5.1.2 Tunnelling

The underground tunnels would be ventilated during construction in order to provide a safe working environment for the construction workforce. Tunnel ventilation would be provided at the four tunnel support sites, which are:

- The southern interchange compound (C5).
- The Wilson Road compound (C6).
- The Trelawney Street compound (C7).
- The northern interchange compound (C9).

This ventilation equipment would have dust extraction and filtration systems installed to minimise dust emissions. Additionally, as the road headers would require water for dust suppression while cutting rock, dust generation from tunnelling activities is expected to be minimal.

The primary pollutants emitted from the detonation of explosives used for blasting (if it is required) are carbon monoxide, hydrogen sulfide, sulfur dioxide, oxides of nitrogen and ammonia (NPI, 2012a). In addition to the emissions associated with the fuel detonation, particulates are also emitted.

As blasting would be undertaken underground on an intermittent basis, the pollution emissions associated with these activities would be expected to be of short duration. Particulates generated by underground blasting would be captured by the air filtration system. As blasting works would only be carried out underground, the potential for dust emissions from this activity to affect receivers is considered to be negligible.

5.1.3 Water treatment

Water treatment plants would be located at the southern interchange compound (C5), Wilson Street compound (C6), Trelawney Street compound (C7) and the northern interchange compound (C9) to treat groundwater extracted from the underground workings. Emissions to air associated with water treatment depend on the nature of the contamination of the wastewater being treated and the treatment process. Primary air emissions associated with water treatment may include odorous compounds, such as ammonia and VOCs, which are associated with aeration (primary treatment), aerobic digestion, anaerobic digestion and sedimentation (NPI, 2011).

The nature of any odours would depend on the degree and type of any contamination present in the groundwater. A management plan would be developed to address any odours should contamination be encountered and if odours arise. The plan would include identification of odours, identification of the extent to which the odours are detectable, and, if necessary, mitigation measures to reduce any odours affecting receivers if they arise. Such mitigation measures could include modifications to the operating process, or the installation of carbon filters to capture odorous compounds before they are emitted. The water treatment plants would be located as far from receivers as can be reasonably and feasibly achieved.

This page has been left blank intentionally.

6.0 Operational impact assessment

As discussed in **Section 4.2**, dispersion modelling was used to predict resultant pollutant concentrations from the ventilation outlets (using CALPUFF) and from vehicles using the surface road network in proximity to the project portals at the southern and northern interchanges (using CAL3QHCR). The predicted emission concentrations from each model at each receiver location (where relevant) were combined to provide a total project contribution for each pollutant for each assessment scenario.

For PM_{10}, $PM_{2.5}$, NO_2 and CO, the predicted concentrations were added to the relevant ambient (background) pollutant concentrations to estimate cumulative pollutant concentrations, which were compared to the relevant assessment criteria. For PM_{10}, $PM_{2.5}$ and NO_2, the ambient pollutant concentrations were added contemporaneously – that is, the measured ambient pollutant concentrations were added to the associated model predictions for each receiver for that same time period. The maximum of the CAL3QHCR predictions and the OEH monitoring data at each receiver location were used to represent ambient pollutant concentrations.

6.1 Summary of results

This section of the report presents the results for:

- With project – expected traffic flows 2019 (scenario 2a) and 2029 (scenario 2b).
- The comparison of air quality with and without the project.
- The breakdown scenario.

Results for the design analysis assessments are presented in **Appendix G**.

6.1.1 With project – ventilation facilities – expected traffic flows

A summary of the dispersion modelling results for expected operation of the project in 2019 and 2029 (scenarios 2a/ 2b) for each ventilation outlet is presented in **Table 29** to. Predicted exceedences of the applicable air quality criteria are shown in bold text. Contour plots of project contributions were prepared for the pollutants with predicted cumulative concentrations closest to the relevant impact assessment criteria (i.e. PM_{10}, $PM_{2.5}$ and NO_2). **Figure 11** to **Figure 34** show contour plots for the maximum predicted project contributions of PM_{10}, $PM_{2.5}$ and NO_2 for the relevant averaging periods. It should be noted that plots of cumulative concentrations are not provided.

In the following tables, the 'project contribution' reflects the pollutant concentrations at receiver locations attributable to emissions from the ventilation outlets. The background data presented represent the maximum background pollutant concentrations from the road modelling or the background concentrations measured at Lindfield/Prospect for the associated time period. The values for PM_{10}, $PM_{2.5}$, NO_2 and CO in the following tables represent the peak predicted concentrations from the project alone or the peak cumulative concentration (where relevant) across the modelling domain. The NO_2 results represent the conversion of the model NO_X predictions to NO_2 using the OLM as described in **Section 4.2.11.1**. Results are presented in terms of maximum concentrations relative to each of the ventilation outlets; the maximum concentrations anywhere in the modelling domain equal the maximum of the northern and southern ventilation data.

