Late 1940s to early 1960s	- Sodium chlorate
• Early 1960s to mid 1970s	- Amitrole/atrazine mixture
• Mid 1970s to late 1980s	- Amitrole/atrazine mixture
	- Bromoxynil
	- Diuron
	- Ethidimuron
• Late 1980s to present	- Sulfometuron-methyl (Oust)
	- Metsulfuron-methyl (Brushoff)
	- Glyphosate (Roundup)

WAGR annually rotates the application of Oust and Brushoff between the permanent way and railyards. Roundup is used for "touch-up" purposes, to eradicate weeds remaining after the application of Oust and Brushoff.

Other areas and sources of potential contamination at the site include the marshalling yard, waste disposal areas and wooden sleepers. Marshalling yards may contain traces of fuels and oils leaked from the trains. The disposal of waste from train operations, such as ash, may have potentially occurred at the site. There is the possibility that chemicals used to treat wooden sleepers including creosote, light oil and aldrin may have leached into the underlying soil.

Prior to 1965 train brakes were cast iron. Non-metallic brake shoes were introduced which contained a percentage of asbestos, which was bound in resin in the shoe. During activation of brakes, temperatures of the shoes are known to reach up to 800°C. At this temperature asbestos decomposes to the non-fibrous forsterite compound (silica bearing powder). Asbestos fibres remaining on-site are therefore considered unlikely.

Further Investigation Requirements

Further investigations are required to assess the presence of contamination, including metals, hydrocarbons and pesticides from historical activities within the rail reserve.

4.2 Industrial

4.2.1 General

The proposed alignment passes adjacent to the Jandakot Noxious Industry Area and the Mandurah Light Industrial Area south of Gordon Road. Both areas are upgradient in terms of groundwater flow from the alignment. The sources of potential contamination include the Mandurah Waste Water Treatment Plant and the soil blending area of "The Great Outdoors Landscape and Trade Centre". Details are summarised on Table 2 and described below.

4.2.2 Waste Water Treatment

History

The Mandurah Waste Water Treatment Plant (WWTP) has been in operation at the site since the late 1960s (Location Id 12, Photograph K). The plant was upgraded in the 1970s and the current system has been in place since 1985.

The treatment offered at the plant is extended aeration with secondary treatment for nutrient removal. The effluent is disposed to soakage ponds on-site and the sludge is dried on-site for disposal off-site. Previous systems in place at the treatment plant included trickle filtration to an offsite soak in the adjacent quarry on the western side of the plant. This is within the proposed alignment.

Potential Contamination

The Contaminated Sites Management Series (DEP, 2001) identifies the principal contaminants associated with sewage treatment plants as nutrients (nitrogen, phosphorus and potassium), metals (aluminium, arsenic, cadmium, chromium, cobalt, lead, nickel and zinc) and phenols.

Contaminants that occur at trace levels in sewage tend to concentrate in the sludge. Significant soil contamination is most likely to occur at the sludge pits and disposal areas but may extend to the effluent infiltration pits and channels.

Effluent disposed to the infiltration ponds may have penetrated through the soil profile and impaired local groundwater quality. Monitoring at the facility indicates that groundwater contains elevated nitrate concentrations.

Contaminants that may remain in soils at the site may infiltrate with rainfall and continue to impair groundwater quality at the site.

Further Investigation Requirements

Soil testing is required to investigate the possibility of contamination within the alignment. Groundwater investigations may also be required to confirm if contaminant concentrations beneath the alignment are elevated and require management.

4.2.3 <u>Soil Blending</u>

History

The eastern side of the landscape and trade centre contains a retail soil blending facility (Location Id 13, Photograph K). Soil stockpiles are located within the proposed alignment.

Potential Contamination

The potential contaminants associated with soil blending facilities are related to the source of the soil and peat. Peat may have come from areas surrounding wetlands which have historically been used for market gardening. Should this be the case metals and pesticides may potentially remain in the peat.

Soil generally poses less of a risk unless it has originated from demolition sites. If this is the case it may have been contaminated with metals associated with the decomposition of metallic products such as strapping wire, sheeting etc, or pesticides associated with historical treatment of soils beneath buildings against termites.

Further Investigation Requirements

The risk of soil or groundwater contamination from this facility impacting the proposed development appears low, although the presence of contamination cannot be discounted without further investigations. At this stage these investigations do not appear to be necessary due to the low risk involved and the type of development planned.

4.3 Agricultural

4.3.1 General

The proposed alignment passes through a number of former and active market gardens and a piggery. The sources of potential contamination identified in these areas are summarised in Table 3 and described below.

4.3.2 Intensive Horticulture - Market Gardens and Orchards

History

Four market gardens are located within the alignment. An historical summary of these areas is presented below.

Numerous market gardens exist between Berrigan Drive and North Lake Road in Jandakot (Location Id 7, Photograph D). Market gardens have occupied a number of lots throughout the subdivision since the late 1950s. Prior to this time the land was cleared and its historical use is unknown, although land in the Jandakot area, especially close to wetlands, was reported to have been used for market gardening since the late 1800s (Berson, 1978). The area within the alignment is now covered by the freeway.

Most active gardens on the eastern side of the freeway between Russell Road/Gibbs Road and Anketell Road, Banjup/Wandi (Location Id 8, Photographs E, F & G) were established in 1980s and some were present in the early 1970s. The area was uncleared in the mid 1960s.

Orchards and market gardens are present east of Ennis Avenue from Mandurah Road, Baldivis to south of Stakehill Road, Karnup (Location Id 9, Photograph H & I). This area was mostly uncleared in the mid 1960s. During the late 1960s the first market gardens were established directly south of Stakehill Road. During the 1970s, further gardens were established in the southern area. In the 1980s, the market garden and orchard off Mandurah Road was established. Most of the gardens remain active. A piggery was historically operated at Lot 24 but was converted to the present vineyard in the 1990s.

Market gardens are located on Mandurah Road, north of Paganoni Road, Karnup (Location Id 11, Photograph J). The north western corner of the garden was established prior to the mid 1960s. The central and south sections were established in the 1970s. The eastern section was established in the 1980s. Sheds and work areas are located adjacent to the petrol station in the north western corner of the site.

Potential Contamination

The principal contaminants of concern associated with horticulture are pesticides and trace metals from fertilisers. Organochlorine pesticides that were generally used before the 1980s such as DDT, dieldrin, heptachlor and chlordane, which may persist in soils for decades, are the most likely to occur in soils at potentially harmful levels. The pesticides used in the last twenty years typically biodegrade to negligible levels in less than one year.

Fertilisers may contain trace levels of metals, principally zinc and copper, which may concentrate to elevated levels in soils. Arsenic based herbicides may also have been historically used to control weeds. Trace metals are essentially non-biodegradable.

Contamination within market gardens and orchards is often most concentrated in soils at former chemical mixing and formulation areas and equipment washdown areas. In general, contaminant concentrations in gardens soils are substantially lower but may occur at significant concentrations in isolated patches.

Other potential sources of contamination include ancillary activities such as machinery storage, fuel storage and waste disposal areas.

The alignment traverses active market gardens surrounding Stakehilll Road (Location Id 9, Photographs H & I) and north of Paganoni Road (Location Id 11, Photograph J). Former market gardens occur within the alignment in Jandakot (Location Id 7, Photograph D) and Banjup/Wandi (Location Id 8, Photographs E, F & G). Contaminant concentrations that occur in garden bed soils rarely exceed levels that would be harmful to construction workers. The risk of contaminants occurring at harmful levels requiring remediation is greatest at the three properties surrounding Stakehill Road and one north of Paganoni Road within the alignment where chemical storage, mixing and ancillary activities may have occurred.

Local groundwater quality may have been impacted by historical market garden operations throughout extensive areas around the alignment. The risk of groundwater contamination would increase with decreasing depth to the water table.

Further Investigation Requirements

Soil quality investigations are required within sections of the alignment that have historical horticulture activities. The investigations should focus on the chemical storage and formulation areas suspected to occur within the alignment at Lot 29 Stakehill Road and Lots 23 and 24 Fletcher Road.

4.3.3 Intensive Piggery

History

A piggery was historically located on Lot 24 Fletcher Road, Karnup (Location Id 10, Photograph I) operated from the 1970s to the 1990s. The site is currently a vineyard.

Potential Contamination

Although unlikely, historical pesticide and fertiliser applications to the piggery paddocks may have contaminated soils with trace metals and organochlorine based pesticides. Depending upon feeding supplements, pig manure may contain high concentrations of trace metals.

Other sources of potential contamination associated with piggeries include:

- Trace metal contamination at swill tanks where boiling of swill may have led to degradation of the metal tanks and contamination of the underlying soil. Polycyclic aromatic hydrocarbons (PAH) may also be present from incomplete combustion.

- Manure stockpiles which can contain elevated concentrations of nutrients and trace metals associated with feed supplements.

- Unlined wastewater ponds where wash water from daily shed cleaning may have been disposed. This water is likely to contain manure, urine and spilt feed. Piggery wastewaters typically contain elevated concentrations of nutrients, dissolved organics and possibly trace metals.

- Stockyards where pesticide treatment, such as lice control sprays etc, may have been applied to the animals.

Three sheds at the piggery are located within the proposed railway alignment. It is likely that potential contamination associated with the piggery is located in the vicinity of the sheds.

The piggery is identified by the Water and Rivers Commission as a potential source of groundwater contamination.

Further Investigation Requirements

Potential soil contamination investigations are required to determine if contamination occurs within the proposed alignment.

4.4 Other

4.4.1 General

The proposed alignment extends over a petrol station, two waste disposal areas and along the reclaimed foreshore of the Swan River. The sources of potential contamination identified in these areas are summarised in Table 4 and described below.

4.4.2 Uncontrolled Filling

History

The Freeway Reserve from the Narrows Bridge to Canning Highway (Location Id 5, Photograph B) is situated on reclaimed land. Dredge spoil was historically used for the majority of the reclamation.

Reclamation of the foreshore north of the Royal Perth Golf Club to Mill Point began in 1935. A stone retaining wall was constructed at the western edge of the reclamation area and progressively filled with dredge sand from the ferry channels. The fill levels were up to 3 feet deep. In 1938 Millers Pool at the northern end of Mill Point was also filled. Further use of dredge soil for reclamation included:

- South Perth Foreshore (1935-1941)
- Mill Point (1956)
- Kwinana Freeway (1958-1960 & 1969)
- Canning Bridge Embankment (1959)
- Como Sea Scouts (1969)
- Como Foreshore (1972)

Construction of the Narrows Bridge commenced in 1952. The bridge and freeway to Canning Highway were officially opened in 1959. The freeway was constructed on reclaimed land and natural river foreshore.

Potential Contamination

Potential contamination associated with uncontrolled filling, particularly from river dredge spoil is described in Section 4.1.2. Dredge spoil from the river may contain contaminant levels exceeding environmental or human health guidelines.

Further Investigation Requirements

Due to the change in land use proposed, further investigation of the potential contamination in this area does not appear warranted.

4.4.3 Petrol Station

History

A petrol station (Location Id 6, Photograph C) was historically located on Canning Highway, Como. The station was removed to allow the construction of the Kwinana Freeway extension in the late 1970s.

Potential Contamination

The leakage and spillage of fuels and chemicals may contaminate soils and groundwater at petrol stations. Contaminants of concern include:

- Metals – including barium, cadmium, copper, lead, nickel and zinc
- Petroleum hydrocarbons
- Monocyclic aromatic hydrocarbons (MAH)
- Polycyclic aromatic hydrocarbons (PAH)
- Chlorinated hydrocarbons
- Phenols
- Oil and grease

Albeit unconfirmed it is anticipated that fuel tanks were removed from the Como petrol station when it was demolished. It is uncertain if the soil quality beneath the tanks was investigated or remediated.

Further Investigation Requirements

The freeway has been constructed over the petrol station. Further investigation of potential contamination associated with the construction of the railway is expected to be minimal, especially since the concrete slab surface of the railway will prevent groundwater infiltration.

4.4.4 Landfills and Waste Disposal

History

Anecdotal evidence suggests a former landfill was historically located between the light industrial area and the greyhound track (Location Id 14, Photograph K) within the area currently used by "The Great Outdoors" for soil blending, which is located in the proposed alignment. It is understood the landfill was operated approximately 20 years ago by the City of Mandurah. Waste disposal at the site has been described as uncontrolled.

The road reserve north of Carleton Place, Greenfields is currently used for uncontrolled waste disposal (Location Id 15, Photograph K). The reserve forms part of the proposed alignment. The following items were identified in the reserve during site inspection:

- Building Rubble
- Limestone Rubble
- Disused Storage Tanks
- Steel Frames
- Concrete Pipes
- Domestic Waste

Potential Contamination

Potential contaminants from uncontrolled landfills identified by the Department of Environmental Protection (DEP, 2001) include:

- Polychlorinated biphenols
- Alkanes
- Sulphides
- Heavy metals
- Organic acids
- Nutrients
- Total petroleum hydrocarbons
- Polycyclic aromatic hydrocarbons
- Ammonia
- Landfill Gas
- Total dissolved solids

Landfills generate greater volumes of leachate in the initial waste decomposition phase. As a landfill ages after site closure the impact on the underlying groundwater reduces. Methane generation also declines over time. Additional issues with regard to construction upon landfills include subsidence and stability.

Waste disposal within the road reserve creates potential for soil contamination to have occurred from the disposal of uncontrolled waste. Contamination is likely to be principally restricted to the uncontrolled fill.

Further Investigation Requirements

Further site investigation is required to assess the contamination status and remedial requirements within the former Mandurah landfill and uncontrolled fill within the reserve.

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5.0 FURTHER WORK REQUIREMENTS

The PSI has identified the following areas of potential contamination within the proposed alignment:

- Perth City Rail Reserve, including former area of Lake Kingsford
- Perth Foreshore where dredge spoil has been historically placed
- Market Gardens in Stakehill
- Former piggery in Stakehill
- Paganoni Road Market Garden
- Former infiltration basins adjacent to the Mandurah Wastewater Treatment Plant
- Former Uncontrolled Landfill and Disused Road Reserve in Mandurah

Consistent with the DEP guidance the results of this phase will be reviewed to define the requirement and scope for any following phases. It is proposed to assess identified potential contamination at the above areas in accordance with the site contamination assessment process described in DEP Contaminated Sites Management Series (Figure 4). The next assessment phase will involve site specific PSIs for each of the identified areas. The scope of the PSIs will include:

- Site specific inspections
- Further consultations with persons knowledgeable of site histories
- A targeted soil sampling and analysis program for the potential contaminants

In addition it is proposed to investigate groundwater quality where dewatering is required for the construction of the Perth City Tunnel. The bores installed to monitor water levels during the dewatering program will be sampled for potential contaminants. A groundwater sampling and analysis program will be developed in consultation with the DEP.

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TABLES

Table 1
Areas / Sources of Potential Contamination in the Perth CBD

Name	Reference Details		Description	Location	Distance to Alignment	Environmental Characteristics		Potential Contaminants	Potential Contamination		Further Investigation Required
	Location Identification	Photograph Reference				Soil Type	Depth to Groundwater		Soil	Groundwater	
Perth Foreshore Reclaimed Land	1	A	Uncontrolled Filling	Perth Foreshore	Within	Fill above Estuarine sediments	<1-6 mbgl	• Metals • Oil and Grease	I	I	Yes
Historical Roads	2	A	Historical Road Construction Materials	William Street and cross overs on St Georges Tce, Hay St, Murray St & Wellington St	Within	Spearwood sands	<1-6 mbgl	• Metals • Oil and Grease (including Creosote)	I	I	Yes
Lake Kingsford Reclaimed Land	3	A	Uncontrolled Filling	North of Wellington Street	Within	Fill above wetland sediments	Approx. 2 mbgl	• Metals • Oil and Grease	I	I	Yes
Rail Reserve	4	A	Steam and Electric Train Rail Reserve	North of Wellington Street	Within	Fill above wetland sediments	Approx. 2 mbgl	• Total petroleum hydrocarbons • Monocyclic aromatic hydrocarbons • Phenols • Metals • Creosote • Nutrients • Carbamates • Organochlorine pesticides • Organophosphate Pesticides • Herbicides	I	I	Yes

Table 2
Areas / Sources of Potential Contamination from Industrial Land Uses

Name	Reference Details		Description	Location	Distance to Alignment	Environmental Characteristics		Potential Contaminants	Potential Contamination		Further Investigation Required
	Location Identification	Photograph Reference				Soil Type	Depth to Groundwater		Soil	Groundwater	
Mandurah Waste Water Treatment Plant (WWTP)	12	K	Waste Water Treatment Plant former infiltration basins.	Gordon Road, Mandurah	Adjacent (infiltration within)	Spearwood Sand (Cottesloe Complex)	6-12 mbgl	• Nutrients including phosphorus, potassium and nitrogen. • Heavy metals including aluminium, arsenic, cadmium, chromium, cobalt, lead, nickel and zinc • Phenols	I	K	Yes
The Great Outdoors Landscape and Trade Centre	13	k	Soil Blending Facility	Quarry Way, Mandurah	Within	Spearwood Sand (Cottesloe Complex)	6-12 mbgl	• Metals • Pesticides	I		No

Table 3
Areas / Sources of Potential Contamination from Agricultural Land Uses

Name	Reference Details		Description	Location	Distance to Alignment	Environmental Characteristics		Potential Contaminants	Potential Contamination		Further Investigation Required
	Location Identification	Photograph Reference				Soil Type	Depth to Groundwater		Soil	Groundwater	
Market Gardens	7	D	Intensive Horticulture	Opposite the Jandakot industrial area	Within	Bassendean Sands	0-2mbgl	• Metals including aluminium, arsenic, cadmium, copper, iron, lead, magnesium, mercury • Organochlorine pesticides • Organophosphate pesticides • Carbamates	I	I	No
Market Gardens	8	E, F & G	Intensive Horticulture	Adjacent of Freeway between Russell Road and Thomas Road	Within	Bassendean Sands	<1-10 mbgl	• Metals including aluminium, arsenic, cadmium, copper, iron, lead, magnesium, mercury • Organochlorine pesticides • Organophosphate pesticides • Carbamates	I	I	No

Table 3 Continued

Name	Reference Details: Location Identification	Reference Details: Photograph Reference	Description	Location	Distance to Alignment	Environmental Characteristics: Soil Type	Environmental Characteristics: Depth to Groundwater	Potential Contaminants	Potential Contamination: Soil	Potential Contamination: Groundwater	Further Investigation Required
Orchards and Market Gardens	9	H & I	Intensive Horticulture (Sheds located within proposed alignment)	Surrounding Stakehill Rd, Baldivis & Karnup	Within	Karrakatta / Cottesloe / Herdsman Soils	2-35 mbgl	• Metals including aluminium, arsenic, cadmium, copper, iron, lead, magnesium, mercury • Organochlorine pesticides • Organophosphate pesticides • Carbamates	I	I	Yes (Lots 23, 24 & 29)
Former Piggery	10	i	Intensive Agriculture – Piggery	Fletcher Rd, Karnup	Within	Karrakatta Sand	Approx 2mbgl	• Pesticides • Nitrates • Metals • Nutrients including nitrogen and phosphorus	I	I	Yes
Market Garden & Floriculture	11	j	Intensive Horticulture	North of Paganoni Rd, Karnup	Within	Karrakatta Sand	3-6 mbgl	• Metals including aluminium, arsenic, cadmium, copper, iron, lead, magnesium, mercury • Organochlorine pesticides • Organophosphate pesticides • Carbamates	I	I	Yes

Table 4
Areas / Sources of Potential Contamination from Other Land Uses

Name	Reference Details		Description	Location	Distance to Alignment	Environmental Characteristics		Potential Contaminants	Potential Contamination		Further Investigation Required
	Location Identification	Photograph Reference				Soil Type	Depth to Groundwater		Soil	Groundwater	
Freeway Reclaimed Land	5	B	Uncontrolled Filling	Kwinana Freeway Between the Narrows and Canning Bridge	Within	Fill over Karrakatta and Bassendean sands	<1 mbgl	• Metals • Oil and Grease	I	I	No
Former Petrol Station	6	C	Fuel Storage	Kwinana Freeway/ Canning Highway, Como	Potentially Within	Bassendean sand	<1 mbgl	• Metals including lead, zinc, copper, nickel, cadmium and barium • Total Petroleum Hydrocarbons • Monocyclic Aromatic Hydrocarbons • Polycyclic Aromatic Hydrocarbons • Chlorinated Hydrocarbons • Phenols • Oil and Grease	I	I	No

Table 4 Continued

Name	Reference Details		Description	Location	Distance to Alignment	Environmental Characteristics		Potential Contaminants	Potential Contamination		Further Investigation Required
	Location Identification	Photograph Reference				Soil Type	Depth to Groundwater		Soil	Groundwater	
Former City of Mandurah Landfill	14	K	Abandoned Landfill	Quarry Way, Mandurah	Within	Cottesloe soil	6-12 mbgl	• Polychlorinated biphenols • Alkanes • Sulphides • Heavy metals • Organic acids • Nutrients • Total petroleum hydrocarbons (TPH) • Polycyclic aromatic hydrocarbons • Ammonia • Landfill Gas • Total dissolved solids	I	I	Yes
Disused Road Reserve	15	K	Uncontrolled Waste Disposal	Quarry Way, Mandurah	Within	Cottesloe soil	6-12 mbgl	• Polychlorinated biphenols • Alkanes • Sulphides • Heavy metals • Organic acids • Nutrients • Total petroleum hydrocarbons (TPH) • Polycyclic aromatic hydrocarbons • Ammonia • Landfill Gas • Total dissolved solids	I	I	Yes

FIGURES

Figure 1

Alignment Location

Source: PURD & DPI, 2002

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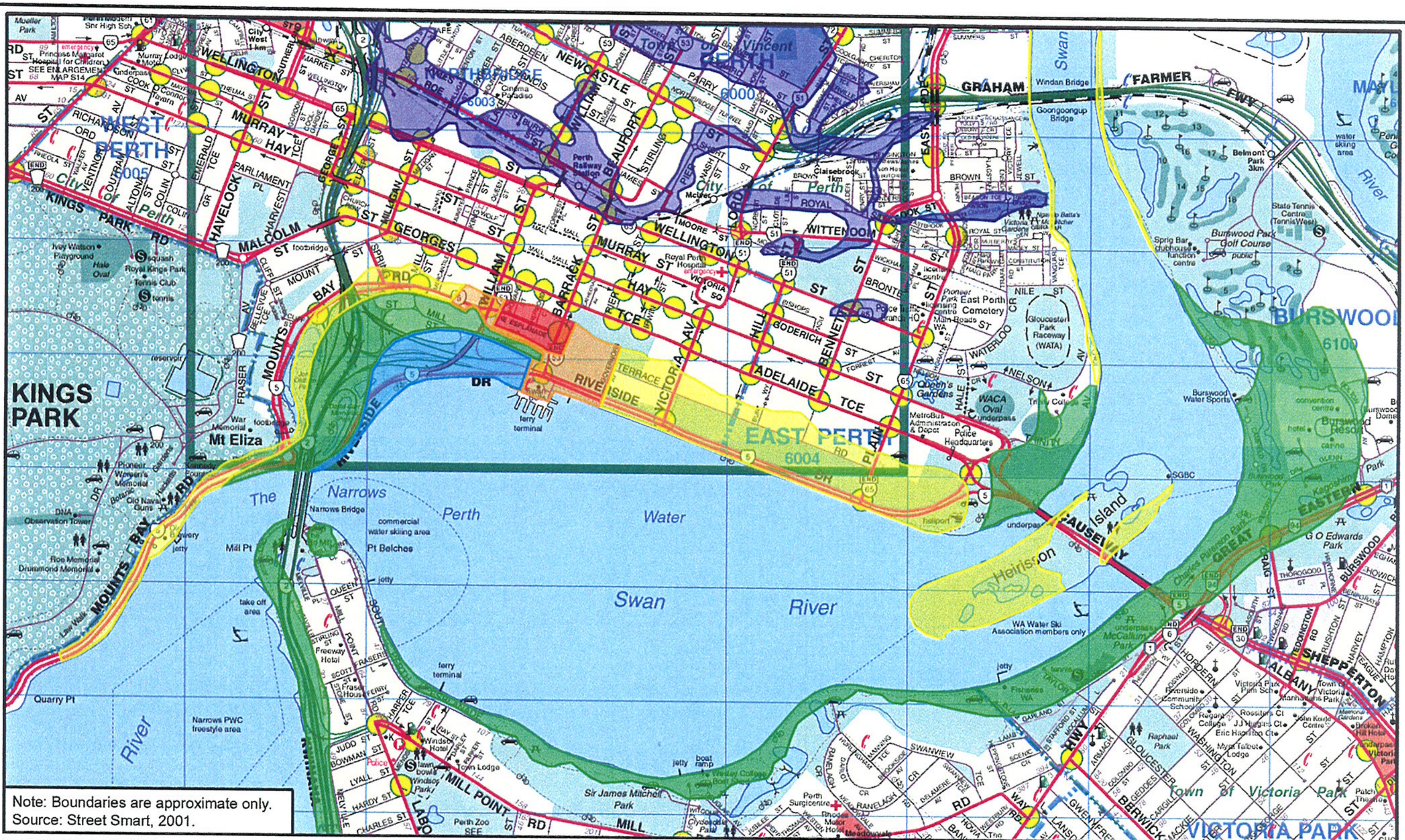

LEGEND
- Lakes and swamps drained prior to 1883

YEAR OF RECLAMATION AREA
- Reclamation area in 1883
- Reclamation area in 1903
- Reclamation area from 1921 to 1935
- Reclamation area from 1955 to 1960
- Reclamation area from 1963 to 1967

N

0 300 900 1500m

Figure 2

Original Lakes and Reclamation Areas of Perth

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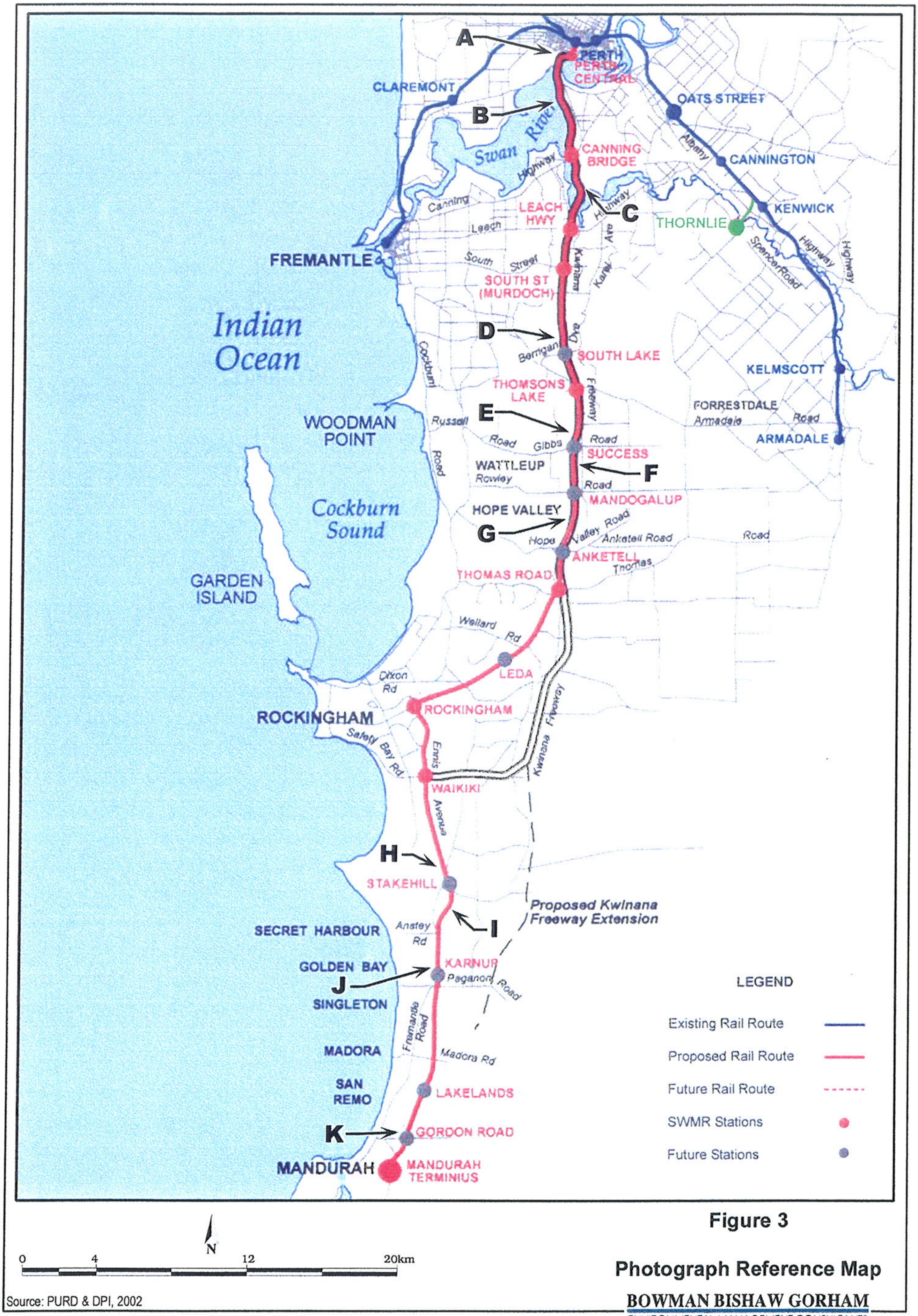

Figure 3

Photograph Reference Map

Source: PURD & DPI, 2002

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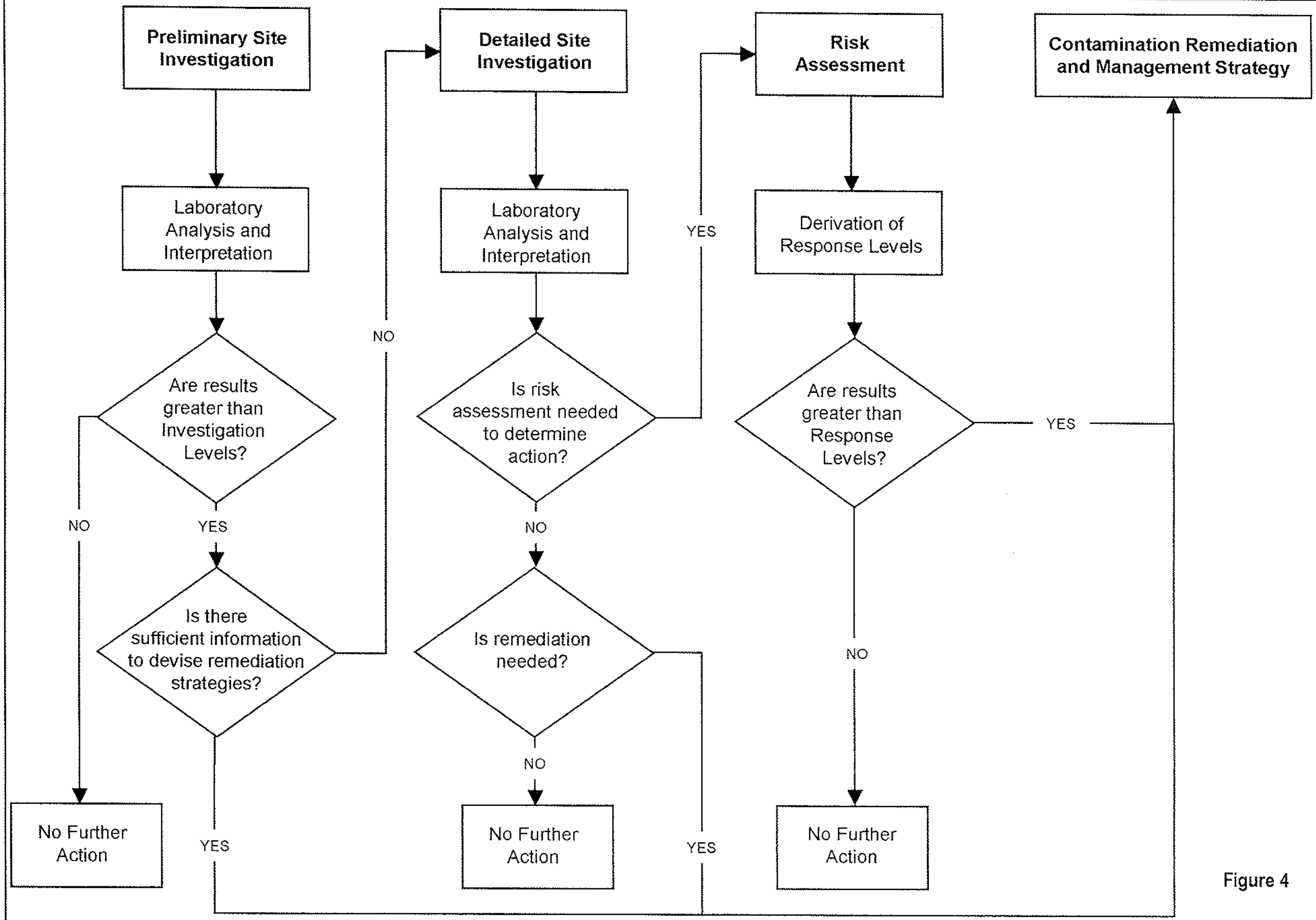

Figure 4

Site Contamination Assessment Process (DEP, 2001)

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PHOTOGRAPHS

Photograph A

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Photograph B

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Photograph C

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Photograph D

BOWMAN BISHAW GORHAM
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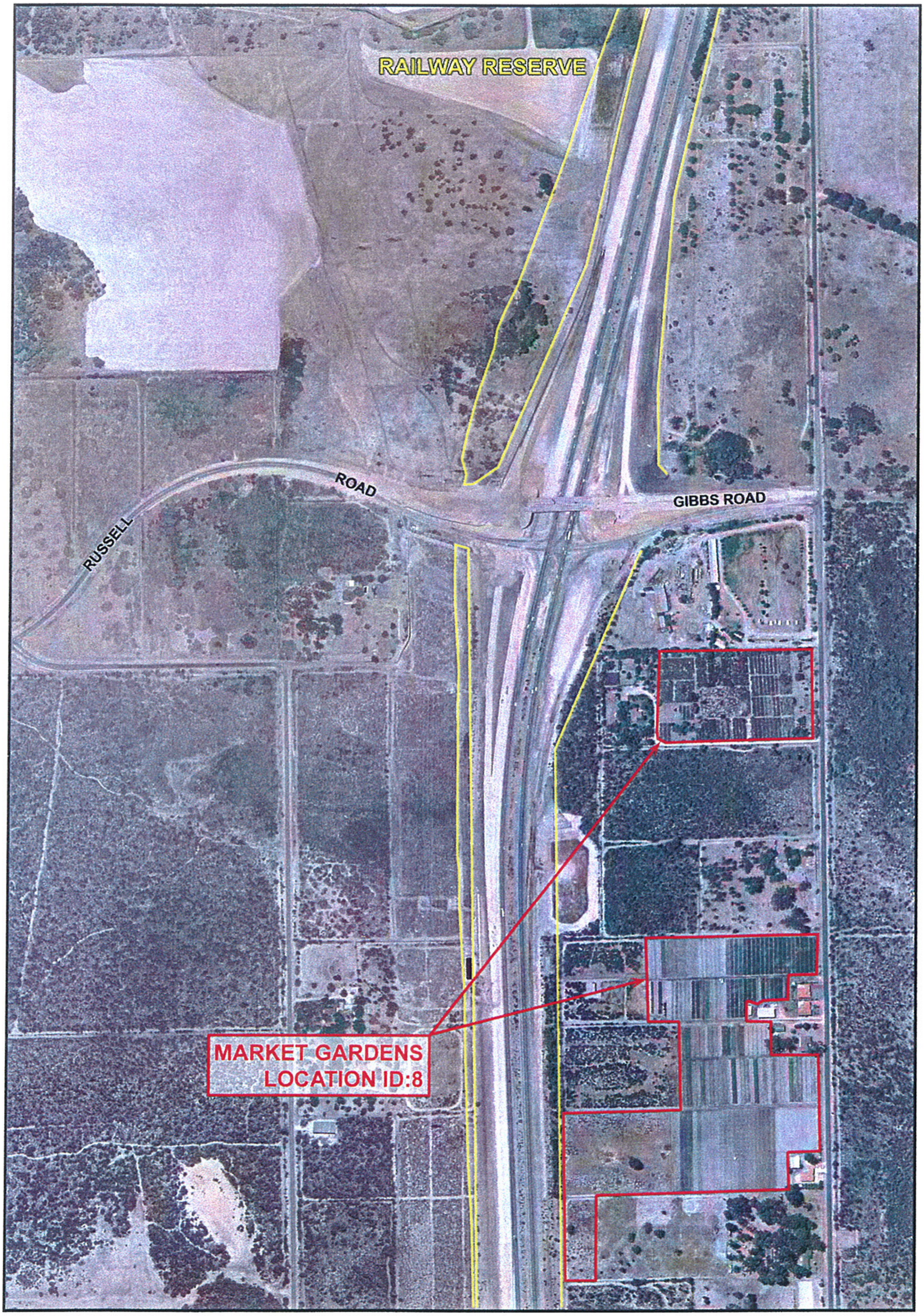

