Appendix C. Operation: Airborne Noise from Trains

C.1 Introduction

The Melbourne Metro Rail Project (Melbourne Metro) would change the rail infrastructure in the vicinity of the Western and Eastern Portals and also at the turnback at West Footscray station. The impact of airborne train noise due to these changes to the rail infrastructure is provided in this Appendix. The airborne train noise is predicted at assessed locations with respect to the relevant criteria.

Airborne noise from railways is generally due to:

- Rolling noise from the wheel-rail interface (this includes wheel squeal, flanging)
- Traction systems
- Fans and air-conditioning units
- Exhaust
- Engine and motor noise
- Aerodynamic noise (this would not apply to the Melbourne Metro as it only usually occurs at train speeds above approximately 250 km/h).

The primary source of rail noise from the wheel rail interface is due to:

- Roughness of the rail and wheel (including wheel flats)
- Rail corrugation
- Wheel squeal (or track curves)
- Rail imperfections
- Joints, switches and crossings.

The subjective response of humans to noise varies between individuals. Typical impacts include:

- Loss of amenity
- Discomfort
- Stress
- Loss of concentration
- Health effects (increase in blood pressure)
- Sleep arousal.

Rolling stock for the Melbourne Metro would be new High Capacity Metro Trains (HCMTs). These are currently being procured by the Victorian Government.

The rolling stock includes:

- Diesel Multiple Units (DMUs) (VLocity and Sprinters vehicles)
- Electric Multiple Units (EMUs) (Comeng, X'Trapolis, Siemens and HCMT vehicles)
- Freight (N and P Class).

Good practice has been employed in the rail design to reduce rail noise levels. The approach includes:

- Where possible, avoiding tight radius curves which can result in noise from curving noise (flanging or wheel squeal). This can occur on tracks with a curve radius of 500 m or less. If curving noise results it would need to be controlled using gauge face lubrication or top-of–rail friction modifiers supplied from trackside applicators
- Use of continuously welded rail
- Minimising the number of joints, switches and crossings
- Good maintenance regime
- Noise mitigation (noise barriers) to comply with criteria.

All noise mitigation elements would need to be carefully integrated into the design to ensure a safe, reliable and maintainable railway.

C.2 Criteria

Railway noise is to comply with:

- The Victorian Passenger Rail Infrastructure Noise Policy April 2013 (PRINP)

The policy provides Investigation Thresholds to guide transport bodies when assessing the impacts of rail noise on nearby communities - they are not a limit on allowable noise emissions. If they are exceeded then options for avoiding, minimising and mitigating rail noise should be considered (as proposed in the policy).

Cost-effective options should be selected considering the economic context and the social and environmental impacts. All reasonable efforts to limit impacts of noise should be made taking account what is practicable, reasonable and cost-effective given the specific local circumstances and the broader public good.

As the Melbourne Metro involves the redevelopment of existing passenger rail infrastructure in the vicinity of the portals and at West Footscray station the Investigation Thresholds in Table C.1 are relevant.

Table C.1: External Investigation Thresholds for redevelopment of existing passenger rail infrastructure

Time	Type of Receiver	Investigation Thresholds
Day **(6am – 10pm)**	• Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks • Noise sensitive community buildings, including schools, kindergartens, libraries	65 dBL_{Aeq} and a change in 3 dB(A) or more or 85 dBL_{Amax} and a change in 3 dB(A) or more
Night **(10pm – 6am)**	• Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks	60 dBL_{Aeq} and a change in 3 dB(A) or more or 85 dBL_{Amax} and a change in 3 dB(A) or more

Notes:

1. If an investigation shows that the thresholds are not exceeded then no further action is considered under this policy.
2. L_{Amax}, for this assessment, is defined as maximum A-weighted sound pressure level and is the 95 percentile of the highest value of the A-weighed sound pressure level reached within the day or night.
3. For the Melbourne Metro the location of assessment is at 1 m from the centre of the window of the most exposed external façade. All levels of buildings are included.

C.3 Methodology

C.3.1 Approach

The following approach is proposed to assess airborne noise from trains:

- Noise measurement of train noise and measurements at sensitive receivers in the vicinity of the portals.
- Creation of an acoustic model of the existing operational railway in the vicinity of the portals
- Updating the acoustic model to include the infrastructure associated with the Melbourne Metro including portals.
- Prediction of noise levels for the following scenarios:
  - existing noise levels (at the western and eastern Portal locations – this information was used to verify the acoustic model and has been used for comparison with measured baseline noise levels only)
  - future base-case noise levels, 2026 (base case is defined as the day before the proposed opening assuming the Melbourne Metro does not proceed)
  - future noise levels 10-years after opening of the Melbourne Metro, 2036 (assuming the Melbourne Metro does proceed)
- Where the Investigation Thresholds as defined in the PRINP are predicted to be exceeded, options for avoiding, minimising and mitigating rail noise have been considered.

C.3.2 Scenarios

Train noise levels have been predicted for the following scenarios:

Precinct 2: Western Portal (South Kensington)

- Scenario 1: Existing noise levels
- Scenario 2: Future (2026) base-case noise levels (assuming the Melbourne Metro does not proceed)
- Scenario 3: Concept Design option future (2036) noise levels (assuming the Melbourne Metro proceeds with Design)
- Scenario 4: Variation option future (2036) noise levels (assuming the Melbourne Metro proceeds with Variation)

Precinct 8: Eastern Portal (South Yarra)

- Scenario 1: Existing noise levels
- Scenario 2: Future (2026) base-case noise levels (assuming the Melbourne Metro does not proceed)
- Scenario 3: Future (2036) noise levels (assuming the Melbourne Metro does proceed)

Precinct 9: West Footscray Turnback

- Scenario 1: Future (2026) base-case noise levels (assuming the Melbourne Metro does not proceed)
- Scenario 2: Future (2036) Melbourne Metro noise levels (assuming the Melbourne Metro does proceed)

Operation would include the occasional turnback of trains.

The Turnback Track would have trains standing for a minimum of 5 minutes and maximum 15 minutes in the morning and afternoon peak only (as there are four trains per hour expected to turn back). These would be EMU's only.

The Pocket Track (downside of the Turnback Track) would have trains standing for a minimum of 5 minutes and may average 15-30 minutes towards the end of the morning peak. However, in delayed running or to provide a replacement service, they may sit there for up to an hour.

No trains are predicted to be idling during off peak times or during the night time period.

Trains would not be stabled at this location.

C.3.3 Prediction Methodology

Airborne railway noise levels have been predicted at the nearby noise sensitive receivers using the methodology from Nord 2000 - New Nordic Prediction Method for Rail and Traffic Noise (NORD2000). This methodology allows the prediction of the daytime ($L_{Aeq,16hour}$), night time ($L_{Aeq,\ 8hour}$) and the L_{Amax} noise levels. NORD2000 has been implemented in SoundPLAN version 7.2.

The model has been used to predict noise levels at the nearby noise sensitive receivers and is based upon:

- Air absorption
- Atmospheric refraction
- Split height source modelling
- Ground effects
- Meteorological effects
- Screening
- Reflection
- One-third octave band source levels
- Operational timetables
- Train lengths / speed

C.3.4 Source Noise Levels

Rail Noise Emissions

Rail noise emissions have been based on the following:

- The NSW Rail Noise Database Stage III Measurement and Analysis - January 2015 prepared by SLR for the NSW Transport Asset Authority (TfNSW train noise database) and NORD2000 for the reference source noise levels for trains

  In addition, reference source noise levels of all rail vehicles (EMU, DMU and freight locomotives) used have been compared with noise measurements (undertaken by Jacobs staff and those used for the Regional Rail Link from the document Regional Rail Link Guideline for Railway Noise Predictions and Assessment Section 4 – January 2016)
- Noise levels for all speeds, as contained within the TfNSW train noise database, have been processed in accordance with the NORD2000 methodology. This involved a regression analysis of each 1/3 octave bandwidth for all train speeds to obtain the source inputs. These levels were then compared to the train noise measurements taken of the existing Melbourne train fleet and adjustments made accordingly to match the actual train noise emissions. Freight noise levels were sourced from the 'Regional Rail Link Guideline for Railway Noise Predictions and Assessment (January 2016)
- Noise source heights are as defined by default in NORD2000. All noise source heights are above rail height and are:
  - 0.01 m (wheel / rail)
  - 0.35 m (wheel)
  - 0.7 m (engine)

  For the exhaust for the DMUs / Freight Locos, a height of 4.2 m above rail height has been used
- Noise levels have been predicted at all residential building levels and façade reflection has been included.

EMU and DMU Rail Noise Measurements

Noise measurements have been undertaken to determine the noise level emissions for Melbourne's existing rail fleet. Noise measurements have been conducted for the following trains:

- Comeng
- X'Trapolis
- Siemens
- VLocity.

The purpose of these measurements has been to compare the Sound Exposure Level (SEL) and the 95th percentile of the maximum noise levels from the rail bound vehicle ($L_{Amax,\ 95\%}$) with the reference source noise levels from the TfNSW train noise database. These reference source noise levels have then been adjusted to develop the noise emissions for each of the above trains.

Measurements have been conducted in compliance with AS2377-2002 *Acoustics – Methods for the measurement of railbound vehicle noise,* with trains travelling at speeds in the order of 60 to 95 km/h.

Measurement equipment was placed at a distance of 15 m from the centreline of the tracks, with microphones placed 1.5 m and 3.5 m above the rail level.

The train noise emission for the HCMTs is based upon the average measured noise levels of the two newest (and quietest) EMU train types (X'Trapolis and Siemens). Table C.2 presents the corresponding SEL and L_{Amax} values upon which the noise sources have been based.

Checks have been undertaken in the noise model in SoundPLAN to ensure these values have been achieved for each train type.

Measurements for freight were not conducted and freight noise emissions were sourced from 'Regional Rail Link Guideline for Railway Noise Predictions and Assessment (January 2016)'.

Table C.2: Noise Levels at 80 km/h, 15 m distance and a height of 1.5 m / 3.5 m above rail level

Train set	SEL dB(A)	L_{Amax} dB(A)
Comeng	88	82
X'trapolis	87	82
Siemens	85	79
HCMT	86	81
VLocity	89	87
Freight (Locomotive)	98	96

Notes:

1) Freight noise levels were sourced from 'Regional Rail Link Guideline for Railway Noise Predictions and Assessment (Jan 2016)'
2) Since passenger wagons are always hauled by an accompanying locomotive, the maximum noise level is determined by the locomotive

Rail Bridge Noise

For this assessment the bridges along the rail alignment in the vicinity of the Western Portal have been modelled as ballasted concrete bridge structures. The following correction has been applied for the appropriate span length:

- Concrete with Ballast, +0 dB

(Reference: NSW Rail Noise Database Stage III Measurement and Analysis - January 2015, Table 19 'Bridge Noise Level Correction Factors').

Curve Noise

Tight radius curves along rail tracks can result in noise from flanging and / or wheel squeal. This can occur on tracks with a curve radius of less than 500 m. There are areas near to the eastern portal where it has not been possible to achieve radii of 500 m or greater.

The following overall noise corrections have been applied to these curved sections of track:

- 8 dB addition to the source noise levels for curve radii less than 300 m
- 3 dB addition to the source noise levels for curve radii between 300 and 500 m.

(Reference: NSW Rail Noise Database Stage III Measurement and Analysis - January 2015, Section 6.9 'Curve Noise').

If flanging or wheel squeal result, it would need to be controlled using gauge face lubrication or top-of-rail friction modifiers supplied from trackside applicators.

Track Joint, Switch and Crossing Noise

Switches and crossings built into rail tracks can result in noise from interaction with the wheel and the rail head joints. Noise from this effect can increase with severity depending on the complexity of the joint (i.e. diamond crossings). For the Melbourne Metro there are sections of track that include turnout crossings at the Western and Eastern portals and also at the Western Turnback.

The following overall noise corrections have been applied to these sections of track:

- 6 dB addition to the source noise levels for turnout crossings.

(Reference: Nord 2000 - New Nordic Prediction Method for Rail and Traffic Noise – December 2001, Section 2.3.4 'Corrections for track conditions').

Train Timetables

The type and number of rail vehicles assumed to be travelling in the rail corridor are provided in Table C.3. This information has been supplied by MMRA and is based on the Concept of Operations (the COO) developed by the PTV and current PTV Timetables.