The results in **Table 29** to show that applicable air quality criteria are comfortably met, with the exception of cumulative PM_{10} and $PM_{2.5}$ concentrations over a 24-hour averaging period. In the case of these two pollutants, however, the following should be noted:

- For 24 hour PM_{10}, the contribution from the project is predicted to be very minor, with a maximum of 2.1 $\mu g/m^3$ attributable to the ventilation outlet emissions (2029). This contribution represents 4.2 per cent of the applicable impact assessment criterion of 50 $\mu g/m^3$ (refer to **Table 29**).
- For 24 hour $PM_{2.5}$, the maximum contribution from the project was predicted to be 2.0 $\mu g/m^3$ (2029), which is eight per cent of the Air NEPM advisory reporting standard of 25 $\mu g/m^3$ (refer to **Table 30**).

Because background concentrations for PM_{10} (24-hour average) are already elevated across the Sydney airshed, the predicted 24-hour average PM_{10} concentrations for the project were subjected to a contemporaneous analysis, which considered the actual modelled contribution of the project for a particular period with the actual background concentration for that same period rather than combining the maxima in both cases. This approach allows a more refined assessment of air quality impacts, taking into account the likelihood of maximum project contributions and maximum background concentrations occurring at the same time. Contemporaneous analyses were also conducted for $PM_{2.5}$, given that this pollutant is key to the air quality performance of the project (refer to **Section 6.1.2** and **Section 6.1.3**).

The predicted concentrations of NO_2, CO and PAHs were well below the relevant impact assessment criteria. As such, no further analysis of these pollutants was undertaken.

The total VOC concentrations were speciated based on data published by the NSW Office of Environment and Heritage (2012), and are discussed further in **Section 6.1.5**.

As stated previously, the particulate emissions from vehicles primarily comprise the smaller fractions, such as PM_{10} and $PM_{2.5}$. As such, the estimated TSP emissions from vehicles essentially equate to PM_{10} emissions. The EPA has an annual criterion for TSP of 90 µg/m^3. The maximum annual average PM_{10} concentrations predicted by the modelling are well below this criterion. As a consequence, no adverse impacts from TSP are expected to result from the project.

Table 29 Predicted maximum PM_{10} pollutant concentrations – 'with project – expected traffic flows' (µg/m^3)

Averaging period	Source	Predicted maximum PM_{10} concentrations (µg/m^3)				Impact assessment criteria (µg/m^3)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
24 hours	Peak project contribution	1.0	1.4	1.4	2.1	-
	Peak cumulative concentration (project plus background)	Refer to **Table 34**				50
	Project contribution (% of criteria)	2.0 %	2.8 %	2.8 %	4.2 %	-
Annual average	Peak project contribution	0.09	0.11	0.11	0.13	-
	Peak cumulative concentration (project plus background)	21.27	21.31	21.29	21.35	30
	Project contribution (% of criteria)	0.3 %	0.4 %	0.4 %	0.4 %	-

Table 30 Predicted maximum $PM_{2.5}$ pollutant concentrations – 'with project – expected traffic flows' (µg/m³)

Averaging period	Source	Predicted maximum $PM_{2.5}$ concentrations (µg/m³)				Advisory reporting standards (µg/m³)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
24 hours	Peak project contribution	0.9	1.3	1.3	2.0	-
	Peak cumulative concentration (project plus background)	Refer to **Table 35**				25
	Project contribution (% of criteria)	3.6 %	5.2 %	5.2 %	8.0 %	-
Annual average	Peak project contribution	0.08	0.11	0.10	0.13	-
	Peak cumulative concentration (project plus background)	**8.70**	**10.28**	**8.71**	**10.29**	8
	Project contribution (% of criteria)	1.0 %	1.4 %	1.3 %	1.6 %	-
Exceedences denoted in **bold type**						

Table 31 Predicted maximum NO_2 pollutant concentrations – 'with project – expected traffic flows' (µg/m³)

Averaging period	Source	Predicted maximum NO_2 concentrations (µg/m³)				Impact assessment criteria (µg/m³)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
1 hour	Peak project contribution	68.9	61.8	74.6	65.0	-
	Peak cumulative concentration (project plus background)	150.8	165.1	159.3	166.7	246
	Project contribution (% of criteria)	28 %	25 %	30 %	26 %	-
Annual average	Peak project contribution	1.4	1.2	1.7	1.4	-
	Peak cumulative concentration (project plus background)	38.7	42.4	39.9	42.8	62
	Project contribution (% of criteria)	2 %	2 %	3 %	2 %	-