N

0 100 300 500m

Photograph E

BOWMAN BISHAW GORHAM
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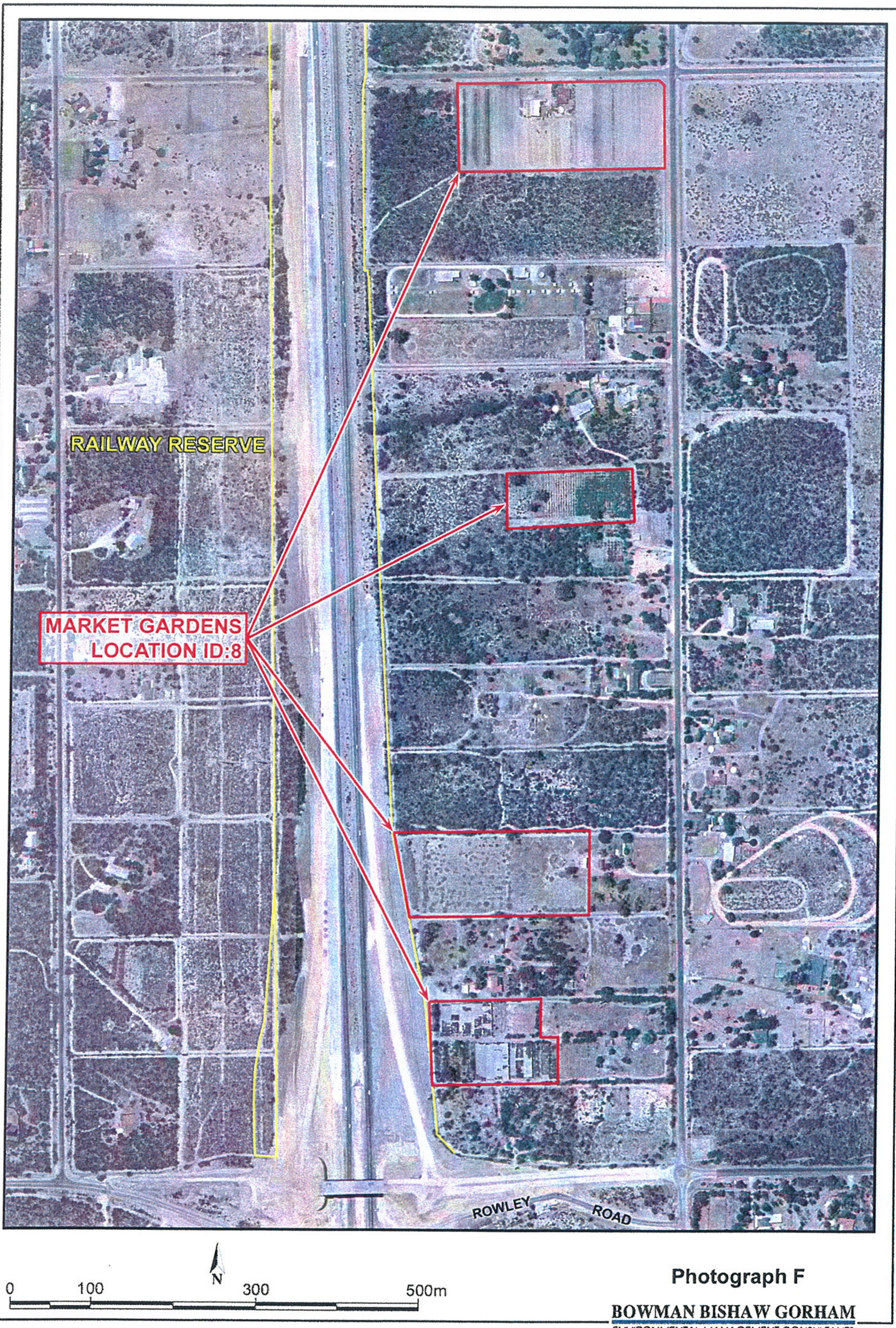

Photograph F

BOWMAN BISHAW GORHAM
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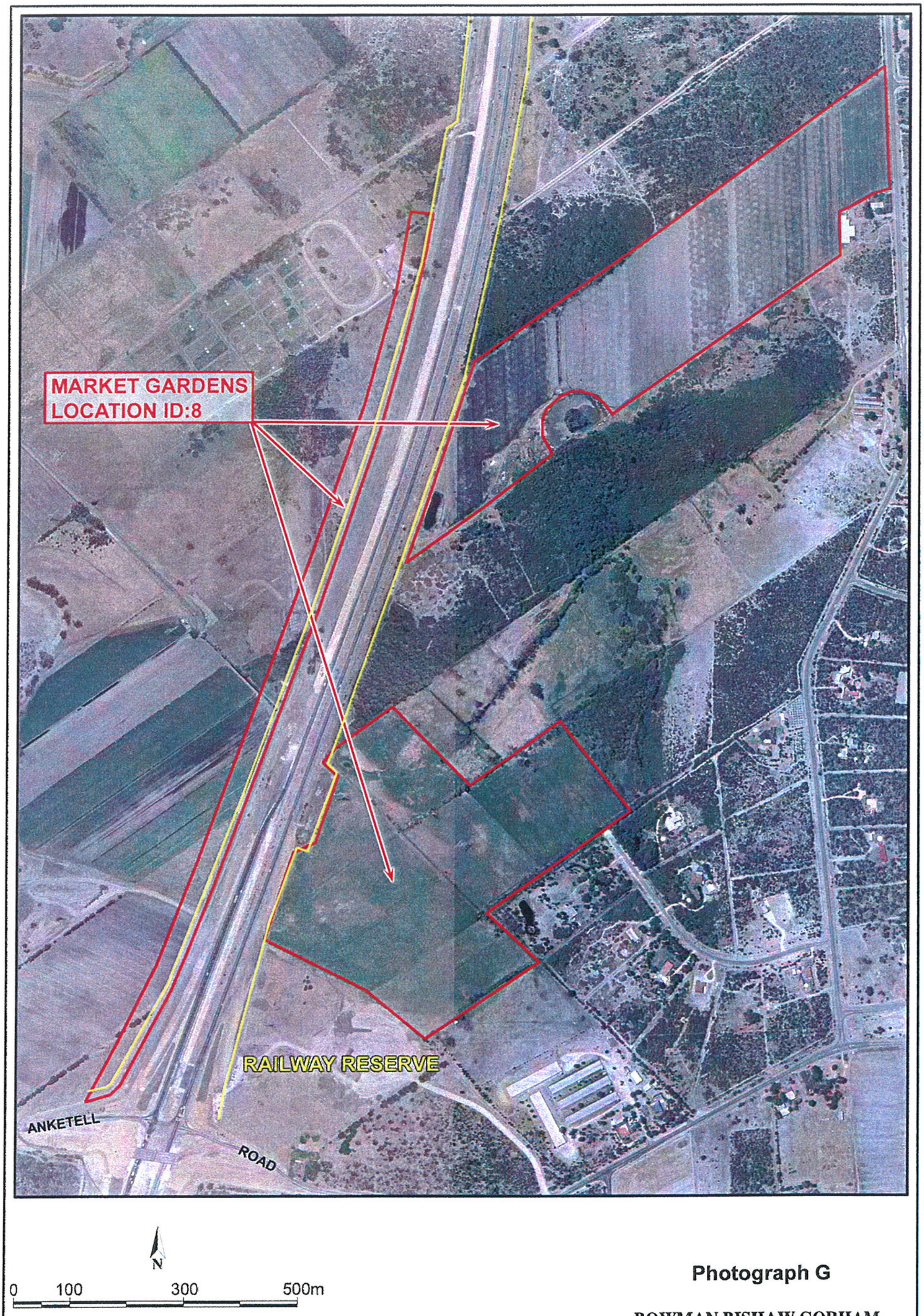

Photograph G

BOWMAN BISHAW GORHAM
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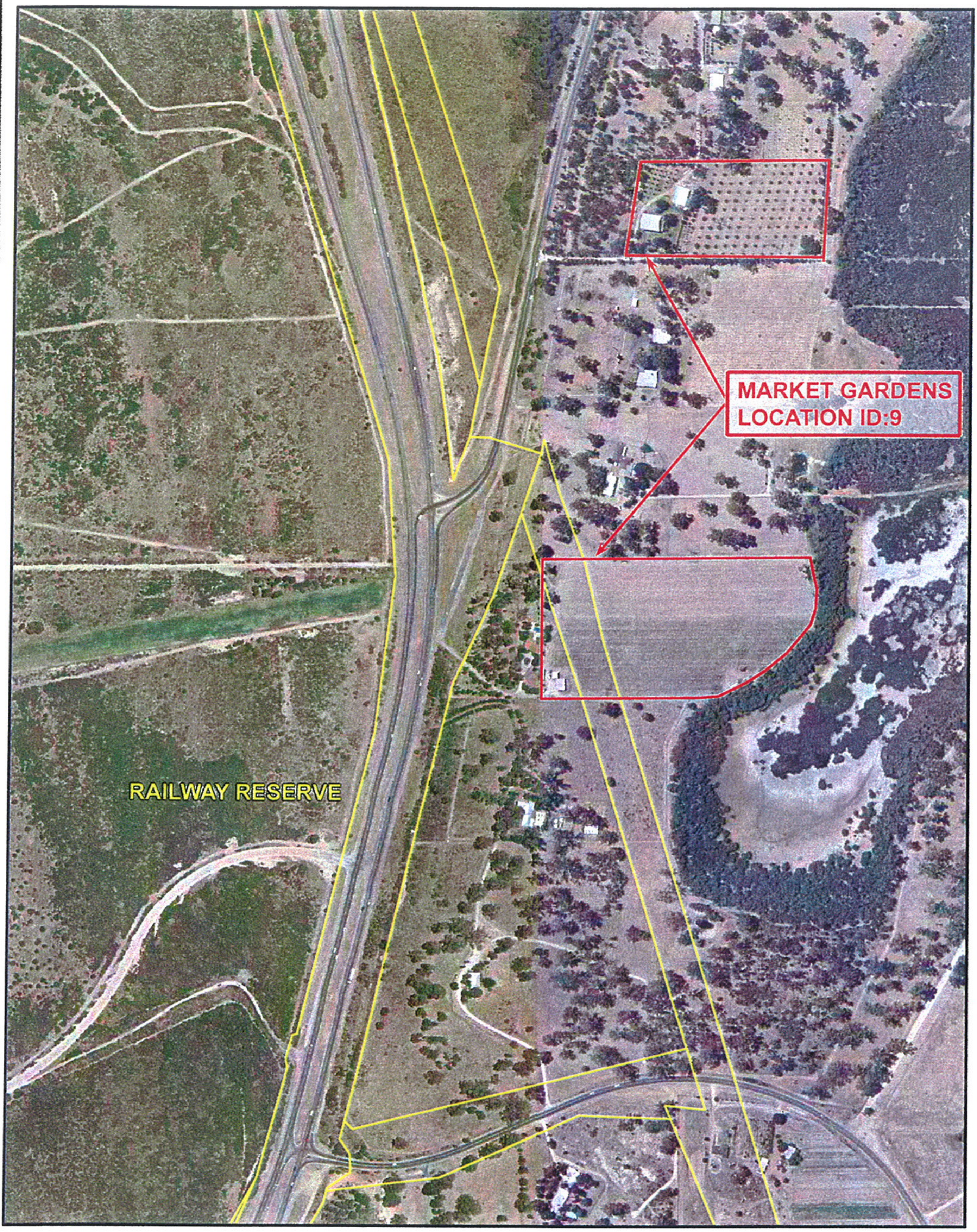

Photograph H

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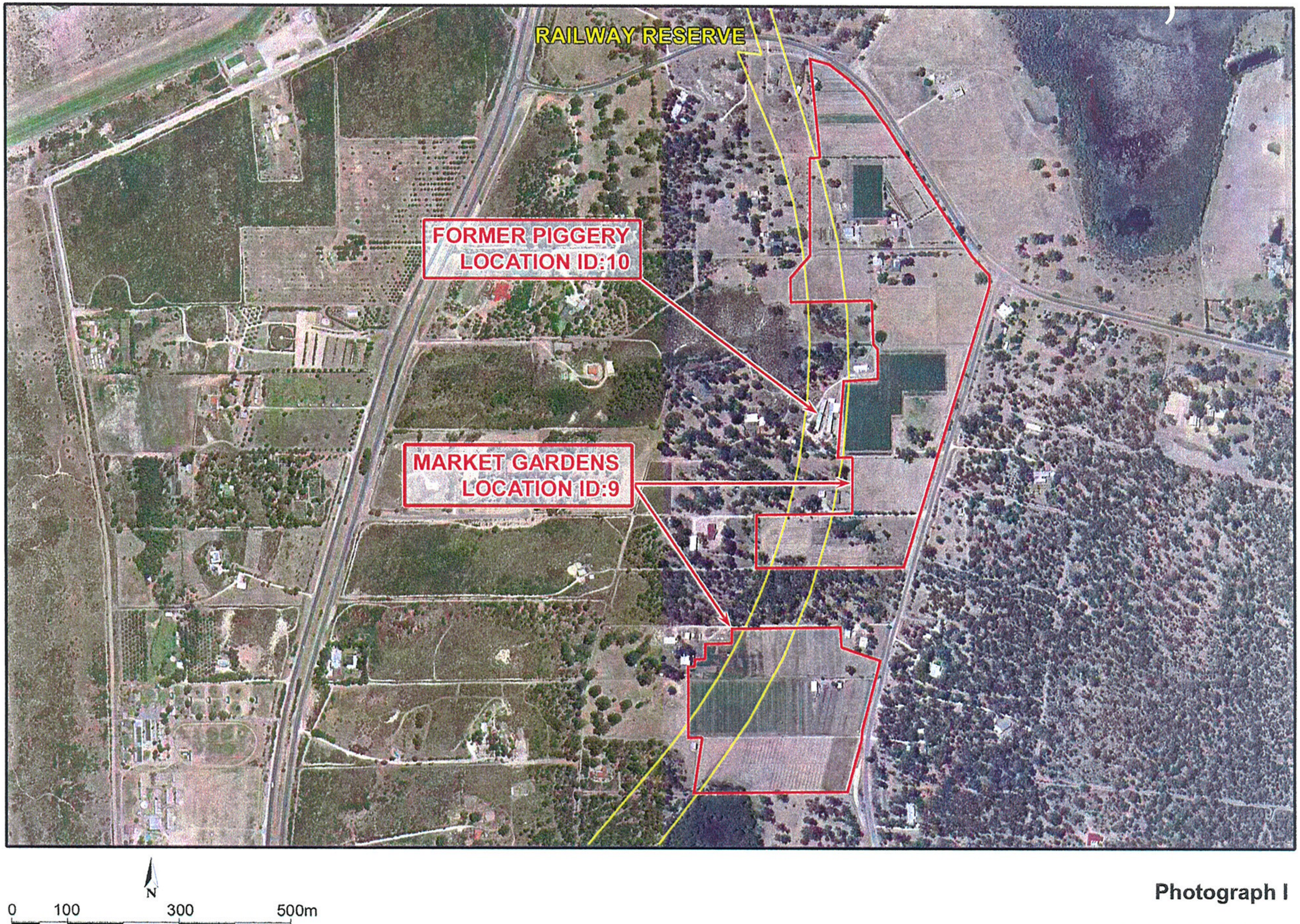

Photograph I

BOWMAN BISHAW GORHAM
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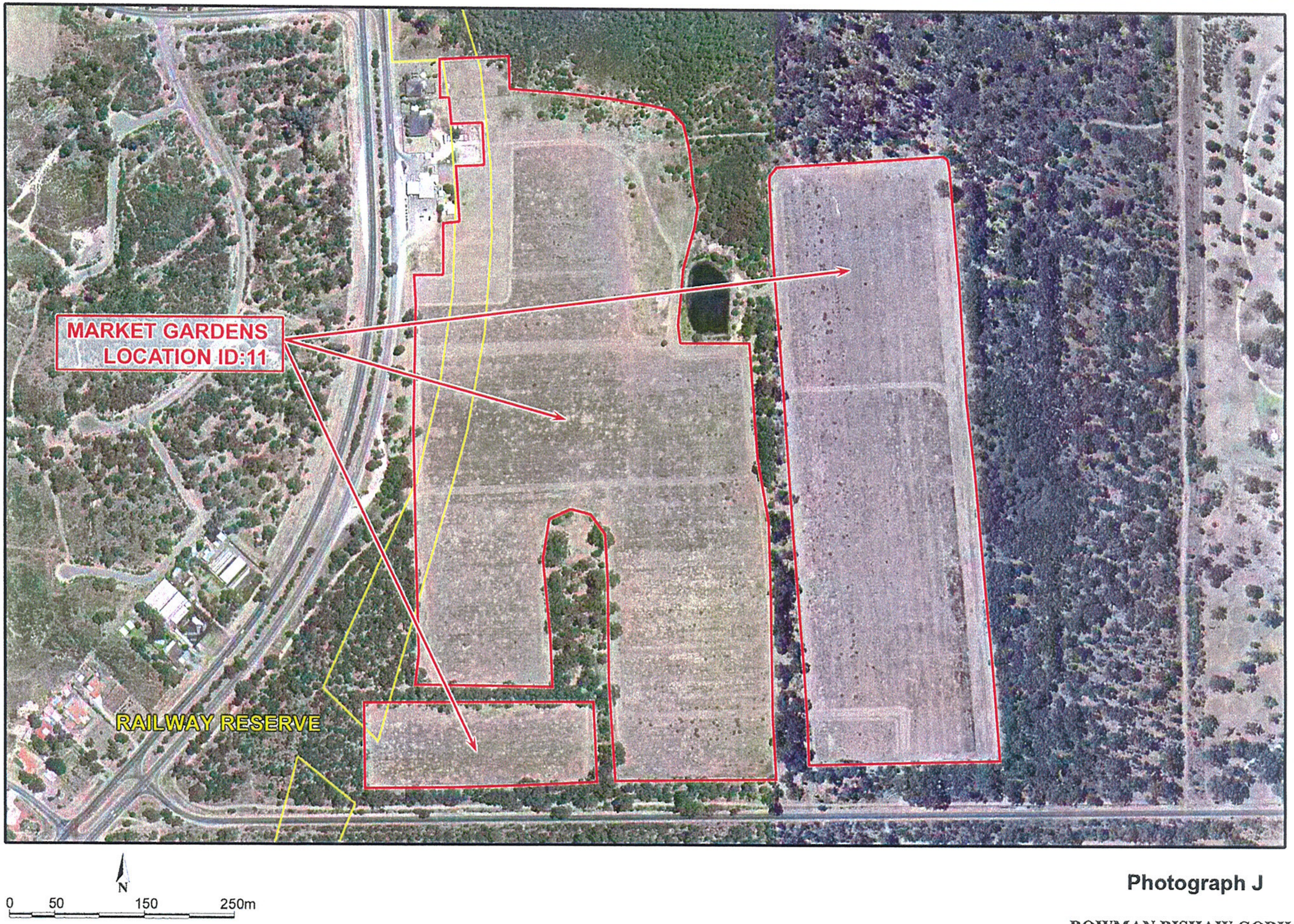

Photograph J

BOWMAN BISHAW GORHAM
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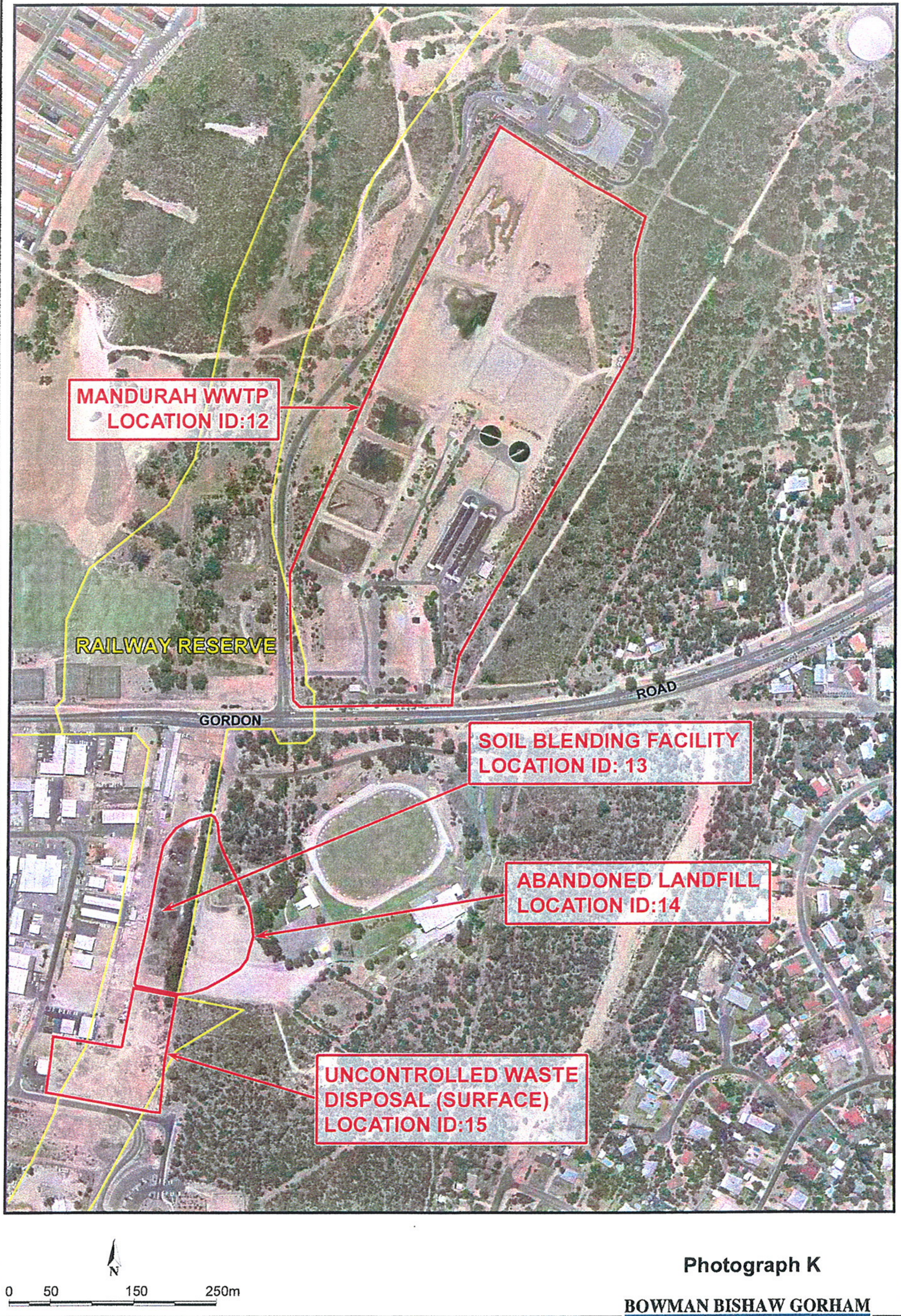

Photograph K

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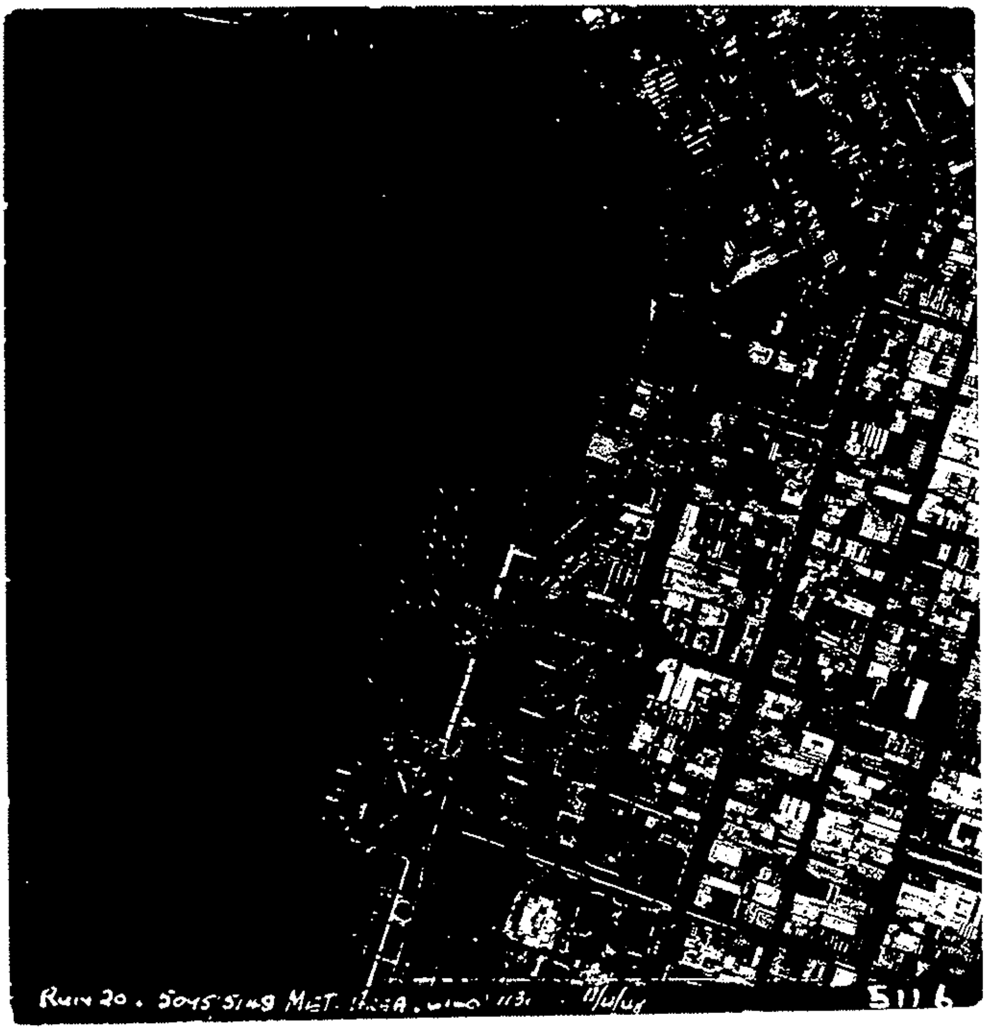
ATTACHMENT 1

HISTORICAL AERIAL PHOTOGRAPHS

Perth Foreshore

N 15.2.47

(Location Id 1)



Perth Foreshore

N ▷ 13.4.48

(Location Id 1)

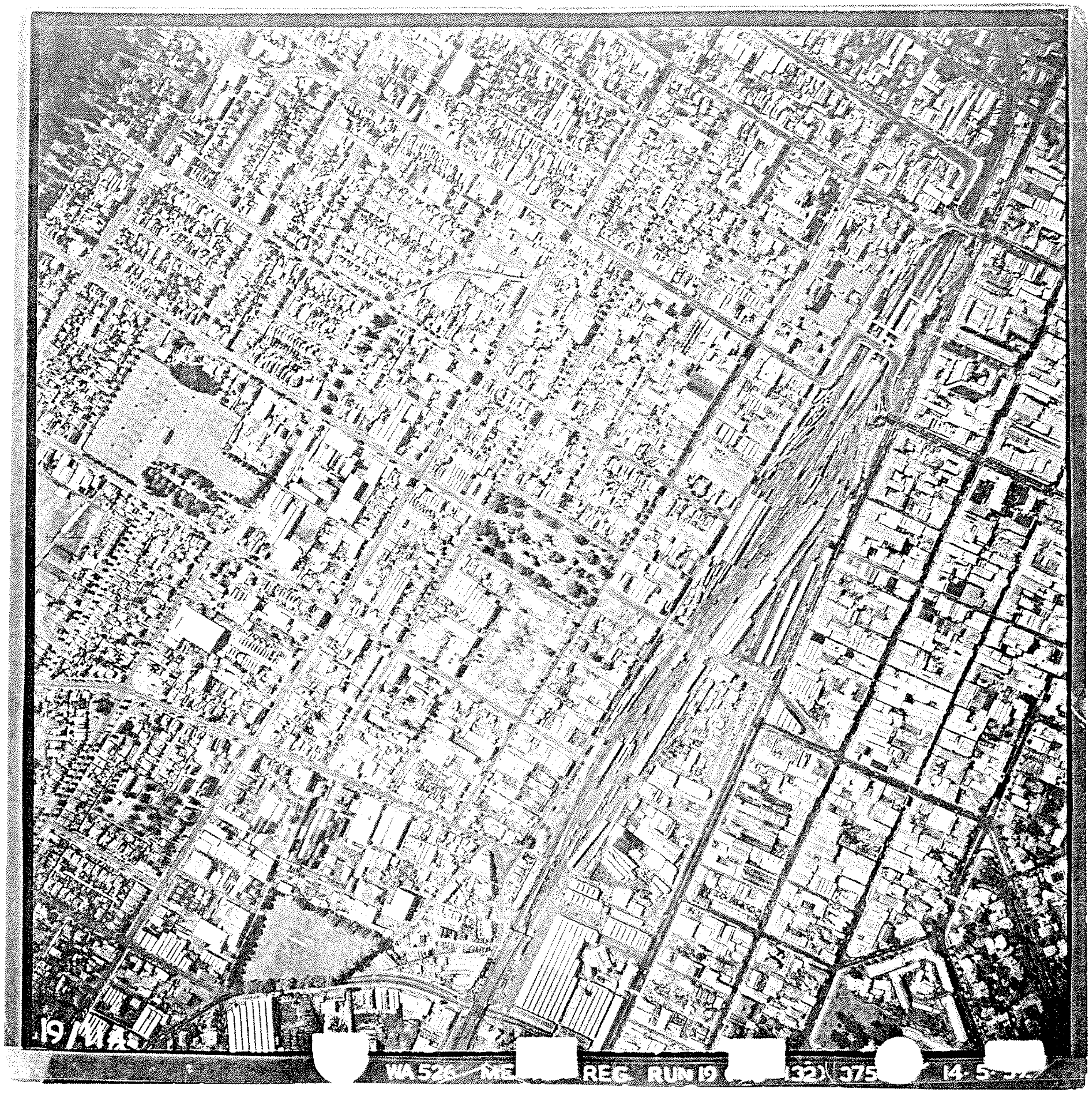
N

Perth City and Narrows Bridge
30.10.53
(Location Id 1 to 5)

Perth City and Narrows Bridge

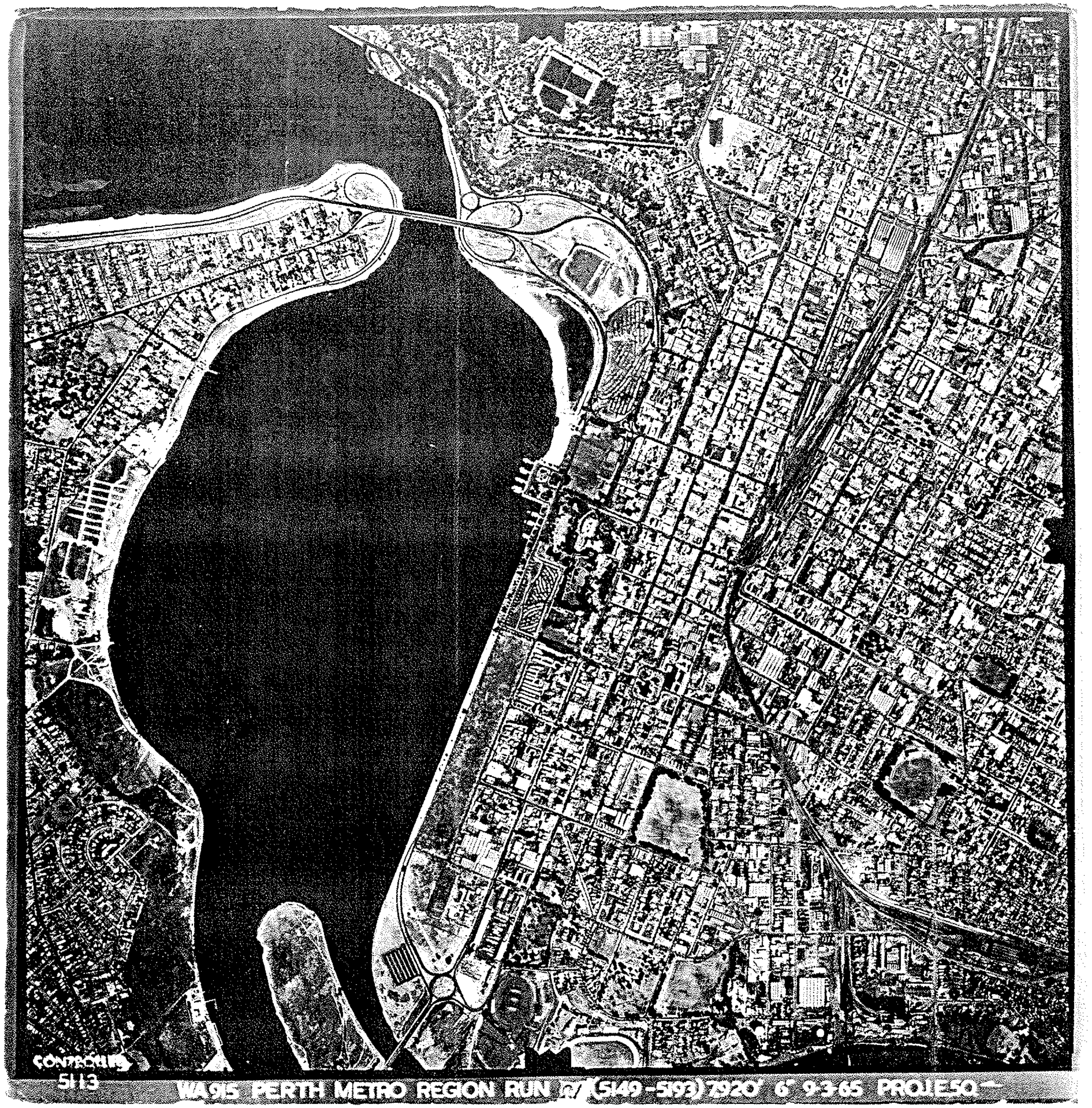
N ▷ June 1959

(Location Id 1 to 4)



N

Perth City Rail Reserve
14.5.59
(Location Id 3 and 4)



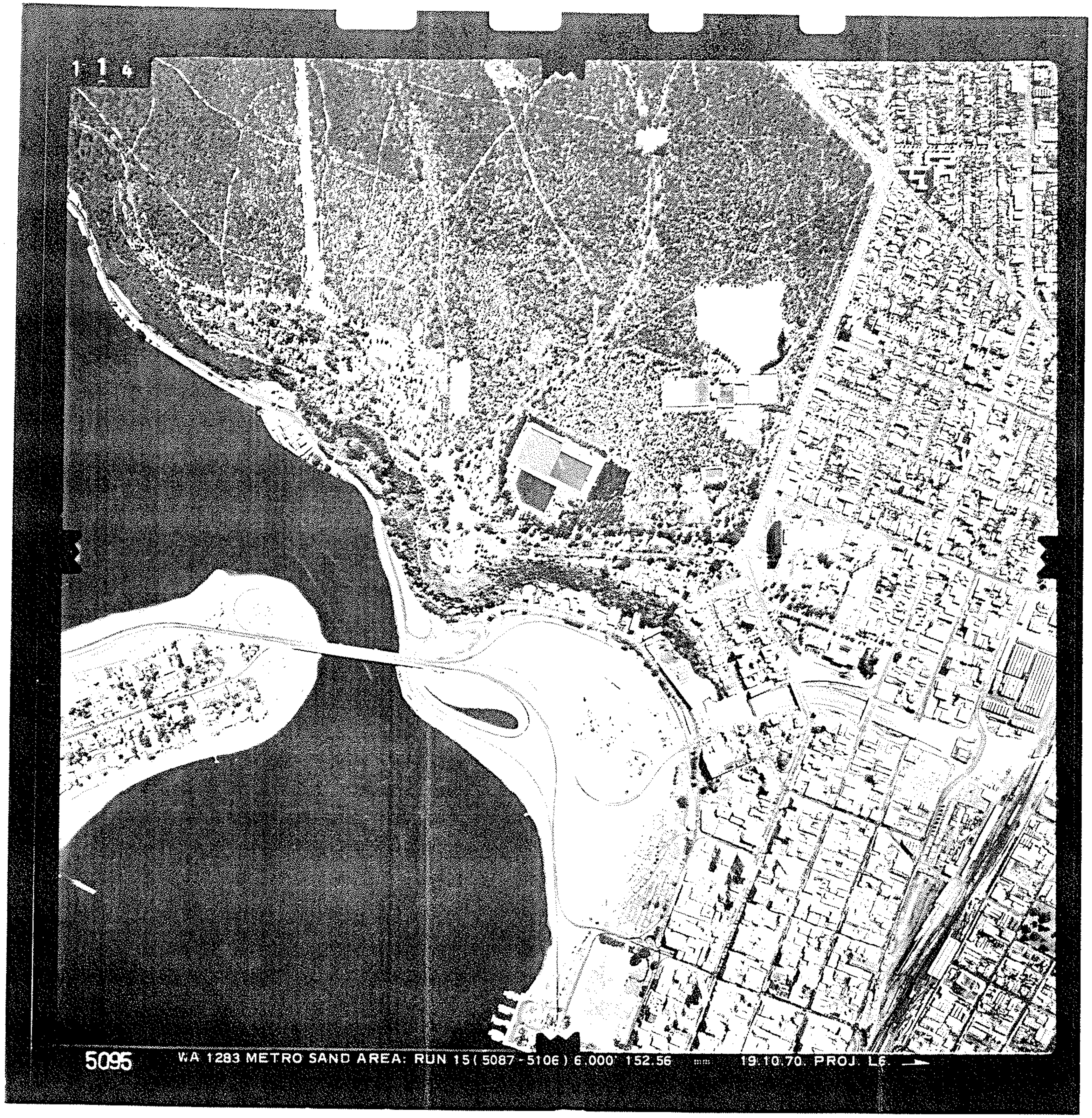
N

Perth City and Narrows Bridge
9.3.65
(Location Id 1 to 5)

Perth City and Narrows Bridge

N ▷ 19.10.70

(Location Id 1 to 5)



N

Perth City and Narrows Bridge
11.6.75
(Location Id 1 to 5)

N

Perth City and Narrows Bridge
12.6.80
(Location Id 1 to 5)

N

Perth City and Narrows Bridge
20.12.89
(Location Id 1 to 5)

N

Perth City and Narrows Bridge
20.4.85
(Location Id 1 to 4)

N

Perth City and Narrows Bridge
2.1.96
(Location Id 1 to 5)

N

Canning Bridge
June 1959
(Location Id 5 and 6)