Table C.3: Train vehicles for Precinct 2: Western Portal

Rail Corridor (Section)	Train Type	No. of Trains		Operational Speed	Maximum Length (m)
		Day Period	Night Period	km/hr	
Scenario 1: Existing					
Caulfield to South Yarra (Dandenong Corridor)	Metro EMU	233	20	50	144
	Regional DMU	42	3	50	50
	Freight	3	1	50	600
Caulfield to South Yarra (Frankston Corridor)	Metro EMU	202	20	50	144
	Regional DMU	-	-	-	-
	Freight	3	1	50	600
South Yarra (Sandringham Corridor)	Metro EMU	161	16	50	144
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
South Kensington to Footscray (Sunbury Corridor)	Metro EMU	129	17	80	144
	Regional DMU	205	17	80	75
	Freight	-	-	-	-
South Kensington to Footscray (Werribee Corridor)	Metro EMU	233	24	80	144
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
Scenario 2: Future (2026) – Base Case					
Pakenham to Dandenong	Metro EMU	176	30	115	150
	Regional DMU	52	12	115	150
	Freight	2	4	60	800
Cranbourne to Dandenong	Metro EMU	128	30	115	150
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
Dandenong to Westall	Metro EMU	328	60	80	150
	Regional DMU	52	12	80	150
	Freight	13	5	60	800
Westall to Caulfield	Metro EMU	328	60	80	150
	Regional DMU	52	12	80	150
	Freight	13	5	60	800
Caulfield to South Yarra (Dandenong Corridor)	Metro EMU	604	90	80	150
	Regional DMU	52	12	80	150
	Freight	13	5	60	800
Caulfield to South Yarra (Frankston Corridor)	Metro EMU	276	30	80	155
	Regional DMU	-	-	-	-
	Freight	1	1	60	800
South Yarra (Sandringham Corridor)	Metro EMU	204	30	70	155
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
South Kensington to Footscray (Sunbury Corridor)	Metro EMU	660	120	80	150
	Regional DMU	266	28	80	200
	Freight	2	1	60	800
South Kensington to Footscray (Werribee Corridor)	Metro EMU	372	60	80	155
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
Footscray to Sunshine	Metro EMU	288	60	80	144
	Regional DMU	266	28	80	200
	Freight	23	19	60	1800
Sunshine to Albion	Metro EMU	208	30	80	150
	Regional DMU	56	8	80	150
	Freight	15	15	80	1800
Albion to Watergardens	Metro EMU	208	30	80	150
	Regional DMU	56	8	80	150
	Freight	-	-	-	-
Watergardens to Sunbury	Metro EMU	136	30	115	150
	Regional DMU	56	8	130	150
	Freight	-	-	-	-
Scenario 3: Future (2036) - Melbourne Metro					
Pakenham to Dandenong (up and down tracks)	Metro EMU	176	36	115	150
	Regional DMU	52	12	115	150
	Freight	2	4	60	800
Cranbourne to Dandenong	Metro EMU	128	36	115	150
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
Dandenong to Westall	Metro EMU	368	72	80	150
	Regional DMU	52	12	80	150
	Freight	17	5	60	800
Westall to Caulfield	Metro EMU	368	72	80	150
	Regional DMU	54	12	80	150
	Freight	17	5	60	800
Caulfield to South Yarra	Metro EMU	660	72	80	150

Rail Corridor (Section)	Train Type	No. of Trains		Operational Speed	Maximum Length (m)
		Day Period	Night Period	km/hr	
(Dandenong Corridor)	Regional DMU	52	12	80	150
	Freight	17	5	60	800
Caulfield to South Yarra (Frankston Corridor)	Metro EMU	292	36	80	155
	Regional DMU	-	-	-	-
	Freight	1	1	60	800
South Yarra (Sandringham Corridor)	Metro EMU	244	30	70	155
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
South Kensington to Footscray (Sunbury Corridor)	Metro EMU	852	168	80	150
	Regional DMU	362	44	80	200
	Freight	2	1	60	800
South Kensington to Footscray (Werribee Corridor)	Metro EMU	412	72	80	155
	Regional DMU	-	-	-	-
	Freight	-	-	-	-
Footscray to Sunshine	Metro EMU	440	96	80	150
	Regional DMU	362	44	80	200
	Freight	27	19	60	1800
Sunshine to Albion	Metro EMU	256	36	80	150
	Regional DMU	56	8	80	150
	Freight	17	17	80	1800
Albion to Watergardens	Metro EMU	256	36	80	150
	Regional DMU	56	8	80	150
	Freight	-	-	-	-
Watergardens to Sunbury	Metro EMU	136	36	115	150
	Regional DMU	56	8	130	150
	Freight	-	-	-	-

Notes:

1. The number of trains is combined for up and down tracks.
2. Train types for the existing were evenly split between Comeng and Siemens.
3. Train types for the Melbourne Metro and base-case scenarios were based on the ratios presented in the COO.
4. All trains are assumed to operate at their maximum length.
5. Speeds and lengths of all trains (excluding HCMT) do not change from base case to Melbourne Metro.

C.3.5 Assumptions

The following assumptions apply for the Melbourne Metro:

- Level crossing bells and train horns have not been modelled as they are safety features.
- Continuously welded track is assumed unless there are known joints, switches or crosses.

C.3.6 Meteorology

Meteorological conditions were modelled under the following conditions:

- Relative Humidity: 70%
- Temperature: 15 degrees Celsius
- Air Pressure: 1013 mbar
- Wind Speed: 1 ms^{-1}
- Wind Direction: Receiver directly downwind

These meteorological conditions are conducive to the propagation of noise, and as such represent a reasonable worst-case prediction of the propagation of rail noise.

C.3.7 Verification

Noise levels have been predicted for the existing train timetable. The levels predicted have been compared with noise monitoring at strategically selected properties (e.g. those that have an unobscured view of the railway and are not impacted significantly by noise sources other than the railway).

For the western portal, 3 Childers Street, Kensington, was selected. At this location the rail noise levels were predicted to be less than 2 dB lower than the measured noise level. This is considered to be a good correlation.

For the eastern portal, 6 William Street, South Yarra was selected. At this location the predicted rail noise levels were less than 2 dB higher than the measured noise level. This is considered to be a good correlation.

C.4 Results

The predicted train noise levels are provided for the (i) Base Case 2026 and (ii) with the Melbourne Metro 2036 (10 years after the Melbourne Metro us completed and open for operation).

C.4.1 Precinct 2: Western Portal – Concept Design

Train noise levels have been predicted for the following scenarios and colour noise contours displaying the predicted rail noise levels are provided in the figures as stated:

- Base-Case 2026, Day Period predicted train noise levels - Figure C.1
- Base-Case 2026, Night Period predicted train noise levels - Figure C.2
- Base-Case 2026, L_{Amax} predicted train noise levels - Figure C.3
- Melbourne Metro 2036, Day Period predicted train noise levels - Figure C.4
- Melbourne Metro 2036, Night Period predicted train noise levels - Figure C.5
- Melbourne Metro 2036, L_{Amax} predicted train noise levels- Figure C.6.

The Investigation Thresholds are predicted to be exceeded at some residences in the western portal in some locations.

Noise level increases were associated with:

- Increased rail traffic on the Sunbury, Werribee and RRL rail corridors
- Properties on Ormond Street and Altona Street where houses on Childers Street providing shielding have been removed.

Table C.4 presents the sensitive receivers locations and level of noise exceedance for the Western Portal Concept Design.

Table C.4: Location of exceedances for the Western Portal

Location	Exceedance Trigger	Predicted increase (dB)	Comment
5 Altona Street Kensington	$L_{Aeq\ (Day/Night)}$	>10	Ground Floor
7 Altona Street Kensington	$L_{Aeq\ (Day/Night)}$	>10	Ground Floor
9-11 Altona Street Kensington	$L_{Aeq\ (Day/Night)}$	8	Ground Floor
15 Altona Street Kensington	$L_{Aeq\ (Day/Night)}$	5	Ground Floor
123 Ormond Street Kensington	$L_{Aeq\ (Day/Night)}$	5	Ground Floor
125 Ormond Street Kensington	$L_{Aeq\ (Day/Night)}$	4	Ground Floor
127 Ormond Street Kensington	$L_{Aeq\ (Day/Night)}$ / L_{Amax}	3	Ground Floor
131 Ormond Street Kensington	$L_{Aeq\ (Day/Night)}$	9	Ground Floor

C.4.2 Precinct 2: Western Portal - Variation

Train noise levels have been predicted for the following scenarios and colour noise contours displaying the predicted rail noise levels are provided in the figures as stated:

- Melbourne Metro 2036, Day Period train noise levels - Figure C.7
- Melbourne Metro 2036, Night Period train noise levels - Figure C.8
- Melbourne Metro 2036, L_{Amax} train noise levels - Figure C.9.

The investigation thresholds are predicted to be exceeded at one location at the Western Portal.

Noise level increases were associated with:

- Increased rail traffic on the Sunbury, Werribee and RRL rail corridors
- Loss of shielding from the property removed on Ormond Street.

Table C.5 presents the sensitive receivers locations and level of noise exceedance for the western portal Variation.

Table C.5: Location of exceedances for the Western Portal

Location	Exceedance Trigger	Predicted increase (dB)	Comment
133 Ormond Street KENSINGTON	$L_{Aeq\ (Day/Night)}$	4	Ground Floor

C.4.3 Precinct 8: Eastern Portal

Train noise levels have been predicted for the following scenarios and colour noise contours displaying the predicted rail noise levels are provided in the figures as stated:

- Base-case 2026, Day Period predicted train noise levels - Figure C.10
- Base-case 2026, Night Period predicted train noise levels - Figure C.11
- Base-case 2026, L_{Amax} predicted train noise levels - Figure C.12:
- Melbourne Metro 2036, Day Period predicted train noise levels - Figure C.13
- Melbourne Metro 2036, Night Period predicted train noise levels - Figure C.14
- Melbourne Metro 2036, L_{Amax} predicted train noise levels - Figure C.15.

The Investigation Thresholds are predicted to be exceeded at the Eastern Portal in some locations.

Noise level increases correlated with the following:

- Increased rail traffic on the Dandenong (including regional units), Frankston and Sandringham rail corridors
- Changes in track position and elevations
- Removal of properties that would otherwise have provided shielding for other properties.

Table C.6 presents the sensitive receivers locations and level of noise exceedance for the eastern portal.

Table C.6: Location of exceedances for the Eastern Portal

Location	Exceedance Trigger	Predicted increase (dB)	Comment
1 Arthur Street South Yarra	L_{Amax}	4	First Floor, Second Floor, Third Floor
3 Arthur Street South Yarra	L_{Amax}	4	First Floor, Second Floor
23 Arthur Street	L_{Amax}	3	Ground Floor
3 William Street South Yarra	L_{Amax}	6	Ground Floor, First Floor
4 William Street South Yarra	$L_{Aeq\ (Day/Night)}$	6	Ground Floor
4 William Street South Yarra	L_{Amax}	11	Ground Floor
10 William Street South Yarra	$L_{Aeq\ (Day/Night)}$	5	Ground Floor, First Floor
10 William Street South Yarra	L_{Amax}	7	Ground Floor, First Floor
12 William Street South Yarra	$L_{Aeq\ (Day/Night)}$	5	Ground Floor, First Floor
12 William Street South Yarra	L_{Amax}	6	First Floor

C.4.4 Precinct 9: Turnback at West Footscray Station

Train noise levels have been predicted for the following scenarios and colour noise contours displaying the predicted rail noise levels are provided in the figures as stated:

- Base-Case 2026, Day Period predicted train noise levels - Figure C.16
- Base-Case 2026, Night Period predicted train noise levels - Figure C.17
- Base-Case 2026, L_{Amax} predicted train noise levels - Figure C.18
- Melbourne Metro 2036, Day Period predicted train noise levels - Figure C.19
- Melbourne Metro 2036, Night Period predicted train noise levels - Figure C.20
- Melbourne Metro 2036, L_{Amax} predicted train noise levels - Figure C.21.

The Investigation Thresholds are not predicted to be exceeded for the Western Turnback. Noise associated with idling trains on the Turnback Track and Pocket Track is expected to be negligible compared to the trains operating at higher speeds during the peak period.