Table 32 Predicted maximum CO pollutant concentrations – 'with project – expected traffic flows' (µg/m³)

Averaging period	Source	Predicted maximum CO concentrations (µg/m³)				Impact assessment criteria (µg/m³)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
1 hour	Peak project contribution	86.6	70.1	107.4	90.3	-
	Peak cumulative concentration (project plus background)	3,712	3,695	3,732	3,715	30,000
	Project contribution (% of criteria)	0.29 %	0.23 %	0.36 %	0.30 %	-
8 hour	Peak project contribution	32.4	33.1	54.2	57.9	-
	Peak cumulative concentration (project plus background)	2,634	2,635	2,656	2,660	10,000
	Project contribution (% of criteria)	0.32 %	0.33 %	0.54 %	0.58 %	-

Table 33 Predicted 99.9th percentile total VOC and PAH pollutant concentrations – 'with project – expected traffic flows' (µg/m³)

Pollutant	Source	Predicted 99.9th percentile concentrations (µg/m³) (one hour)				Impact assessment criteria (µg/m³)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
Total VOCs	Peak project contribution	4.07	3.72	5.38	5.36	29*
	Project contribution (% of criteria)	14 %	13 %	19 %	18 %	-
PAHs	Peak project contribution	0.00074	0.00068	0.00089	0.00092	0.4**
	Project contribution (% of criteria)	0.19 %	0.17 %	0.22 %	0.23 %	-