South Lake Market Gardens

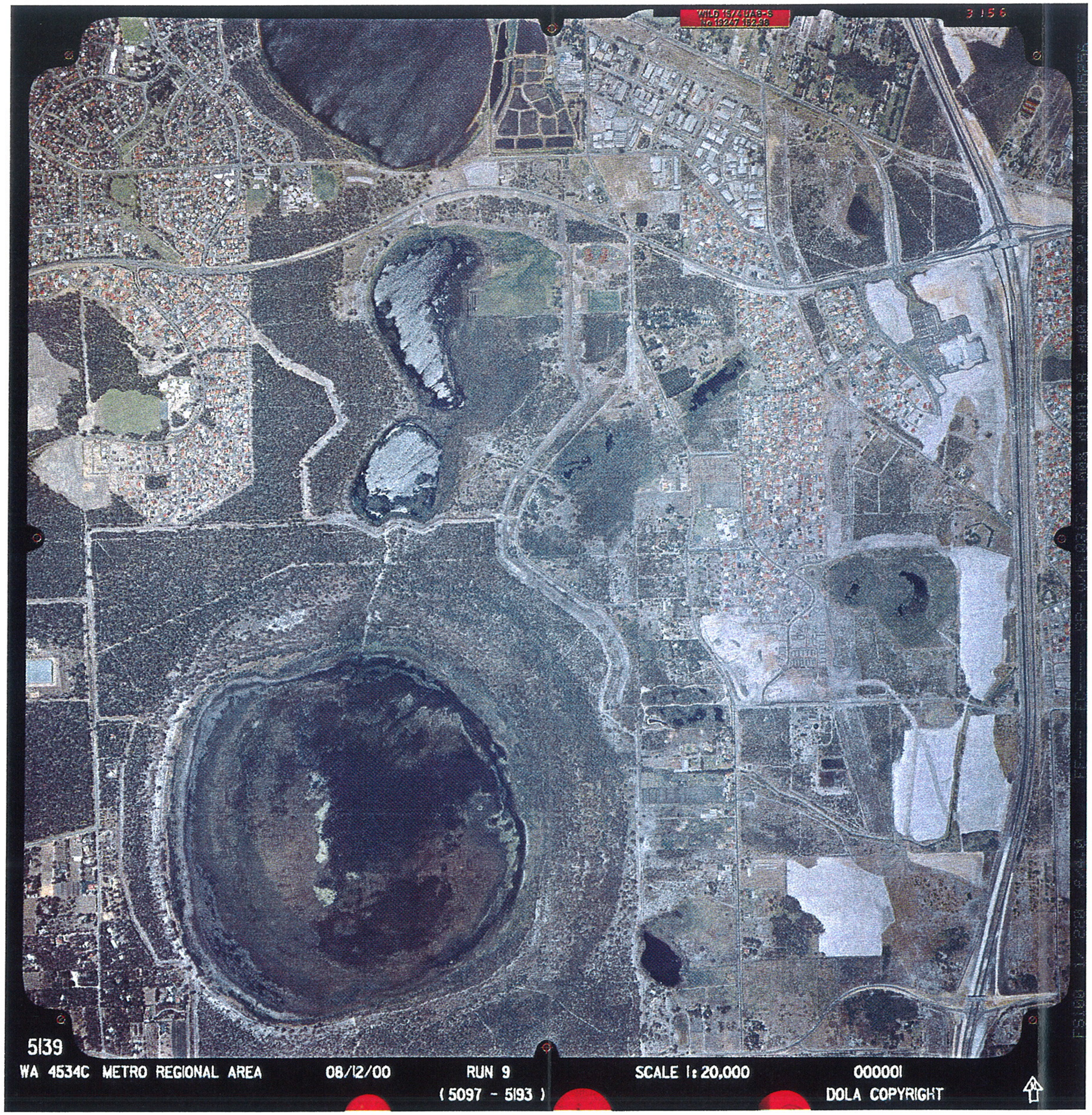
N

19.10.70

(Location Id 7)

N

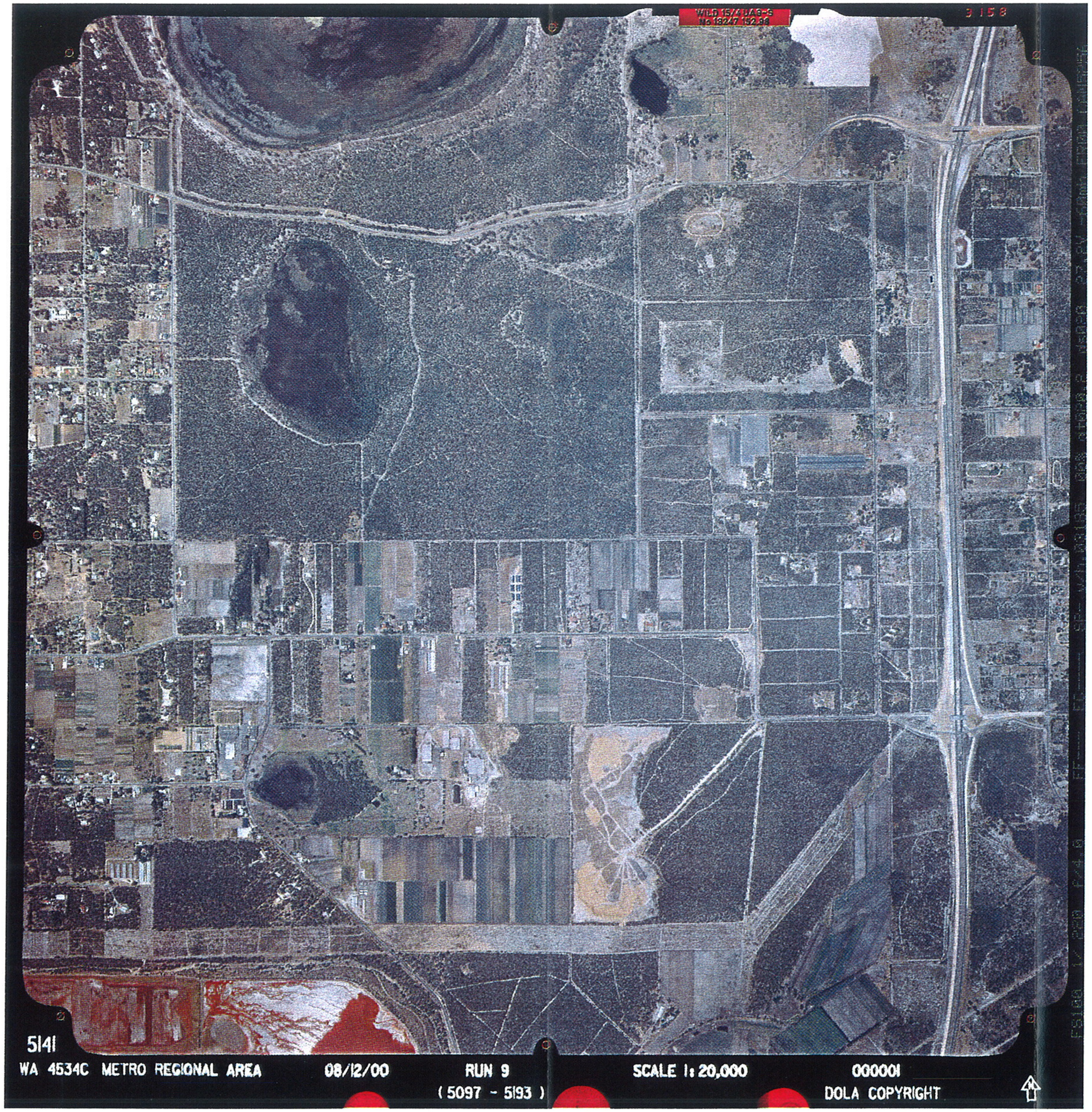
South Lake Market Gardens
20.4.85
(Location Id 7)



N

Areas east of Yangebup Lake and Thomsons Lake
8.12.00
(Location Id 7)


N
Banjup Market Gardens
12.6.80
(Location Id 8)



N

Area south east of Thomsons Lake
8.12.00
(Location Id 8)

N

Alignment Between the Spectacles and Bollard Bulrush Swamp
8.12.00

Leda Nature Reserve and Lake Cooloongup
8.12.00

N

Mandurah Industrial Area
20.12.89
(Location Id 12 to 15)

N

Mandurah
8.12.00
(Location Id 12 to 15)

APPENDIX E

Noise and Vibration Report

South West Metropolitan Railway

Noise and Vibration Management Plan

Prepared For

Perth Urban Rail Development

November 2002

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Lloyd Acoustics

Report Number A010915

This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd Acoustics Pty Ltd ACN 097 356 093 and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client, and Lloyd Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Approved by:	Daniel Lloyd
Position:	Managing Director
Signed:	[signature]
Date:	25 November 2002

Table of Contents

Table of Contents

NOISE LEVEL PREDICTIONS (CONT)

VIBRATION LEVEL PREDICTIONS

NOISE MITIGATION OPTIONS

Chapter 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The State Government has identified the need for a passenger railway linking the existing Perth rail network to the cities of Rockingham and Mandurah. The proposed railway has been designed to minimise travel time and to create a viable alternative to using private transportation by enabling train speeds of up to 130 kilometres per hour.

Throughout the design process, there have been a number of alignments considered including a proposal (May 2001) to run the trains through the existing railway corridor from Perth to Kenwick, through Thornlie, to join the Kwinana Freeway north of Berrigan Drive. From this location, the railway was to run south down the centre of the freeway and the southwest towards Rockingham just north of Thomas Road.

The proposed alignment, described above, has now been revised to enable trains to run from Perth, under William Street, to the Esplanade near the new convention centre, across the Narrows Bridge and down the Kwinana Freeway towards Mandurah. The alignment will connect with the previously proposed alignment just north of Berrigan Drive.

Changes to the alignment at Rockingham have also been reviewed. Whereas the previous proposal turned south from the Fremantle-Rockingham Highway transportation corridor between Lake Cooloongup and the Rockingham Kwinana District Hospital and joined Ennis Avenue just north of the Rockingham golf course, this proposal now continues down the Fremantle-Rockingham Highway transportation corridor and heads south towards Mandurah along Ennis Avenue at the Rae Road intersection.

1.2 THE NOISE AND VIBRATION MANAGEMENT PLAN

The aim of the Noise and Vibration Management Plan (NVMP) is to quantify the noise and vibration levels along the proposed rail route and to compare these levels against a range of criteria currently being evaluated for Western Australia by the

Infrastructure Co-ordinating Committee (ICC) of the WA Planning Commission Working Group. The report specifically addresses the following:

- *Discussion of Noise Level Criteria* - The criteria used in this report to assess the impacts on noise sensitive receivers will be discussed together with the rationale behind its adoption.

- *Prediction of Noise Levels* - Noise levels to residential properties adjacent the proposed route from Perth to Mandurah will be predicted based on expected peak volume of trains and speeds.

- *Noise Mitigation Measures* - Where predicted noise levels exceed the suggested criteria, noise mitigation options will be discussed in broad terms.

- *Discussion of Vibration Level Criteria* - The criteria used in this report to assess vibration impacts will be discussed together with the rationale behind its adoption.

- *Ground Vibration Levels* - Ground vibration levels resulting from train pass-bys will be evaluated. The evaluation will be based on actual measurements of electric trains carried out within the Perth Metropolitan region.

- *Summary* - The results of the study will be summarised and presented in a format that is easily interpreted.

In addition to the above, options such as alignment location or track and barrier configurations, that have been considered through the design process, will be commented on, in particular their implications in the context of noise impacts to receivers.

Due to the complexity of the rail alignment the NVMP has been divided into the following sections:

- Narrows Bridge to Mt Henry Bridge;

- Mt Henry Bridge to Bibra Lake;

- Jandakot to Thomas Road;

- Thomas Road to the Garden Island Highway Reserve;

- Garden Island Highway Reserve to Willmott Drive; and

- Willmott Drive to Mandurah.

1.3 LIMITATIONS OF THE NOISE AND VIBRATION MANAGEMENT PLAN

Every effort has been made to ensure the receiver location included in this NVMP are representative of all receivers along the railway alignment. The receiver locations have been determined using aerial photography and observations during on-site surveys. It should be noted that the distances from the railway to receivers described in this report may vary once the final railway design has been determined.

The NVMP does not consider the following areas:

- **Noise and Vibration from the Narrows Bridges to Perth Central Station.** – This is to be covered in a separate report.
- **Re-generated Noise from Bridge Structures.** – This will be assessed as required. However, Perth Urban Rail Development have made a commitment to isolate the track using resilient fasteners on all bridge structures to ensure re-generated noise does not become an issue.

1.4 DESCRIPTION OF TERMINOLOGY USED IN THIS REPORT

The following is an explanation of the terminology used throughout this report.

Noise Level Terms

i. Decibel – Noise Levels

The decibel (dB) describes the sound pressure level of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

ii. A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound pressure level is described by the symbol dB(A).

iii. Linear

A sound pressure level described in the linear scale is a noise level that has not been filtered. A linear sound pressure level is described by the symbol dB(L).

iv. L_{A90}

An L_{A90} level is an A-weighted noise level which is exceeded for 90 per cent of the measurement period. An L_{A90} level is considered to represent the "*background*" noise level.

v. L_{Aeq}

The equivalent steady-state A-weighted sound level ("equal energy") which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the "*average*" noise level

vi. $L_{Aeq\ (x\ hours)}$

The equivalent steady-state A-weighted sound level over a certain time period in hours.

vii. L_{Amax}

An L_{Amax} level is the maximum A-weighted noise level measured during the measurement period.

<u>Vibration Level Terms</u>

viii. Decibel – Vibration Levels

The decibel (dB) describes the vibration level of a source. It is a logarithmic scale referenced to 10^{-6} mm/s.

ix. Peak Velocity

Level of vibration velocity measured as a non root mean square (r.m.s.) quantity in millimetres per second (mm/s).

Chapter 2

NOISE IMPACTS AND CRITERIA

2.1 NOISE IMPACTS

As a train travels down a railway track, particularly if it is travelling at high speed, the resultant noise being generated may impact on noise sensitive receivers located adjacent to the transportation corridor. The majority of the noise produced by passenger trains results from the interaction between the wheels of the train and the track, however, aerodynamic noise and to some extent, noise from the pantograph connected to the power lines may also contribute to the overall noise levels. To ensure that these noise emissions are controlled as far as is practicable at the source, the successful supplier of the railcars must comply with specified noise levels which have been set at 85 dB(A) at a distance of 15 metres (when the train is travelling at full speed of 130 km/h).

An important impact to consider is often termed "wheel squeal" and occurs due to the wheels slipping on the rail when the train is on a tight bend. It is our understanding that the track and train design will ensure that wheel squeal does not occur at any location on the South West Metropolitan Railway.

This assessment only deals with noise levels associated with the train travelling along the track. Other potential noise impacts from railways, such as the public address system from stations and warning systems on crossings will be addressed on an individual basis as required.

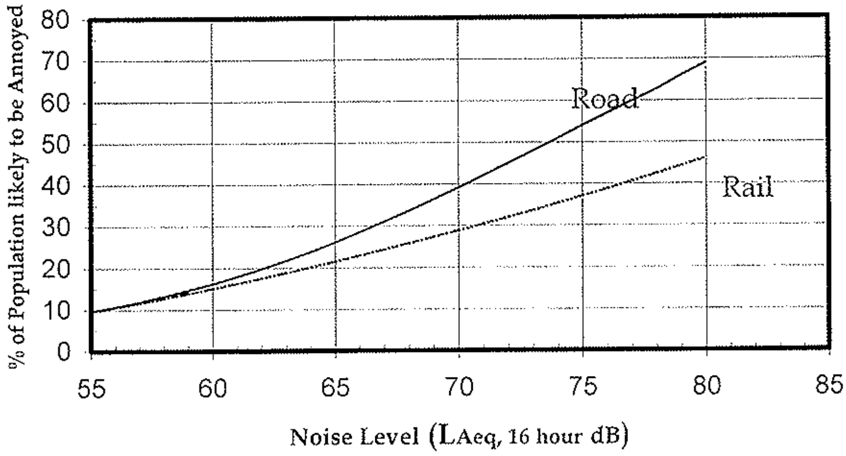
2.2 RATIONALE FOR CRITERIA

The final design, in respect to noise mitigation measures along the proposed South West Metropolitan Railway, is to ensure that the noise levels at noise sensitive premises adjacent to the alignment are "as low as is reasonable practicable" as required in the Environmental Protection Authority's (EPA) guidelines. However, in the first instance a set of criteria are required in which to compare the predicted noise levels against and to determine the extent of noise mitigation required. The chosen criteria must have proven links between: a) what is generally considered an acceptable level of noise; and b) the response from the community to noise from rail transportation infrastructure. The following sections explore this relationship and report on current research in this area.

2.2.1 *Community Response to Transportation Noise*

When considering the effect transportation noise has on the population, the two responses of most interest are annoyance and sleep disturbance. The relationship between annoyance and transportation noise level is well understood and is illustrated in *Figure 2.1*.

Figure 2.1 ROAD AND RAILWAY NOISE ANNOYANCE RESPONSE FUNCTIONS



Source: Design Manual for Roads and Bridges, Volume 11, Section 3, 1994 and PPG24.

It can be seen from *Figure 2.1* that lower noise levels results in a lower percentage of the population likely to be annoyed. In considering suitable criteria for a transportation noise policy, a convention has developed subtly over the past few decades in which an acceptable level of transportation noise is one where no more than 10% to 15% of the affected residents are being annoyed. This equates to an $L_{Aeq,\,16\,hour}$ of between 55 dB(A) and 60 dB(A) for railway noise.

There has been considerable research into determining suitable noise level descriptors to assess sleep disturbance. However, the conclusions to these studies are often contradictory.

In a number of studies, it has been shown that intermittent noise was found to have a significantly more noticeable effect on sleep quality than continuous noise at the same L_{Aeq} level. Several published studies on the effects of noise on sleep conclude that for continuous traffic noise conditions, L_{Aeq} appears to provide appropriate measure of sleep disturbance. However, where traffic noise is intermittent, as is the case for railway noise, it is the number of individual noise events exceeding a particular level ($L_{A\,max}$) that effects sleep disturbance more than the L_{Aeq} level. In a number of studies, such as the recent Sleep Disturbance Index (SDI) (Bullen 1996), it has been proposed that a combination of L_{Aeq} and $L_{A\,max}$ may be the most appropriate indication of the potential to disturb sleep.

Ultimately, any descriptor used to assess the impact of rail traffic noise on sleep should be able to predict the level of sleep disturbance directly, as is possible for annoyance using the daytime L_{Aeq} level. This would necessarily involve a relatively complex methodology, taking into account the distribution of numbers of noise events by noise level, as well as the emergence of noise events above the background level. Such a methodology has not yet been adequately demonstrated or tested.

It can be concluded that sleep disturbance is a real issue, however, until a tried and tested methodology has been demonstrated it cannot be easily addressed through a single noise level criterion.

A review of international transportation noise criteria presented in *Table 2.1*, it can be seen that most daytime noise level criteria range from 55 dB(A) to 65 dB(A) and night-time between 45 dB(A) to 55 dB(A). This is within the range currently being considered by the ICC Working Group.

Table 2.1 COMPARISON OF INTERNATIONAL RAIL TRAFFIC NOISE CRITERIA

Jurisdiction	Daytime L_{Aeq} Criterion	Night-time L_{Aeq} Criterion
United Kingdom	55 dB(A)	45 dB(A)
Canada	55 dB(A)	50 dB(A)
Queensland	60 dB(A)	-
New South Wales	55 dB(A)	-
*Austria	60-65 dB(A)	50 55 dB(A)
*France	60-65 dB(A)	-
*Germany	55 dB(A)	45 dB(A)
*Netherlands	65 dB(A)	55 dB(A)
*Korea	65 dB(A)	55 dB(A)
*Switzerland	55 dB(A)	45 dB(A)

*Notes: 1*Obtained for study carried out by Dieter Gottlob in 1995. Levels shown are simplified and are subject to certain conditions*

2.3 DESCRIPTION OF CRITERIA

As described previously, every effort will be made to reduce noise impacts from the South West Metropolitan Railway to as low as is reasonably practicable. However, for the initial assessment of the noise impacts to residents adjacent to the railway, the suggested criteria, which take into consideration the range of transportation noise criteria currently being evaluated for Western Australia by the Infrastructure Co-ordinating Committee (ICC) of the WA Planning Commission Working Group, are detailed below:

Criteria 1 Noise level above which noise mitigation will be provided:

- $L_{Aeq\ (daytime)}$ 60 dB(A); and
- $L_{Aeq\ (night\text{-}time)}$ 55 dB(A).

Criteria 2 Noise level above which noise mitigation will be considered:

- $L_{Aeq\ (daytime)}$ 55 dB(A); and
- $L_{Aeq\ (night\text{-}time)}$ 50 dB(A).

The daytime period is between 6.00 am and 10.00 pm and the night-time period is between 10.00 pm and 6.00 am

For receivers that exceed *Criteria 2*, the decision whether noise mitigation is practicable, or in some circumstances desired, would be made through a process of:

- consultation with the stakeholders;
- consideration of the benefits of noise mitigation taking into account the existing noise environment; and
- assessment of the practicability of providing noise mitigation including the cost implications.

The L_{Amax} noise levels are considered in this assessment for information purposes only. Although a criteria level for maximum noise levels is not recommended, it can be used to illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels. A common goal is to keep the maximum noise levels below 80 dB(A).

To assist the reader, typical average noise levels for everyday events are provided in *Figure 2.2*

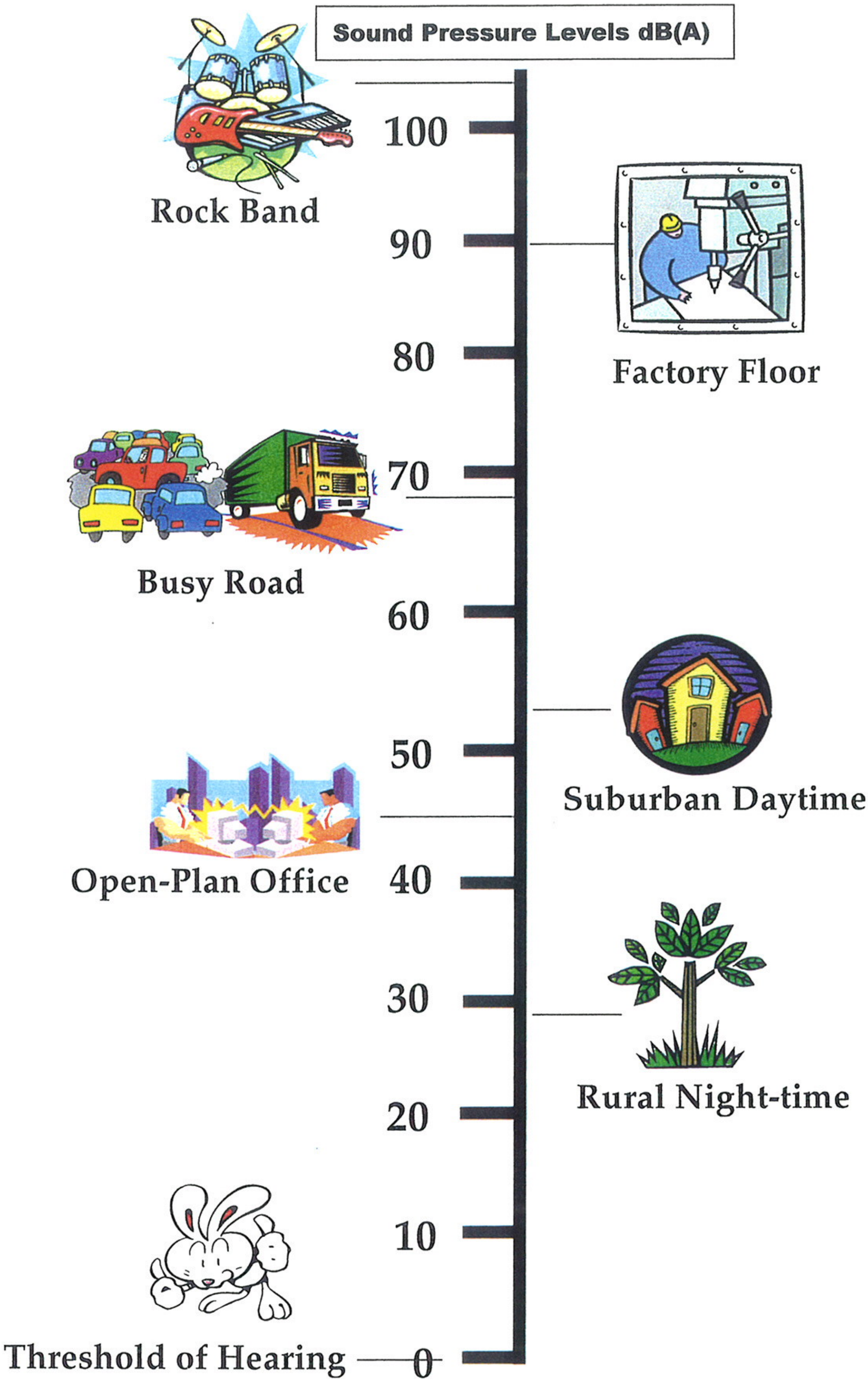


Figure 2.2 TYPICAL AVERAGE NOISE LEVELS FOR EVERYDAY EVENTS

Chapter 3

VIBRATION IMPACTS AND CRITERIA

3.1 INTRODUCTION

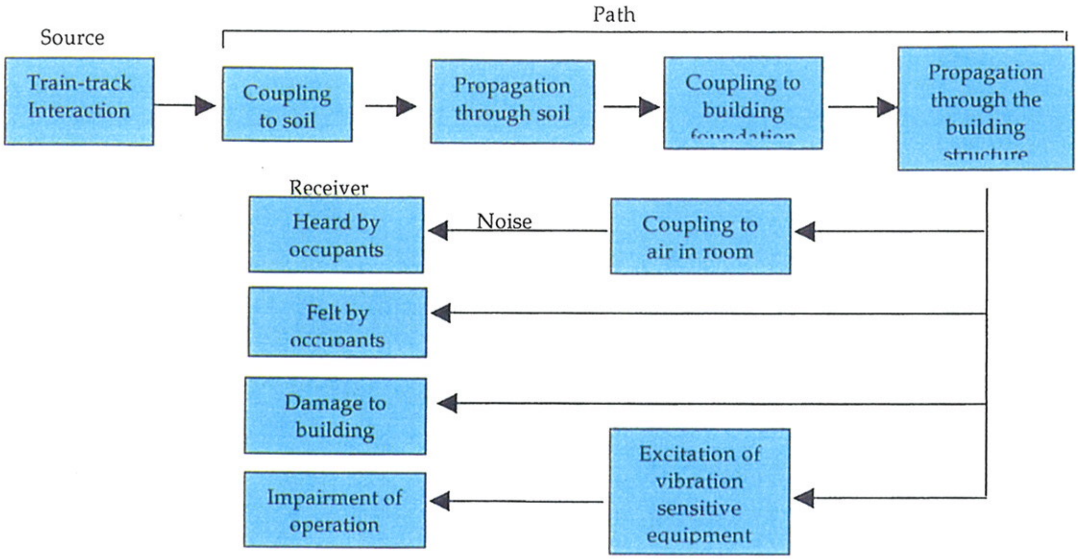
This section of the report assesses the potential impact resulting from vibration energy as the train passes a receiver. For railways, two types of vibration impacts are usually considered, these being: a) felt vibration; and b) re-generated noise. Criteria with which to assess vibration impacts are considered and compared against predicted vibration levels at receivers adjacent to the proposed railway alignment.

3.2 OVERVIEW

When a train travels along a railway track, vibration resulting from the interaction between the train wheels and the railhead can be transmitted into the ground. This energy can then propagate through the intervening soil and into buildings in the near vicinity. There the vibration may be felt by the occupant or may be radiated into the rooms of the building and heard as a low-frequency rumble. Vibration energy that can be felt through the structure of the building can, depending on the energy levels, result in structural damage or annoyance to the receiver. Vibration energy can also excite the structure of the building sufficiently for the walls and floors to create noise, which is known as re-generated noise and is generally only an issue when trains are in tunnels. As there are no tunnels proposed for the section of the railway covered in this assessment, re-generated noise has not been addressed.

The mechanisms involved in the transference of vibration from passing trains into buildings and the receiver response is illustrated in *Figure 3.1*

Figure 3.1 SCHEMATIC REPRESENTATION OF VIBRATION CAUSE AND EFFECT



Vibration can be transmitted in three different planes, all of which have a different effect on the body and therefore attract a different criterion. The three planes are:

- x-axis back to chest;
- y-axis right side to left side; and
- z-axis foot (or buttocks) to head.

For vibration resulting from the passing by of trains, it is widely accepted that a combination of the three planes is most appropriate in assessing the vibration impacts.

3.3 DISCUSSION

In Western Australia, there are no criteria addressing vibration levels from transportation corridors to affected premises. Therefore, any chosen vibration level criterion for this assessment must ensure that good public amenity is achieved at premises affected by vibration from the South West Metropolitan Railway. Australian standards that specifically address vibration resulting from transportation sources also have not been developed. The best available criteria for assessing the impacts from vibration is Australian Standard AS2670-1990 – *Evaluation of Human Exposure to Whole Body Vibration,* Part 2, *Continuous and shock* *induced Vibration in Buildings (1 to 80 Hz).* This standard contains a number of curves that relate vibration levels to frequency which are accepted by the Department of Environmental Protection (DEP) in the assessment of vibration impacts. For transient vibration excitation with several occurrences per day, the suggested criterion to residential premises at night is between *Curve 1.4* (0.2 mm/s) and *Curve 20* (3.0 mm/s). However, it should be noted that AS2670.2-1990, states "*Experience has shown in many countries that complaints regarding building vibrations in residential situations are likely to arise from occupants of buildings when the vibration magnitudes are only slightly in excess of perception levels. In general, the satisfactory magnitudes are related to the minimum adverse comment level by the occupants and are not determined by any other factors, such as short-term health hazard and working efficiency. Indeed, in practically all cases the magnitudes are such that there is no possibility of fatigue or other vibration-induced symptoms.*" This would suggest that a criterion, which protects buildings from structural damage, is unlikely to address issues of general annoyance.

3.4 SUGGESTED CRITERIA

3.4.1 Annoyance Vibration

From discussions with the DEP, and from the complaints history records for passenger railway systems in Western Australia, there have been very few complaints resulting from vibration issues from railways. Of the complaints that have been received, the *Curve 1.4* (figure 5c AS2670.2-1990) appears to be the threshold whereby complaints under this criterion have never occurred (this relates to a of approximately 0.2 mm/s or 106 dB).

Our literature searches have determined that although there are very few vibration criteria internationally, the Swiss government have recently formed a working group to address rail vibration levels. In a recent paper by Swiss federal railways SBB, (Mr. Peter Hübner, 5th UIC Environment Coordinators Meeting at PKP Warsaw, 16/17 September 1999) the criteria provided in *Table 3.1*, have been adopted by SBB in lieu of a policy developed at government level. It can be seen that the night-time peak vibration level criterion for residential is 0.28 mm/s (or 109 dB) which is equivalent to *Curve* 2 of AS2670.

Table 3.1 *SBB CRITERIA FOR VIBRATION LEVELS FROM TRAINS*

Area	Extensions or conversions of existing installations (PeakV mm/s)	New Installations (PeakV mm/s)
	Day/Night	Day/Night
Residential, public utilities (Hospitals Schools)	0.56/0.4	0.4/0.28
Mixed use, inner city areas, rural villages.	0.7/0.56	0.56/0.4

It is clear that *Curve 1.4* (106 dB) represents the best possible public amenity under which complaints are not likely to be made and *Curve 2* (109 dB) represents a level that takes into consideration the practicability and cost implications of isolation the track to reducing vibration levels.

The difficulty with addressing vibration issues is that ameliorative measures generally need to be implemented as part of a railway project and can not readily be implemented later, although measures such as rail grinding do help. If a criterion is selected that is very stringent, then isolation treatments may be required at the time of construction in areas where vibration may not be a issue for residents. On the other hand, if a criterion is selected on the basis that it can easily be met, then the cost of retrofitting isolation treatments becomes significant if vibration becomes an issue after construction.

It is suggested that a range of criteria be adopted for this project, requiring certain actions to be undertaken based on the predicted vibration levels. The criteria would be:

- ***Criterion 1 - Vibration Limit*** – Curve 2 (109 dB); and
- ***Criterion 2 - Vibration Planning and Design Level*** - Curve 1.4 (106 dB).

Above *Criterion 1 (Vibration Limit)*, vibration isolation measures would be required and should be incorporated in the design of the railway. In terms of planning, noise-sensitive rezoning/development would only be permitted where the new building was vibration isolated.

Criterion 2 (*Planning and Design Level*) is a level to which the project should be designed, and above which the planning system should avoid placing new residential areas where practicable. Vibration levels below *Criterion 2* would be considered acceptable.

Between *Criterion 1* and *Criterion 2* would be a conditional level, where isolation measures would be considered at the design stage, but decisions would be based on the cost benefits of their application. Actual levels would be measured during operation, and where found to be between *Criterion 1* and *Criterion 2*, non-isolation measures such as rail grinding would be considered. New residential development would be discouraged, and where this took place, notification on titles would be required.

3.4.2 *Structural Damage*

Australian Standards by which the probability of structural damage to buildings may be assessed do not exist. However, a German Standard, DIN 4150 Part 3 *Structural Vibration in Buildings*, sets specific criteria for assessing the probability of damage to various types of building. This standard sets out recommended maximum vibration levels at the building foundation, as a function of frequency, for three classes of building structure.

The relevant criteria apply to "short-term" vibration. This term is not defined in terms of duration or number of occurrences per day, however, it will be assumed that vibration from train pass-bys can be considered as "short-term" vibration for the purpose of assessment of potential structural damage.

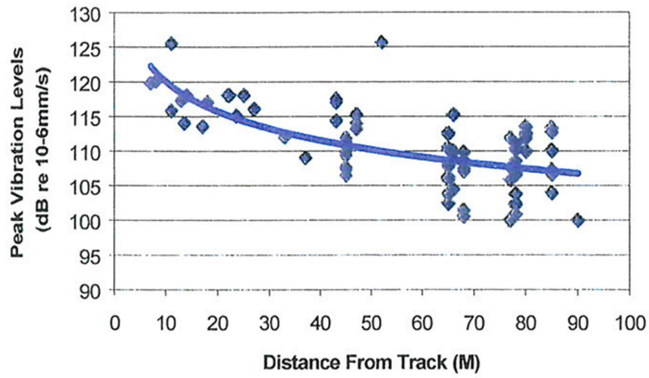
Criteria in DIN 4150 are stated in terms of the maximum peak vibration velocity in any of three orthogonal directions. The criterion chosen for this project is for *"Dwellings and Buildings of similar design and/or use"* and is 2.5 mm/s (128 dB), which is the vibration velocity level unlikely to cause structural damage, for the frequency range 10Hz to 50 Hz.

3.5 VIBRATION LEVEL PREDICTION METHODOLOGY

The propagation of vibrational energy through the ground is highly dependant on the soil/rock structure and ground conditions, including moisture content, and can vary greatly from site to site. Therefore, unless the ground properties are known for each propagation path considered in an assessment, the predictions are generally highly inaccurate and should be taken as indicative only.

To provide indicative vibration levels for the South West Metropolitan Railway, the results of vibration measurements and the corresponding measurement distances undertaken in Perth over the previous nine years have been plotted onto a chart to determine a relationship between the two variables. As expected, the results were widely spread, however, a best-fit curve was determined and this is presented in *Figure 3.2*.

Figure 3.2 *VIBRATION LEVEL VERSUS DISTANCE RELATIONSHIP*

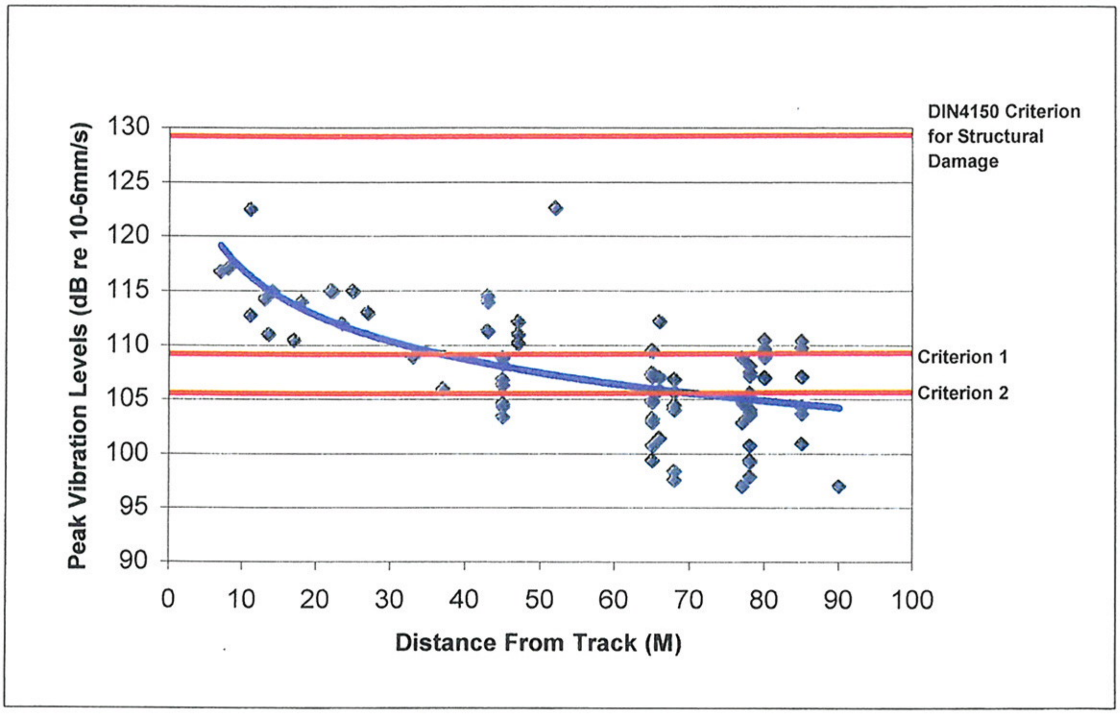


3.6 NEW GENERATION TRAINS

The electric passenger railcars being constructed for the South West Metropolitan Railway differ from the existing electric railcars used in Perth. Of significant importance when considering the generation of vibrational energy, is that on the new railcars the motors are to be mounted as part of the sprung mass as opposed to mounting them onto the axle which is an un-sprung mass (existing railcar configuration). This means that more of the weight of the railcar will be dampened before being transferred onto the rail. The result will undoubtedly be a reduction in the energy transmitted to the rail and therefore a reduction in the resultant vibration levels at the receiver locations. Although specific vibration testing of these trains has not been undertaken and, therefore, the extent of this reduction in vibration levels is not known, a conservative estimation of the effect of the improved design would be a reduction of 3 dB.