Figure C.1: Western Portal Base-Case 2026, Day Period, predicted train noise levels

Figure C.2: Western Portal Base-Case 2026, Night Period, predicted train noise levels

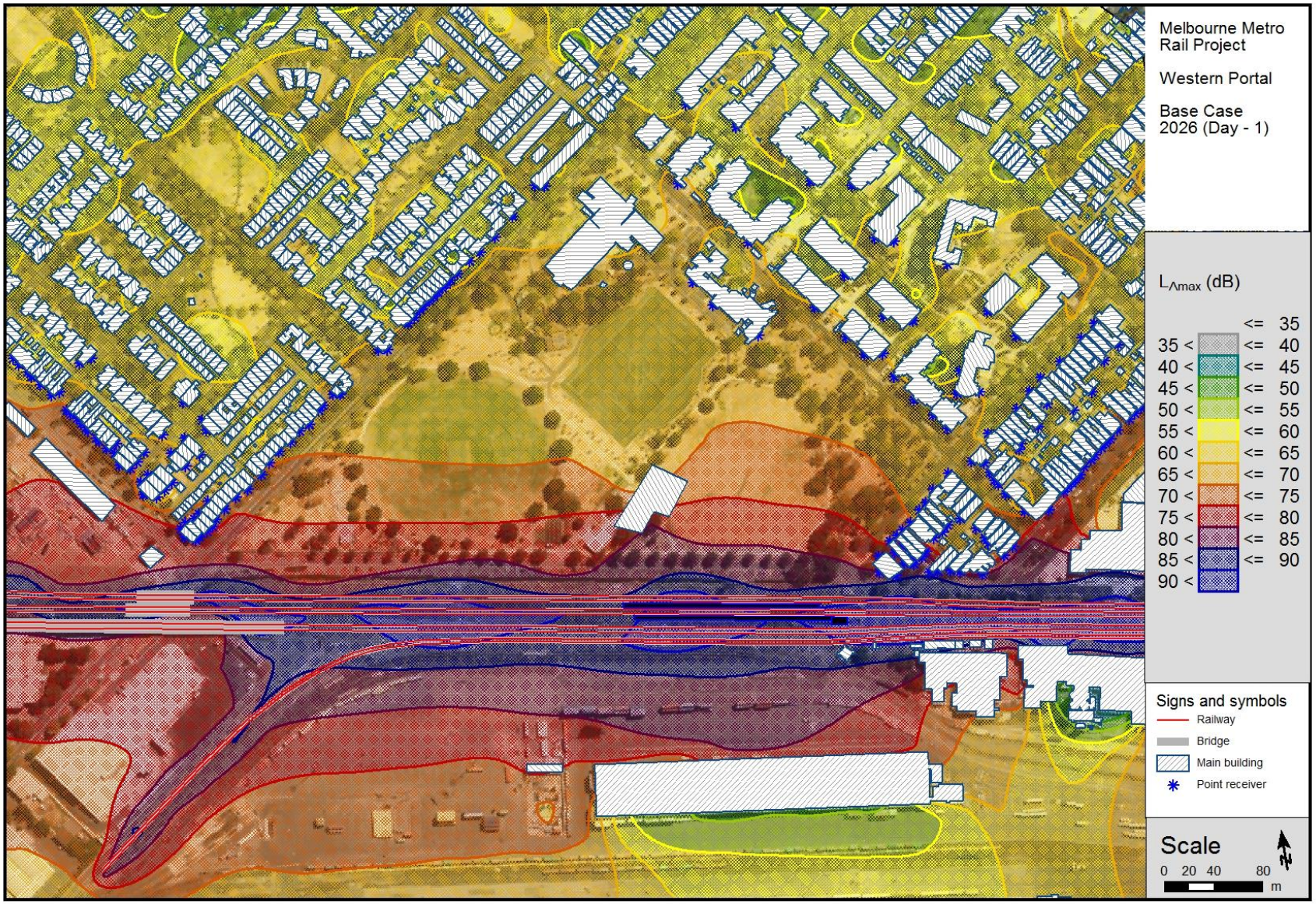

Figure C.3: Western Portal Base-Case 2026, $L_{Amax,}$ predicted train noise levels

Figure C.4: Western Portal Melbourne Metro Concept Design 2036, Day Period, predicted train noise levels

Figure C.5: Western Portal Melbourne Metro Concept Design 2036, Night Period, predicted train noise levels

Figure C.6: Western Portal Melbourne Metro Concept Design 2036, $L_{Amax,}$ predicted train noise levels

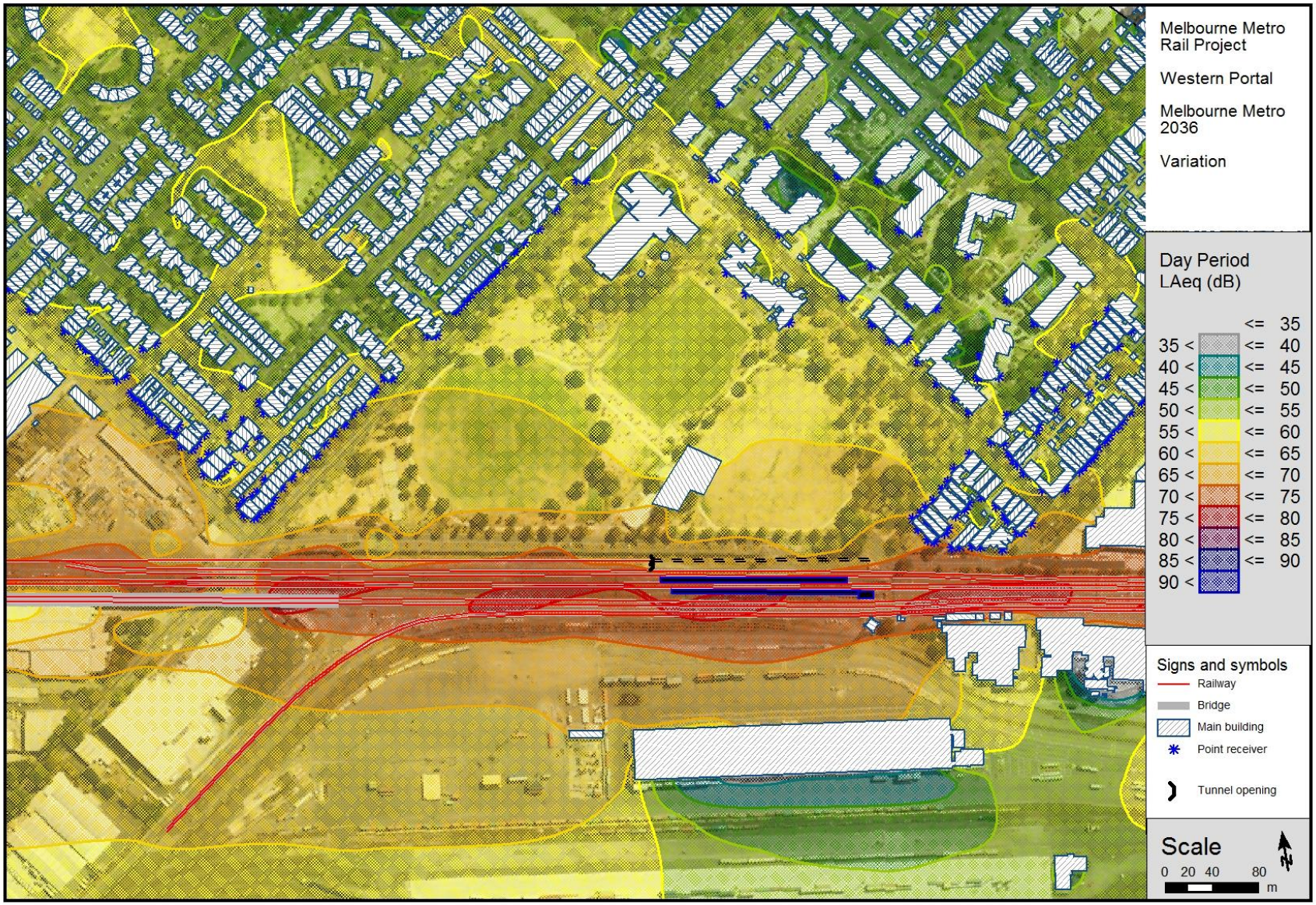

Figure C.7: Western Portal Melbourne Metro Variation 2036, Day Period, predicted train noise levels

Figure C.8: Western Portal Melbourne Metro Variation 2036, Night Period, predicted train noise levels

Figure C.9: Western Portal Melbourne Metro Variation 2036, $L_{Amax,}$ predicted train noise levels

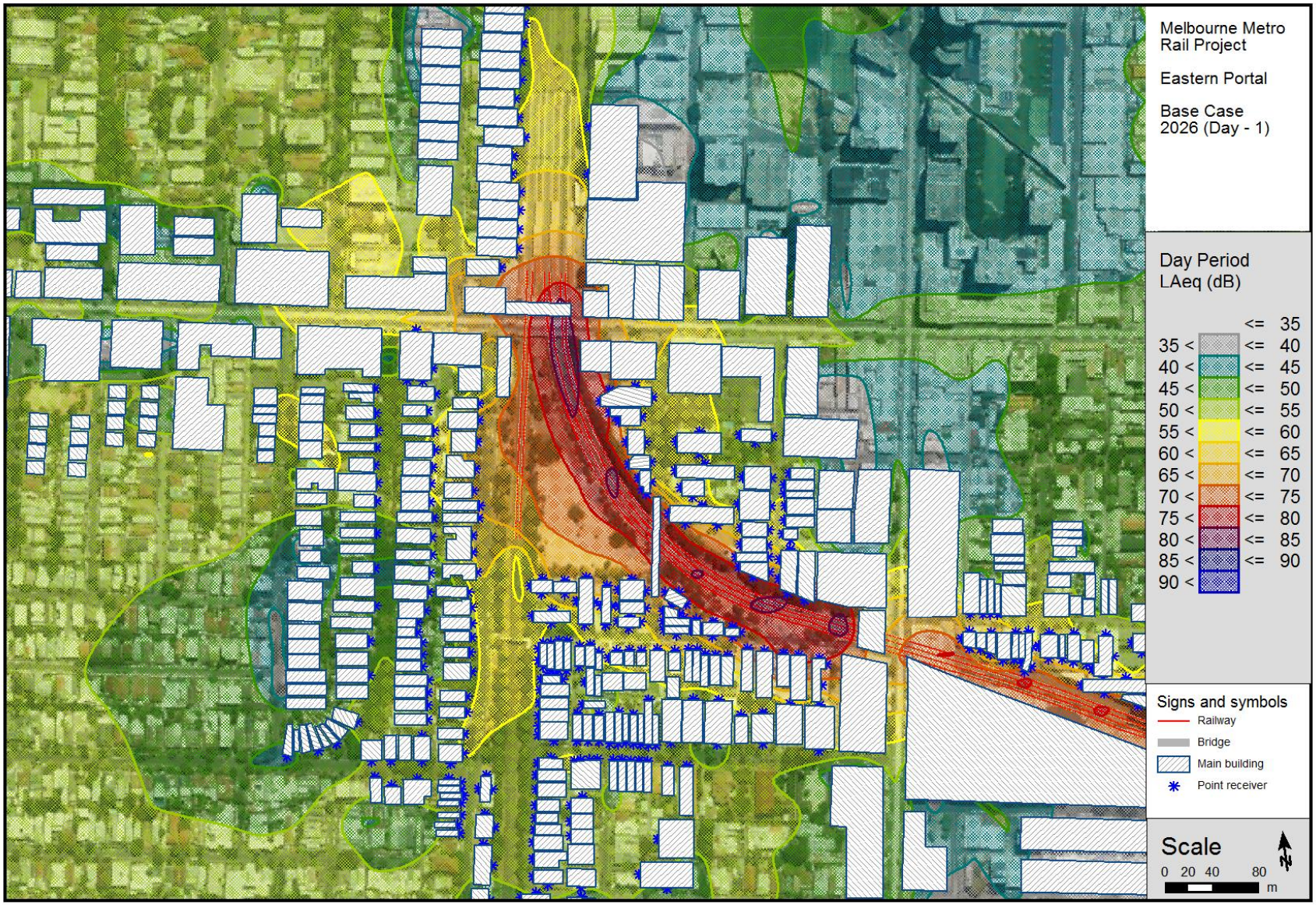

Figure C.10: Eastern Portal Base-Case 2026, Day Period, predicted train noise levels