* as benzo(a)pyrene
** as benzene

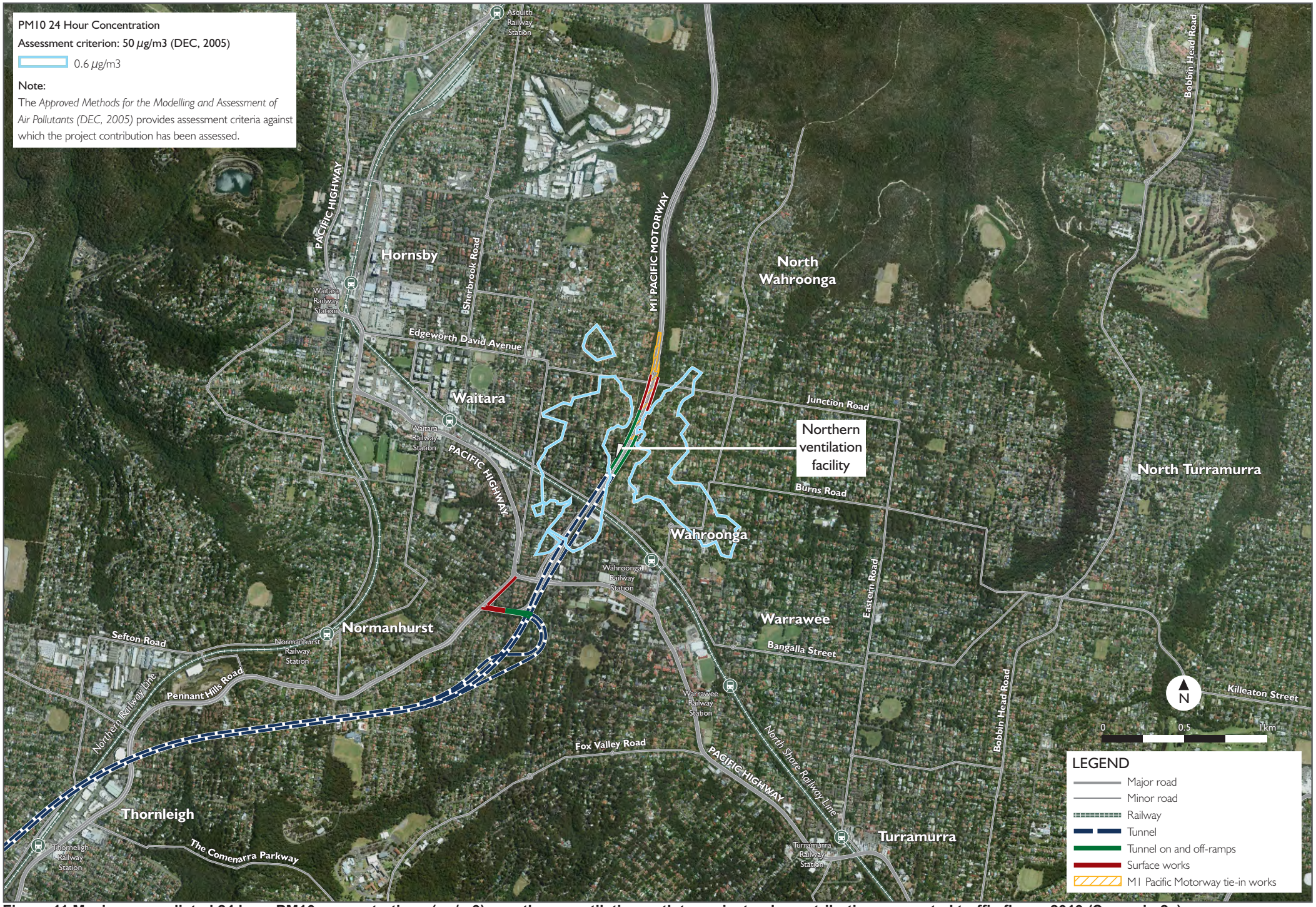

Figure 11 Maximum predicted 24 hour PM10 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (Scenario 2a)

This page has been left blank intentionally.

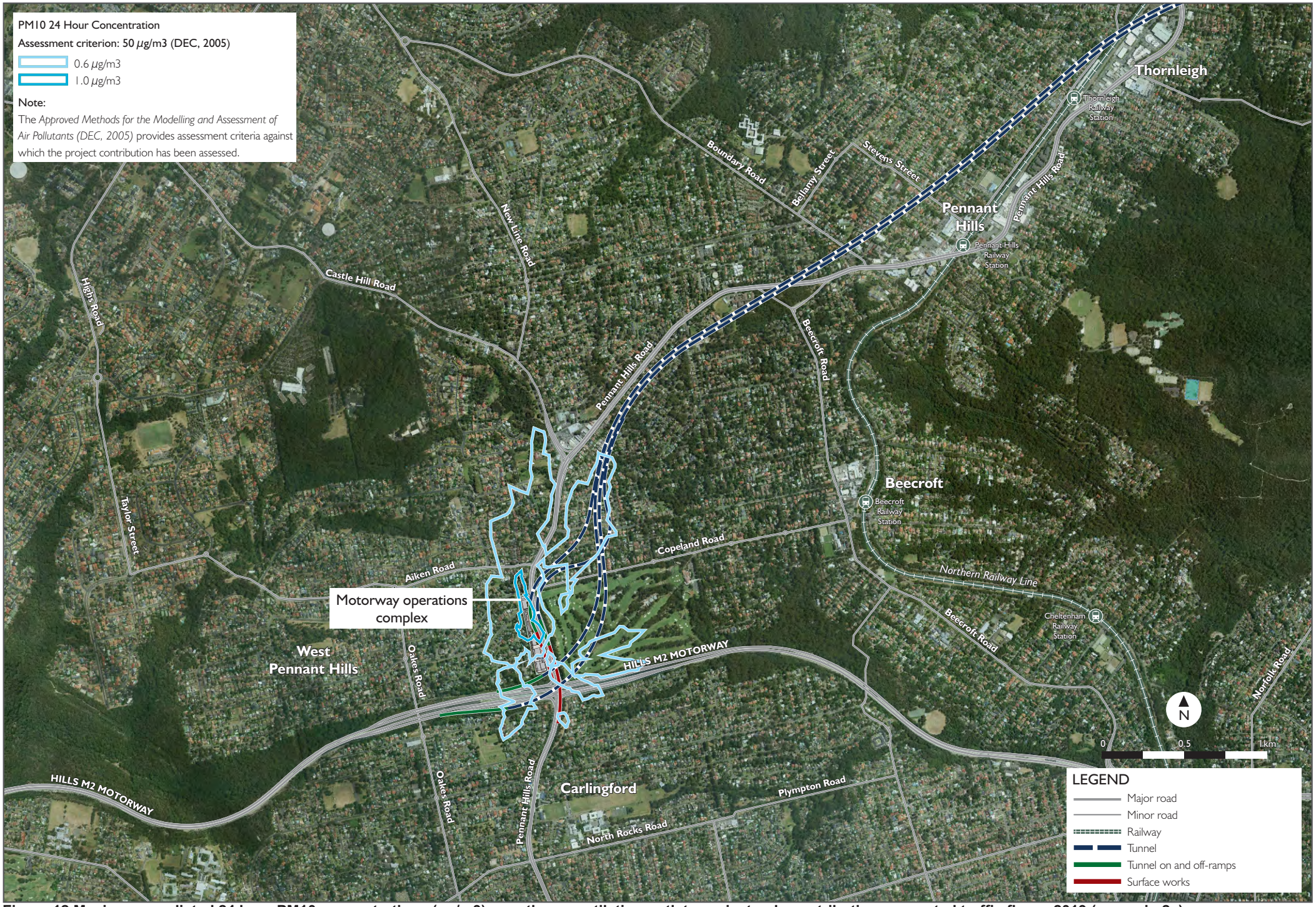

Figure 12 Maximum predicted 24 hour PM10 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