A comparison between the expected vibration levels of the new generation railcars with distance and the suggested criteria range is presented in *Figure 3.3*

Figure 3.3 VIBRATION LEVEL FOR NEW GENERATION RAILCARS VERSUS DISTANCE RELATIONSHIP



3.7 INFLUENCE OF TRAIN SPEED

From assessments of train vibration levels conducted over a number of different sites, no obvious relationship between train speed and resulting vibration levels has been found. As such, the relationship between vibration levels and distance presented in *Figure 3.3* can be said to be valid for all train speeds considered in this assessment.

Chapter 4

NOISE PREDICTION METHODOLOGY

4.1 INTRODUCTION

This chapter describes the methodology used to predict airborne noise levels to noise sensitive receivers adjacent to the proposed South West Metropolitan Railway.

Noise levels resulting from the proposed South West Metropolitan Railway have been predicted to 441 noise sensitive receivers adjacent to the rail corridor from the Narrows Bridges to Mandurah. The predictions consider the equivalent (average) daytime noise level between 6.00 am 10.00 pm and the equivalent night-time noise level between 10.00 pm and 6.00 am. In addition to this, the maximum pass-by noise level has provided, to enable an assessment of the in.

As the alignment of the South West Metropolitan Railway covers such as extensive area, the predictions have been spilt into six distinct sections:

- Narrows Bridges to Mt Henry Bridge;
- Mt Henry Bridge to Bibra Lake;
- Jandakot to Thomas Road;
- Thomas Road to the Garden Island Highway Reserve;
- Garden Island Highway Reserve to Willmott Drive; and
- Willmott Drive to Mandurah.

4.2 DESCRIPTION OF THE NOISE PREDICTION MODEL

The equivalent (L_{Aeq}) and maximum (L_{Amax}) noise levels were calculated to each receiver location, taking into consideration the following variables:

- Distance from the track to the receiver;
- Speed of the train;
- Height of the noise source in respect to the receiver; and
- Existing road barriers, land topography and property fences.

To ensure that the accuracy of the noise level predictions were as high as possible, the calculations were made considering noise impacts from the trains at 10 metre intervals along the entire route.

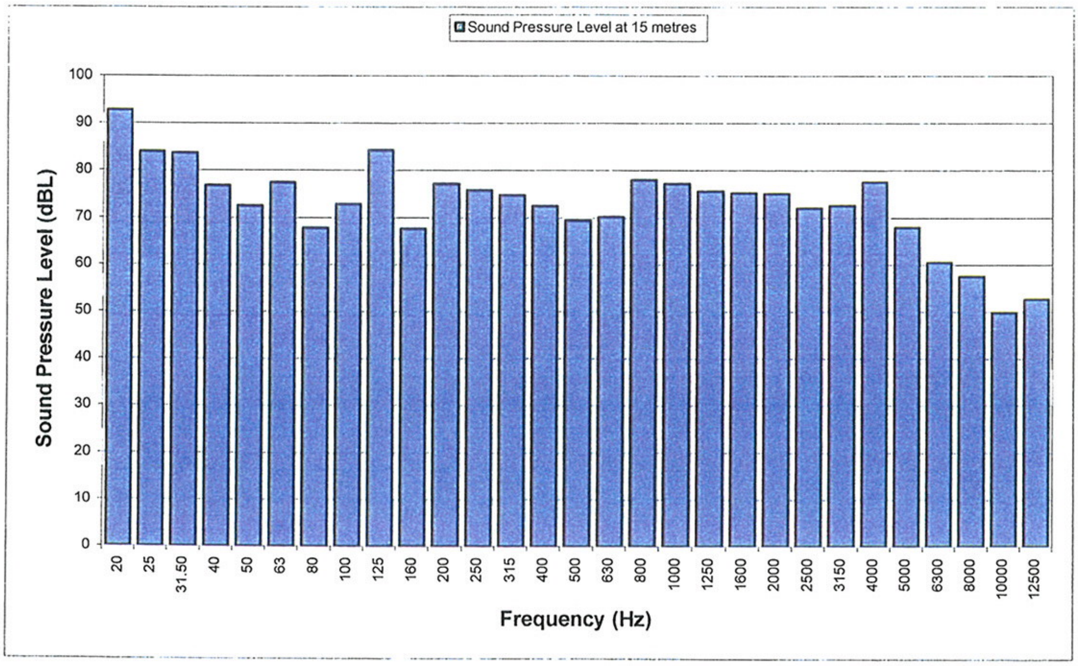
4.3 SOUND PRESSURE LEVELS FOR ELECTRIC PASSENGER TRAINS

The main sources of noise from electric passenger railcars are the rail/wheel interaction and the traction motors. The base sound pressure levels, used to predict noise levels to residents, were determined from pass-by noise measurements undertaken by the South West Metropolitan Railway railcar manufacturer, EDI Rail Bombardier. The noise measurements, undertaken at a distance of 15 metres for the track, at railcar speeds of 140 km/h, have been adjusted to represent a maximum acceptable pass-by sound pressure level of 85 dB(A) at a distance of 15 metres away and a speed of 130 km/h. This pass-by sound pressure level represents best-practice in railcar design and has been guaranteed by the manufacturer as part of the tendering process. The results are presented in *Table 4.1* and graphically in *Figure 4.1*.

Table 4.1 SOUND PRESSURE LEVELS USED IN THE NOISE MODEL

Description	dB (linear) at One-Third Octave Frequencies (Hz)									Overall dB(A)
	31.5	63	125	250	500	1K	2K	4K	8K	
Passenger train travelling at a speed of 130 km/hr at a distance of 15m	84.1	72.6	73	77.3	72.6	78.2	75.4	72.1	67.9	85
	83.8	77.6	84.5	76	69.6	77.4	75.2	72.6	60.5	
	77	67.9	67.8	75	70.3	75.8	72.1	77.6	57.5	

Figure 4.1 GRAPHICAL REPRESENTATION OF SOUND PRESSURE LEVELS USED IN THE NOISE MODEL



4.4 RELATIONSHIP BETWEEN SOUND PRESSURE LEVEL AND TRAIN SPEED

The relationship between the sound pressure level from trains and the speed at which they are travelling is well documented. Generally, this relationship is described by the formula $30*Log_{10}$ (train speed/reference train speed). The result is then added or subtracted from the sound pressure levels at the reference train speed, which for this project, is 85 dB(A) at 130 km/h. However, the way in which this relationship is applied must be carefully considered. Investigations by Lloyd Acoustics into train speeds during braking and acceleration have shown that the relationship only holds true when trains are braking lightly or travelling at a constant speed. When trains are accelerating or braking heavily, noise levels of approximately 5 dB(A) higher than those predicted for trains travelling at the same constant speed occur. To accommodate this in the noise level predictions, speed reductions and acceleration in and out of stations, and the corresponding noise reductions have been ignored, however speed reductions as trains negotiate bends have been considered. This provides for a more conservative approach to predicting the impacts to noise sensitive receivers adjacent to the proposed railway.

4.5 OTHER VARIABLES USED IN THE PREDICTION OF NOISE LEVELS FROM TRAINS

Other variables used in the prediction of noise levels at residences along the proposed rail route are described in *Tables 4.2* and *4.3*. The source of this information was Perth Urban Rail Development.

Table 4.2 VARIABLES USED IN THE NOISE PREDICTION MODEL

Description of Variable		Value
Type of noise source		Line source
Train length	3 Car Set	75 metres
	4 Car Set	100 metres
	6 Car Set	150 metres
Height of noise source above rail head		0.65 metres
Train Speeds		Up to 130 km/h

Table 4.3 RAIL MOVEMENTS PER HOUR ASSUMED IN NOISE MODEL

Section of Rail Alignment	Time Period	Number of Train Movements per Hour
Narrows Bridge to Mt Henry Bridge	Daytime	3 Car Sets: 5.00 Up/5.30 Down
		4 Car Sets: 0.88 Up/0.88 Down
		6 Car Sets: 0.88 Up/0.88 Down
	Night-time	3 Car Sets: 1.00 Up/1.00 Down
Mt Henry Bridge to Bibra Lake	Daytime	3 Car Sets: 5.00 Up/5.30 Down
		4 Car Sets: 0.88 Up/0.88 Down
		6 Car Sets: 0.88 Up/0.88 Down
	Night-time	3 Car Sets: 1.00 Up/1.00 Down
Jandakot to Thomas Road	Daytime	3 Car Sets: 5.00 Up/5.30 Down
		4 Car Sets: 0.88 Up/0.88 Down
		6 Car Sets: 0.88 Up/0.88 Down
	Night-time	3 Car Sets: 1.00 Up/1.00 Down
Thomas Road to the Garden Island Highway Reserve	Daytime	3 Car Sets: 5.36 Up/5.08 Down
		6 Car Sets: 0.38 Up/0.38 Down
	Night-time	3 Car Sets: 0.75 Up/0.88 Down

Table 4.3(cont) RAIL MOVEMENTS PER HOUR ASSUMED IN NOISE MODEL

Section of Rail Alignment	Time Period	Number of Train Movements per Hour
Garden Island Highway Reserve to Willmott Drive	Daytime	3 Car Sets: 5.38 Up/5.00 Down 4 Car Sets: 0.88 Up/0.88 Down 6 Car Sets: 0.88 Up/0.88 Down
	Night-time	3 Car Sets: 0.75 Up/0.88 Down
Willmott Drive to Mandurah	Daytime	3 Car Sets: 5.06 Up/5.38 Down 6 Car Sets: 0.38 Up/0.38 Down
	Night-time	3 Car Sets: 0.75 Up/0.88 Down

Chapter 5

NOISE LEVEL PREDICTIONS

5.1 INTRODUCTION

This chapter presents the results of the $L_{Aeq\,(Daytime)}$ and $L_{Aeq\,(Night\text{-}time)}$ noise level predictions for the proposed South West Metropolitan Railway. The predictions cover each section of the alignment including: a) where design options have been considered to minimise noise impacts; b) a comparative assessment; and c) the rationale behind the decision for the final design option. The results, taking into consideration land topography, existing noise barriers and property fences are presented in both tabular and graphical formats and are compared against the suggested noise level criteria for daytime and night-time periods. Any requirements for additional noise mitigation measures are discussed in broad terms.

An indication of the maximum noise level at each of the noise sensitive premises is also provided. Although a criterion for maximum noise levels has not been specified for the proposed South West Metropolitan Railway (*see Chapter* 2), it is acknowledged that short-term noise impacts, generally associated with train pass-bys, can result in issues of sleep disturbance if the noise level is significantly (i.e. 20 dB(A)) higher than the ambient noise level in the sleeping area.

As discussed in *Section 2.3*, two criteria are considered: *Criteria 1* above which noise mitigation will be provided; and *Criteria 2* above which noise mitigation will be considered. The criteria used for each section will predominantly depend on the existing noise environment, which will be assessed from either historical data or measurements undertaken as part of this assessment.

RECEIVER LOCATIONS

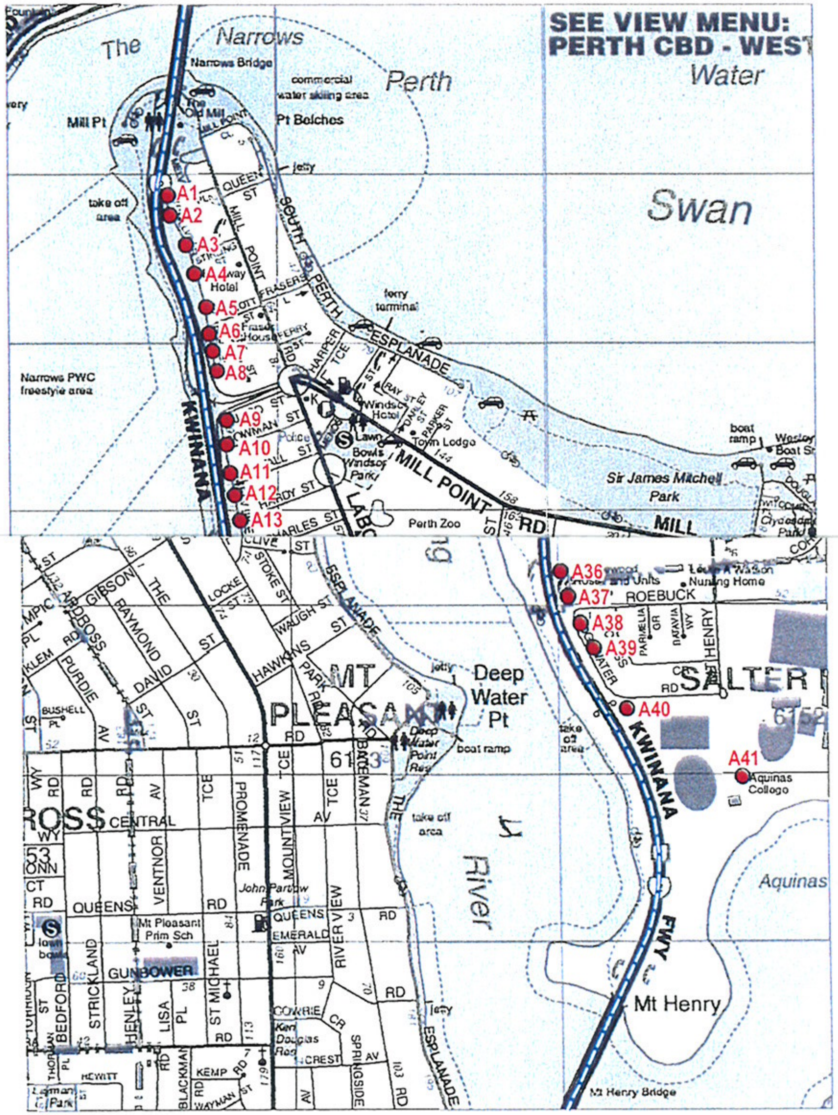


Figure 5.1 Receiver Locations from the Narrows Bridge to Mt Henry Bridge

8010857/Kwinana1

5.2 NARROWS BRIDGES TO MT HENRY BRIDGE

5.2.1 *Description*

This section of the alignment, illustrated in *Figure 5.1*, starts at the Narrows Bridges in South Perth and extends to the start of the Mt. Henry Bridge. It is proposed that between the Narrows Bridges and Canning Highway, the railway alignment is to run along the existing Busway, taking advantage of the noise attenuation achieved by the concrete safety barriers. Once past Canning Highway, the railway will continue down the centre of the Kwinana Freeway towards Mt. Henry. Between the Narrows Bridge and Canning Highway the following three options were considered:

- Track on ballast with existing safety barriers;
- Track on road slab with existing safety barriers; and
- Track on road slab with an additional barrier infill between the top of the safety barrier and the existing metal guardrail.

Past Canning Highway, the track would be placed on ballast and run along the centre of the Kwinana Freeway.

A comparison of the predicted noise levels, assuming each of the above options, is presented graphically in *Figures 5.2* to *5.4*.

5.2.2 *The Preferred Option and Results*

Based on the analysis of the noise prediction data, the preferred design option for this section of the railway is as follows:

- Between the Narrows Bridges and Canning Highway, the track will be placed on the existing road slab using resilient fasteners;
- Between Canning Highway and Mt. Henry Bridge, the track will be placed on ballast; and
- The height of the existing Busway barriers between the Narrows Bridges and Canning Bridge will be increased to the existing metal guardrail*.

*Note: Increasing the height of the existing Busway barriers is subject to review in terms of social impact and community acceptance. In particular, the visual amenity and the preservation of views from residences to the river.

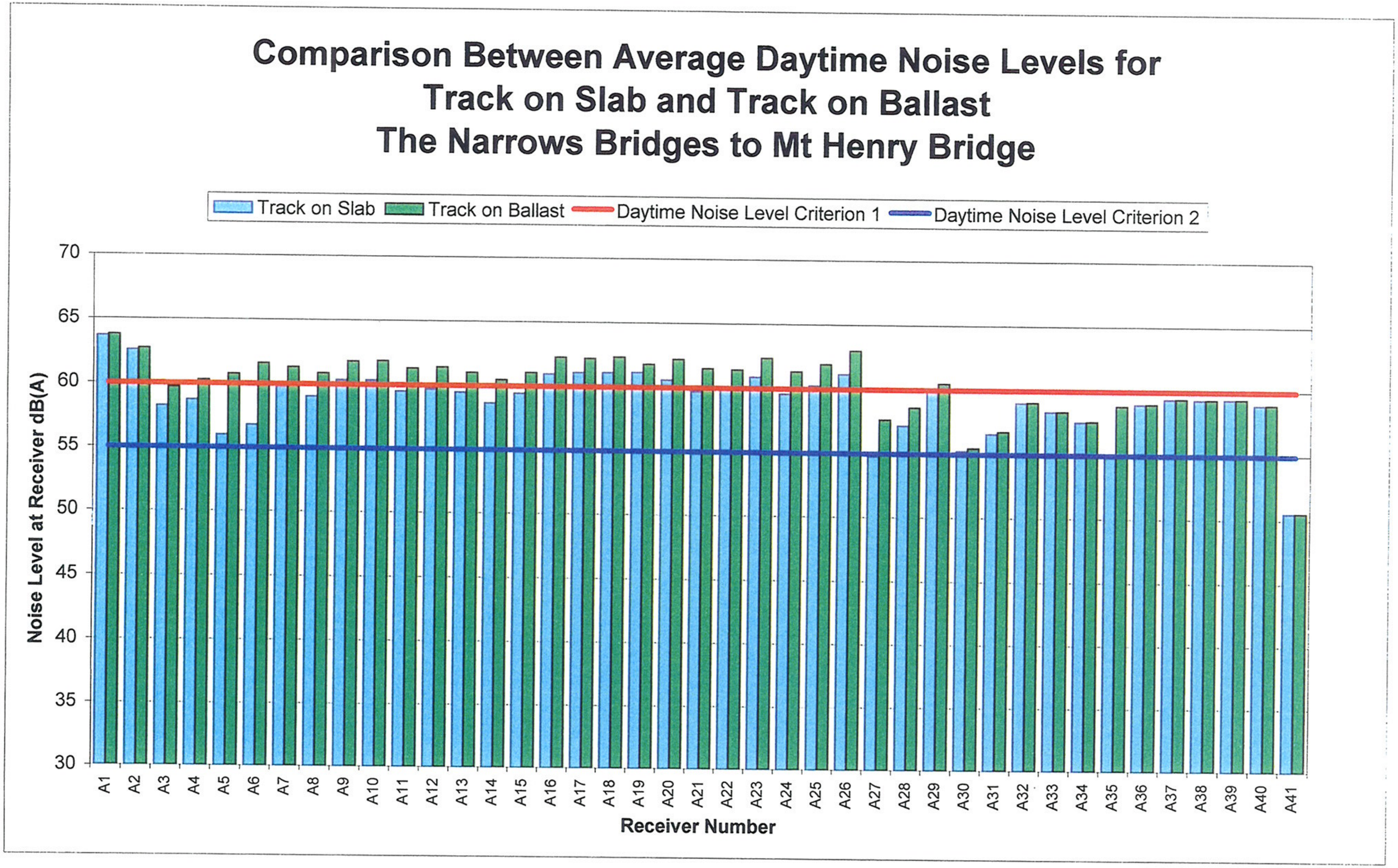


Figure 5.2

Lloyd Acoustics

RECEIVER LOCATIONS

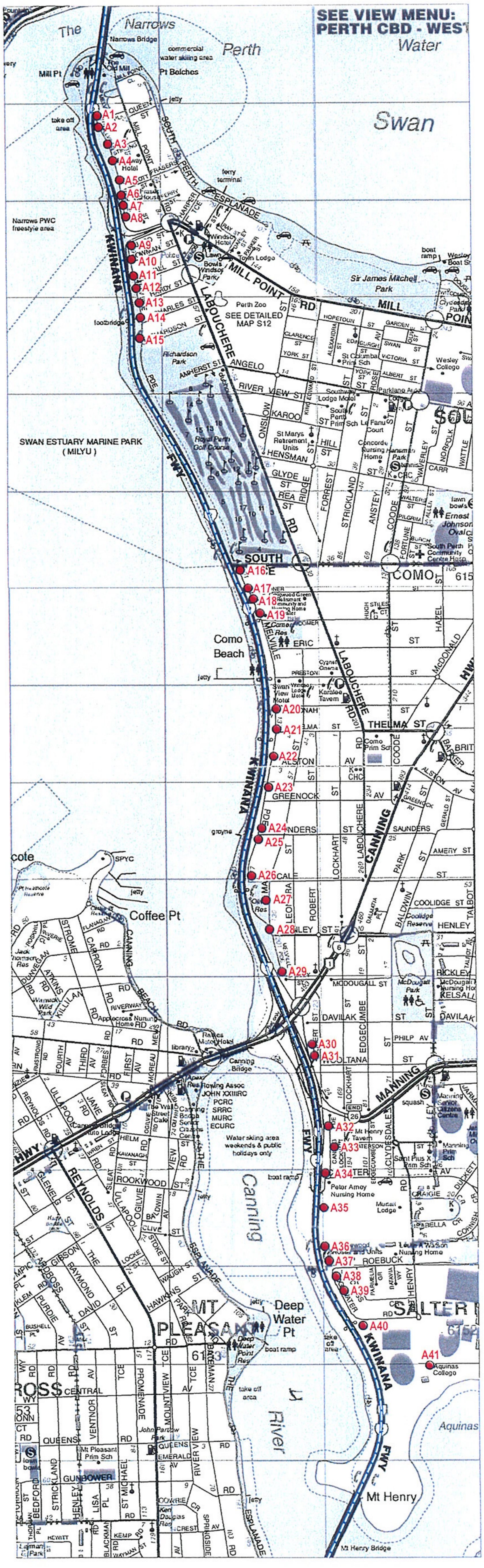


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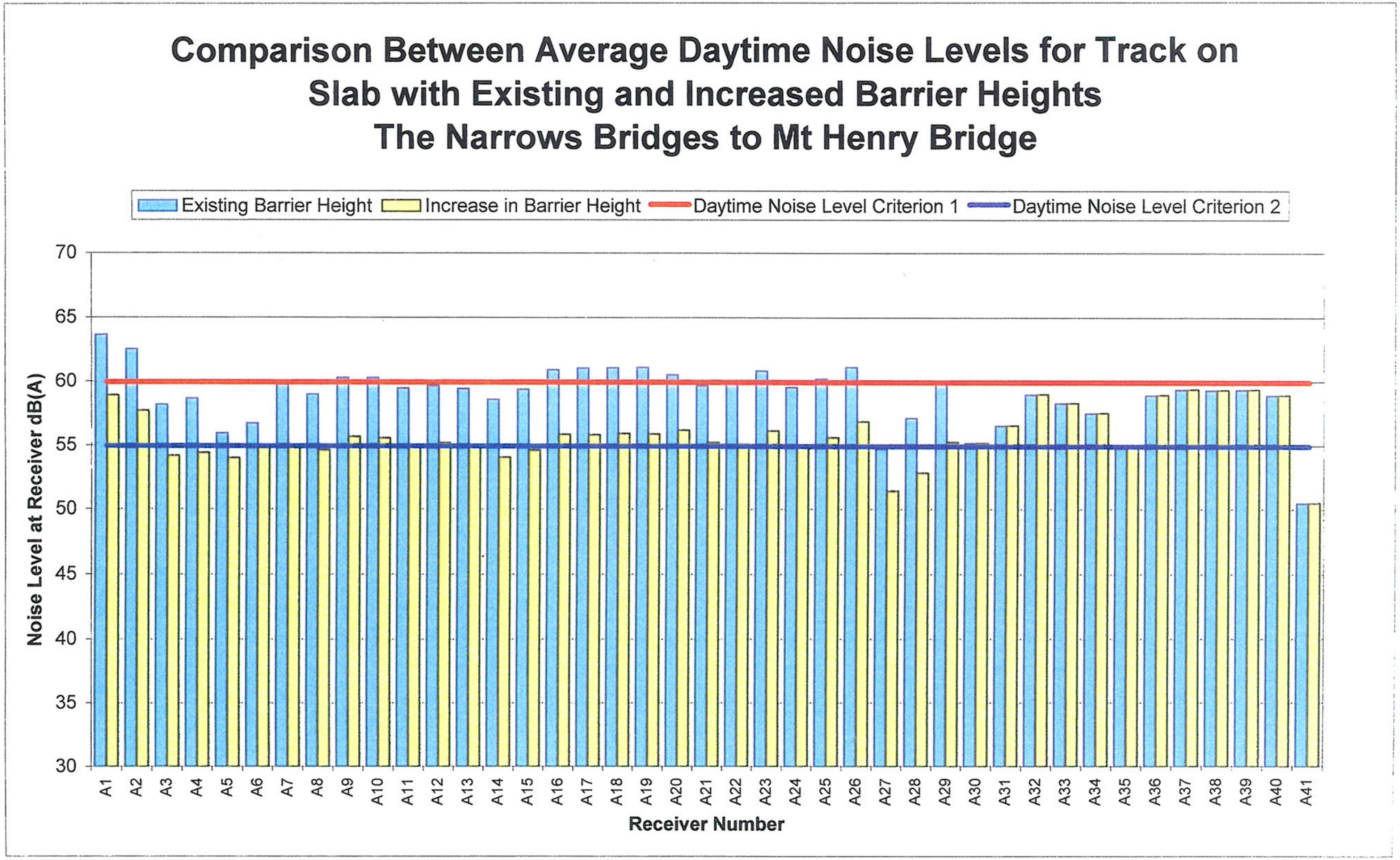
Figure 5.1 Receiver Locations from the Narrows Bridge to Mt Henry Bridge



Comparison Between Average Daytime Noise Levels for Track on Slab with Existing and Increased Barrier Heights The Narrows Bridges to Mt Henry Bridge
Existing Barrier Height
Increase in Barrier Height
Daytime Noise Level Criterion 1
Daytime Noise Level Criterion 2
Noise Level at Receiver dB(A)
70
65
60
55
50
45
40
35
30
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26 A27 A28 A29 A30 A31 A32 A33 A34 A35 A36 A37 A38 A39 A40 A41
Receiver Number

Figure 5.3

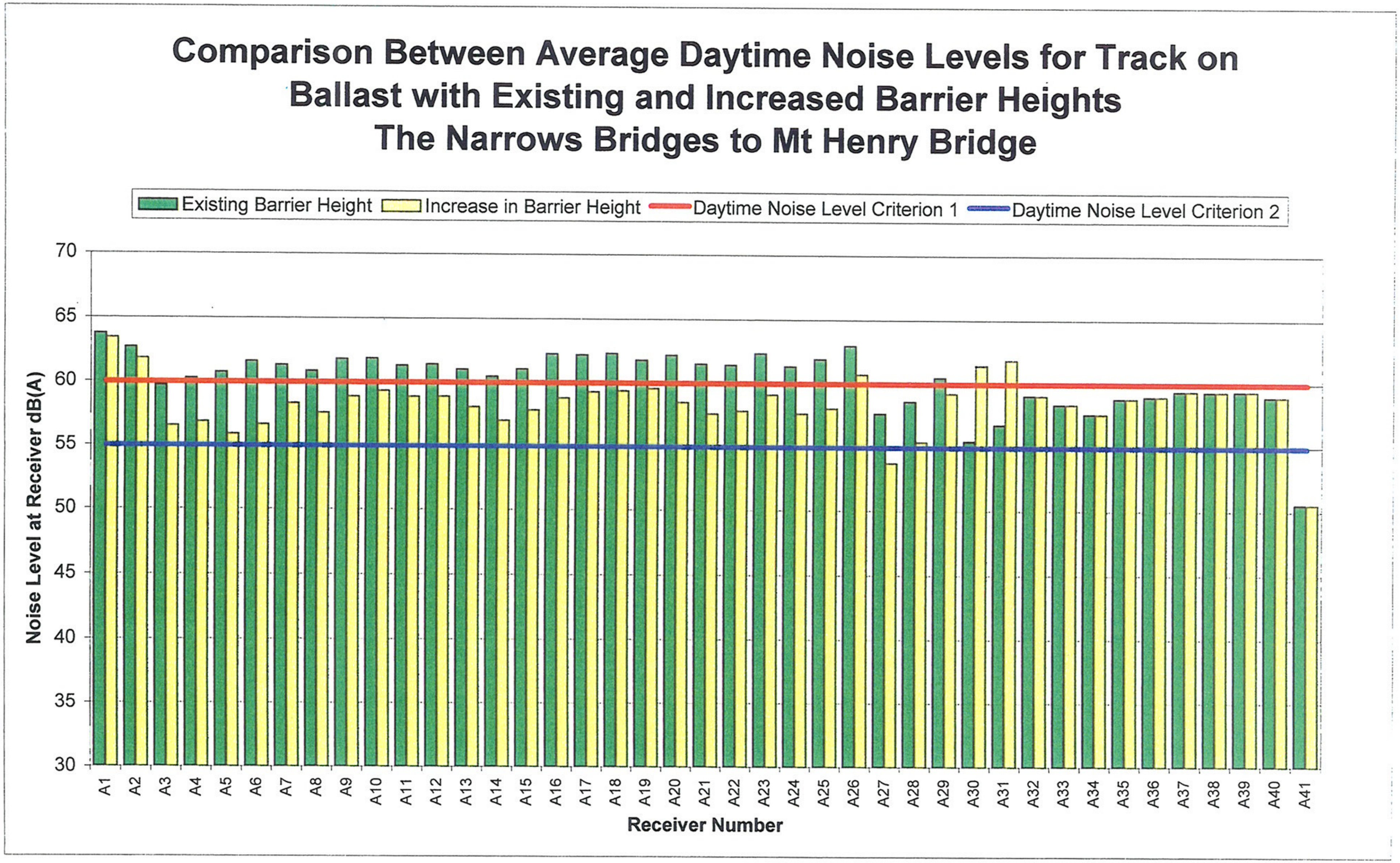


Figure 5.4

Lloyd Acoustics

The option of placing the track on the existing road slab increases the effectiveness of the existing Busway barriers and has the benefit of reducing the overall height of the railway and associated services, therefore reducing the visual impact.

The results of the noise level predictions at each of the noise sensitive receivers considered (see *Figure 5.1*) are presented in *Table 5.1*. This information is also presented graphically in *Figures 5.5* and *5.6*.

Table 5.1 RESULTS OF NOISE LEVEL PREDICTIONS FOR CHOSEN OPTION FROM THE NARROWS TO Mt HENRY BRIDGE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
A1	Melville Pde. Nth of Golf Course	25	59	51
A2	Melville Pde. Nth of Golf Course	33	58	50
A3	Melville Pde. Nth of Golf Course	85	54	46
A4	Melville Pde. Nth of Golf Course	72	54	46
A5	Melville Pde. Nth of Golf Course	63	54	46
A6	Melville Pde. Nth of Golf Course	51	55	47
A7	Melville Pde. Nth of Golf Course	55	55	47
A8	Melville Pde. Nth of Golf Course	62	55	46
A9	Melville Pde. Nth of Golf Course	50	56	47
A10	Melville Pde. Nth of Golf Course	48	56	47
A11	Melville Pde. Nth of Golf Course	55	55	47
A12	Melville Pde. Nth of Golf Course	54	55	47
A13	Melville Pde. Nth of Golf Course	59	55	47
A14	Melville Pde. Nth of Golf Course	68	54	46
A15	Melville Pde. Nth of Golf Course	62	55	46
A16	Melville Pde. Sth of Golf Course	46	56	48
A17	Melville Pde. Sth of Golf Course	46	56	48
A18	Melville Pde. Sth of Golf Course	45	56	48
A19	Melville Pde. Sth of Golf Course	51	56	48
A20	Melville Pde. Sth of Preston St	46	56	48
A21	Melville Pde. Sth of Preston St	54	55	47
A22	Melville Pde. Sth of Preston St	55	55	47
A23	Melville Pde. Sth of Preston St	45	56	48

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

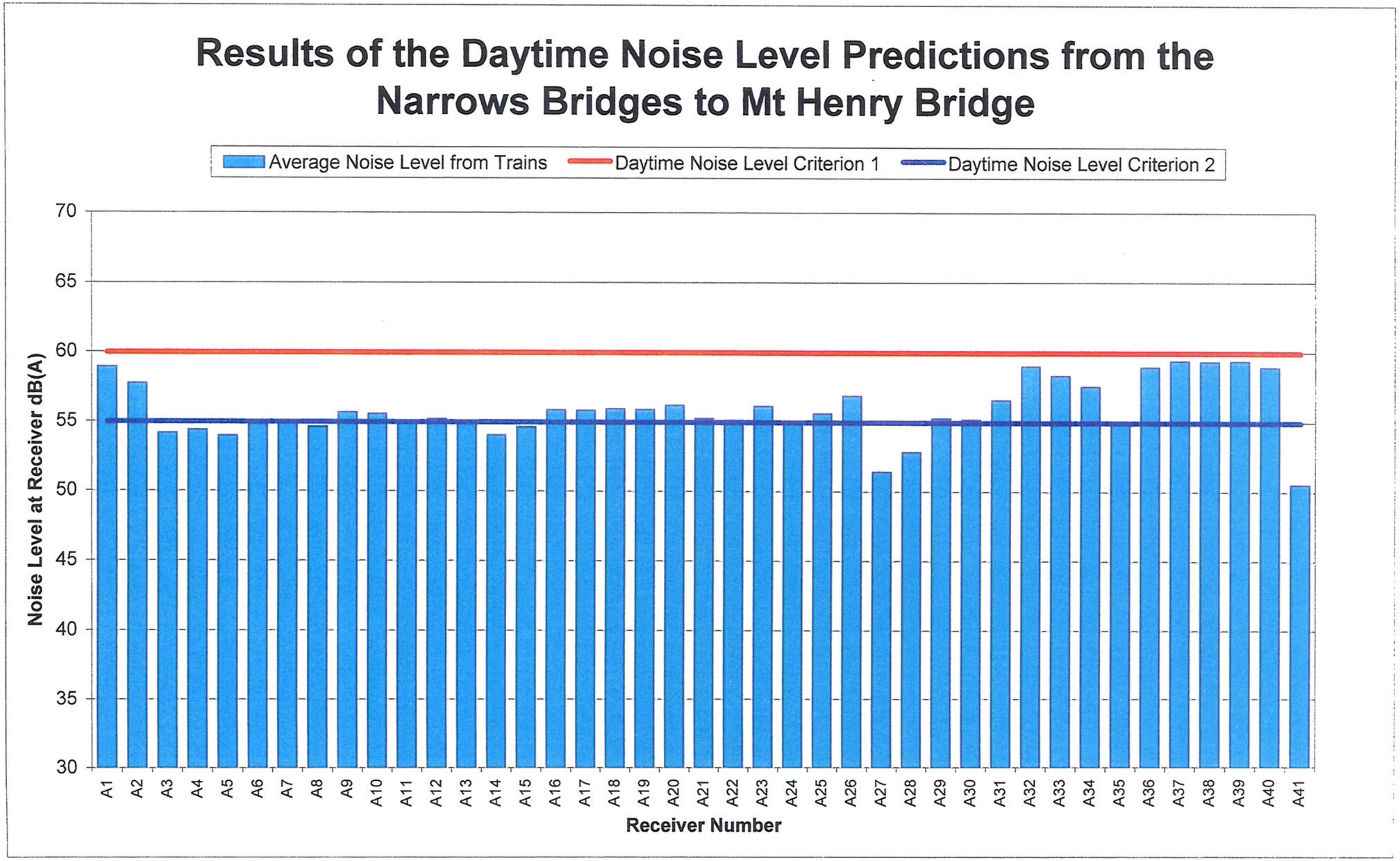
Table 5.1 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FOR CHOSEN OPTION FROM THE NARROWS TO Mt HENRY BRIDGE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\,(daytime)}$ dB(A)	$L_{Aeq\,(night\,time)}$ dB(A)
A24	Melville Pde. Sth of Greenock Ave	58	55	47
A25	Melville Pde. Sth of Greenock Ave	50	56	47
A26	Melville Pde. Sth of Greenock Ave	40	57	49
A27	Mary Street	145	51	43
A28	Mary Street	110	53	45
A29	Melville Pde. Sth of Henley St	70	55	47
A30	Robert Street. Sth of Canning Hwy	55	55	46
A31	Robert Street. Sth of Canning Hwy	49	57	47
A32	Canning Pde. Sth of Manning Rd	60	59	50
A33	Canning Pde. Sth of Manning Rd	67	58	49
A34	Canning Pde. Sth of Manning Rd	78	58	48
A35	Peter Arney Nursing Home	61	55	46
A36	Peter Arney Nursing Home	60	59	50
A37	Roebuck Drive	55	59	50
A38	Edgewater Road	56	59	50
A39	Edgewater Road	56	59	50
A40	Edgewater Road	60	59	50
A41	Aquinas College	275	51	41

Notes:
1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded
3. Receivers A30 to A41 do not have a Busway barrier and are therefore not influenced by the barrier height increase.