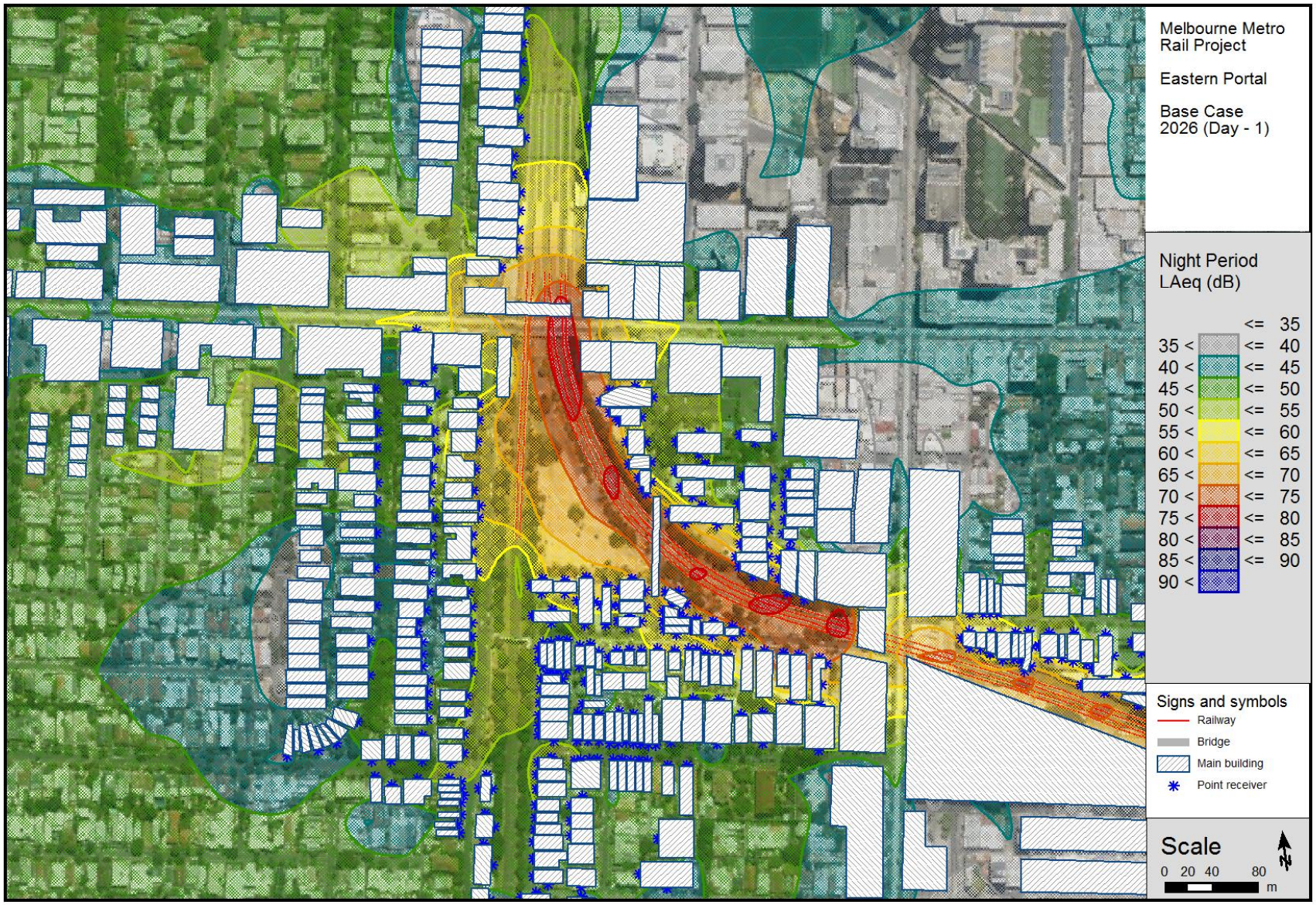

Figure C.11: Eastern Portal Base-Case 2026, Night Period, predicted train noise levels

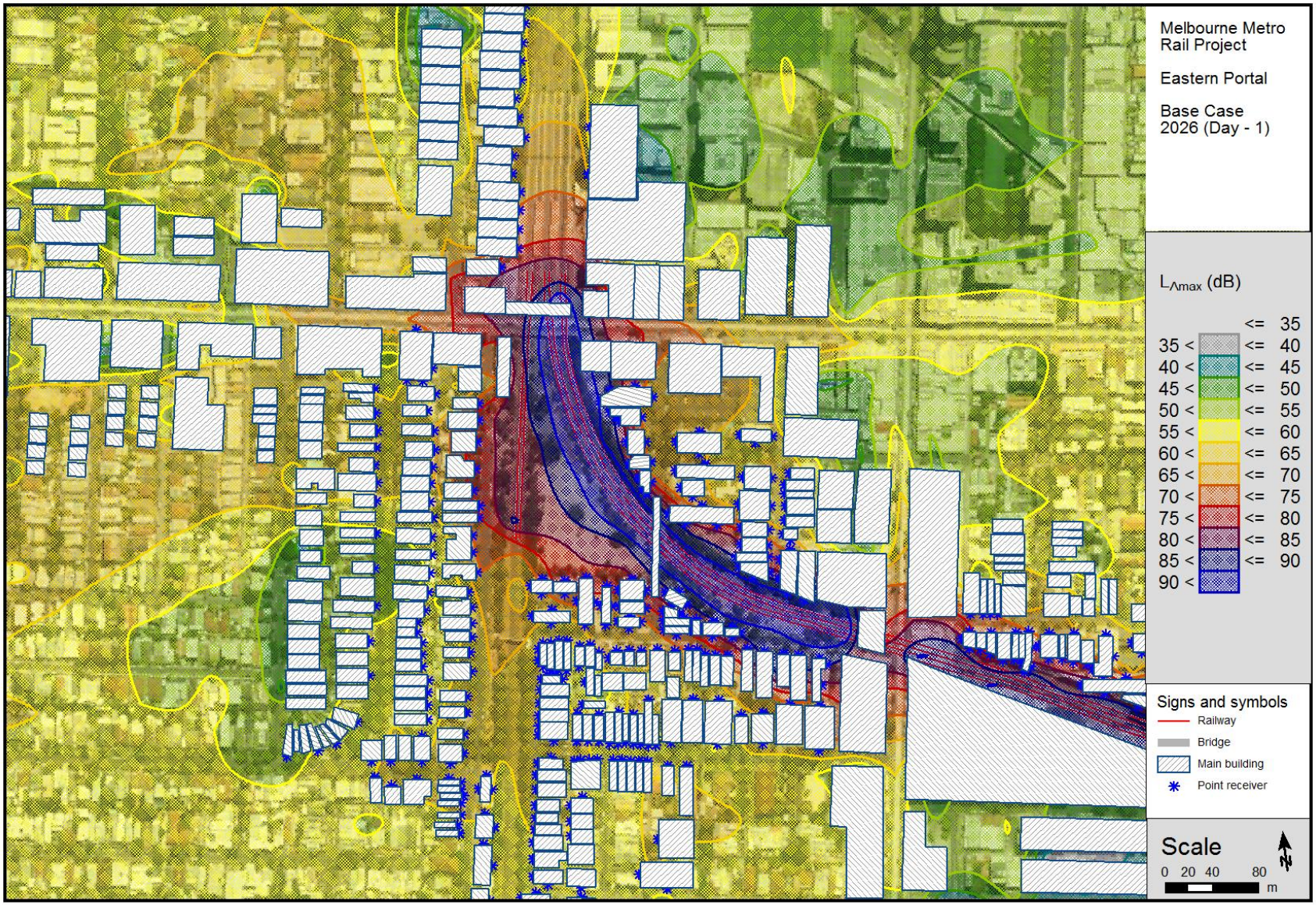

Figure C.12: Eastern Portal Base-Case 2026, $L_{Amax,}$ predicted train noise levels

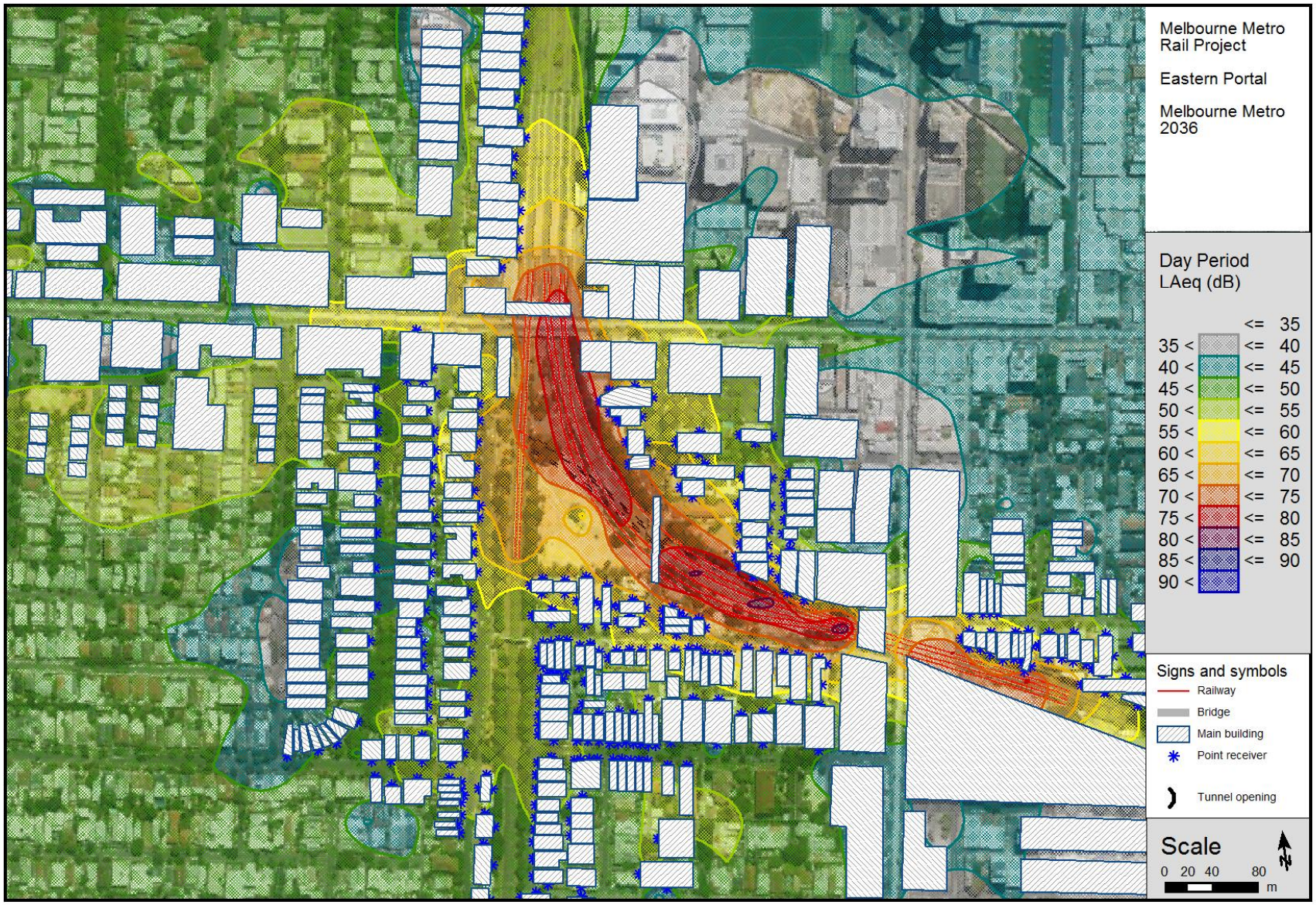

Figure C.13: Eastern Portal Melbourne Metro 2036, Day Period, predicted train noise levels

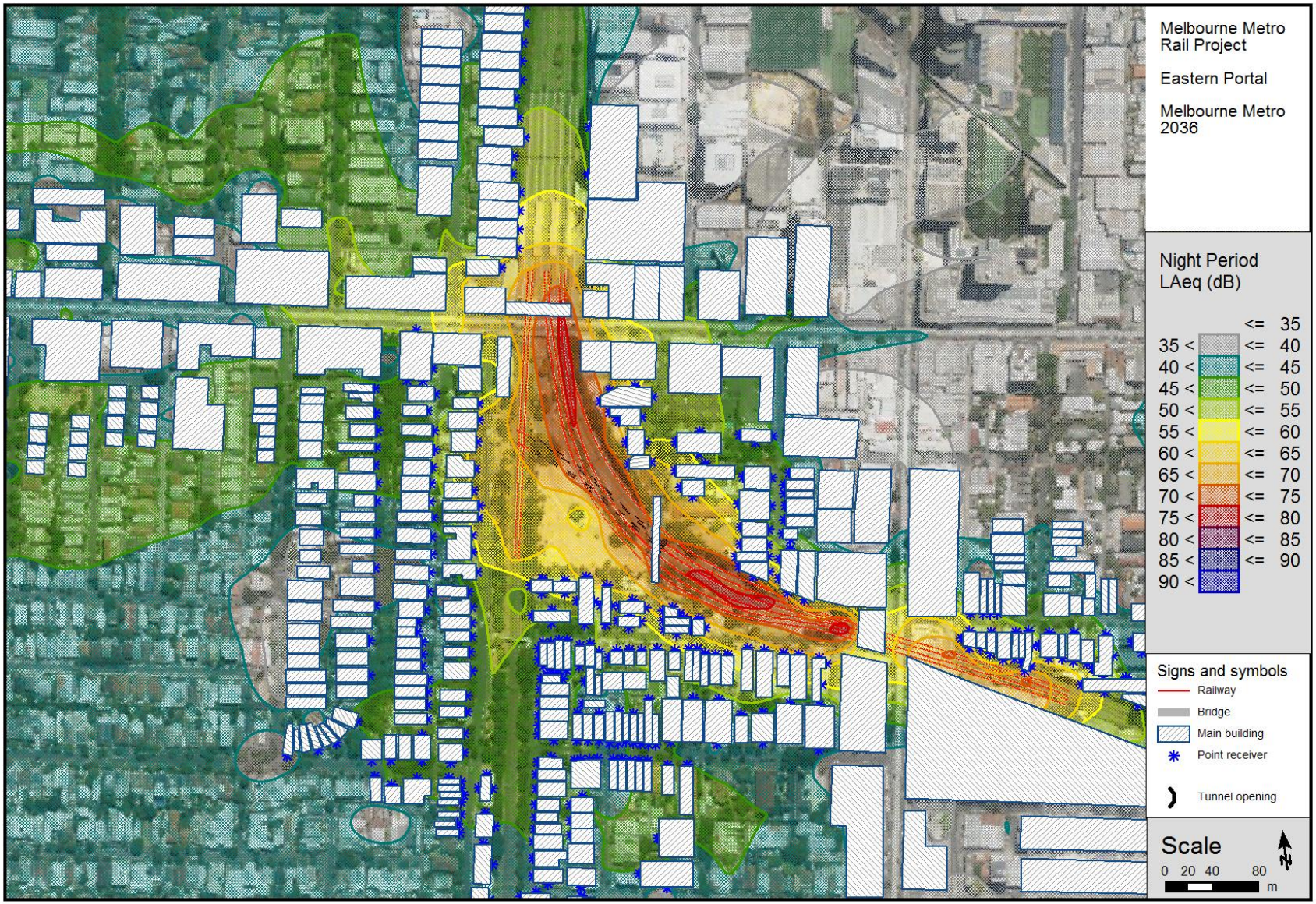

Figure C.14: Eastern Portal Melbourne Metro 2036, Night Period, predicted train noise levels

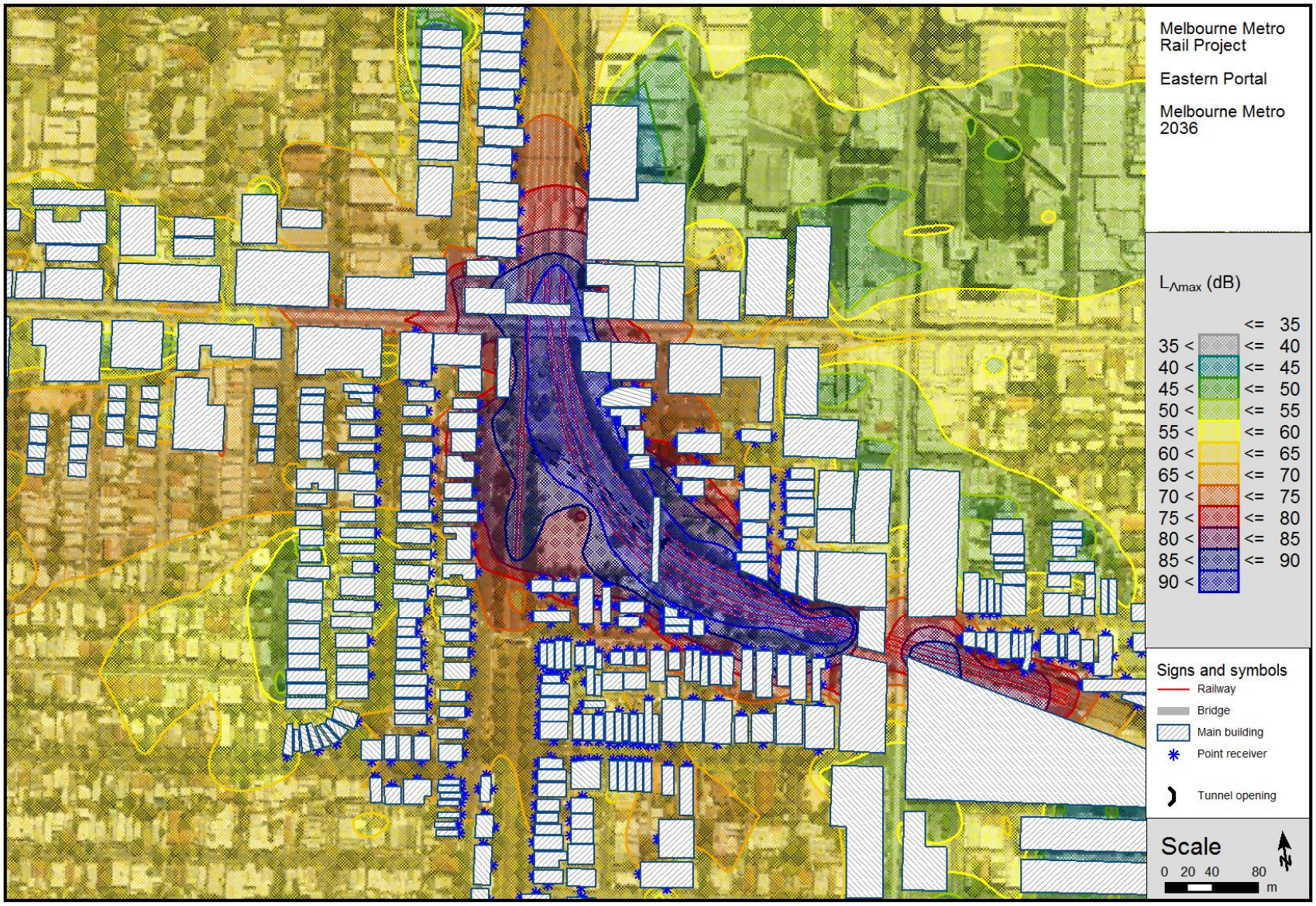

Figure C.15: Eastern Portal Melbourne Metro 2036, $L_{Amax,}$ predicted train noise levels

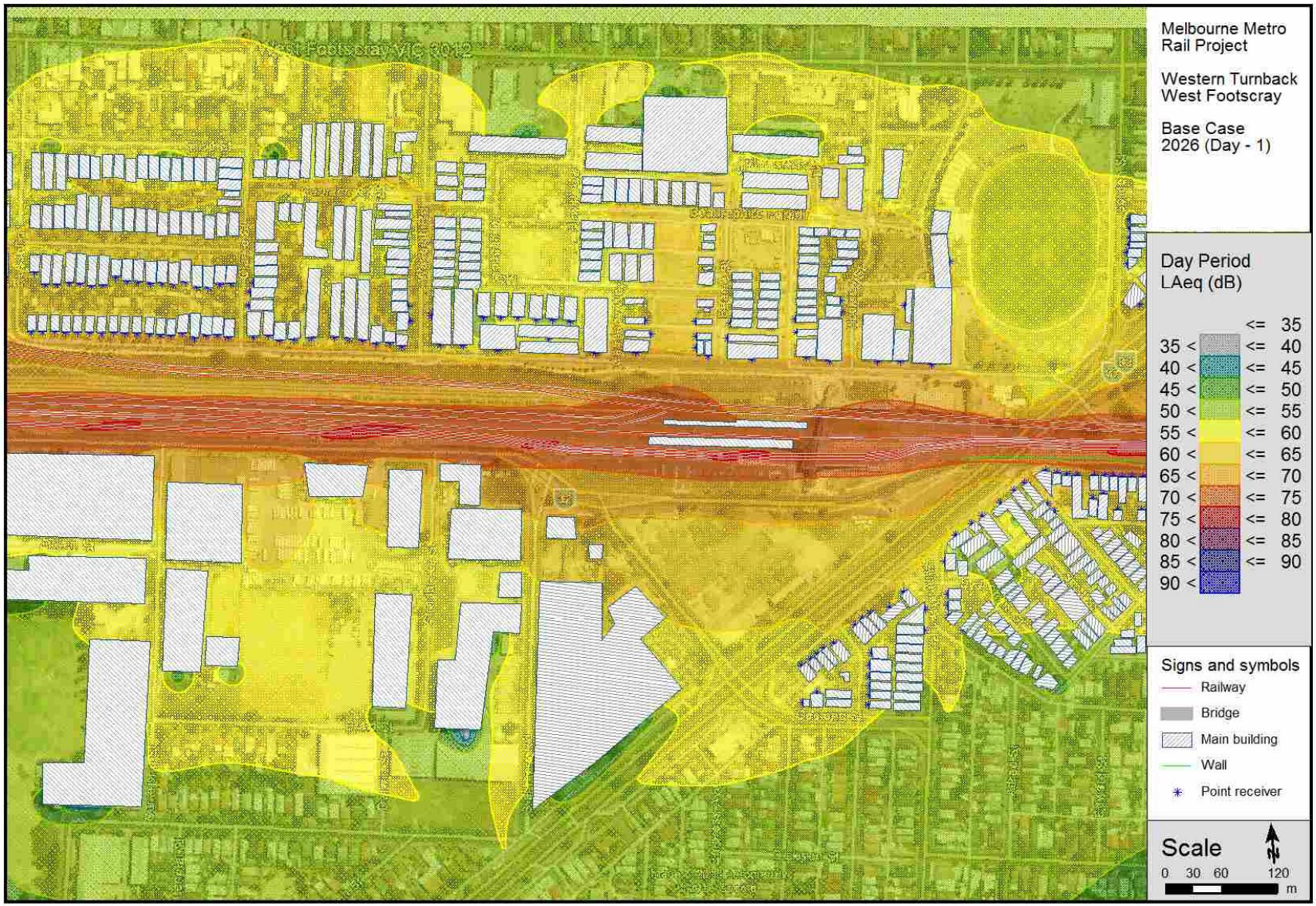

Figure C.16: Western Turnback at West Footscray Base-Case 2026, Day Period, predicted train noise levels