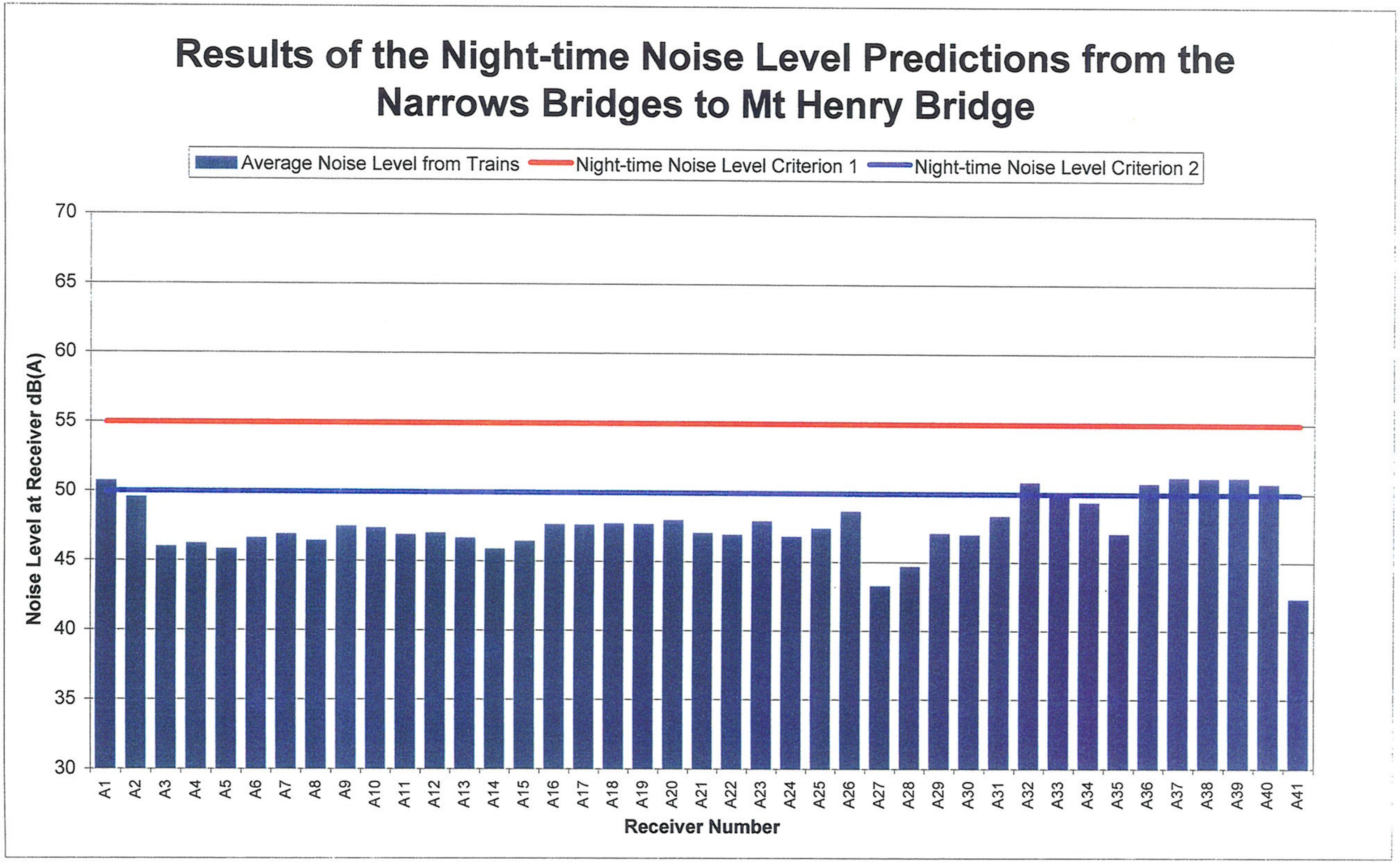
5.2.3 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.7*. As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).



Results of the Daytime Noise Level Predictions from the Narrows Bridges to Mt Henry Bridge
Average Noise Level from Trains
Daytime Noise Level Criterion 1
Daytime Noise Level Criterion 2
Noise Level at Receiver dB(A)
70
65
60
55
50
45
40
35
30
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26 A27 A28 A29 A30 A31 A32 A33 A34 A35 A36 A37 A38 A39 A40 A41
Receiver Number

Figure 5.5



Results of the Night-time Noise Level Predictions from the Narrows Bridges to Mt Henry Bridge
Average Noise Level from Trains
Night-time Noise Level Criterion 1
Night-time Noise Level Criterion 2
Noise Level at Receiver dB(A)
70
65
60
55
50
45
40
35
30
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26 A27 A28 A29 A30 A31 A32 A33 A34 A35 A36 A37 A38 A39 A40 A41
Receiver Number

Figure 5.6

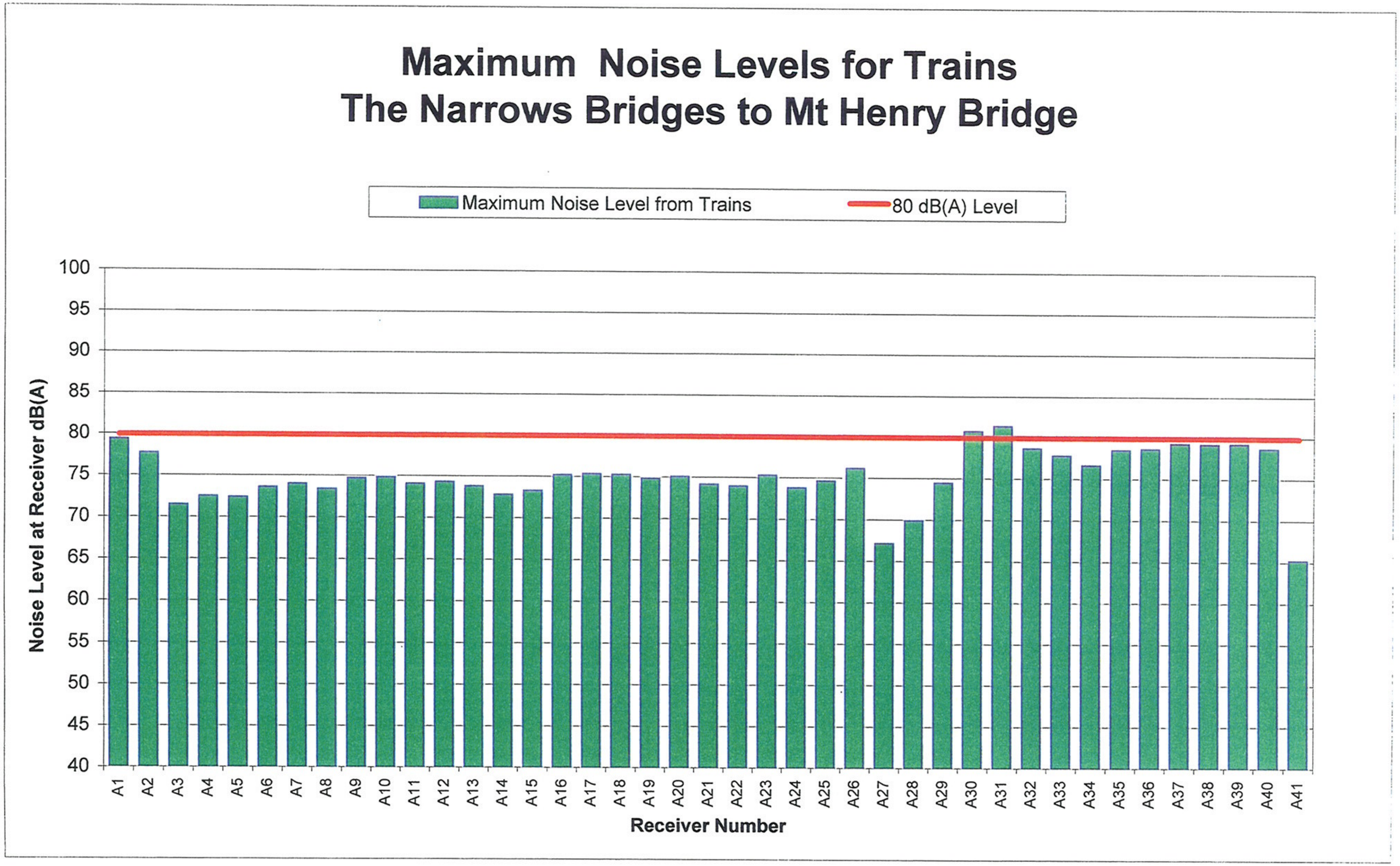

Maximum Noise Levels for Trains
The Narrows Bridges to Mt Henry Bridge
Maximum Noise Level from Trains
80 dB(A) Level
Noise Level at Receiver dB(A)
100
95
90
85
80
75
70
65
60
55
50
45
40
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
A24
A25
A26
A27
A28
A29
A30
A31
A32
A33
A34
A35
A36
A37
A38
A39
A40
A41
Receiver Number

Figure 5.7

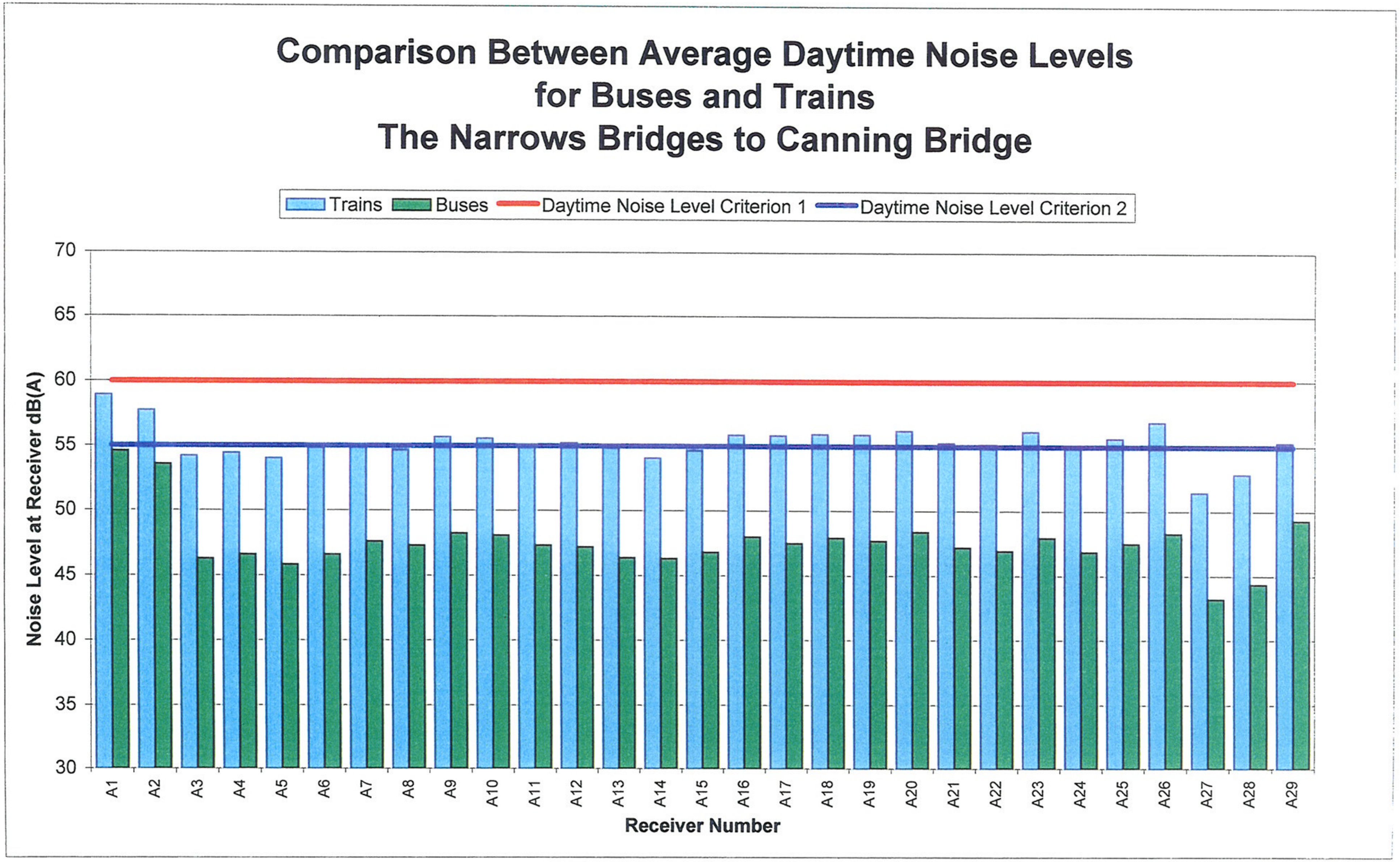


Figure 5.8

Lloyd Acoustics

5.2.4 *Comparison against Existing Impacts from Buses*

Although impacts from existing transportation noise sources are not being considered when assessing the noise impacts resulting from the South West Metropolitan Railway, the railway will replace the Busway running between Perth and Canning Highway. Currently, there are over 800 bus movements between 6.00 am and 10.00 pm along this section of the alignment, the associated noise impacts from these bus movements should be taken into consideration when assessing the impact to noise sensitive receivers from the proposed South West Metropolitan Railway. To assist in this process, predicted daytime noise levels from existing bus movements are compared against the predicted daytime noise levels from the proposed train movements. The results are presented in *Figure 5.8.*

5.2.5 *The Existing Environment*

Noise sensitive receivers along this section of the alignment face the freeway and are therefore, currently exposed to high levels of transportation noise. Measurements conducted in recent years indicate that the transportation noise levels along this section of the alignment are generally as follows:

Narrows Bridges Area (Aug. 2001)

- Daytime L_{Aeq} levels 62 dB(A);
- Night-time L_{Aeq} levels 56 dB(A).

Canning Bridge Area June 1997)

- Daytime L_{Aeq} levels 68 dB(A);
- Night-time L_{Aeq} levels 63 dB(A).

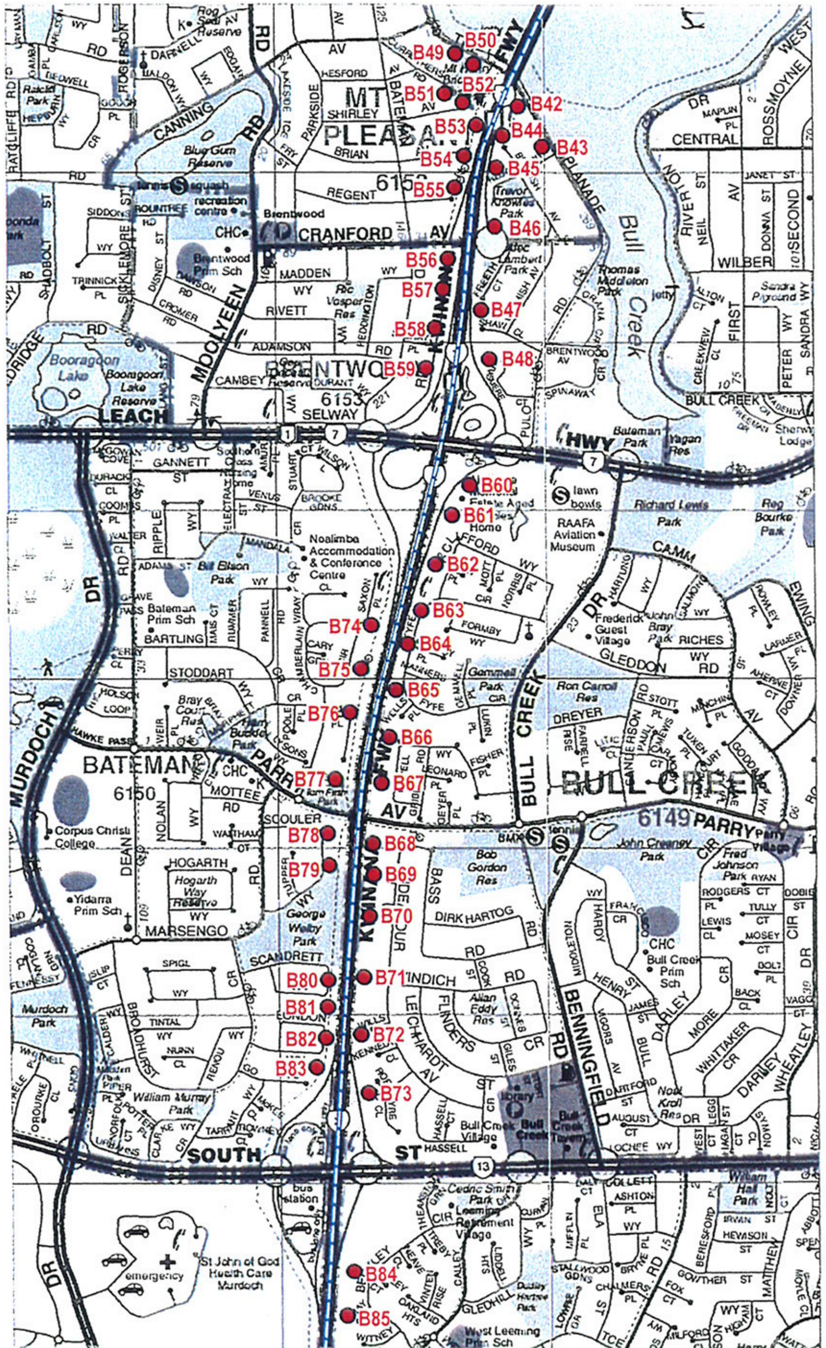
5.2.6 *Discussion*

Noise levels resulting from the South West Metropolitan Railway between the Narrows Bridges and Mt. Henry Bridge have been predicted to 41 receiver locations. The results, assuming the option of placing the track on the existing road slab and increasing the height of the existing Busway safety barriers between the Narrows Bridges and Canning Highway, show compliance with both the daytime and night-time noise level *Criteria 1* and exceeds the daytime *Criteria 2* at 21 locations and the night-time *Criteria* 2 at 1 location.

As indicated in Section 5.2.2, increasing the height of the existing Busway barriers is subject to review in terms of social impact and community acceptance. If it is found that an increased barrier height is not acceptable, the existing barrier height results in *Criteria 1* being exceeded by 1 dB(A) at nine receiver locations. This is illustrated in *Figure 5.3*.

The predicted noise levels along this section of the alignment, for the preferred option, require noise mitigation to be considered at 21 locations. However, as these receivers are already experiencing high levels of noise from road traffic, the placing of barriers to reduce noise from the railway may be of limited benefit.

RECEIVER LOCATIONS



5.3 MT HENRY BRIDGE TO BIBRA LAKE

5.3.1 Description and Results

This section of the alignment, illustrated in *Figure 5.9*, starts at Mt. Henry Bridge and finishes at Bibra Lake, just north of the Glen Iris Estate. The railway is to be placed on ballast and run down the centre of the Kwinana Freeway. No further design options have been considered for this section of the railway. The results of the noise level predictions at each of the noise sensitive receivers considered are presented in *Table 5.2*. This information is also presented graphically in *Figures 5.10* and *5.11*.

Table 5.2 RESULTS OF NOISE LEVEL PREDICTIONS FROM Mt HENRY BRIDGE TO BIBRA LAKE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
B42	The Esplanade E of Bridge	86	54	46
B43	The Esplanade E of Bridge	102	54	45
B44	Beamish Ave Mt Henry	52	56	48
B45	Regent Way Mt Henry	40	53	44
B46	Regent Way Mt Henry	70	56	47
B47	Freeth Court	47	54	46
B48	Grasmere Court	77	54	46
B49	The Esplanade W of Bridge	190	55	47
B50	The Esplanade W of Bridge	159	56	48
B51	Curruthers Road	148	56	48
B52	Shirley Ave	116	56	48
B53	Shirley Ave	63	51	43
B54	Brian Ave	57	55	47
B55	Regent Ave	60	56	47
B56	Selway Road	61	54	46
B57	Selway Road	60	56	48
B58	Selway Road	67	54	46
B59	Selway Road	85	52	44

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.2 (cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM Mt HENRY BRIDGE TO BIBRA LAKE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
B60	Air force Aged People's Home	97	53	44
B61	Air force Aged People's Home	84	54	46
B62	Clifford Way	61	56	47
B63	Fyfe Circle	69	56	47
B64	Fyfe Circle	78	59	51
B65	Wells Place	70	54	45
B66	Orbell Way	51	56	47
B67	Orbell Way	55	55	47
B68	Endeavour Way	63	53	45
B69	Endeavour Way	56	53	45
B70	Endeavour Way	68	54	45
B71	Endeavour Way	60	54	45
B72	Wills Close	68	51	42
B73	Roe Close	89	54	46
B74	Saxon Place	61	56	47
B75	Chamberlain Circle	56	55	47
B76	Breen Place	56	54	46
B77	Joyce Place	55	55	47
B78	Scouler Way	55	55	47
B79	Scouler Way	55	55	47
B80	Scandrett Way	62	55	47
B81	Scandrett Way	53	56	48
B82	London Way	63	55	47
B83	London Way	60	55	47
B84	Beckley Circle	70	50	42
B85	May Court	77	51	43
B86	Envall Way	82	51	43
B87	Envall Way	81	52	44

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.2 (cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM Mt HENRY BRIDGE TO BIBRA LAKE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
B88	Warman Court	61	51	43
B89	Howlett Place	77	50	42
B90	Earnshaw Loop	86	50	42
B91	Tawson Place	60	55	47
B92	McKivett Crescent	58	51	42
B93	Woodlea Crest	68	53	44
B94	Peterborough Circle	55	55	46
B95	Tetlow Place	54	54	46
B96	Dowell Place	54	51	43

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

5.3.2 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.12.* As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).

5.3.3 *The Existing Environment*

Noise sensitive receivers along this section of the alignment face the freeway and are currently exposed transportation noise. Measurements conducted in recent years indicate that the transportation noise levels along this section of the alignment are generally as follows:

<u>Mt Henry Bridge (Feb. 01)</u>

- Daytime L_{Aeq} levels 57 to 61 dB(A);
- Night-time L_{Aeq} levels 51 to 53 dB(A).

<u>Leeming Area (Nov. 2001 - taken from measurements at Jandakot)</u>

- Daytime L_{Aeq} levels 56 dB(A);
- Night-time L_{Aeq} levels 52 dB(A).

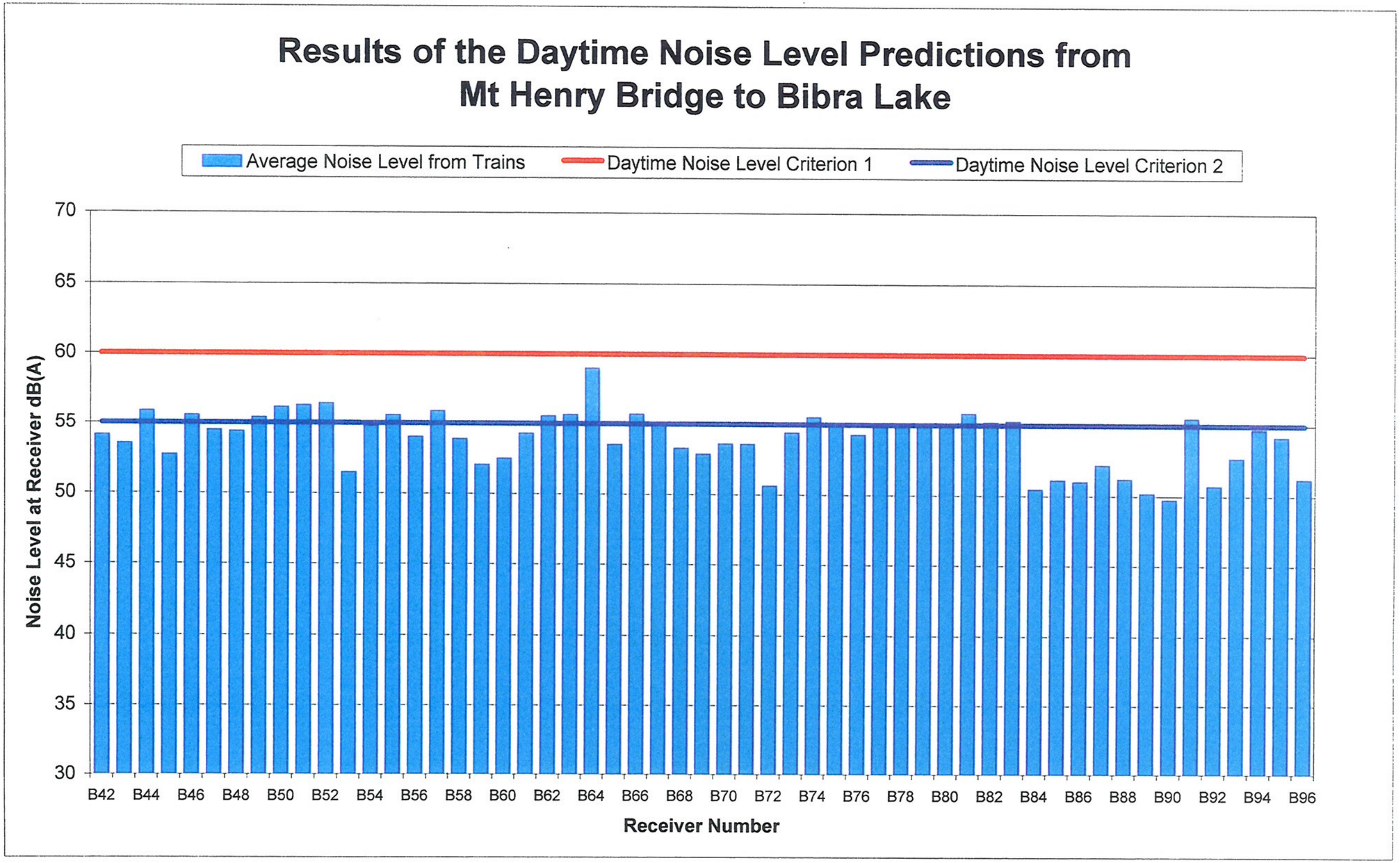


Figure 5.10

Lloyd Acoustics

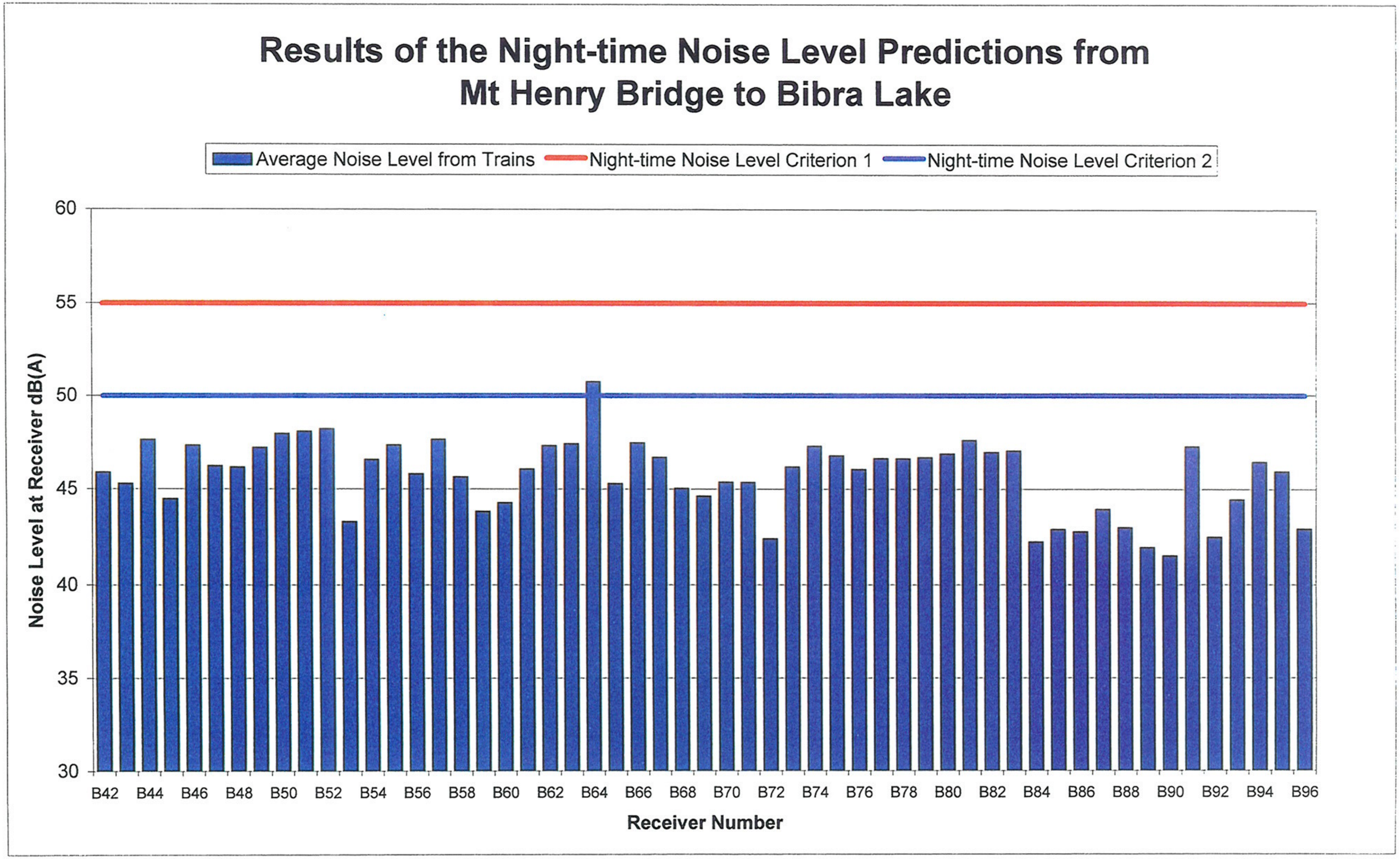


Figure 5.11

Lloyd Acoustics

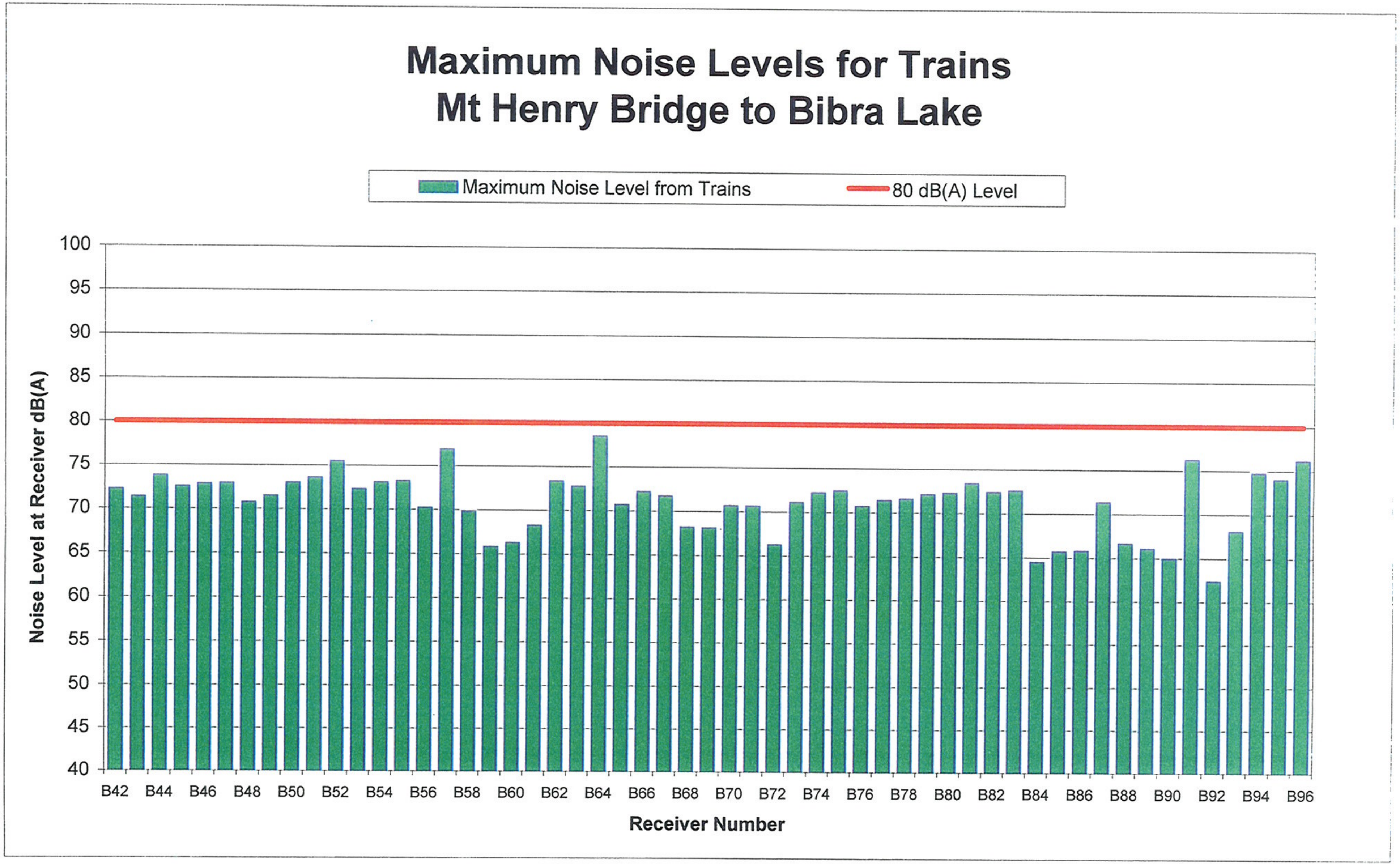

Maximum Noise Levels for Trains
Mt Henry Bridge to Bibra Lake
Maximum Noise Level from Trains
80 dB(A) Level
Noise Level at Receiver dB(A)
100
95
90
85
80
75
70
65
60
55
50
45
40
B42 B44 B46 B48 B50 B52 B54 B56 B58 B60 B62 B64 B66 B68 B70 B72 B74 B76 B78 B80 B82 B84 B86 B88 B90 B92 B94 B96
Receiver Number

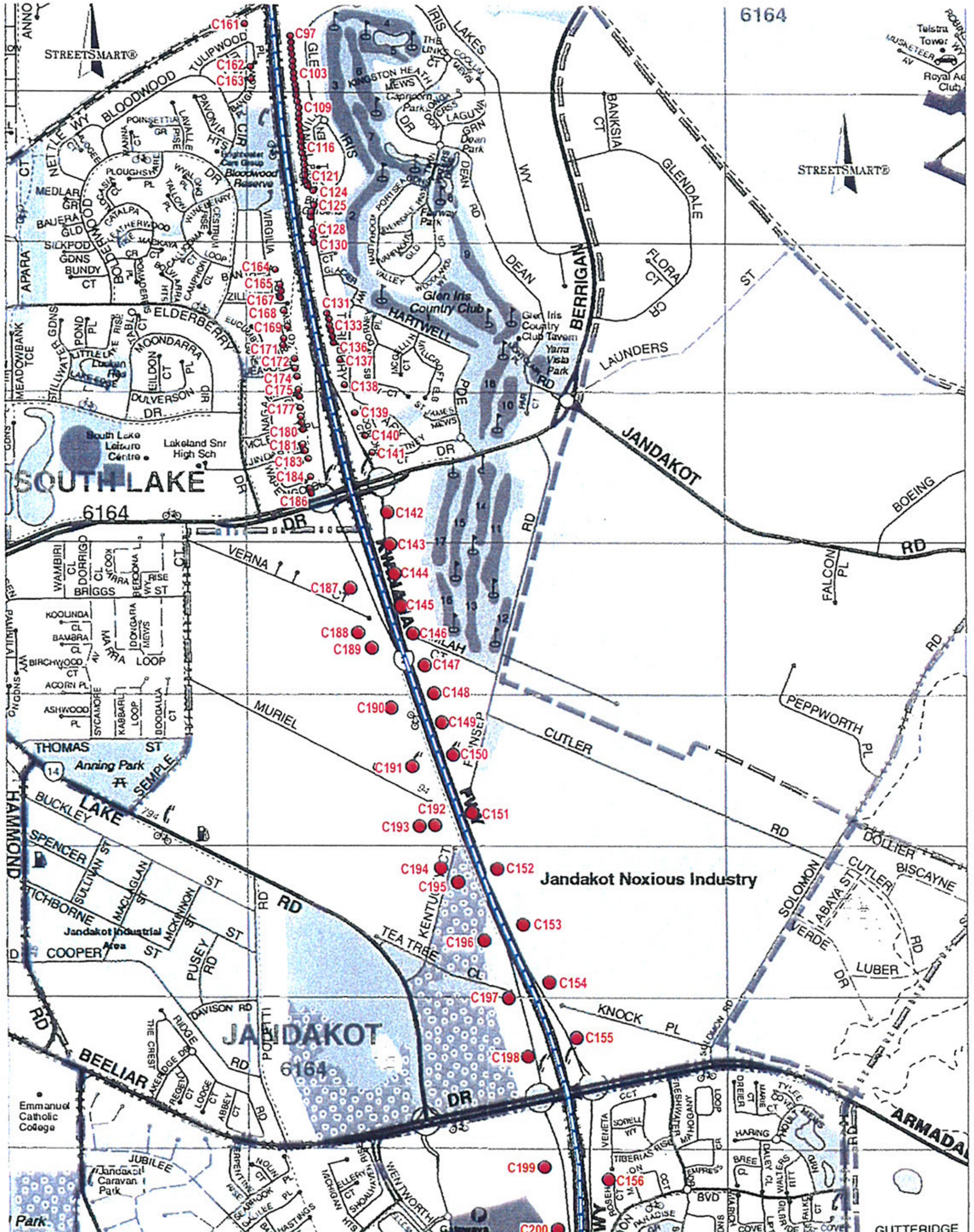
Figure 5.12

5.3.4 *Discussion*

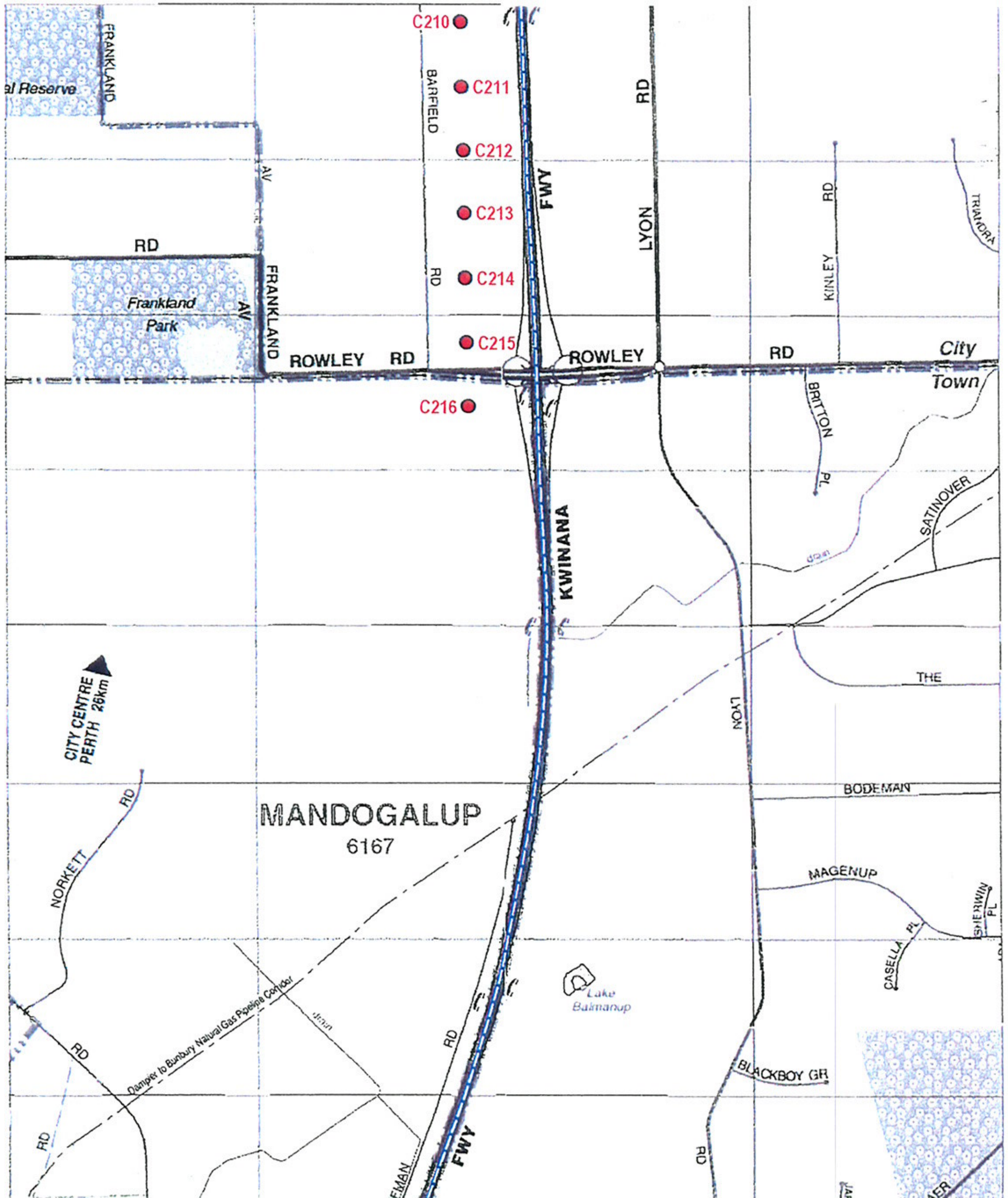
Noise levels resulting from the South West Metropolitan Railway between Mt. Henry Bridge and Bibra Lake have been predicted to 55 receiver locations. The results show compliance with both the daytime and night-time noise level *Criteria 1* at all locations and exceeds the daytime *Criteria 2* at 13 locations and the Night-time *Criteria 2* at 1 location.

The predicted noise levels along this section of the alignment require noise mitigation to be considered at 13 locations. However, as these receivers are already experiencing high levels of noise from road traffic, the placing of barriers to reduce noise from the railway may be of limited benefit.

RECEIVER LOCATIONS



RECEIVER LOCATIONS



5.4 JANDAKOT TO THOMAS ROAD

5.4.1 *Description and Results*

This section of the alignment, illustrated in *Figures 5.13* and *5.14*, starts at Glen Iris Estate, Jandakot, and finishes at Thomas Road. The railway is to be placed on ballast and is to run down the centre of the Kwinana Freeway to the tunnel just north of Thomas Road, where it starts to head towards the southwest. No further design options have been considered. The results of the noise level predictions at each of the noise sensitive receivers considered are presented in *Table 5.3*. This information is also presented graphically in *Figures 5.15* and *5.16*.

Table 5.3 RESULTS OF NOISE LEVEL PREDICTIONS FROM JANDAKOT TO THOMAS ROAD

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions $L_{Aeq\ (daytime)}$ dB(A)	Night-time noise level Predictions $L_{Aeq\ (night\ time)}$ dB(A)
C97	Glen Iris Drive	70	50	42
C98	Glen Iris Drive	70	50	41
C99	Glen Iris Drive	68	54	46
C100	Glen Iris Drive	70	51	43
C101	Glen Iris Drive	70	49	41
C102	Glen Iris Drive	70	49	40
C103	Glen Iris Drive	69	46	38
C104	Glen Iris Drive	70	43	35
C105	Glen Iris Drive	71	42	34
C106	Glen Iris Drive	72	42	34
C107	Glen Iris Drive	72	41	33
C108	Glen Iris Drive	72	41	33
C109	Glen Iris Drive	74	41	32
C110	Glen Iris Drive	73	40	32
C111	Glen Iris Drive	71	40	32
C112	Bonville Glenn	69	40	32
C113	Bonville Glenn	70	40	32

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.3 (cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM JANDAKOT TO THOMAS ROAD

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
C114	Bonville Glenn	71	41	33
C115	Bonville Glenn	70	41	33
C116	Bonville Glenn	69	41	33
C117	Bonville Glenn	69	41	33
C118	Bonville Glenn	70	42	33
C119	The Pines Grove	70	42	34
C120	The Pines Grove	69	42	34
C121	The Pines Grove	68	43	34
C122	The Pines Grove	66	43	35
C123	The Pines Grove	71	43	35
C124	The Pines Grove	88	45	37
C125	Glen Iris Drive	84	46	38
C126	Glen Iris Drive	75	45	36
C127	Glen Iris Drive	71	44	36
C128	Glen Iris Drive	66	48	39
C129	Glen Iris Drive	64	53	45
C130	Glen Iris Drive	62	56	48
C131	Glen Iris Drive	63	56	48
C132	Glen Iris Drive	67	53	45
C133	Glen Iris Drive	65	51	43
C134	Turnbury Park Drive	66	52	44
C135	Turnbury Park Drive	66	52	44
C136	Turnbury Park Drive	66	55	47
C137	Turnbury Park Drive	75	52	44
C138	Turnbury Park Drive	71	52	44
C139	Brookford Court	83	54	46
C140	Brookford Court	96	54	46
C141	Brookford Court	106	51	43
C142	Possible Future Development	103	52	44

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.3 (cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM JANDAKOT TO THOMAS ROAD

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
C143	Possible Future Development	82	52	44
C144	Possible Future Development	66	53	45
C145	Possible Future Development	55	53	45
C146	Possible Future Development	51	53	45
C147	Possible Future Development	50	52	44
C148	Possible Future Development	50	54	46
C149	Possible Future Development	49	53	45
C150	Possible Future Development	52	55	47
C151	Possible Future Development	60	55	47
C152	Possible Future Development	69	55	47
C153	Possible Future Development	72	55	47
C154	Possible Future Development	73	50	42
C155	Possible Future Development	86	50	41
C156	Rosehill Court	79	38	30
C157	Lydon Bvd	60	52	44
C158	Lydon Bvd	60	52	44
C159	Lory Mews	60	56	47
C160	Brenchley Drive	60	57	49
C161	Tulipwood Place	67	50	41
C162	Tulipwood Place	62	53	44
C163	Bagalow Place	62	53	45
C164	Virgilia Terrace	64	57	48
C165	Virgilia Terrace	58	51	43
C166	Virgilia Terrace	59	49	41
C167	Zillner Close	63	52	44
C168	Zillner Close	62	52	44
C169	Curalo Mews	59	50	42
C170	Curalo Mews	77	51	43
C171	Curalo Mews	84	52	44

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

*Table 5.3 (cont)*RESULTS OF NOISE LEVEL PREDICTIONS FROM JANDAKOT TO THOMAS ROAD

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
C172	Jeavons Place	58	52	44
C173	Jeavons Place	61	52	44
C174	Jeavons Place	62	52	44
C175	Nagambie Close	65	54	46
C176	Nagambie Close	66	52	44
C177	Nagambie Close	71	54	46
C178	Mclernon Place	75	55	46
C179	Mclernon Place	76	52	44
C180	Mclernon Place	79	51	43
C181	Jindabyne Heights	92	49	41
C182	Jindabyne Heights	90	49	40
C183	Jindabyne Heights	85	44	36
C184	Wapengo Close	94	44	36
C185	Wapengo Close	107	45	37
C186	Verna Court	105	45	37
C187	Verna Court	70	50	42
C188	Verna Court	90	50	42
C189	Muriel Court	64	53	45
C190	Muriel Court	70	51	43
C191	Muriel Court	68	52	44
C192	Muriel Court	62	53	45
C193	Muriel Court	111	54	46
C194	Kentucky Court	84	56	47
C195	Kentucky Court	58	54	45
C196	Tea Tree Close	54	54	46
C197	Tea Tree Close	59	53	44
C198	Beeliar Drive	69	51	43
C199	Beeliar Drive	121	49	41
C200	Beeliar Drive	93	46	38

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.3 (cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM JANDAKOT TO THOMAS ROAD

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
C201	Malata Crescent	67	53	45
C202	Malata Crescent	79	51	42
C203	Pearson Drive	74	55	47
C204	Minerva Loop	71	57	49
C205	Barfield Road	217	46	38
C206	Barfield Road	185	45	37
C207	Barfield Road	176	51	43
C208	Barfield Road	183	50	42
C209	Barfield Road	187	51	43
C210	Barfield Road	191	45	37
C211	Barfield Road	198	51	42
C212	Barfield Road	202	49	41
C213	Barfield Road	205	49	41
C214	Barfield Road	210	44	35
C215	Rowley Road	216	43	35
C216	Rowley Road	219	50	42
C217	Spectacles Drive	32	60	50
C218	Spectacles Drive	56	55	46
C219	Spectacles Drive	101	57	48
C220	Spectacles Drive	73	57	48

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

5.4.2 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.17.* As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).

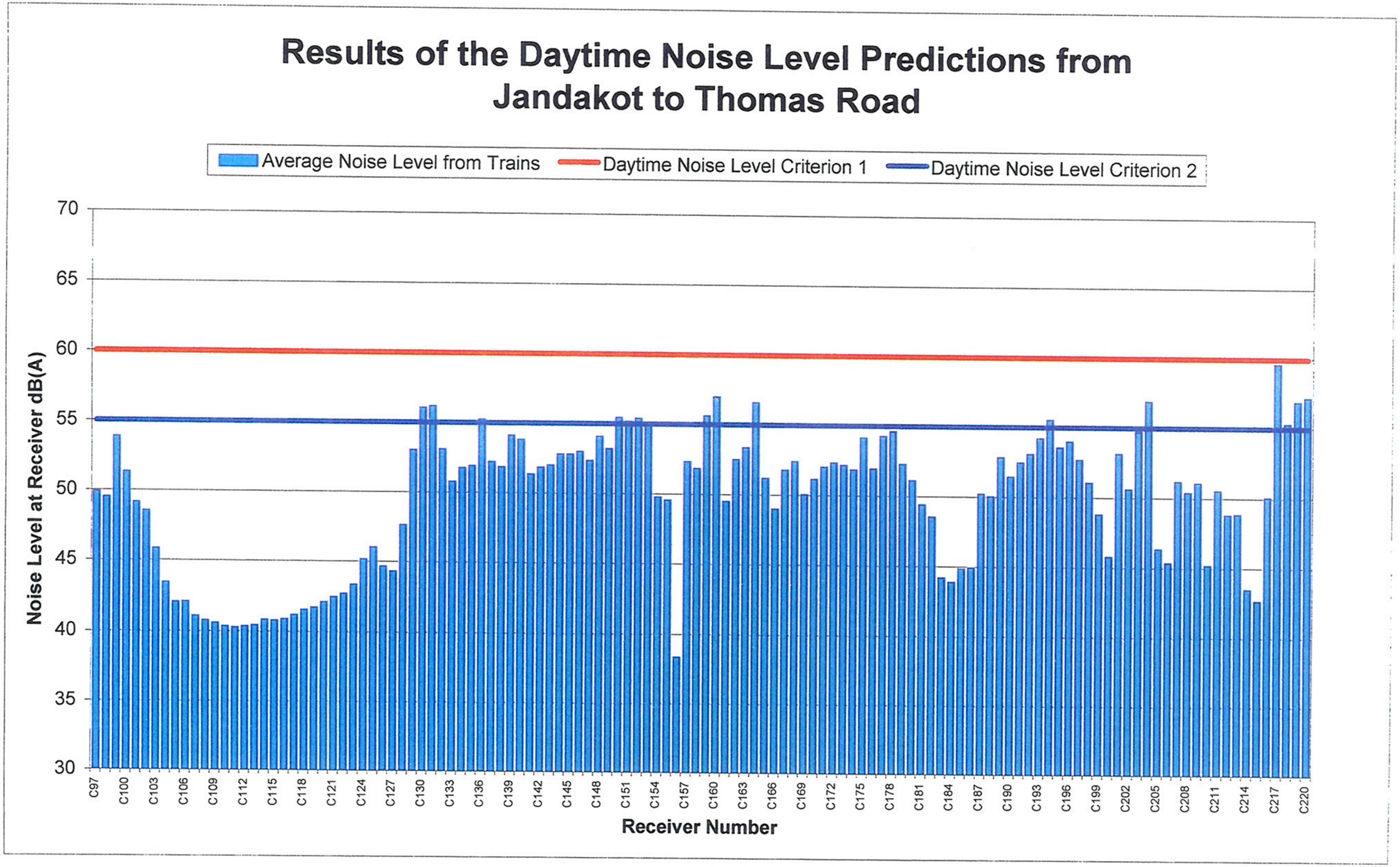


Figure 5.15

Lloyd Acoustics

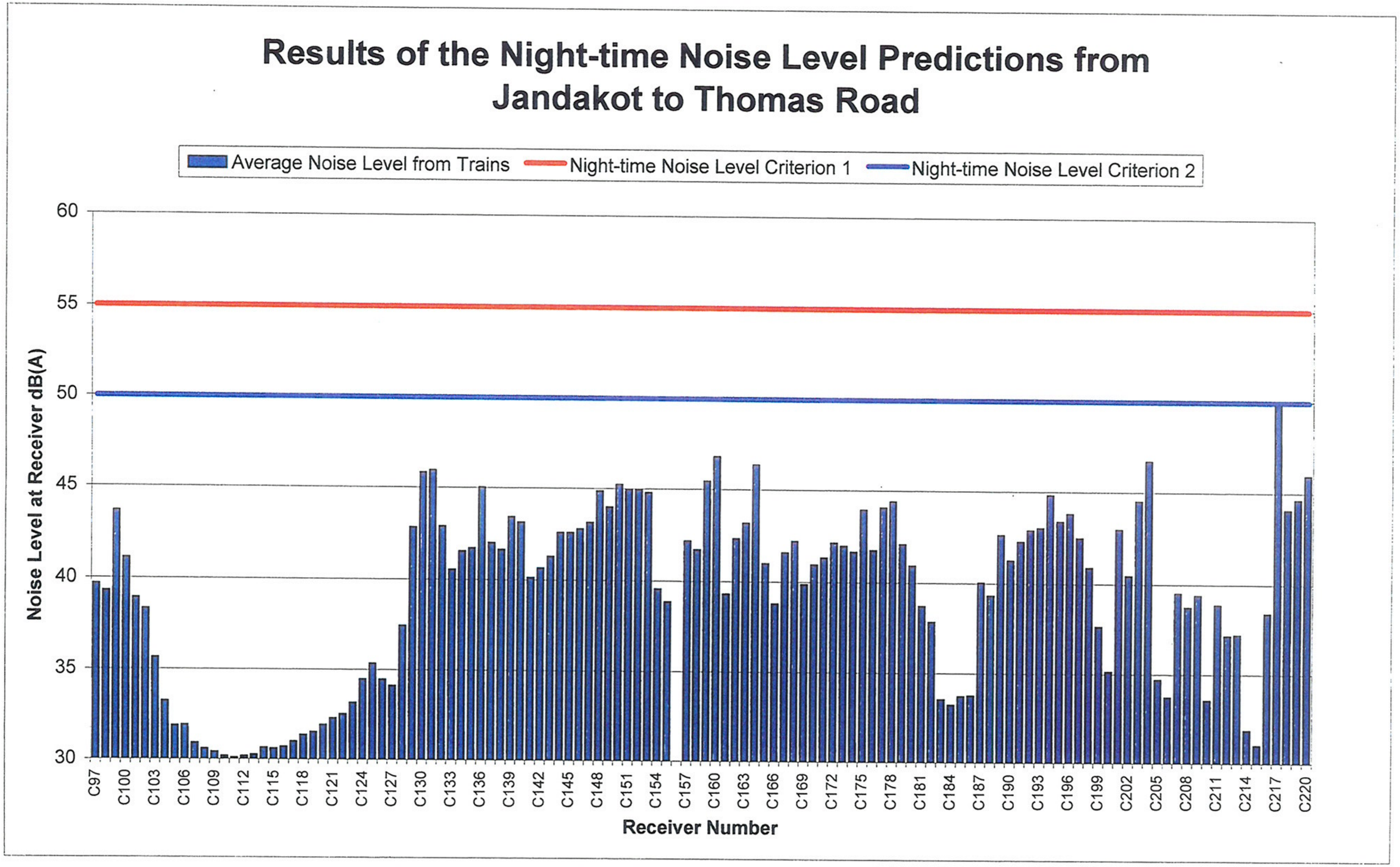
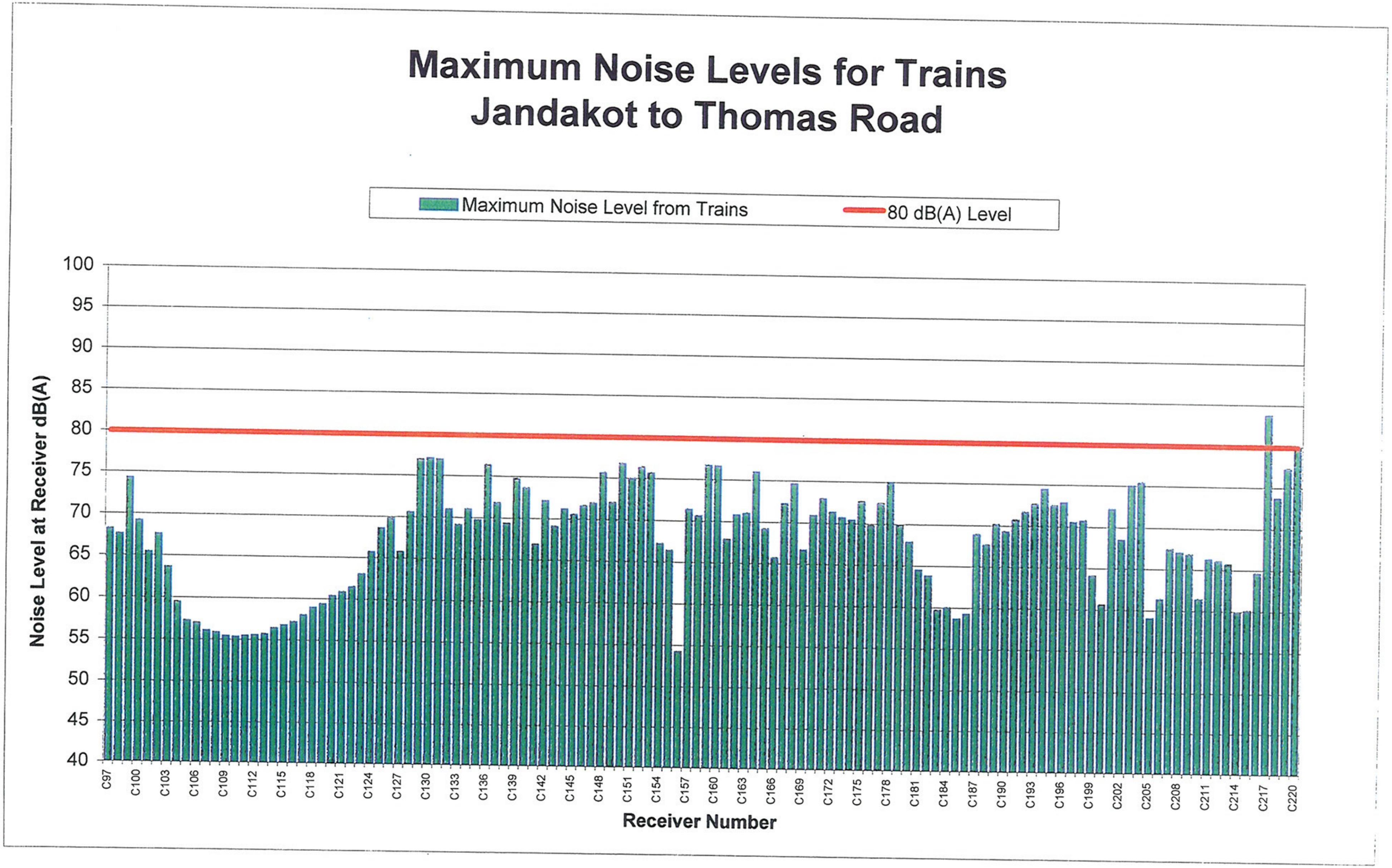


Figure 5.16

Lloyd Acoustics



Maximum Noise Levels for Trains
Jandakot to Thomas Road
Maximum Noise Level from Trains
80 dB(A) Level
Noise Level at Receiver dB(A)
100
95
90
85
80
75
70
65
60
55
50
45
40
C97 C100 C103 C106 C109 C112 C115 C118 C121 C124 C127 C130 C133 C136 C139 C142 C145 C148 C151 C154 C157 C160 C163 C166 C169 C172 C175 C178 C181 C184 C187 C190 C193 C196 C199 C202 C205 C208 C211 C214 C217 C220
Receiver Number

Figure 5.17

5.4.3 *The Existing Environment*

Noise sensitive receivers along this section of the alignment face the freeway and are currently exposed transportation noise. Measurements conducted in recent years indicate that the transportation noise levels along this section of the alignment are generally as follows:

Jandakot Area (Nov. 2001)

- Daytime L_{Aeq} levels 56 dB(A);
- Night-time L_{Aeq} levels 52 dB(A).

5.4.4 *Discussion*

Noise levels resulting from the South West Metropolitan Railway from Jandakot to Thomas Road have been predicted to 124 receiver locations. The results show compliance with both the daytime and night-time noise level *Criteria 1* at all locations and exceeds the daytime *Criteria* 2 at 10 locations.

The predicted noise levels along this section of the alignment require noise mitigation to be considered at 10 locations. For the receivers adjacent to the freeway, the current transportation noise levels along this section are already high levels and the placing of barriers to reduce noise from the railway may be of limited benefit. However, for the receivers adjacent to Barfield Road and Spectacles Drive (C205 to C220), the current background noise levels are considerably less and mitigation measures are likely to be beneficial.

In broad terms a noise barrier 1.5 m high positioned on the boundary of the railway reserve would provide sufficient attenuation to achieve *Criteria* 2.

RECEIVER LOCATIONS

Figure 5.18 Receiver Locations from Thomas Road to Garden Island Highway Reserve

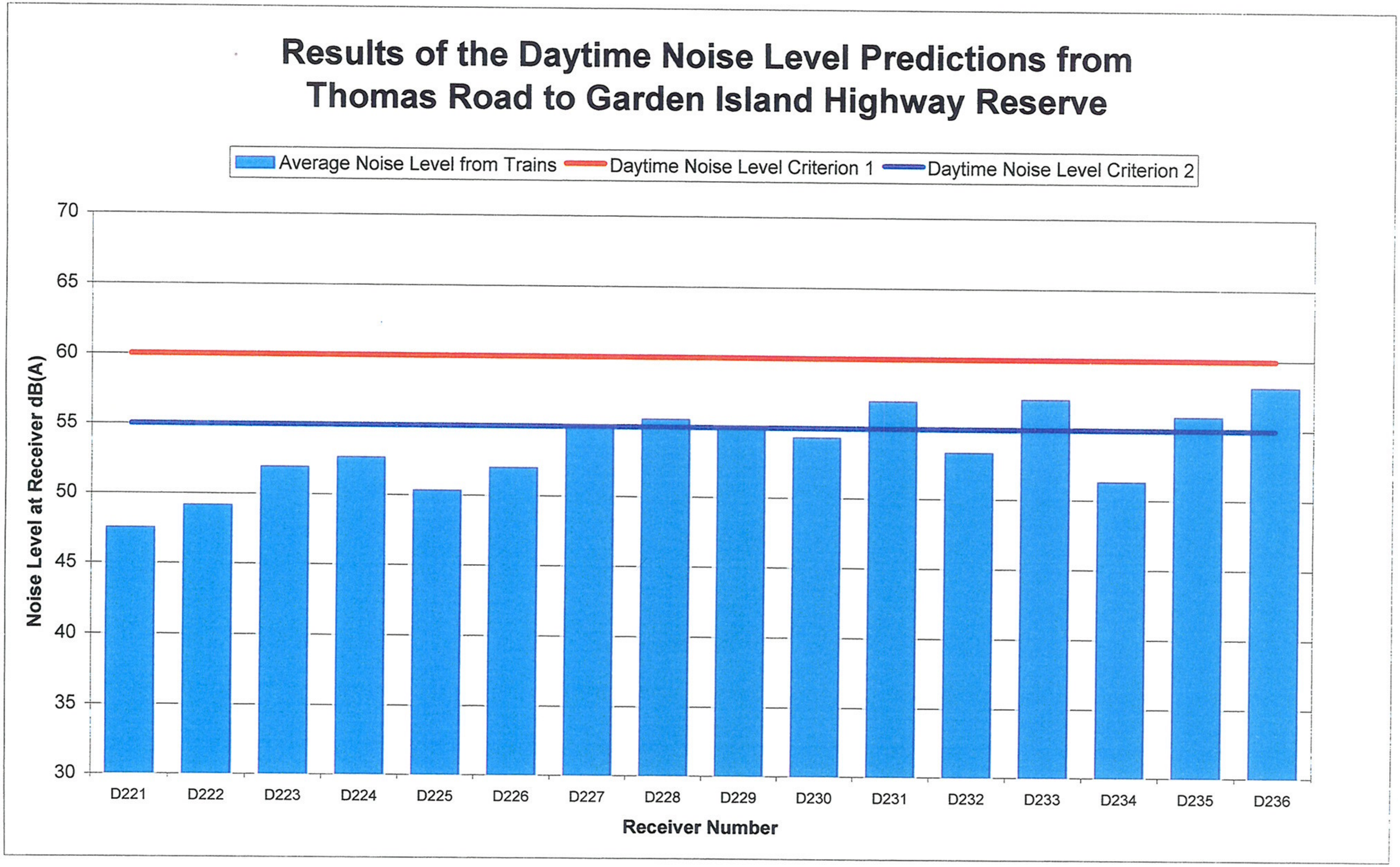


Figure 5.19

Lloyd Acoustics

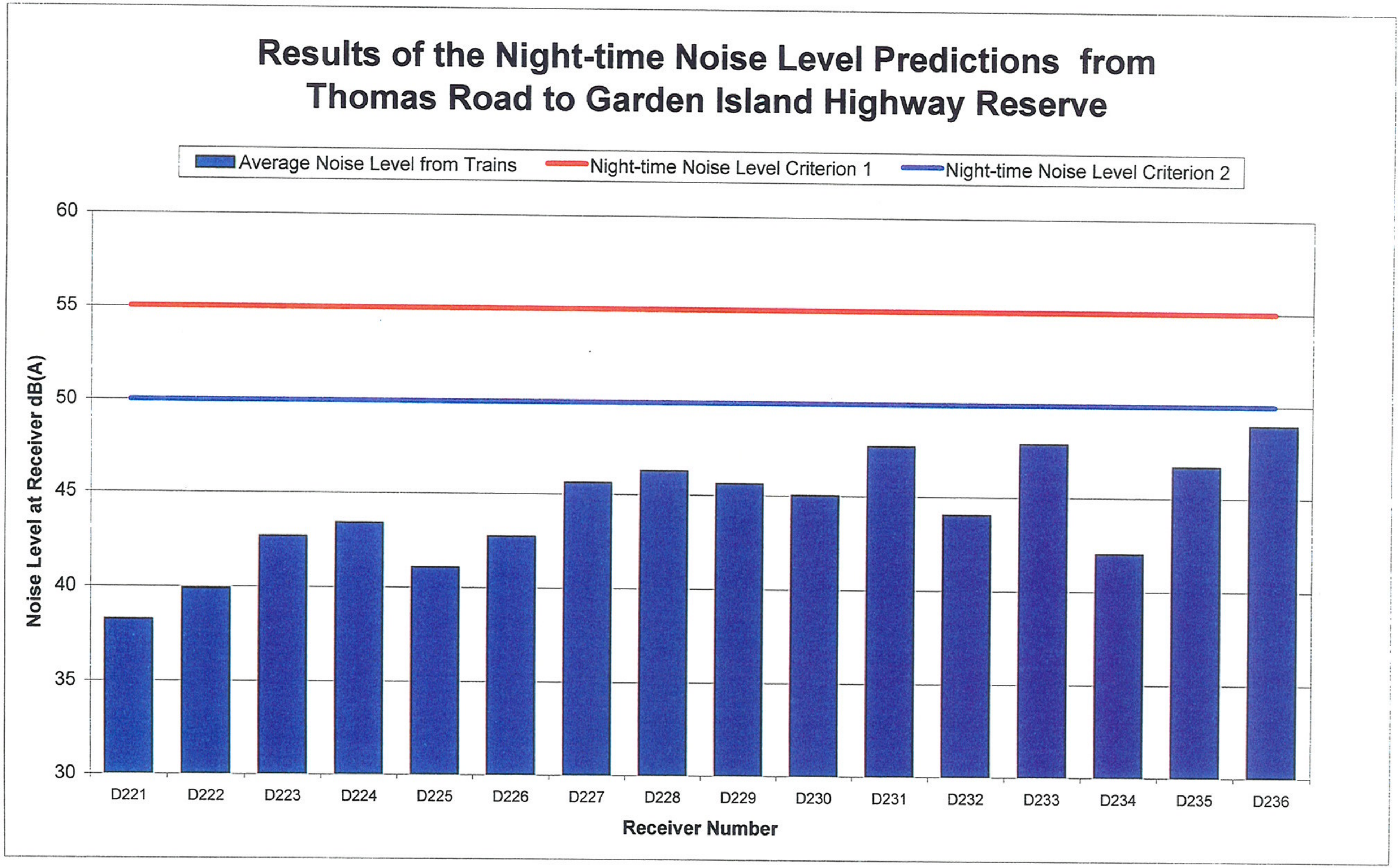

Results of the Night-time Noise Level Predictions from Thomas Road to Garden Island Highway Reserve
Average Noise Level from Trains
Night-time Noise Level Criterion 1
Night-time Noise Level Criterion 2
60
55
50
45
40
35
30
Noise Level at Receiver dB(A)
D221
D222
D223
D224
D225
D226
D227
D228
D229
D230
D231
D232
D233
D234
D235
D236
Receiver Number

Figure 5.20

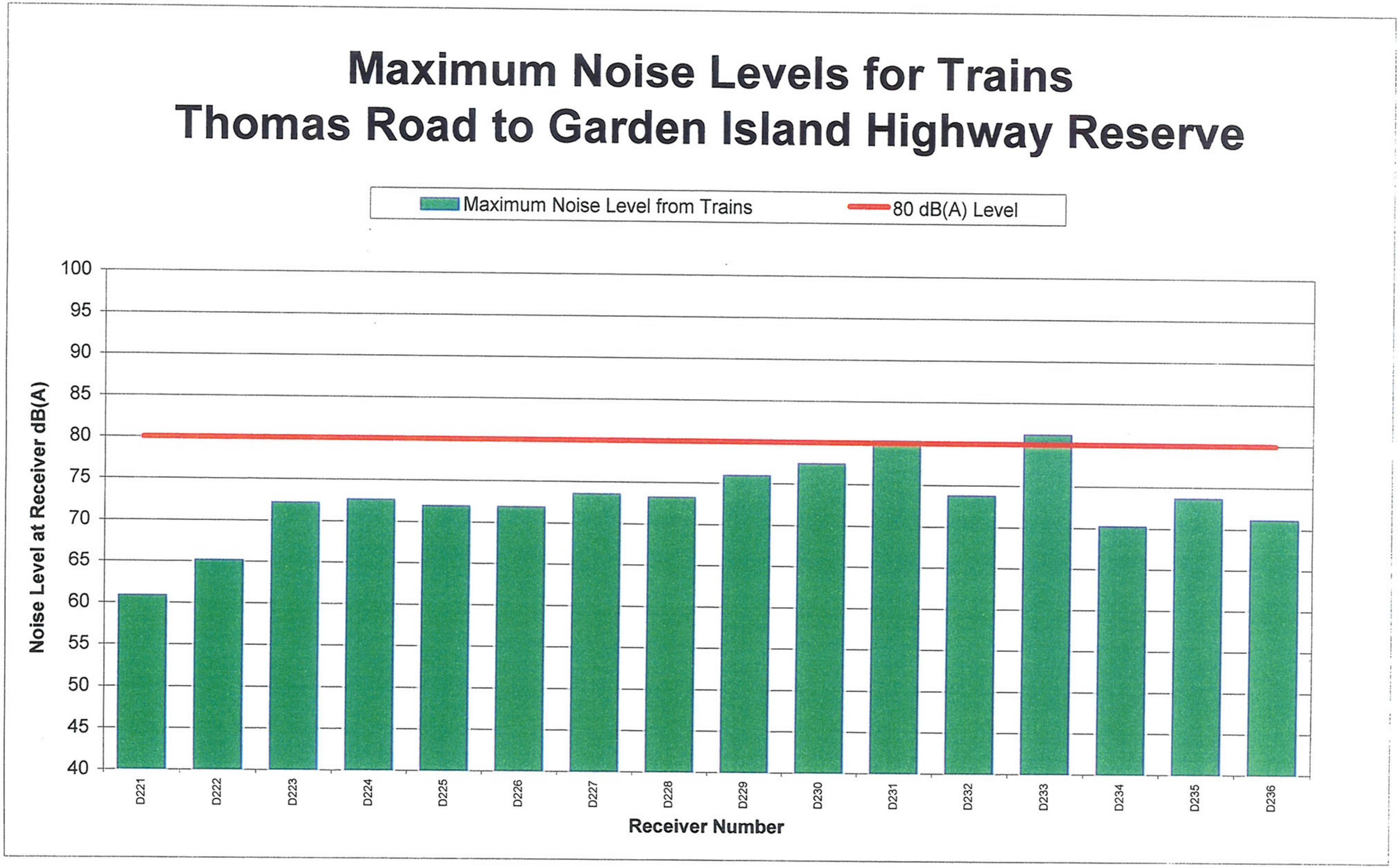


Figure 5.21

Lloyd Acoustics

5.5.2 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.21.* As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).

5.5.3 *The Existing Environment*

Noise sensitive receivers along this section of the alignment are currently exposed some transportation noise from minor roads, however these levels are not significant. Background noise measurements undertaken for this project indicate that the background noise levels along this section of the alignment are generally as follows:

<u>Parmelia Area (Nov. 2002)</u>

- Daytime L_{Aeq} levels 54 dB(A);
- Night-time L_{Aeq} levels 45 dB(A).
- Daytime L_{A90} levels 39 dB(A);
- Night-time L_{A90} levels 35 dB(A).

5.5.4 *Discussion*

Noise levels resulting from the South West Metropolitan Railway between Thomas Road and the Garden Island Highway Reserve have been predicted to 16 receiver locations. The results presented in *Table 5.4,* show compliance with both the daytime and night-time noise level *Criteria 1* at all locations and exceeds the daytime *Criteria 2* by between 1 dB(A) and 2 dB(A) at 4 locations. As the existing noise environment is relatively quiet, noise mitigation would be considered as beneficial for those receivers exceeding the criteria.

In broad terms a noise barrier 1.5 m high positioned on the boundary of the railway reserve would provide sufficient attenuation to achieve *Criteria 2.*

RECEIVER LOCATIONS

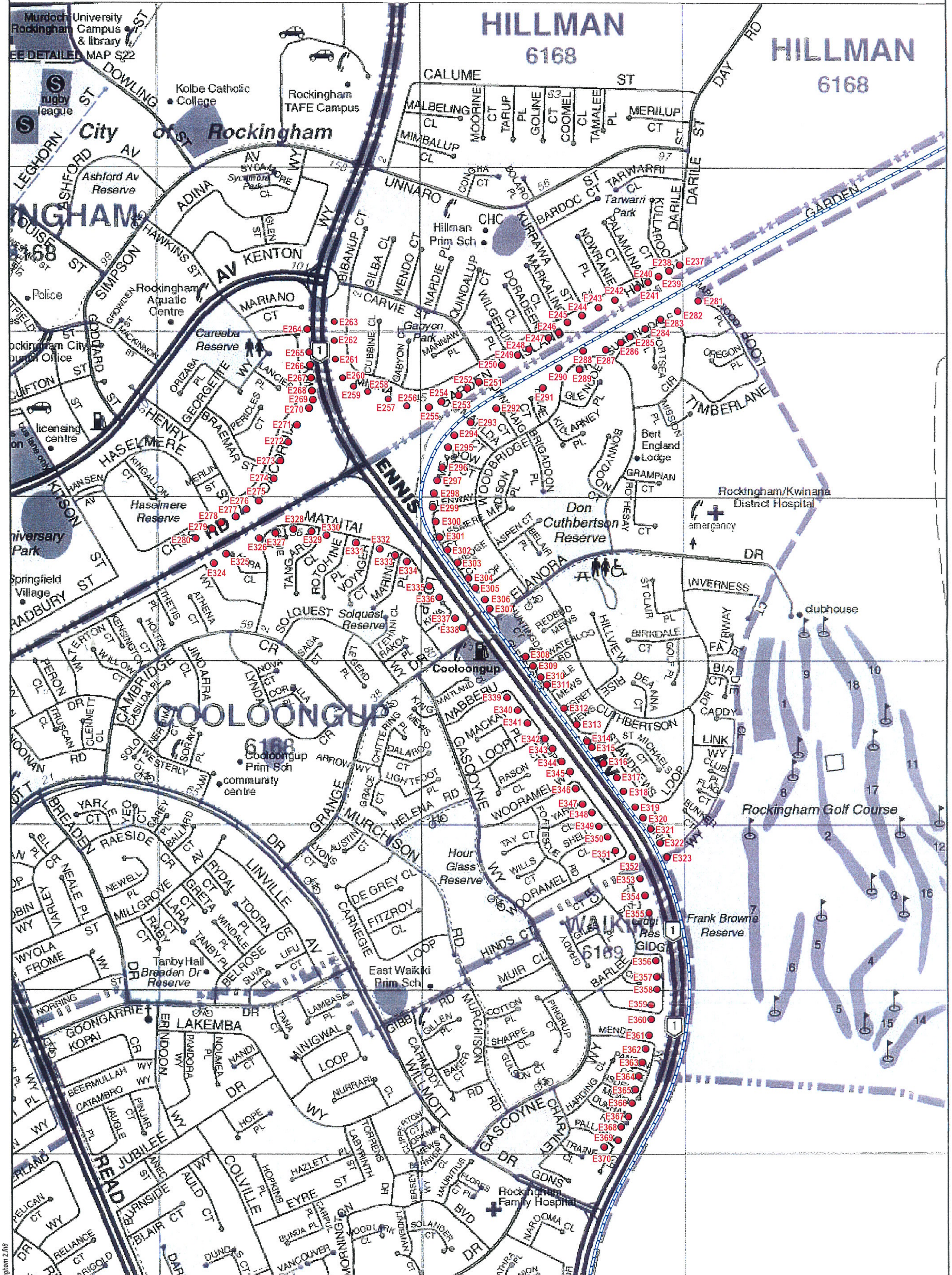


Figure 5.22 Receiver Locations from Garden Island Highway Reserve to Willmott Drive

5.6 GARDEN ISLAND HIGHWAY RESERVE TO WILLMOTT DRIVE

5.6.1 *Description and Results*

This section of the alignment, illustrated in *Figure 5.22,* starts at Darile Street, Hillman and finishes at Willmott Drive, Waikiki. The railway is to be placed on ballast and is to run adjacent to Ennis Avenue. A number of design options were considered for this section of the railway, these being:

- The proposed railway to the east of Ennis Avenue with Ennis Avenue remaining at grade;
- The proposed railway to the east of Ennis Avenue, which is elevated to accommodate a grade-separated junction with the Area Transit System at Rae Road;
- The proposed railway within the centre of Ennis Avenue, which is elevated to accommodate a grade-separated junction at Rae Road to allow rail to access the centre reserve.