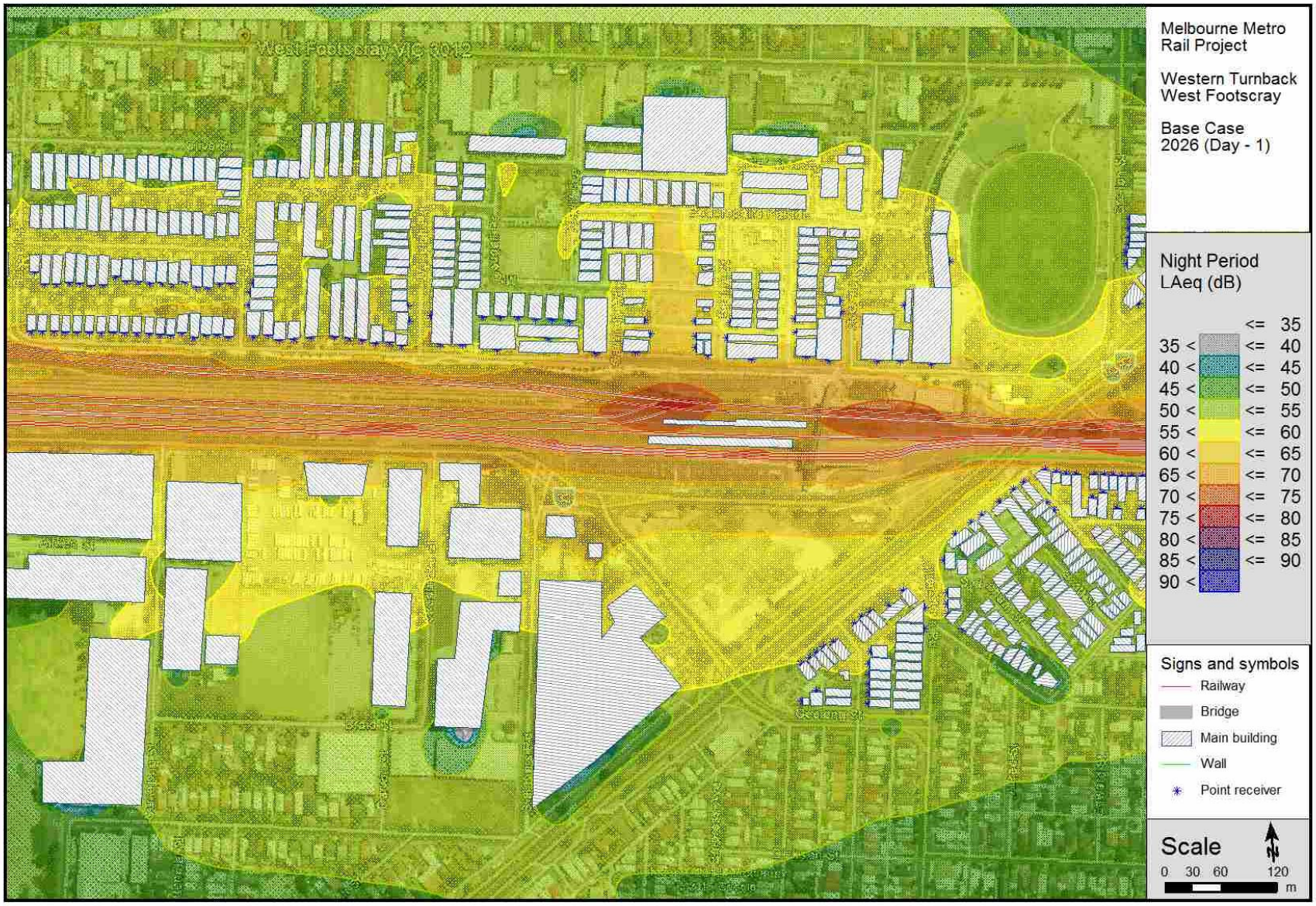

Figure C.17: Western Turnback at West Footscray Base-Case 2026, Night Period, predicted train noise levels

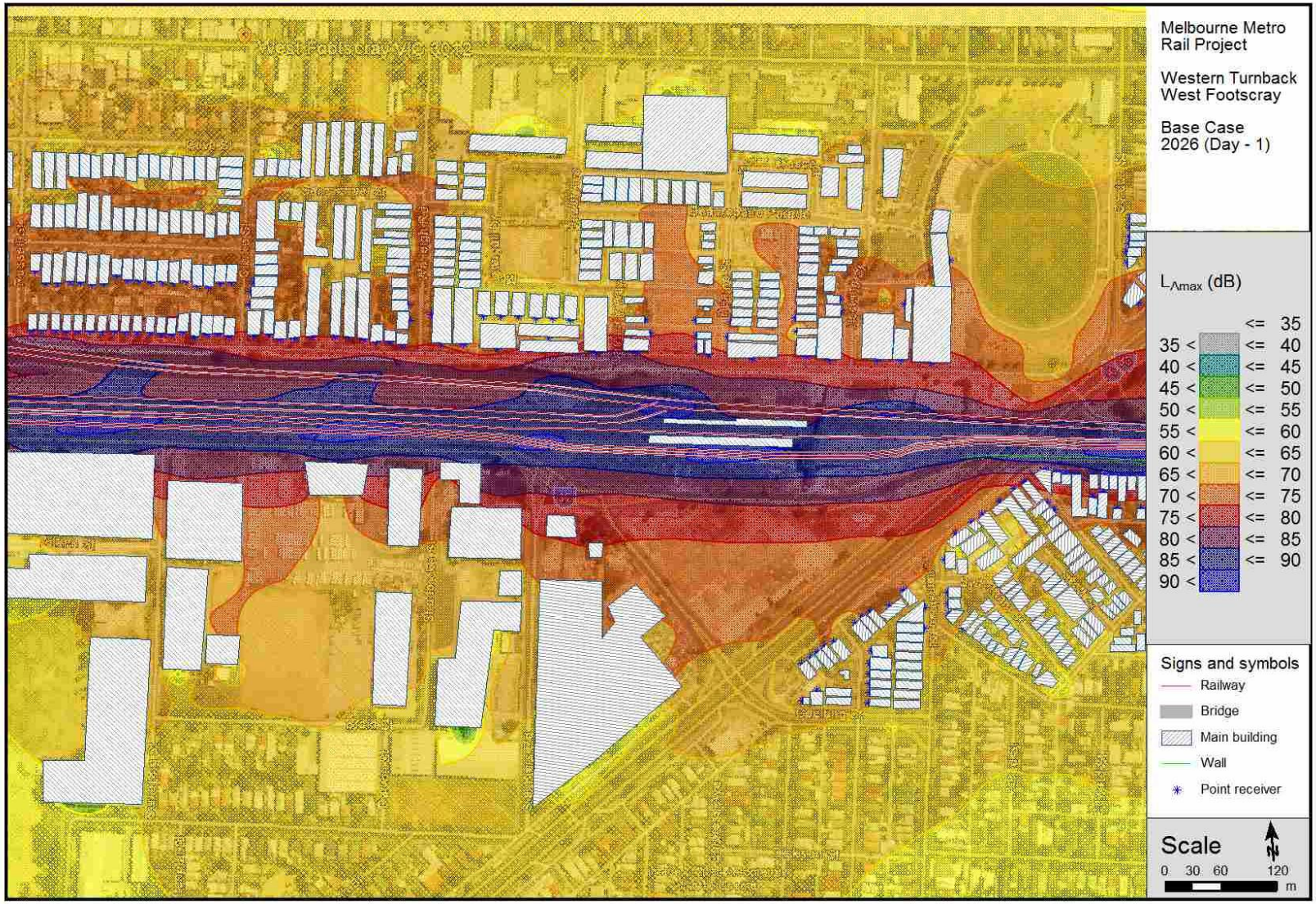

Figure C.18: Western Turnback at West Footscray Base-Case 2026, L_{Amax} predicted train noise levels

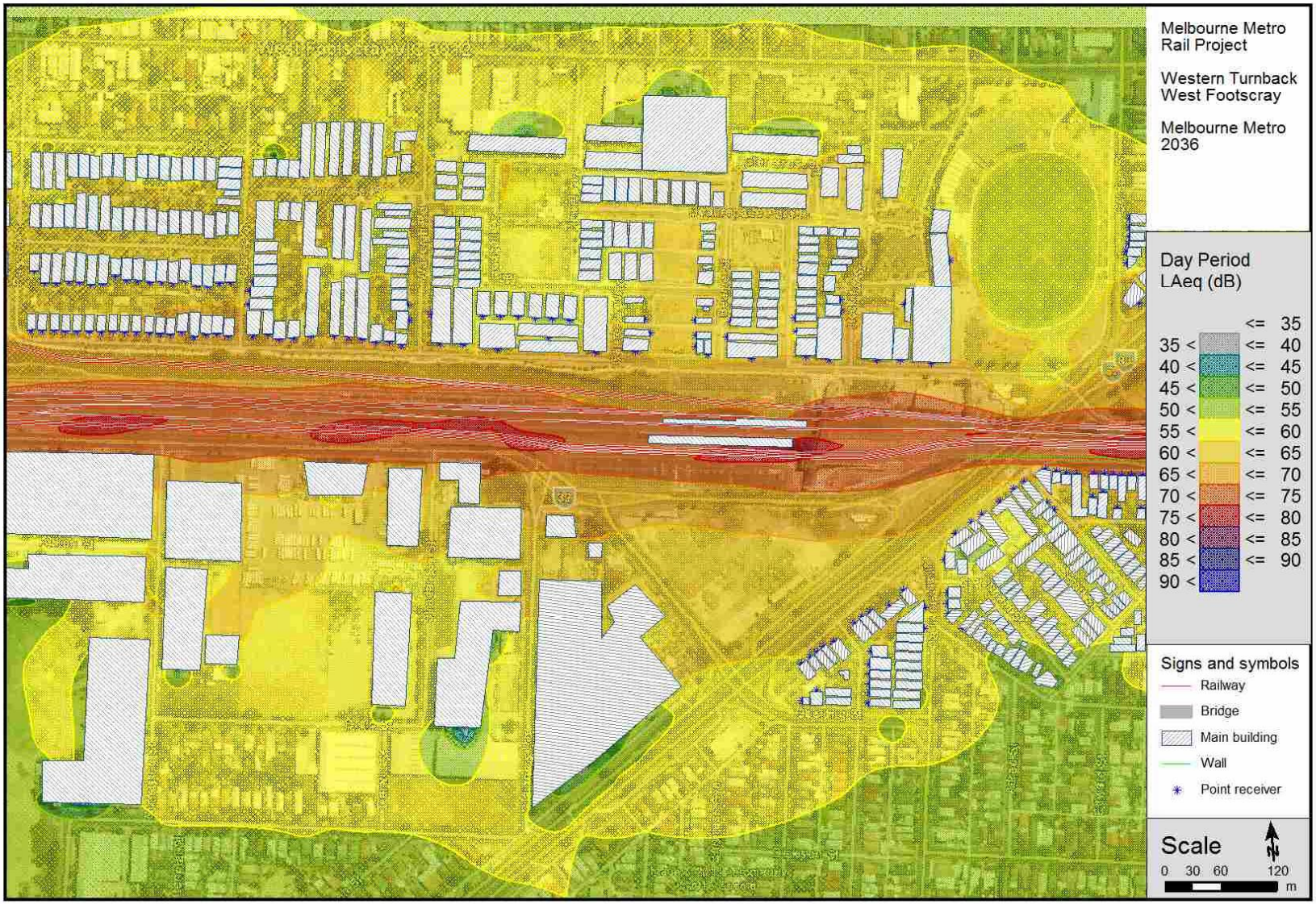

Figure C.19: Western Turnback at West Footscray Melbourne Metro 2036, Day Period, predicted train noise levels

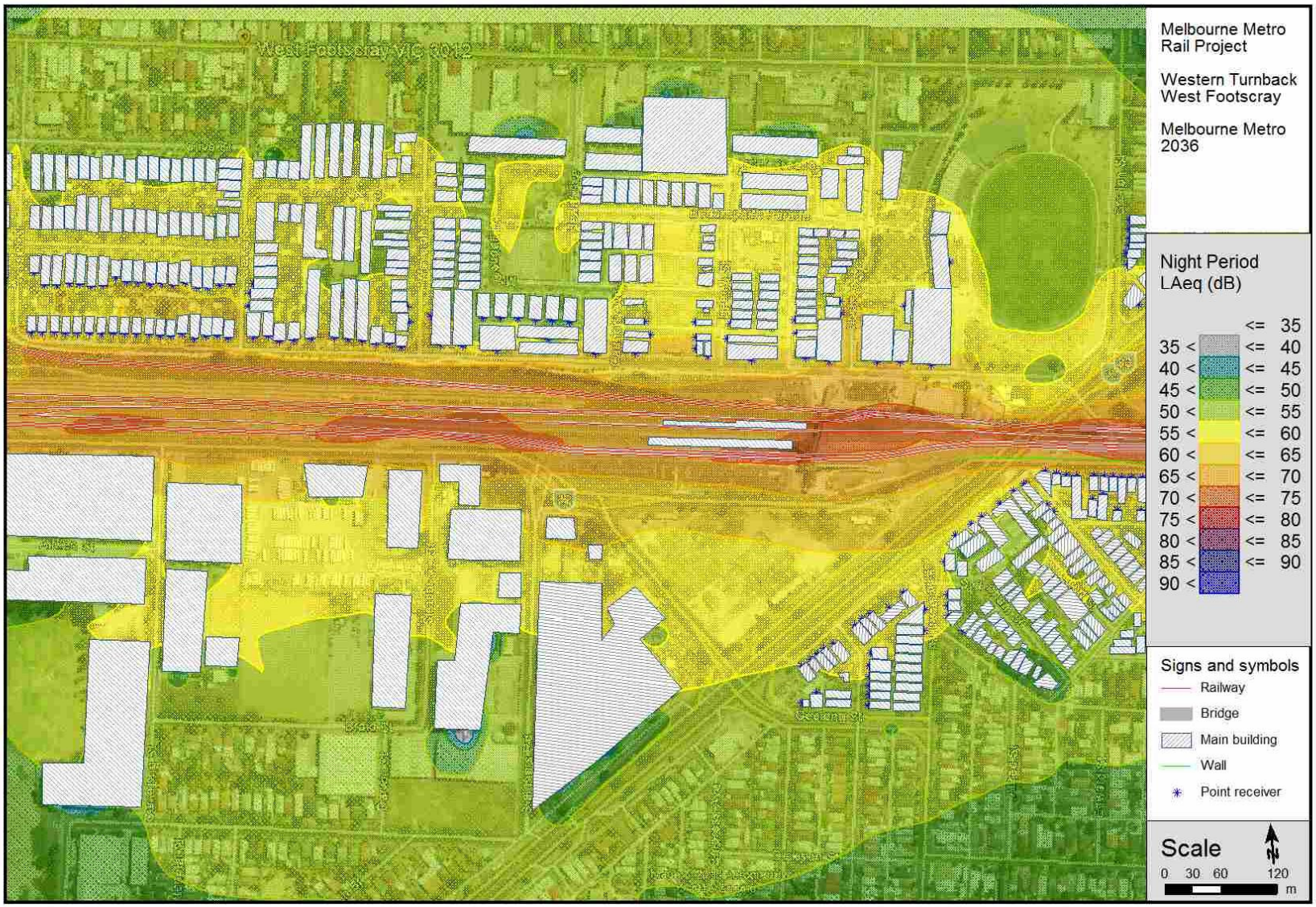

Figure C.20: Western Turnback at West Footscray Melbourne Metro 2036, Night Period, predicted train noise levels

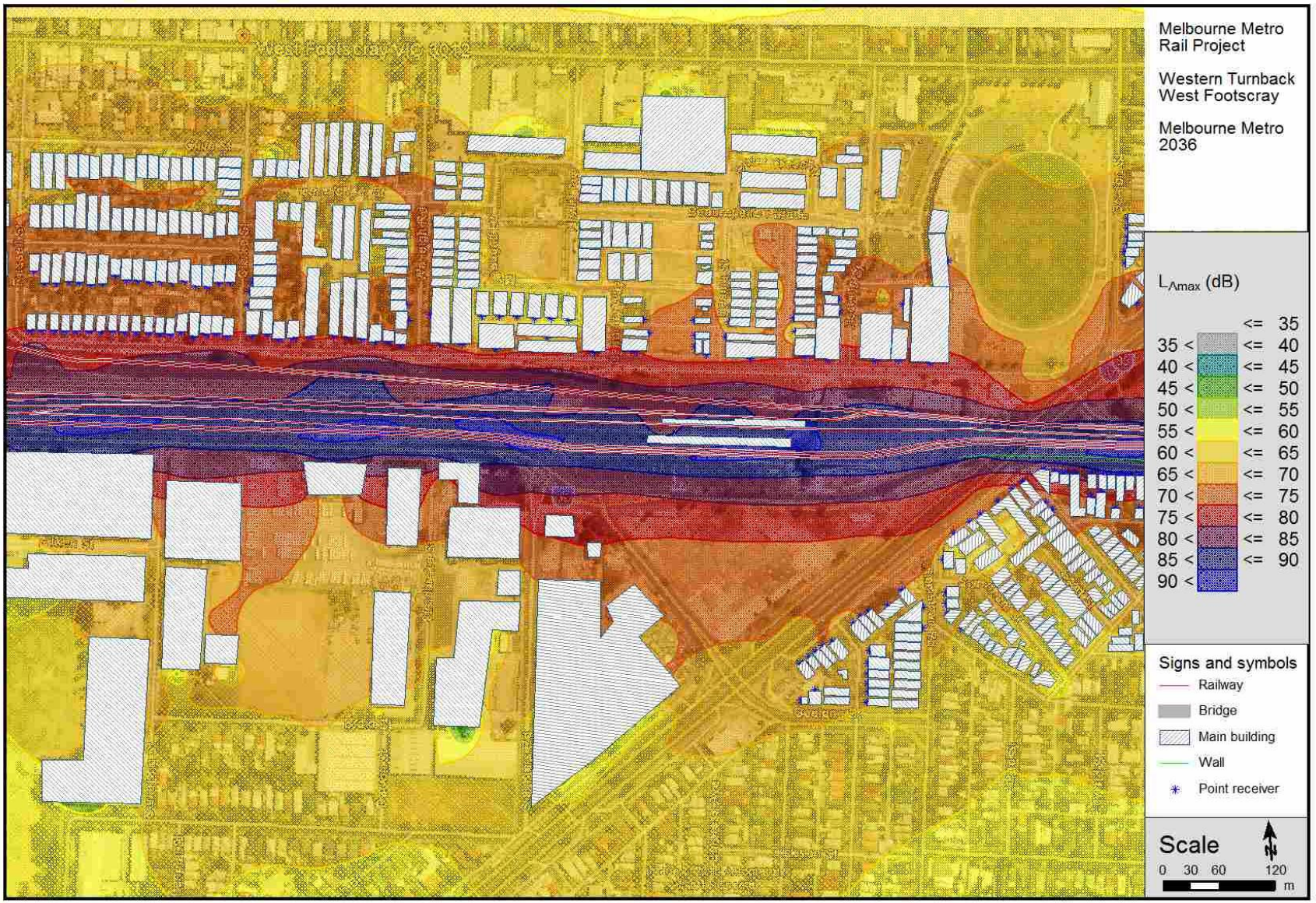

Figure C.21: Western Turnback at West Footscray Melbourne Metro 2036, L_{Amax} predicted train noise levels

C.5 Mitigation

C.5.1 Western Portal

C.5.1.1 Concept Design

The Investigation Thresholds are predicted to be exceeded at properties on Altona Street and Ormond Street, Kensington backing onto Childers Street for the Melbourne Metro Concept Design option. This is because for the Melbourne Metro Concept Design option, a number of houses on Childers Street have been demolished which has left the houses behind exposed to higher levels of train noise. The Investigation Thresholds are predicted to be met with the installation of a 4.5 m high barrier between the railway and Childers Street for a length of approximately 150 m. The base of the noise barrier is at grade of the adjacent rail tracks, on top of the retaining wall located along Childers Street. The predicted noise levels with the noise barrier and the location of the noise barrier are shown in Figures C.22, C.23 and C.24.

Noise barriers are to have a minimum mass per unit area of 15 kg/m^2 and be contiguous without any gaps or holes.

C.5.1.2 Variation

The Investigation Thresholds are predicted to be exceeded at 133 Ormond Street for the Melbourne Metro Variation option. This is due to the removal of the house at 135 Ormond Street that was providing shielding with respect to train noise for 133 Ormond Street. The Investigation Thresholds are predicted to be met with the installation of a 3 m high barrier between the railway and Childers Street for a length of approximately 75 m. The base of the noise barrier is at grade of the adjacent rail tracks, on top of the retaining wall located along Childers Street. The predicted noise levels with the noise barrier and the location of the noise barrier are shown in Figure C.25, C.26 and C.27. Noise barriers are to have a minimum mass per unit area of 15 kg/m^2 and be contiguous without any gaps or holes.

As an alternative to providing a barrier for a single property, off-reservation acoustic treatment (upgrade of the building façade) may be applied to the property.

C.5.2 Eastern Portal

The Investigation Thresholds are predicted to be exceeded at properties on Arthur Street and William Street, South Yarra. This is due to a combination of changes that include:

- increased rail traffic
- widening of the tracks to the south
- ramps for Frankston Line and regional tracks
- removal of properties on Arthur Street and William Street that would otherwise have provided shielding

The Investigation Thresholds are predicted to be met with the installation of noise barriers along the northern side of tracks (2 barriers 50 m and 70 m in length) and southern side of tracks (2 barriers 100 m and 170 m in length) as shown in Figures C.28, C.29 and C.30. Barrier heights range from 2.5 m to 3 m above the ground height of the adjacent houses and are located at the top of cut.

With the mitigation described above and shown on Figures C.28, C.29 and C.30 the predicted train noise levels at the upper floors of 4 William Street, 10 William Street, 1 Arthur Street and 3 Arthur Street exceed the Investigation Thresholds and off-reservation acoustic treatment (upgrade of the building façade) is recommended. It was not considered practical to provide barriers to mitigate for residents at these levels.

Noise barriers are to have a minimum mass per unit area of 15 kg/m^2 and be contiguous without any gaps or holes.

C.5.3 Western Turn-back

The Investigation Thresholds are not predicted to be exceeded and mitigation is not required.

Figure C.22: Western Portal with Melbourne Metro Concept Design (with Mitigation), Day Period predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

Figure C23: Western Portal with Melbourne Metro Concept Design (with Mitigation), Night Period predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

Figure C.24: Western Portal with Melbourne Metro Concept Design (with Mitigation), L_{Amax} predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

Figure C.25: Western Portal with Melbourne Metro Concept Design (with Mitigation), Day Period predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

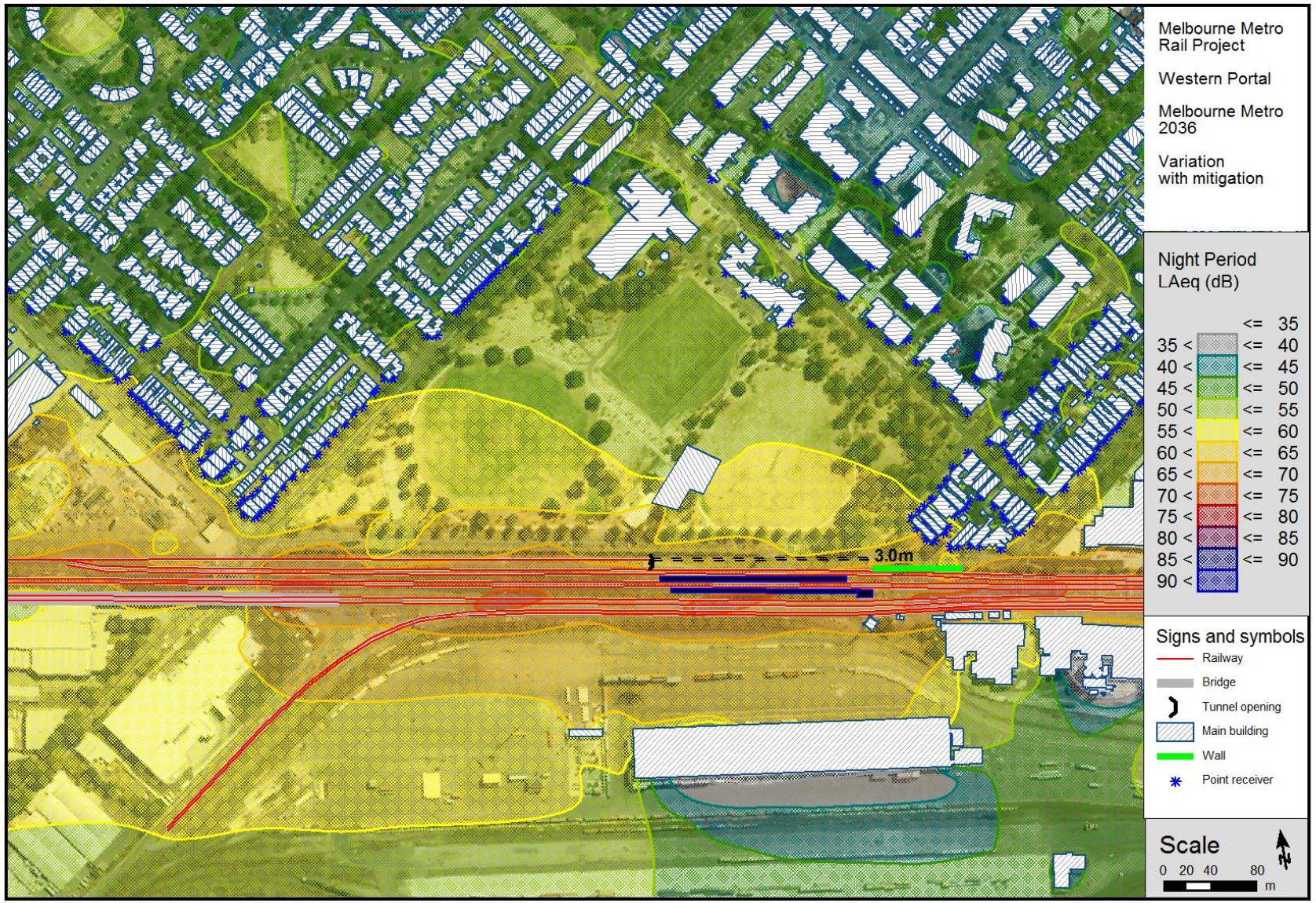

Figure C26: Western Portal with Melbourne Metro Concept Design (with Mitigation), Night Period predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