A full analysis of the noise impacts associated with these options can be found in the report *Rockingham Station Supplementary Report - Lloyd Acoustics Pty Ltd, January 2002.* However, for convenience, a summary of the findings is presented below:

The results showed that noise from the movement of trains complied with the rail noise *Criteria 1,* for both daytime and night-time periods, whereas noise from road traffic was predicted to exceed the Main Roads WA *Noise Level Objectives* at a number of noise sensitive receivers. It was, however, found that for all locations, the road traffic noise levels only exceed the criteria by between 0.5 dB(A) and 3 dB(A) which is easily addressed through the use of either a quieter road surface (open-graded asphalt) or simple noise barriers placed between the road and the receivers.

In a comparison between average noise impacts from road and rail, it was found that the road noise dominated during both daytime and night-time periods, at all locations except residences adjacent to the Garden Island Highway Reserve, east of Ennis Avenue, where there are no roads currently planned.

In respect to the alignment options described above, it was found that:

- For rail noise, the central alignment option has less of an overall impact to noise sensitive receivers than the eastern alignment option, however, for both alignments, the daytime and night-time criteria are achieved at all noise sensitive receivers considered in the study.

- For road noise, the elevated road with the central rail reserve results in a 51% compliance with Main Roads criterion. The raised option with an eastern rail alignment and the at-grade option with an eastern rail alignment resulted in 44% and 46% compliance respectively. However, as stated previously, full compliance for all road options can be easily achieved with simple noise control techniques.

5.6.2 *The Preferred Option and Results*

Through the noise level analysis, it was found that for all options the noise level criteria were achieved for rail noise and only slightly exceeded for road noise. In addition, any impact associated with road noise could be easily reduced using simple noise control. Therefore, it was decided that the eastern alignment with Ennis Avenue at-grade option would be used as this was the most economical and did not result in visual amenity issues with the raising of Ennis Avenue at the Rae Road intersection.

The results of the noise level predictions at each of the noise sensitive receivers considered are presented in *Table 5.5.* This information is also presented graphically in *Figures* 5.23 and 5.24.

Table 5.5 RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
E237	Milina Street	52	56	47
E238	Milina Street	55	56	47
E239	Milina Street	59	57	48
E240	Milina Street	62	56	47
E241	Milina Street	63	56	47
E242	Milina Street	60	55	46
E243	Milina Street	57	55	46
E244	Milina Street	55	55	46
E245	Milina Street	60	55	45

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.5 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
E246	Milina Street	56	55	45
E247	Milina Street	56	54	45
E248	Milina Street	55	54	45
E249	Milina Street	58	54	44
E250	Milina Street	52	53	44
E251	Milina Street	52	54	45
E252	Milina Street	60	53	44
E253	Milina Street	51	54	45
E254	Milina Street	63	52	43
E255	Milina Street	74	50	41
E256	Milina Street	132	48	39
E257	Milina Street	183	47	38
E258	Milina Street	255	46	37
E259	Milina Street	298	45	36
E260	Milina Street	340	45	36
E261	Milina Street	390	45	35
E262	Milina Street	423	44	35
E263	Milina Street	463	44	35
E264	Concordia Way	507	44	34
E265	Concordia Way	468	43	33
E266	Concordia Way	448	43	34
E267	Concordia Way	423	43	34
E268	Concordia Way	403	44	34
E269	Concordia Way	394	43	34
E270	Concordia Way	400	43	34
E271	Concordia Way	415	43	34
E272	Concordia Way	438	42	33
E273	Concordia Way	449	42	33
E274	Concordia Way	456	45	36

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.5 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
E275	Concordia Way	497	42	33
E276	Henry Street	511	41	32
E277	Henry Street	558	41	32
E278	Haselmere Circus	613	41	32
E279	Haselmere Circus	636	40	31
E280	Haselmere Circus	692	40	31
E281	Maplewood Place	41	57	47
E282	Sunningdale Place	41	56	47
E283	Sunningdale Place	38	56	47
E284	Sunningdale Place	45	55	46
E285	Sunningdale Place	39	56	47
E286	Sunningdale Place	38	53	44
E287	Woodbridge Drive	37	56	47
E288	Woodbridge Drive	39	56	47
E289	Woodbridge Drive	55	54	45
E290	Woodbridge Drive	40	55	45
E291	Woodbridge Drive	41	55	46
E292	Duncraig Court	37	54	45
E293	Matilda Court	36	53	44
E294	Matilda Court	30	50	41
E295	Meadow Court	27	48	39
E296	Meadow Court	26	46	37
E297	Meadow Court	19	46	37
E298	Meadow Court	18	46	37
E299	Glenway Loop	23	46	37
E300	Glenway Loop	39	51	42
E301	Glenway Loop	39	49	40
E302	Glenway Loop	40	48	38

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.5 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions $L_{Aeq\ (daytime)}$ dB(A)	Night-time noise level Predictions $L_{Aeq\ (night\ time)}$ dB(A)
E303	Glenway Loop	36	47	38
E304	Glenway Loop	32	46	36
E305	Glenway Loop	32	46	36
E306	Glenway Loop	23	47	37
E307	Glenway Loop	23	46	37
E308	Gleneagles Loop	18	50	40
E309	Gleneagles Loop	17	51	41
E310	Gleneagles Loop	34	49	40
E311	Gleneagles Loop	32	50	41
E312	Gleneagles Loop	30	53	43
E313	Gleneagles Loop	35	52	43
E314	Gleneagles Loop	18	56	47
E315	St Andrews Loop	21	55	46
E316	St Andrews Loop	23	55	46
E317	St Andrews Loop	27	54	45
E318	St Andrews Loop	22	55	46
E319	St Andrews Loop	24	55	45
E320	Link Way	17	57	47
E321	Link Way	22	55	46
E322	Link Way	23	55	46
E323	Link Way	23	55	46
E324	Waterton Way	651	42	33
E325	Hera Close	607	36	27
E326	Mataitai Loop	524	42	32
E327	Mataitai Loop	445	43	34
E328	Mataitai Loop	393	43	34
E329	Mataitai Loop	334	43	34
E330	Mataitai Loop	292	44	35

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.5 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
E331	Mataitai Loop	139	46	37
E332	Mataitai Loop	204	45	36
E333	Mataitai Loop	98	47	38
E334	Mataitai Loop	80	47	38
E335	Mataitai Loop	65	46	36
E336	Kiwi Place	65	45	36
E337	Kiwi Place	64	45	36
E338	Kiwi Place	66	45	36
E339	Nabberu Place	82	47	38
E340	Nabberu Place	83	47	38
E341	Nabberu Place	83	48	39
E342	Moore Court	64	49	40
E343	Moore Court	63	49	40
E344	Moore Court	69	49	40
E345	Wooramel Way	63	50	41
E346	Wooramel Way	84	49	40
E347	Wooramel Way	92	49	40
E348	Wooramel Way	85	49	40
E349	Wooramel Way	94	49	40
E350	Wooramel Way	83	50	40
E351	Wooramel Way	89	49	40
E352	Wooramel Way	55	51	42
E353	Fox Close	72	50	41
E354	Fox Close	66	51	41
E355	Fox Close	75	50	41
E356	Gidgi Way	89	53	43
E357	Gidgi Way	89	53	44
E358	Gidgi Way	83	54	45

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.5 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM THE GARDEN ISLAND RESERVE TO WILLMOTT DRIVE

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions $L_{Aeq\ (daytime)}$ dB(A)	Night-time noise level Predictions $L_{Aeq\ (night\ time)}$ dB(A)
E359	Gidgi Way	93	54	45
E360	Gidgi Way	74	55	46
E361	Mends Way	75	54	45
E362	Mends Way	85	56	47
E363	Mends Way	88	59	50
E364	Mends Way	93	59	50
E365	Mends Way	97	59	50
E366	Mends Way	73	60	51
E367	Dunham Retreat	72	54	45
E368	Dunham Retreat	74	60	51
E369	Pallarup Grove	75	60	51
E370	Pallarup Grove	91	59	50

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

5.6.3 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.25*. As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).

5.6.4 *The Existing Environment*

Noise sensitive receivers along this section of the alignment can be divided into two sections: those located adjacent to the Garden Island Highway reserve, which are not currently exposed to transportation noise; and those located adjacent to Ennis Avenue which are currently exposed to transportation noise. Background noise measurements undertaken for this project indicate that the background noise levels along this section of the alignment are generally as follows:

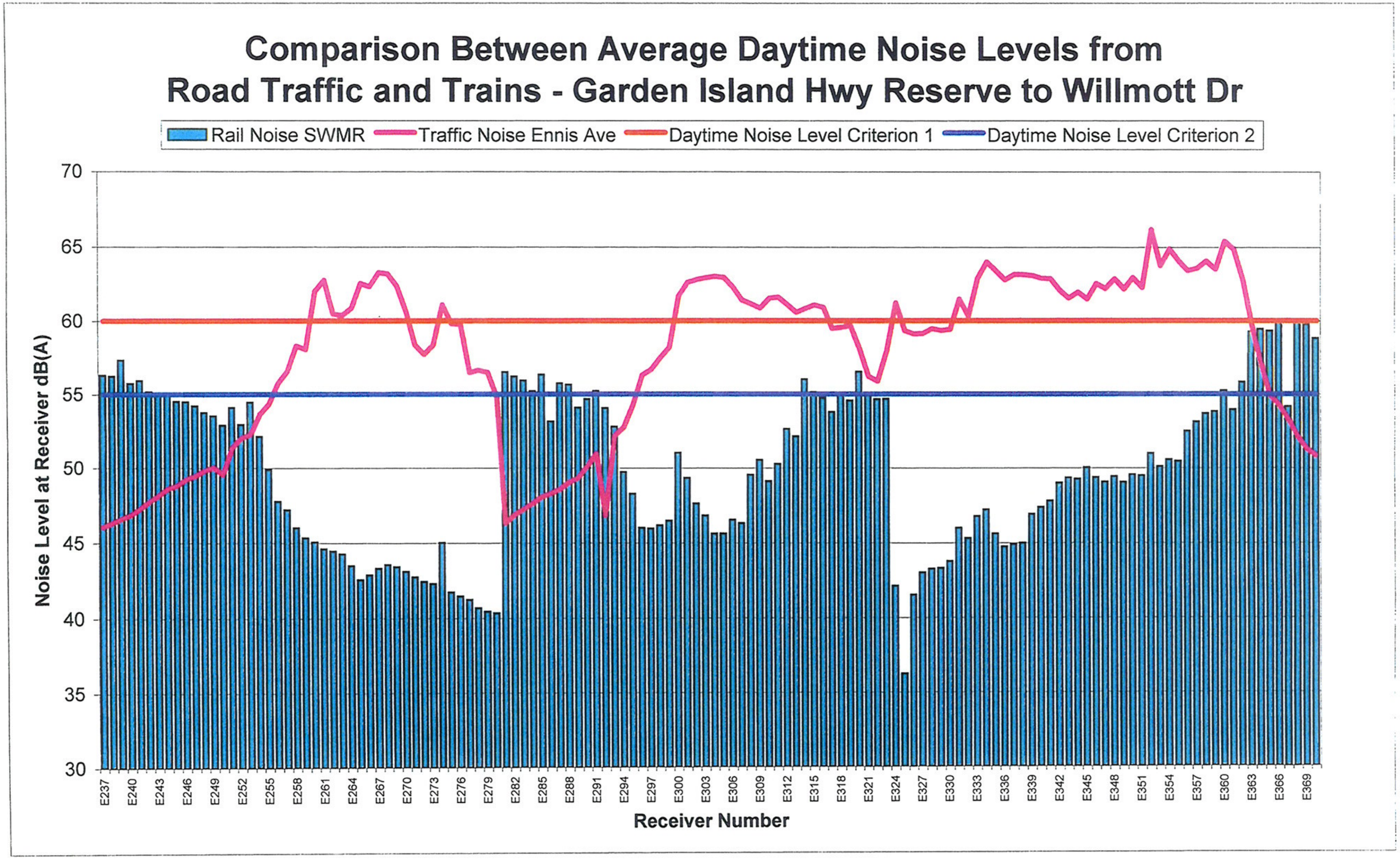


Figure 5.23

Lloyd Acoustics

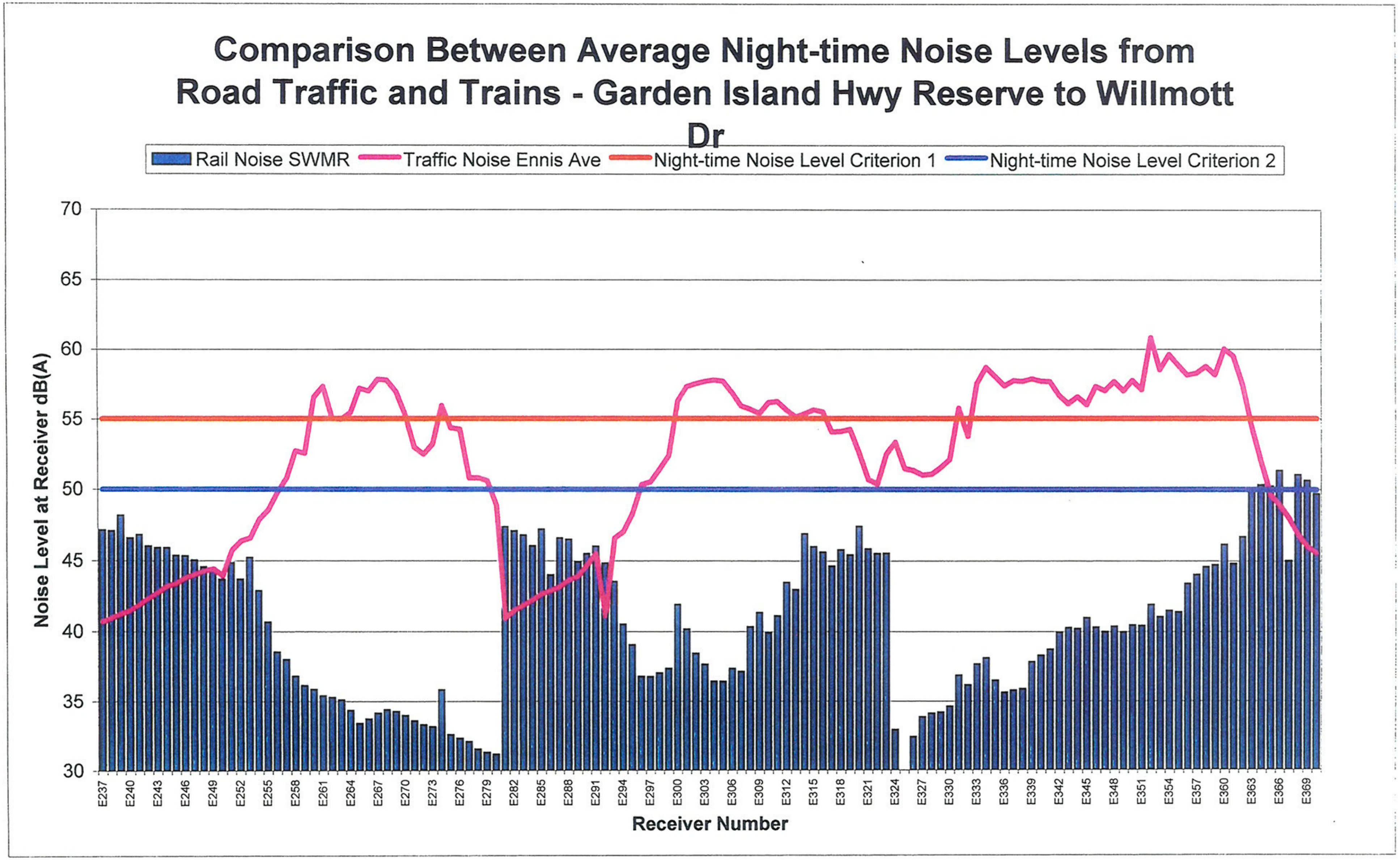

Comparison Between Average Night-time Noise Levels from Road Traffic and Trains - Garden Island Hwy Reserve to Willmott Dr
Rail Noise SWMR
Traffic Noise Ennis Ave
Night-time Noise Level Criterion 1
Night-time Noise Level Criterion 2
Noise Level at Receiver dB(A)
70
65
60
55
50
45
40
35
30
E237
E240
E243
E246
E249
E252
E255
E258
E261
E264
E267
E270
E273
E276
E279
E282
E285
E288
E291
E294
E297
E300
E303
E306
E309
E312
E315
E318
E321
E324
E327
E330
E333
E336
E339
E342
E345
E348
E351
E354
E357
E360
E363
E366
E369
Receiver Number

Figure 5.24

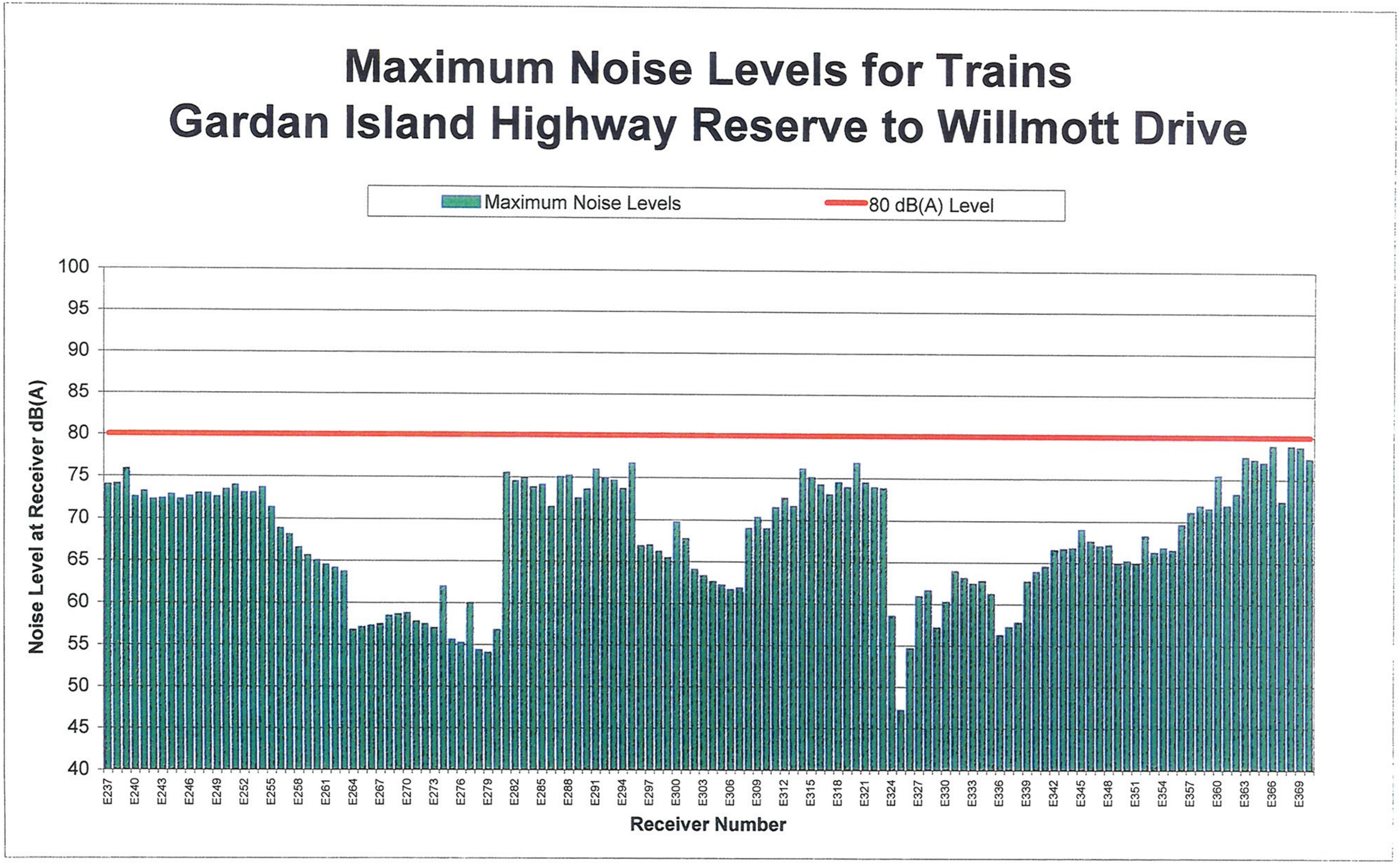

Maximum Noise Levels for Trains
Gardan Island Highway Reserve to Willmott Drive
Maximum Noise Levels
80 dB(A) Level
Noise Level at Receiver dB(A)
Receiver Number
100
95
90
85
80
75
70
65
60
55
50
45
40
E237
E240
E243
E246
E249
E252
E255
E258
E261
E264
E267
E270
E273
E276
E279
E282
E285
E288
E291
E294
E297
E300
E303
E306
E309
E312
E315
E318
E321
E324
E327
E330
E333
E336
E339
E342
E345
E348
E351
E354
E357
E360
E363
E366
E369

Figure 5.25

Garden Island Highway Area (Nov. 2002)

- Daytime L_{Aeq} levels 50 dB(A);
- Night-time L_{Aeq} levels 46 dB(A).
- Daytime L_{A90} levels 42 dB(A);
- Night-time L_{A90} levels 37 dB(A).

Ennis Avenue Area (Dec. 2001)

- Daytime L_{Aeq} levels 60 dB(A);
- Night-time L_{Aeq} levels 55 dB(A).
- Daytime L_{A90} levels 50 dB(A);
- Night-time L_{A90} levels 37 dB(A).

5.6.5 *Discussion*

Noise levels resulting from the South West Metropolitan Railway between the Garden Island Highway Reserve and Willmott Drive have been predicted to 134 receiver locations. The results presented in *Table 5.5*, show compliance with both the daytime and night-time noise level *Criteria 1* at all locations and exceeds the daytime *Criteria 2* at 11 locations and the night-time *Criteria 2* at 3 locations.

The predicted noise levels along this section of the alignment require noise mitigation to be considered at 11 locations. For the receivers adjacent to the Ennis Avenue, the current transportation noise levels along this section are already high levels and placing barriers to reduce noise from the railway may be of limited benefit. However, for the receivers adjacent to the Garden Island Highway reserve (Receivers E237 to E241), the current background noise levels are considerably less and mitigation measures are likely to be beneficial.

In broad terms a noise barrier 1.5 m high positioned on the boundary of the railway reserve would provide sufficient attenuation to achieve *Criteria 2* at Receivers E237 to E241

RECEIVER LOCATIONS

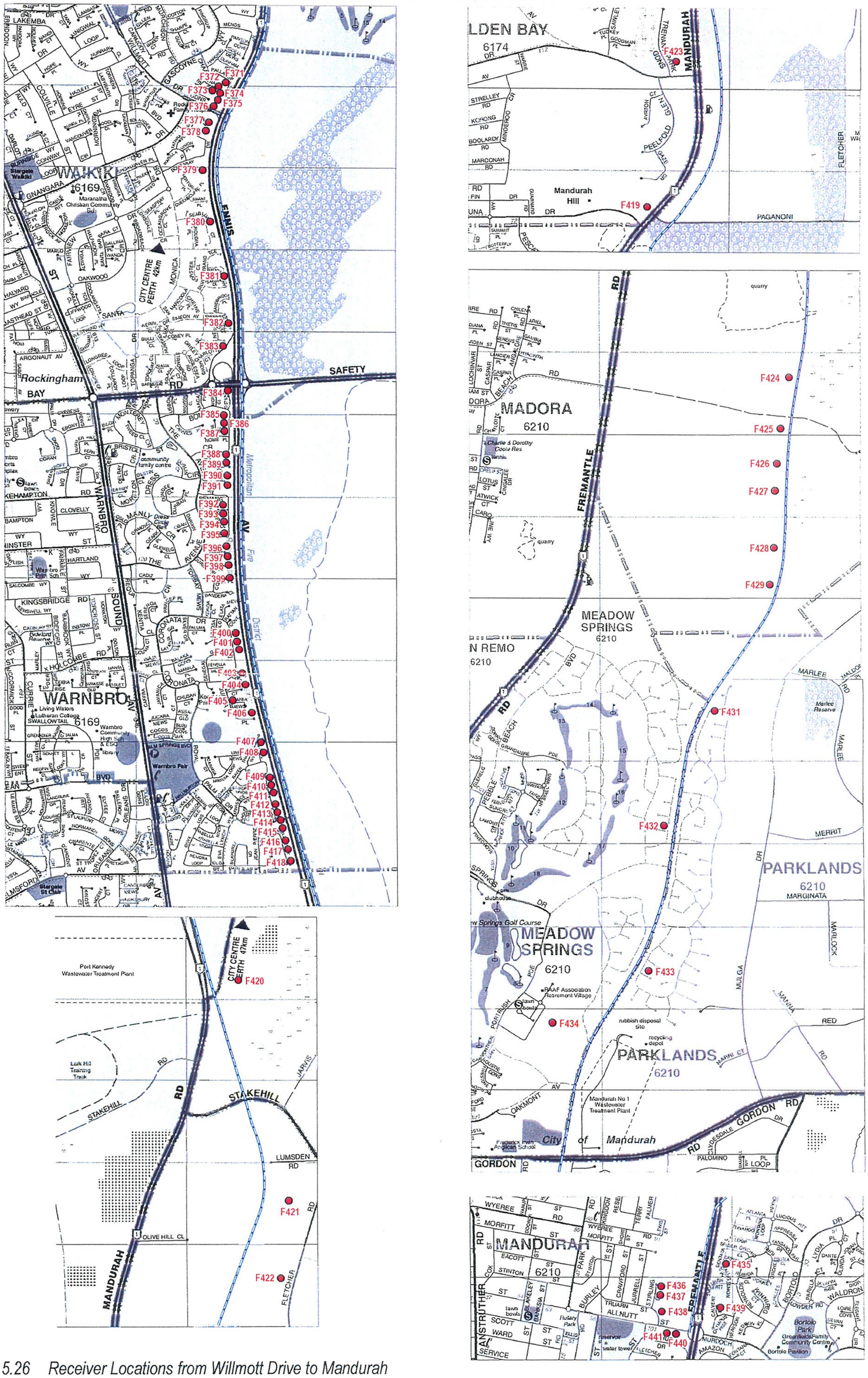


Figure 5.26 Receiver Locations from Willmott Drive to Mandurah

8010857/Ennis34.fh8

5.7 WILLMOTT DRIVE TO MANDURAH

5.7.1 *Description and Results*

This section of the alignment, illustrated in *Figure 5.26* starts at Willmott Drive, Waikiki and finishes at Allnutt Street, Mandurah. The railway is to be placed on ballast and will run to the east of Ennis Avenue and Mandurah Road. No further design options have been considered. The results of the noise level predictions at each of the noise sensitive receivers considered are presented in *Table 5.6*. This information is also presented graphically in *Figures 5.27* and *5.28.*

Table 5.6 RESULTS OF NOISE LEVEL PREDICTIONS FROM WILLMOTT DRIVE TO MANDURAH

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\ (daytime)}$ dB(A)	$L_{Aeq\ (night\ time)}$ dB(A)
F371	Pallarup Grove	87	55	45
F372	Pallarup Grove	90	55	45
F373	Pallarup Grove	99	54	45
F374	Pallarup Grove	85	55	45
F375	Pallarup Grove	84	55	45
F376	Willmott Drive	81	55	45
F377	Narooma Close	78	54	45
F378	Narooma Close	78	54	45
F379	Bolsabay Drive	82	54	45
F380	Seabluffs Court	73	54	45
F381	Redondo Way	80	54	45
F382	Newport Close	130	54	45
F383	Seacliffe Close	139	54	45
F384	Ostend Place	130	54	45
F385	Bondi Crescent	135	54	45
F386	Bondi Crescent	134	54	45
F387	Bondi Crescent	132	54	45

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.6 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM WILLMOTT DRIVE TO MANDURAH

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions $L_{Aeq (daytime)}$ dB(A)	Night-time noise level Predictions $L_{Aeq (night time)}$ dB(A)
F388	Bondi Crescent	108	55	46
F389	Skye Close	107	55	46
F390	Sark Place	101	56	46
F391	Sark Place	99	55	46
F392	Penang Loop	100	59	50
F393	Penang Loop	100	56	47
F394	Penang Loop	97	56	46
F395	Penang Loop	97	56	47
F396	Hove Place	81	55	46
F397	Hove Place	80	56	47
F398	Jurien Close	79	56	47
F399	Cork Place	80	56	47
F400	Coronata Drive	73	56	47
F401	Coronata Drive	74	56	47
F402	Coronata Drive	74	56	47
F403	Ivory Cove	74	56	47
F404	Caliso Court	73	56	47
F405	Orania Mews	173	54	45
F406	Juania Place	74	56	46
F407	Primus Place	74	56	47
F408	Primus Place	75	56	47
F409	Enlie Lane	75	55	45
F410	Enlie Lane	74	55	46
F411	Enlie Lane	75	56	47
F412	Enlie Lane	74	56	47
F413	Enlie Lane	74	56	47
F414	Nightingale Way	74	56	47
F415	Nightingale Way	75	56	47

Notes:
1. Shaded cells indicate where *Criteria 1* is exceeded
2. Shaded cells indicate where *Criteria 2* is exceeded

Table 5.6 (Cont) RESULTS OF NOISE LEVEL PREDICTIONS FROM WILLMOTT DRIVE TO MANDURAH

Receiver ID	Description of Location	Distance from Track	Daytime noise level Predictions	Night-time noise level Predictions
			$L_{Aeq\,(daytime)}$ dB(A)	$L_{Aeq\,(night\,time)}$ dB(A)
F416	Nightingale Way	77	56	47
F417	Nightingale Way	74	56	47
F418	Nightingale Way	77	56	46
F419	Gaze Road	265	57	48
F420	Stakehill	165	58	50
F421	Stakehill	108	60	52
F422	Stakehill	154	58	50
F423	Trenant Park Gardens	175	56	47
F424	Meadow Springs Estate	48	61	53
F425	Meadow Springs Estate	45	61	53
F426	Meadow Springs Estate	43	59	51
F427	Meadow Springs Estate	43	59	50
F428	Meadow Springs Estate	44	60	51
F429	Meadow Springs Estate	60	61	53
F430	Meadow Springs Estate	74	60	52
F431	Meadow Springs Estate	99	60	51
F432	Meadow Springs Estate	30	62	54
F433	Meadow Springs Estate	29	62	54
F434	RAAF Retirement Village	225	51	44
F435	Dentata Lane	294	52	43
F436	Stirling Grove	134	54	44
F437	Stirling Grove	126	54	44
F438	Truarn St	104	52	42
F439	Calvert Place	180	51	42
F440	Allnut Street	146	50	40
F441	Allnut Street	149	50	40

Notes: 1. Shaded cells indicate where *Criteria 1* is exceeded

2. Shaded cells indicate where *Criteria 2* is exceeded

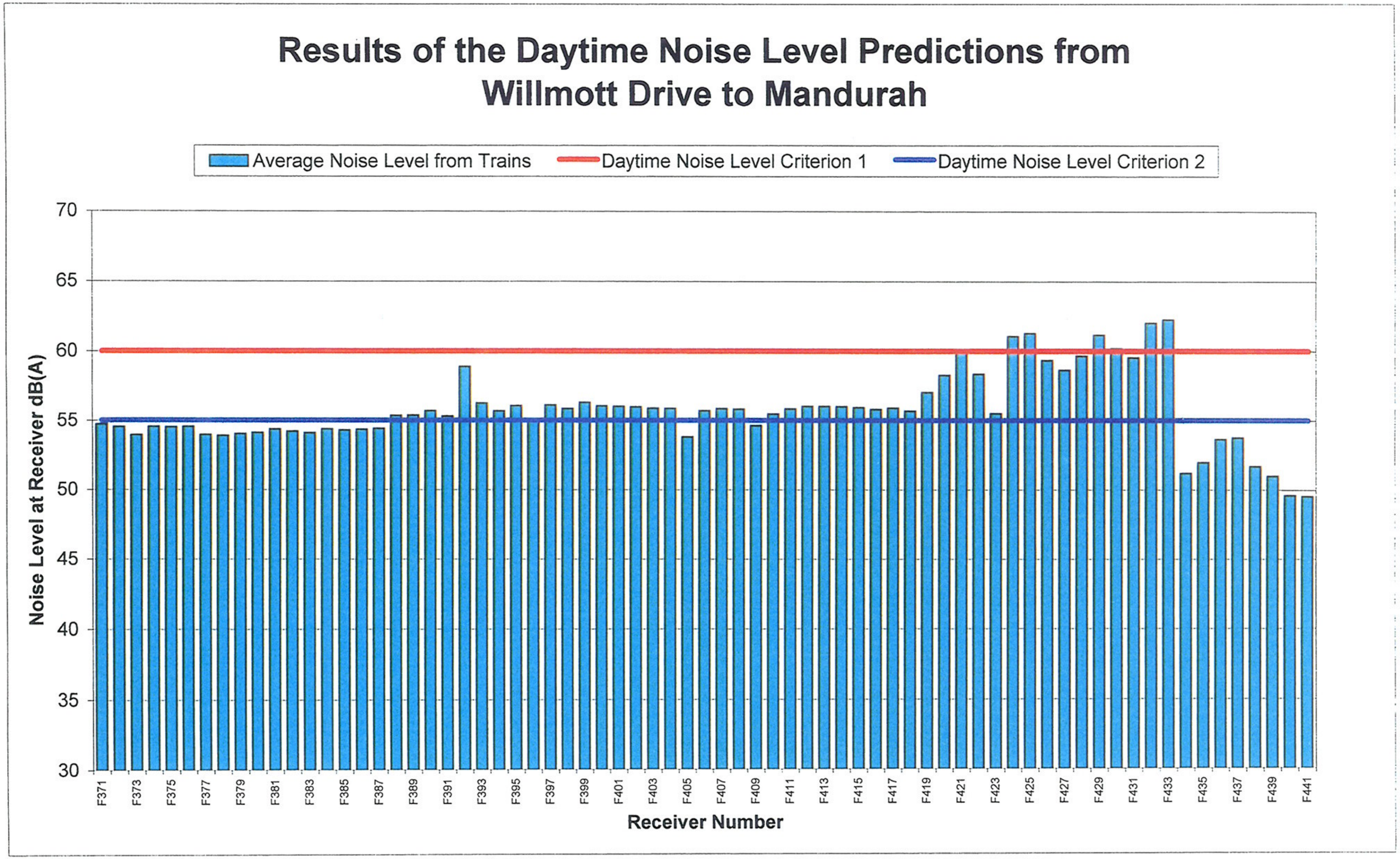


Figure 5.27

Lloyd Acoustics

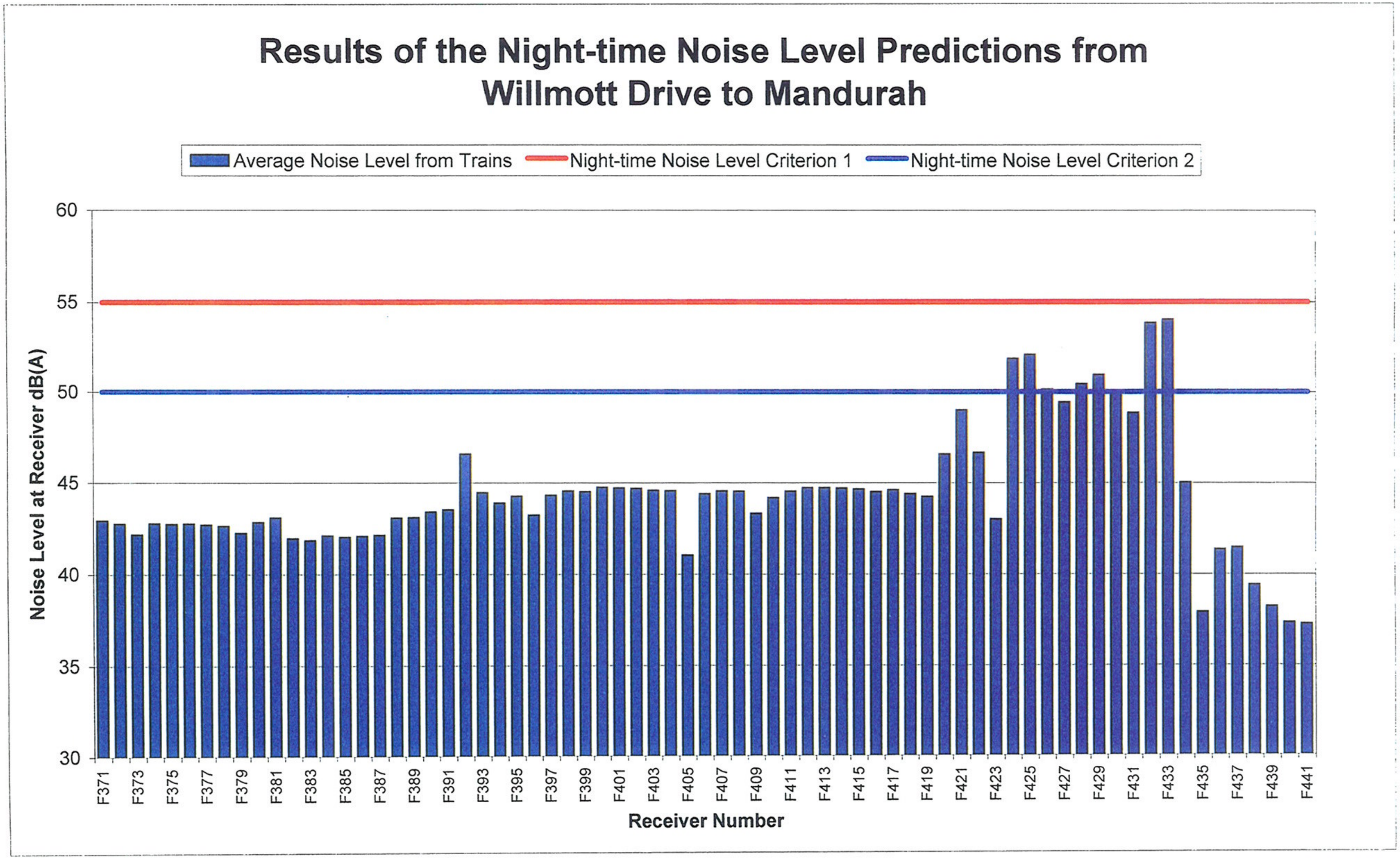
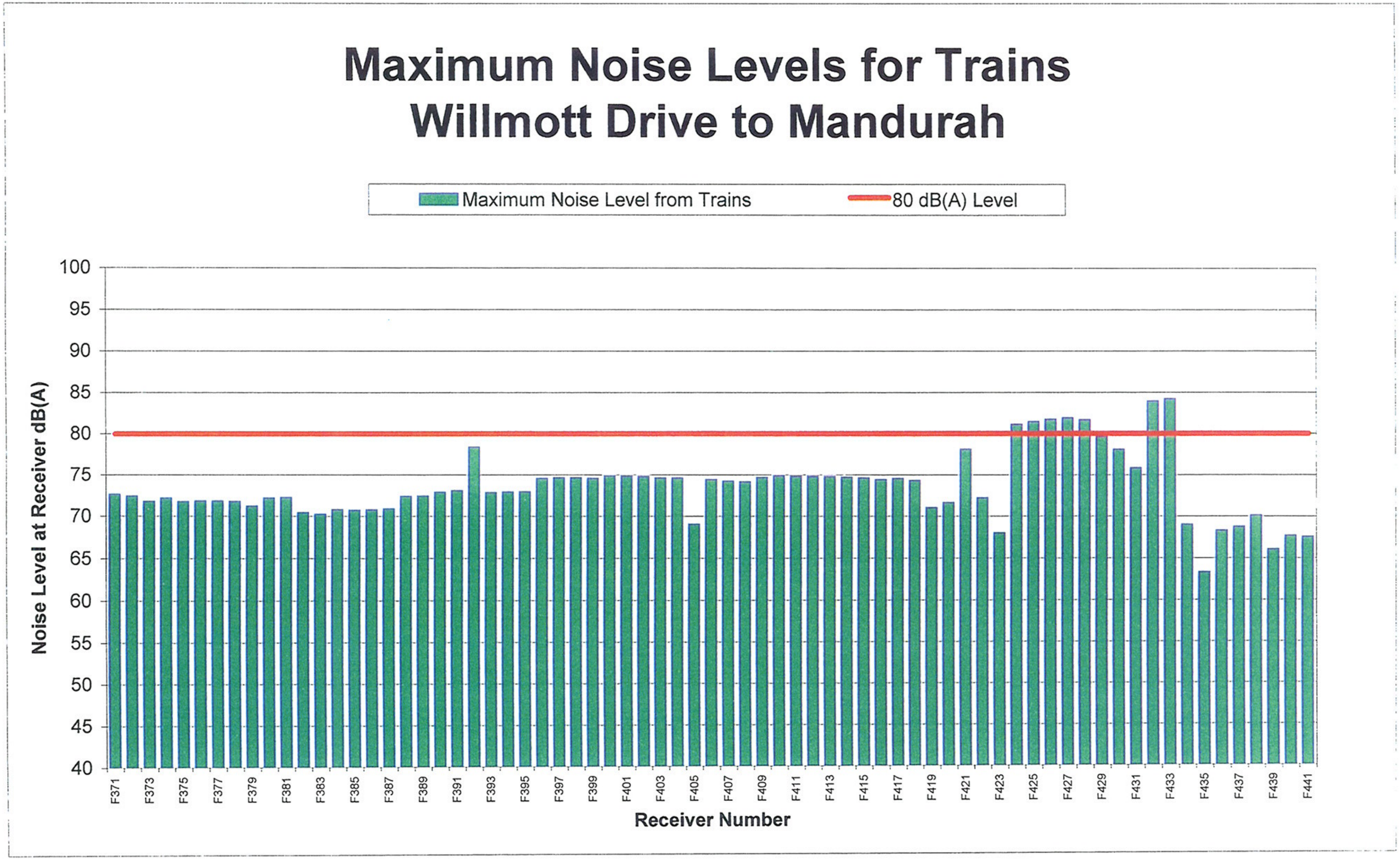