Figure C.27: Western Portal with Melbourne Metro Concept Design (with Mitigation), L_{Amax} predicted noise levels. Barrier height is above the rail height for the RRL and Newport group of trains

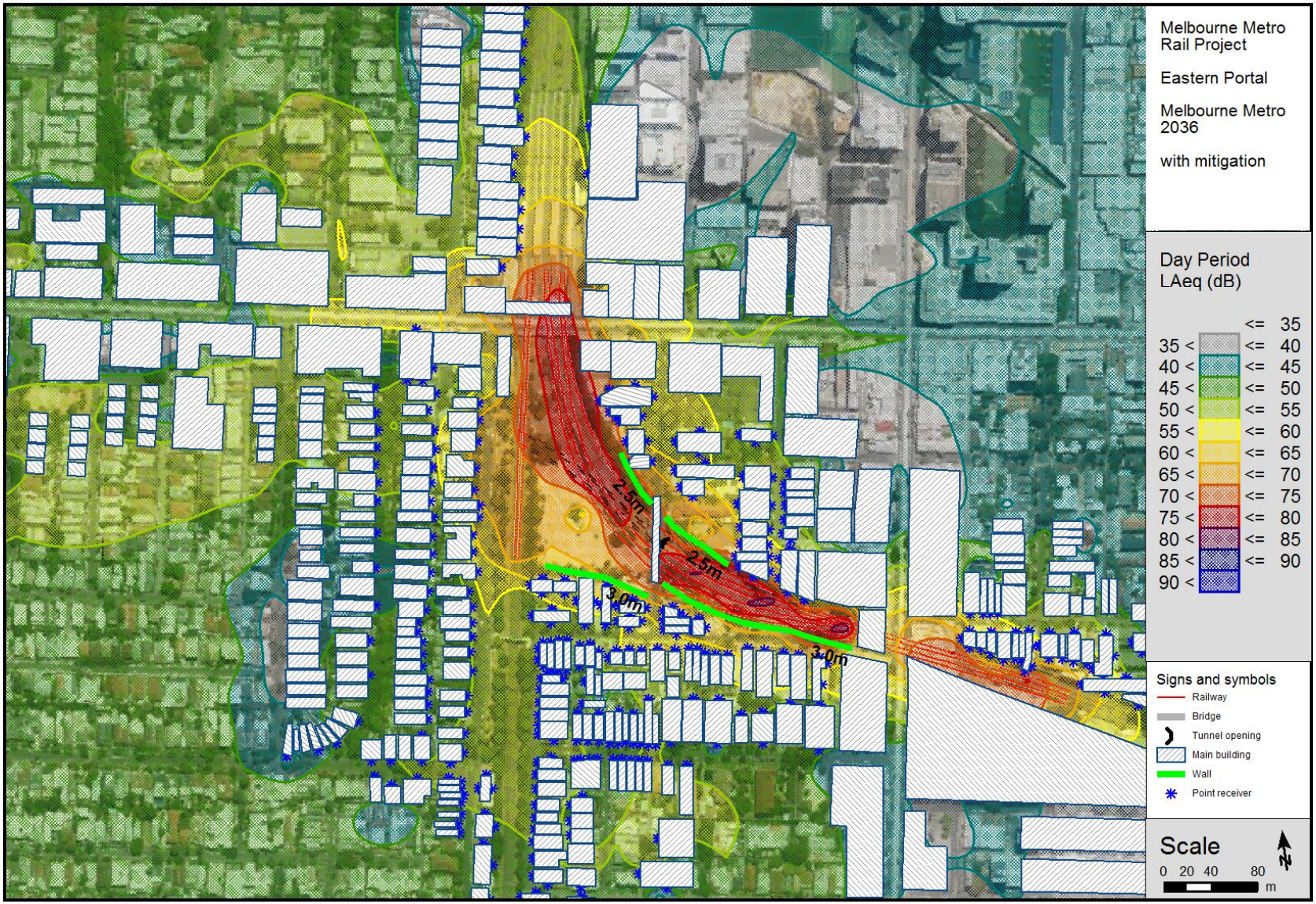

Figure C.28: Eastern Portal with Melbourne Metro (with Mitigation), Day Period predicted noise levels. Barrier height is above the ground height at residential properties

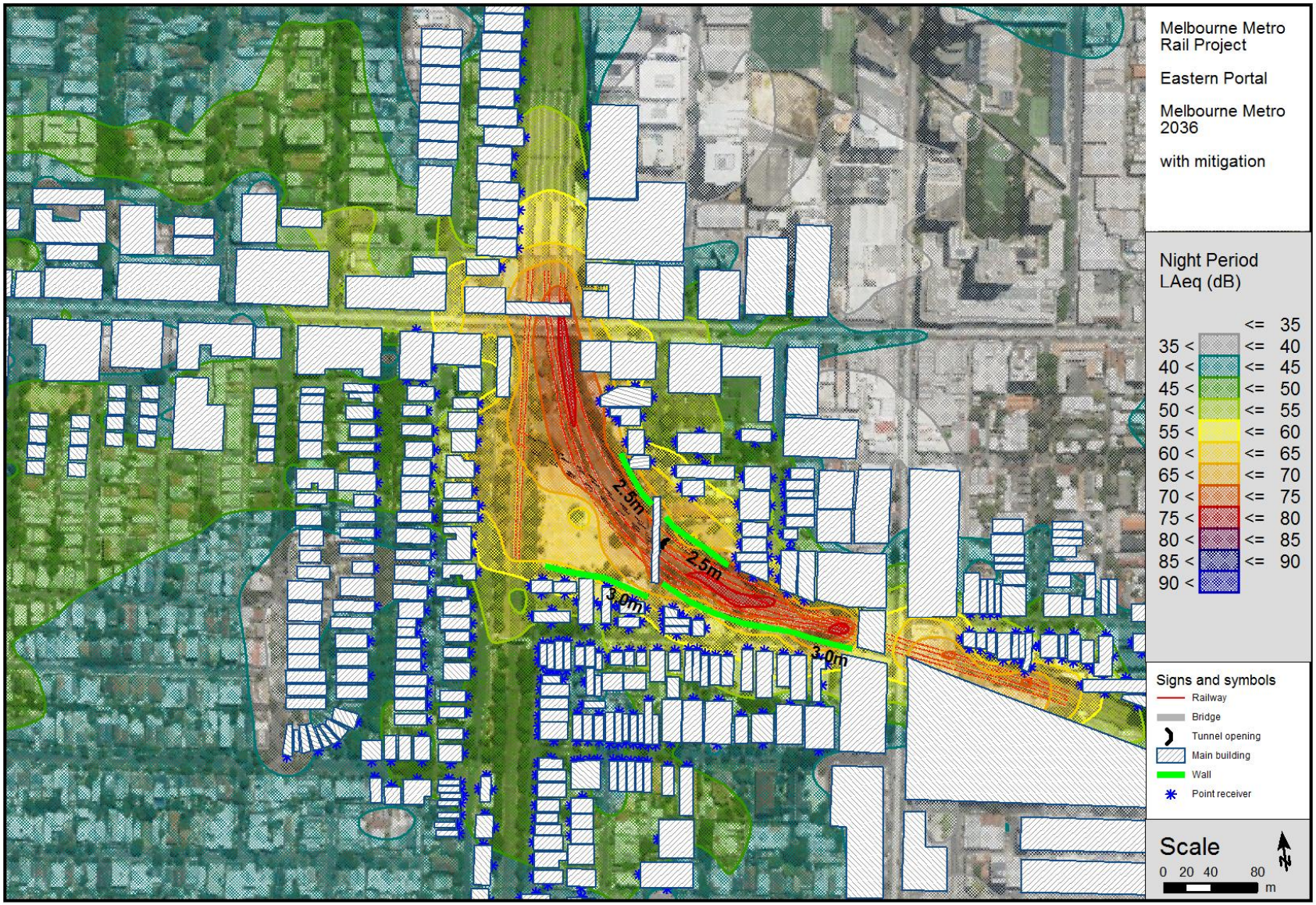

Figure C.29: Eastern Portal with Melbourne Metro (with Mitigation), Night Period predicted noise levels. Barrier height is above the ground height at the residential properties

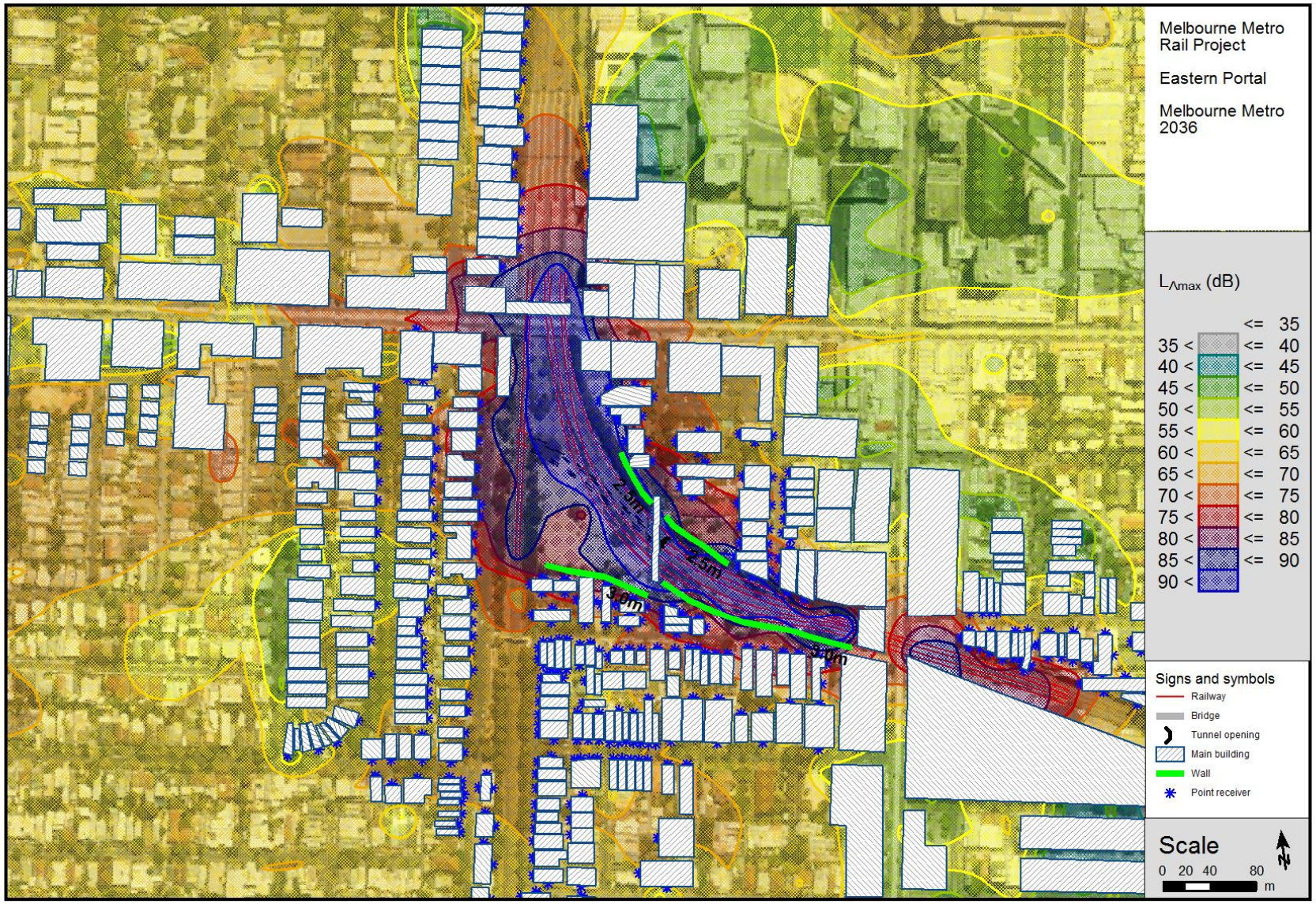

Figure C.30: Eastern Portal with Melbourne Metro (with Mitigation), L_{Amax} predicted noise levels. Barrier height is above the ground height at the residential properties

C.6 Discussion

Train noise levels have been predicted at noise sensitive receivers in the vicinity of the Melbourne Metro and assessed with respect to the PRINP. Noise mitigation is predicted to be required to mitigate train noise for the Western and Eastern Portal Precincts. The specific mitigation to meet the requirements of the PRINP has been detailed.

121 Exhibition Street

Melbourne VIC 3000

PO Box 23061

Docklands VIC 8012

Australia