Figure 5.28

Lloyd Acoustics



Maximum Noise Levels for Trains
Willmott Drive to Mandurah
Maximum Noise Level from Trains
80 dB(A) Level
100
95
90
85
80
75
70
65
60
55
50
45
40
Noise Level at Receiver dB(A)
F371
F373
F375
F377
F379
F381
F383
F385
F387
F389
F391
F393
F395
F397
F399
F401
F403
F405
F407
F409
F411
F413
F415
F417
F419
F421
F423
F425
F427
F429
F431
F433
F435
F437
F439
F441
Receiver Number

Figure 5.29

5.7.2 *Maximum Noise Levels*

To illustrate the short-term noise levels resulting from train pass-bys, and therefore the audibility of the noise from the trains over the existing background levels, the predicted maximum external noise levels are provided in *Figure 5.29*. As a guide, a common criterion for maximum external noise levels used within Australia is 80 dB(A).

5.7.3 *The Existing Environment*

Noise sensitive receivers along this section of the alignment can be divided into three distinct sections: those currently exposed to transportation noise from major roads (Ennis Avenue and Fremantle Road); those, which are not currently exposed to transportation noise; and new residential developments under development. Background noise measurements undertaken for this project indicate that the background noise levels along this section of the alignment are generally as follows:

<u>Ennis Avenue Area (Dec. 2001)</u>

- Daytime L_{Aeq} levels 60 dB(A);
- Night-time L_{Aeq} levels 55 dB(A).
- Daytime L_{A90} levels 50 dB(A);
- Night-time L_{A90} levels 37 dB(A).

<u>Stakehill Area - Old Mandurah Road (Nov. 2002)</u>

- Daytime L_{Aeq} levels 54 dB(A);
- Night-time L_{Aeq} levels 49 dB(A).
- Daytime L_{A90} levels 45dB(A);
- Night-time L_{A90} levels 42 dB(A).

5.7.4 *Discussion*

Noise levels resulting from the South West Metropolitan Railway between the Willmott Drive and Mandurah have been predicted to 71 receiver locations. The results presented in *Table 5.6*, show the daytime noise level *Criteria 1* is exceeded at 5 locations (all of which are future residential developments); the daytime *Criteria 2* is exceeded at 39 locations and the night-time *Criteria 2* at 12 locations.

The predicted noise levels require noise mitigation to be incorporated in the design of the future residential developments proposed for the Centenial Park area, and require noise mitigation to be considered at 39 other receiver locations along this section of the alignment.

For the receivers adjacent to the Ennis Avenue and Fremantle Road, the current transportation noise levels are already high levels and placing barriers to reduce noise from the railway may be of limited benefit. For receivers within the Stakehill area, the existing noise levels are considerably lower and noise mitigation measures are likely to be beneficial.

In broad terms a noise barrier 1.5 m high positioned on the boundary of the railway reserve would provide sufficient attenuation to achieve *Criteria* 2.

It should be noted that background noise measurements have been undertaken for Stakehill (south of stakehill Road), Golden Bay and Meadow Springs, and are available on request.

5.8 CONCLUSION

Noise levels resulting from the proposed South West Metropolitan Railway have been predicted to 441 noise sensitive receivers adjacent to the railway corridor from the Narrows Bridges to Mandurah, and compared to two criteria:

Criteria 1 Noise level above which noise mitigation will be <u>provided</u>:

- $L_{Aeq\ (daytime)}$ 60 dB(A); and
- $L_{Aeq\ (night\text{-}time)}$ 55 dB(A).

Criteria 2 Noise level above which noise mitigation will be <u>considered</u>:

- $L_{Aeq\ (daytime)}$ 55 dB(A); and
- $L_{Aeq\ (night\text{-}time)}$ 50 dB(A).

The results show that, assuming the preferred design options, noise levels will comply with all criteria at 338 (77%) of the receivers considered. *Criteria 1* are predicted to be exceeded at 5 locations, all of which are future residential developments within the Centennial Park Area, and *Criteria 2* are predicted to be exceeded at 98 locations.

For receivers where the noise levels are predicted to exceed *Criteria 2*, the decision whether to provide noise mitigation should take into consideration the existing noise environment. For the receivers located adjacent to major roads, the existing noise levels are generally high and placing barriers to reduce noise from the railway may be of limited benefit. For receivers adjacent to minor roads or located in semi-rural areas where existing background noise levels are relatively low, noise mitigation measures are likely to be beneficial.

It has been found that, for those areas where noise barriers are likely to be beneficial, a 1.5 m high noise barrier positioned on the boundary of the railway reserve would provide sufficient attenuation to achieve *Criteria 2*.

Although not included in the noise prediction calculations, where the railway is located within a road reserve, such as the Freeway and Ennis Avenue, safety barriers will be required to ensure vehicles are unable to cross the railway if involved in an accident. Should these safety barriers be constructed of concrete or other solid material, the noise levels, resulting from the trains, to receivers adjacent to these sections of the railway alignment will be reduced.

Chapter 6

VIBRATION LEVEL PREDICTIONS

6.1 DESCRIPTION

Ground-borne vibration levels resulting from train pass-bys have been predicted to each of the noise sensitive premises determined in *Chapter 5*. As described in *Chapter 3*, the calculations are based on measured vibration levels of trains travelling along a track on ballast within the Perth metropolitan area. However, as described previously, ground-borne vibration predictions are complicated by soil/rock structure of the ground and vary greatly from site to site. As such, the predicted values should be taken as indicative only. Premises where the vibration criteria are predicted to be exceeded will be flagged as potentially affected by vibration impacts. Vibration control should be incorporated in the railway design but only implemented following specific vibration analysis, which would include assessment of the ground geology, prior to construction.

The results of predicted vibration levels are presented graphically in *Figures 6.1 to 6.6*.

6.2 CONCLUSION

Ground-borne vibration levels resulting from the proposed South West Metropolitan Railway have been predicted to 441 noise sensitive receivers adjacent to the railway corridor from the Narrows Bridges to Mandurah, and compared to two criteria:

- *Criterion 1 - Vibration Limit* – Curve 2 AS2670.2 (109 dB); and
- *Criterion 2 - Vibration Planning and Design Level* - Curve 1.4 AS2670.2 (106 dB).

The predicted ground-borne vibration levels to receivers adjacent to the proposed railway alignment show that:

- 37 receivers exceed *Criterion 1 (Vibration Limit)* requiring vibration isolation measures to be incorporated in the design of the railway;
- 269 receivers are below *Criterion 2* (*Planning and Design Level*) and considered acceptable; and
- 135 receivers are between *Criterion 1* and *Criterion 2* requiring consideration of non-isolation vibration control measures after construction.

The areas that are predicted to exceed *Criterion 1* and require consideration during the design of the railway are as follows:

- Receivers A1 and A2 – Melville Parade, South Perth;
- Receivers C217 – Spectacle Drive, The Spectacles;
- Receivers E294 to E323 – Ennis Avenue, Cooloongup; and
- Receivers F432 and F433 – Proposed Meadow Springs Estate, Centennial Park.

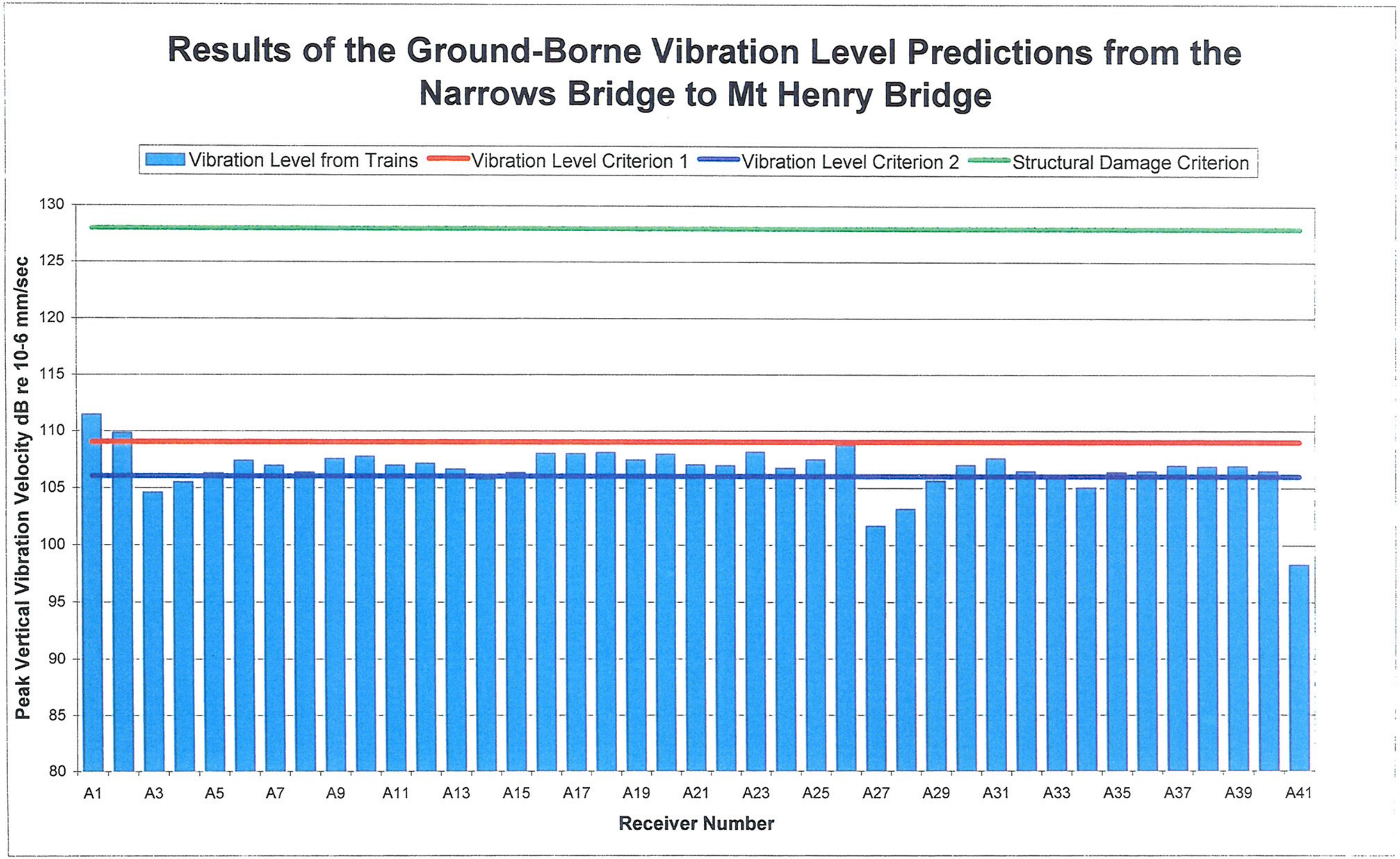

Results of the Ground-Borne Vibration Level Predictions from the Narrows Bridge to Mt Henry Bridge
Vibration Level from Trains
Vibration Level Criterion 1
Vibration Level Criterion 2
Structural Damage Criterion
Peak Vertical Vibration Velocity dB re 10-6 mm/sec
130
125
120
115
110
105
100
95
90
85
80
A1
A3
A5
A7
A9
A11
A13
A15
A17
A19
A21
A23
A25
A27
A29
A31
A33
A35
A37
A39
A41
Receiver Number

Figure 6.1

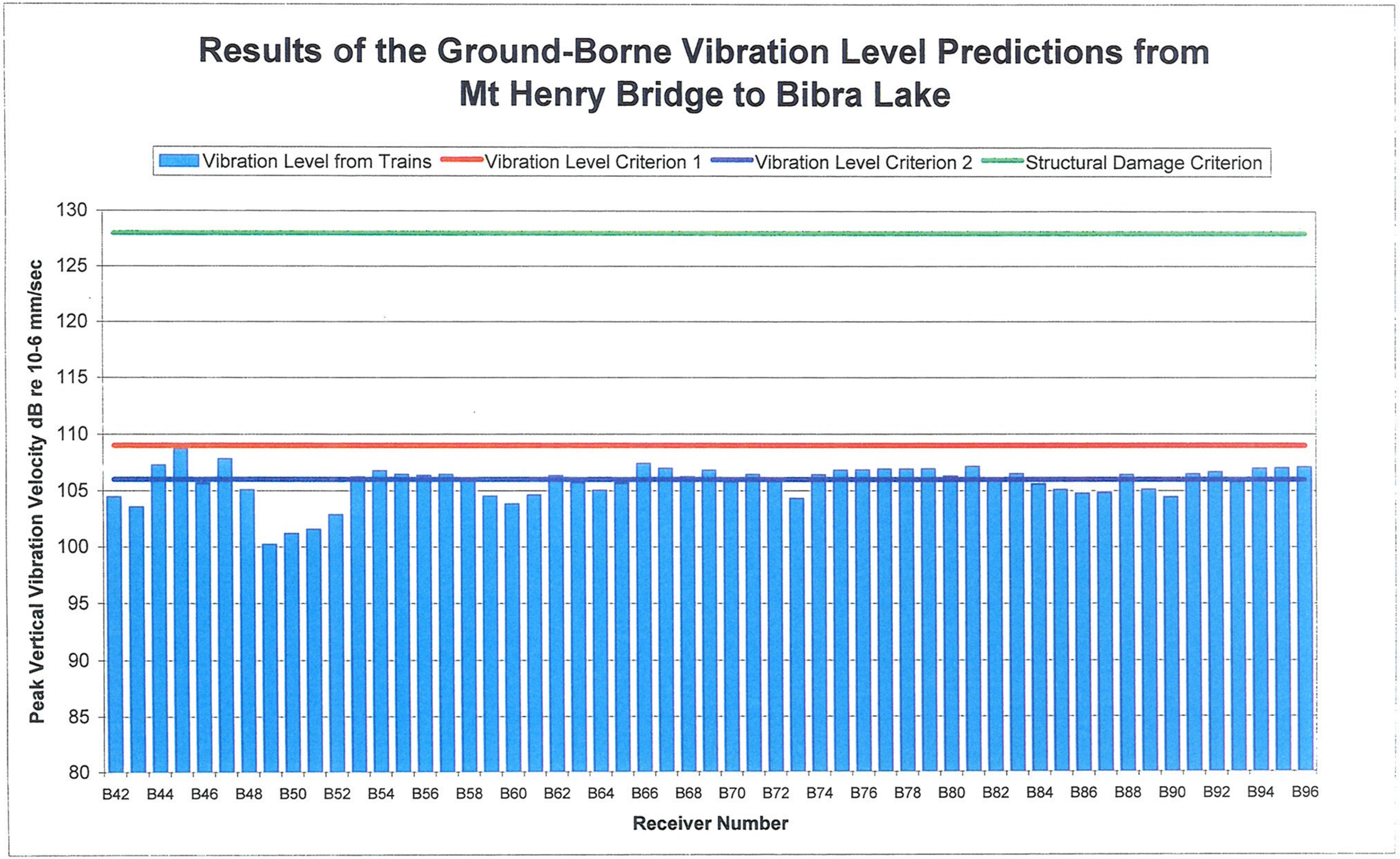
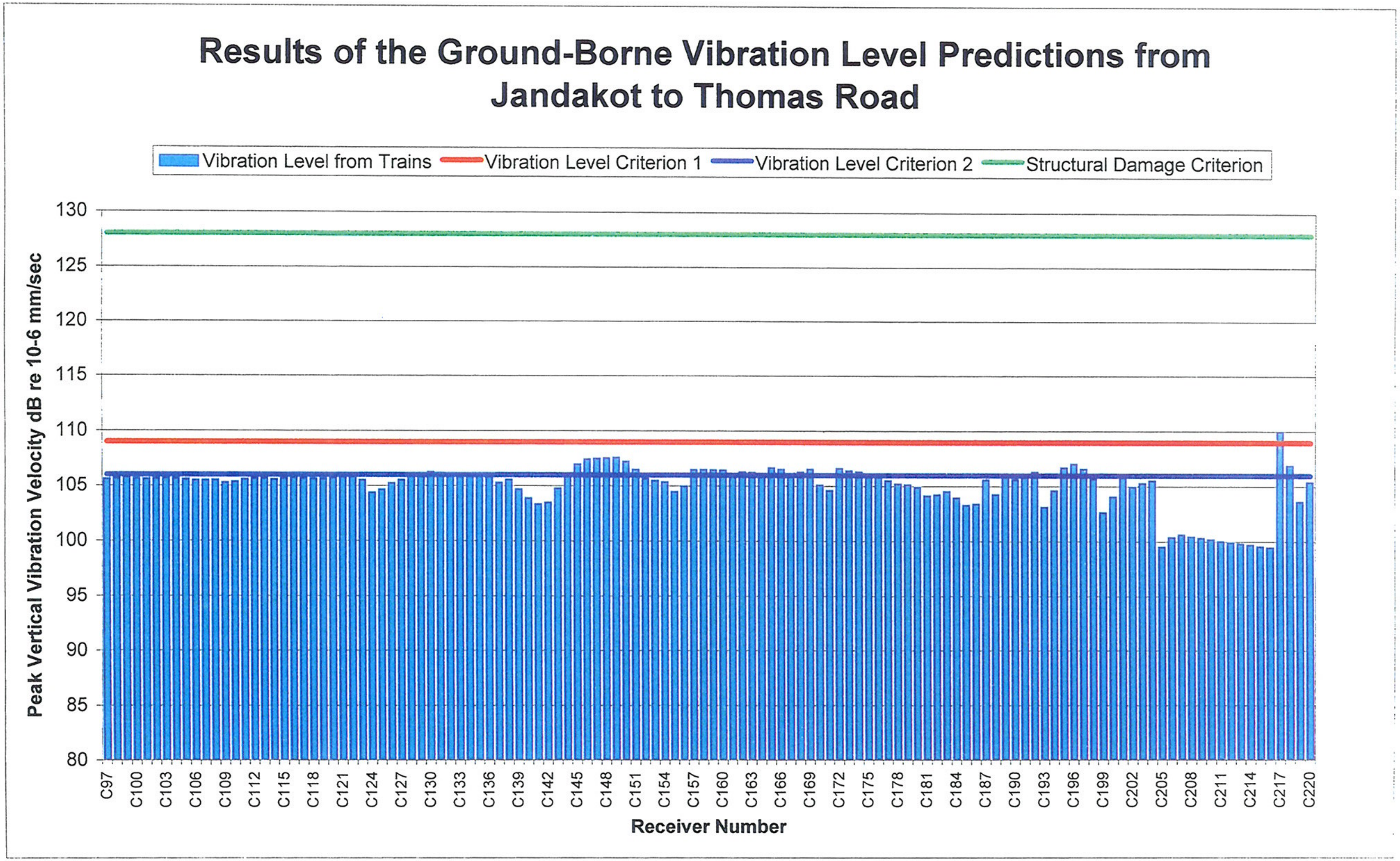


Figure 6.2

Lloyd Acoustics



Results of the Ground-Borne Vibration Level Predictions from Jandakot to Thomas Road
Vibration Level from Trains
Vibration Level Criterion 1
Vibration Level Criterion 2
Structural Damage Criterion
Peak Vertical Vibration Velocity dB re 10-6 mm/sec
130
125
120
115
110
105
100
95
90
85
80
C97 C100 C103 C106 C109 C112 C115 C118 C121 C124 C127 C130 C133 C136 C139 C142 C145 C148 C151 C154 C157 C160 C163 C166 C169 C172 C175 C178 C181 C184 C187 C190 C193 C196 C199 C202 C205 C208 C211 C214 C217 C220
Receiver Number

Figure 6.3

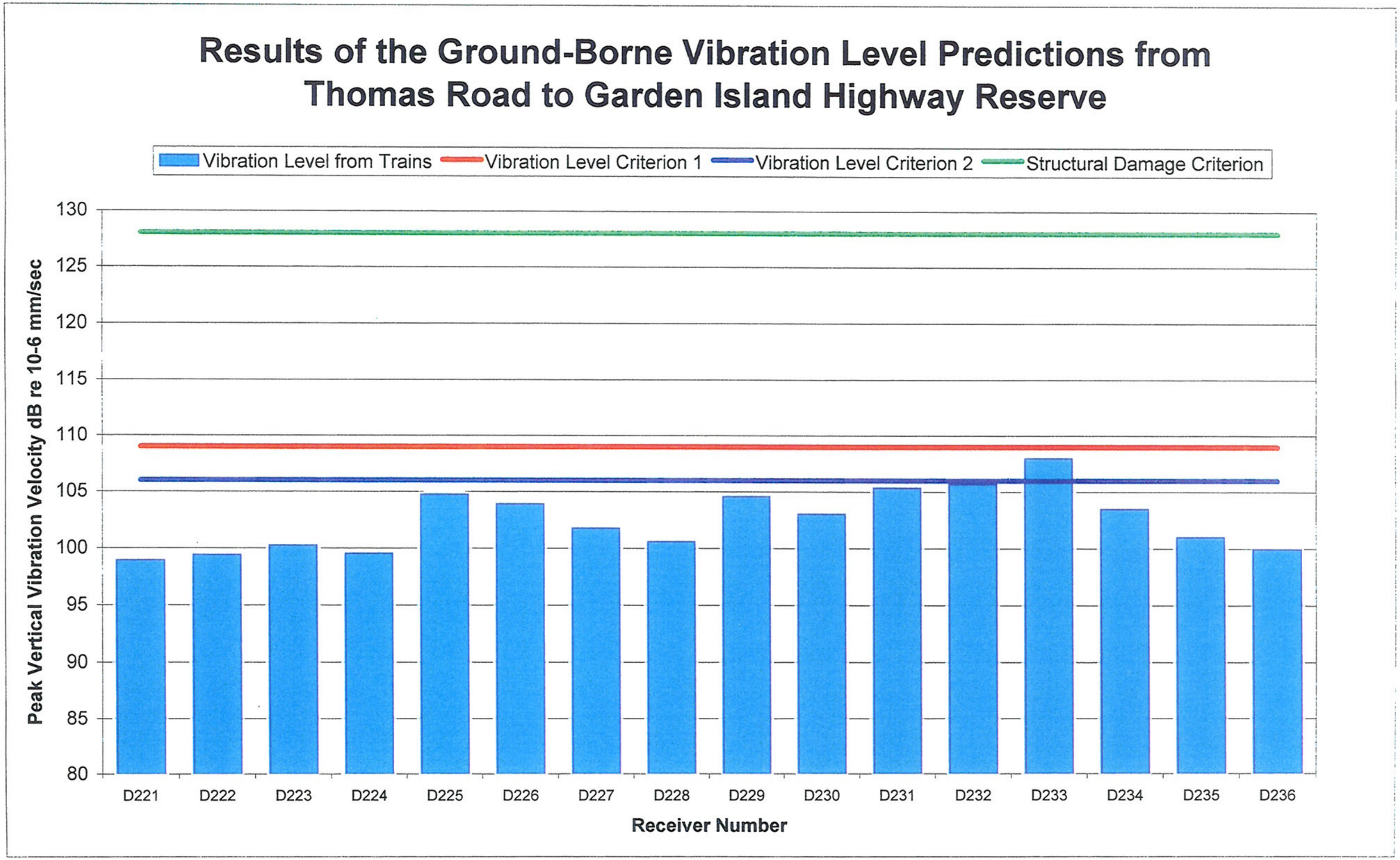

Results of the Ground-Borne Vibration Level Predictions from Thomas Road to Garden Island Highway Reserve
Vibration Level from Trains
Vibration Level Criterion 1
Vibration Level Criterion 2
Structural Damage Criterion
Peak Vertical Vibration Velocity dB re 10-6 mm/sec
130
125
120
115
110
105
100
95
90
85
80
D221
D222
D223
D224
D225
D226
D227
D228
D229
D230
D231
D232
D233
D234
D235
D236
Receiver Number

Figure 6.4

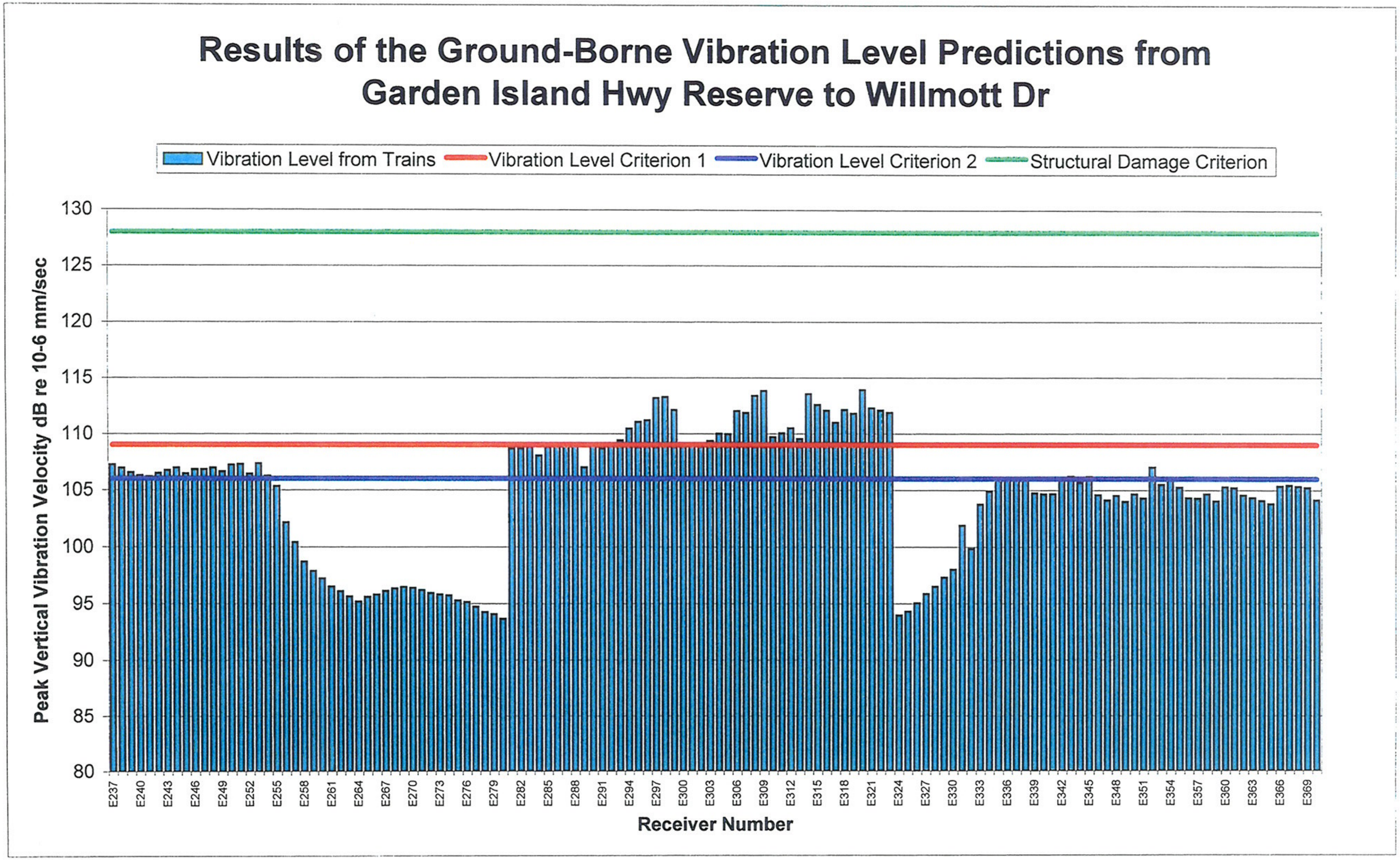


Figure 6.5

Lloyd Acoustics

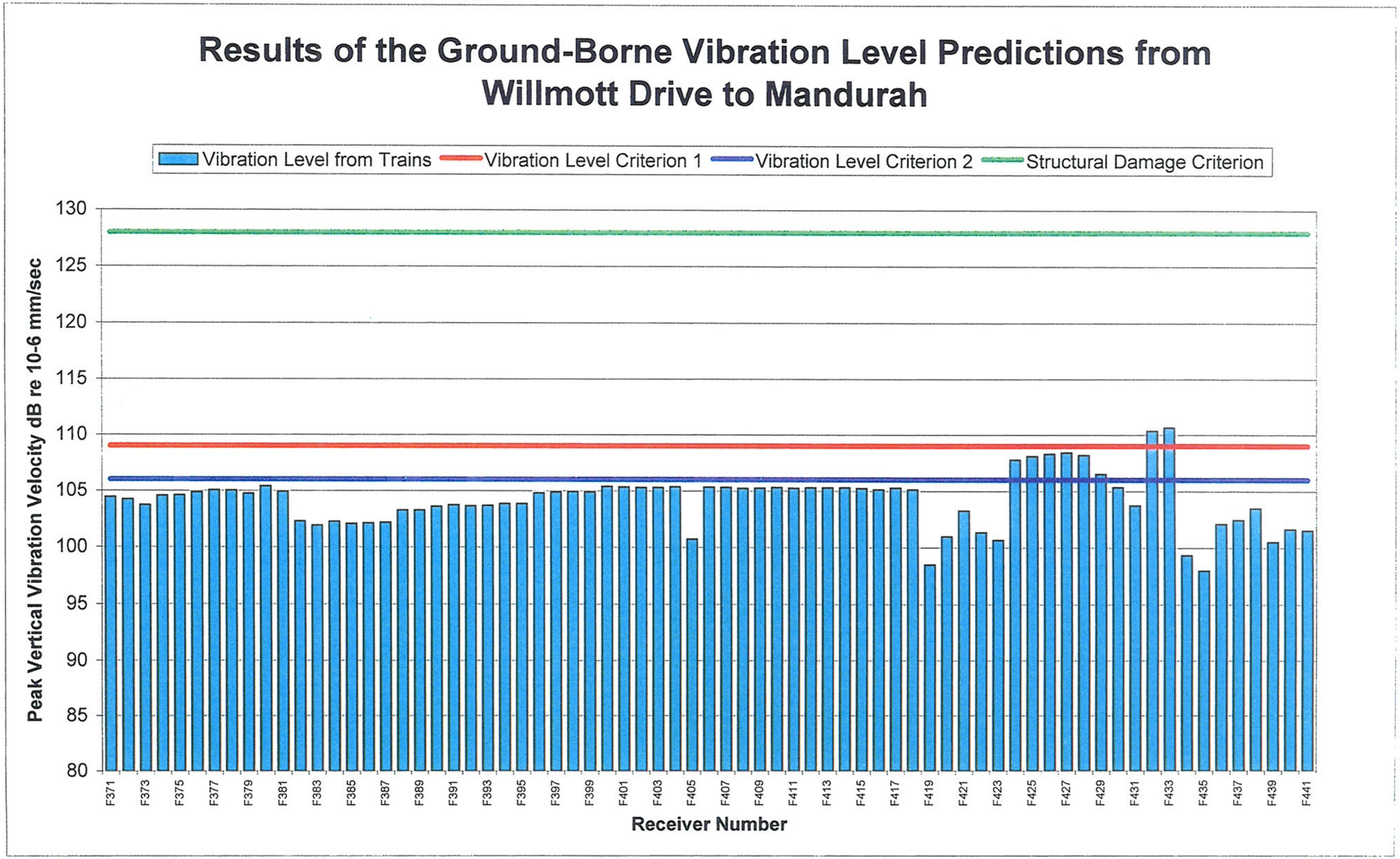


Figure 6.6

Lloyd Acoustics

Chapter 7

NOISE MITIGATION OPTIONS

7.1 DISCUSSION

The predicted noise levels presented in *Chapter 5,* show that noise mitigation should be considered at a number of locations along the alignment of the South West Metropolitan Railway. The erection of noise barriers is the most common method of attenuating ground level transportation noise and the barriers need be heavy enough to prevent the noise travelling straight through them (transmission loss characteristics), as well as being high enough to stop the noise diffracting over the top.

To ensure that the transmission loss is sufficiently high, it is recommended that the surface density of the material is greater than 10 kg/m^2. Suitable barrier materials include:

- Brick and Blockwork;
- Compressed Fibre Cement (SuperSix)
- Concrete;
- Fabricated Metal (Colorbond);
- Lapped and Capped Timber Fencing (at least 12mm thick); and
- Earth Bunding.

Once a suitable material for a noise barrier has been selected, the diffraction of noise over the top or sides of the barrier will determine the noise reduction that can be achieved. In most cases a 1.5m high barrier placed on the edge of the railway reserve will sufficiently attenuate the noise levels to achieve the noise level criteria, however, this must be assessed at each specific site.

The position of these noise barriers will vary depending on the land topography between the railway and the residence and the available space, however, a general rule is to try to position the barrier as close to the source (i.e. the railway) or the receiver as possible.