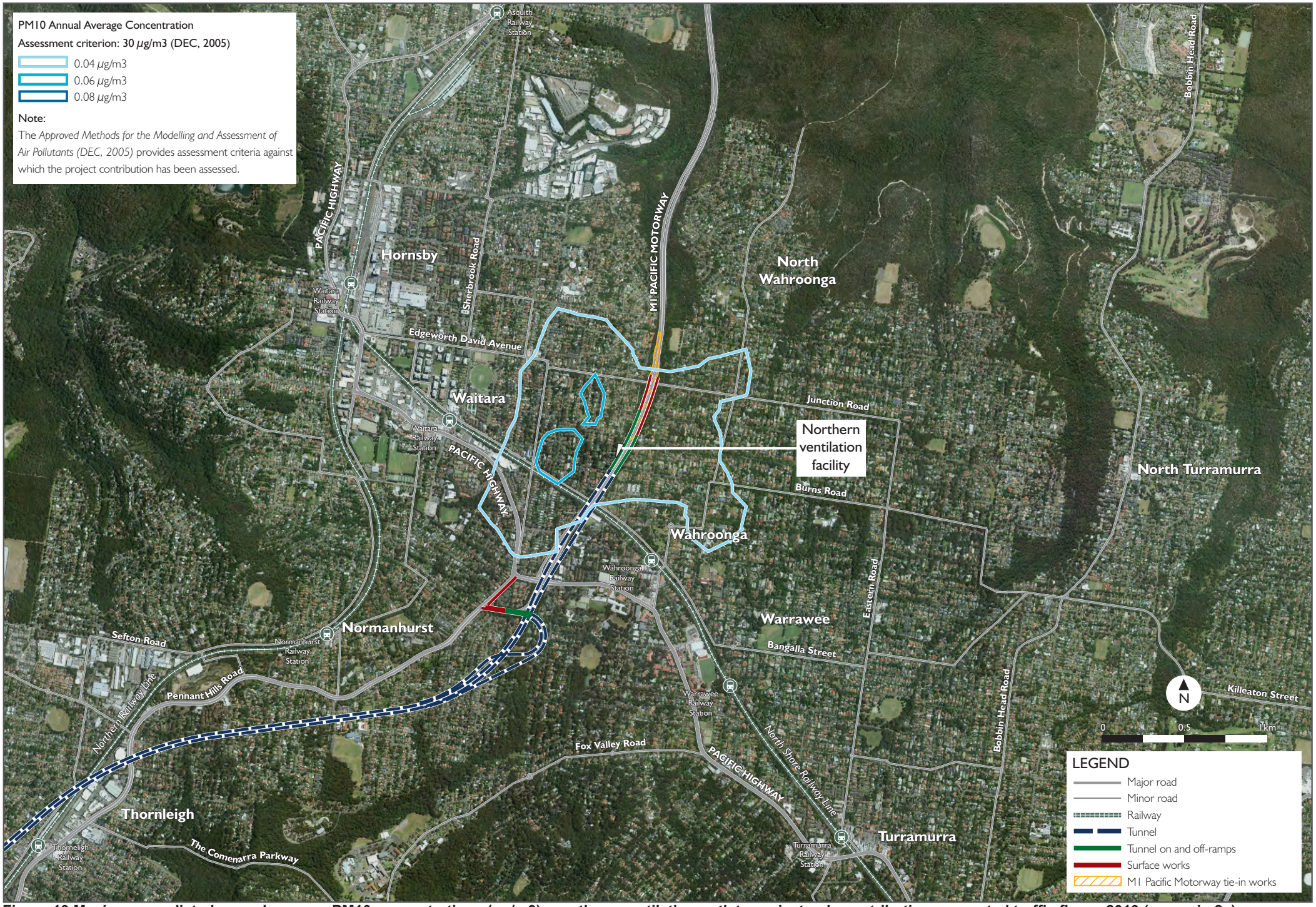

Figure 13 Maximum predicted annual average PM10 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

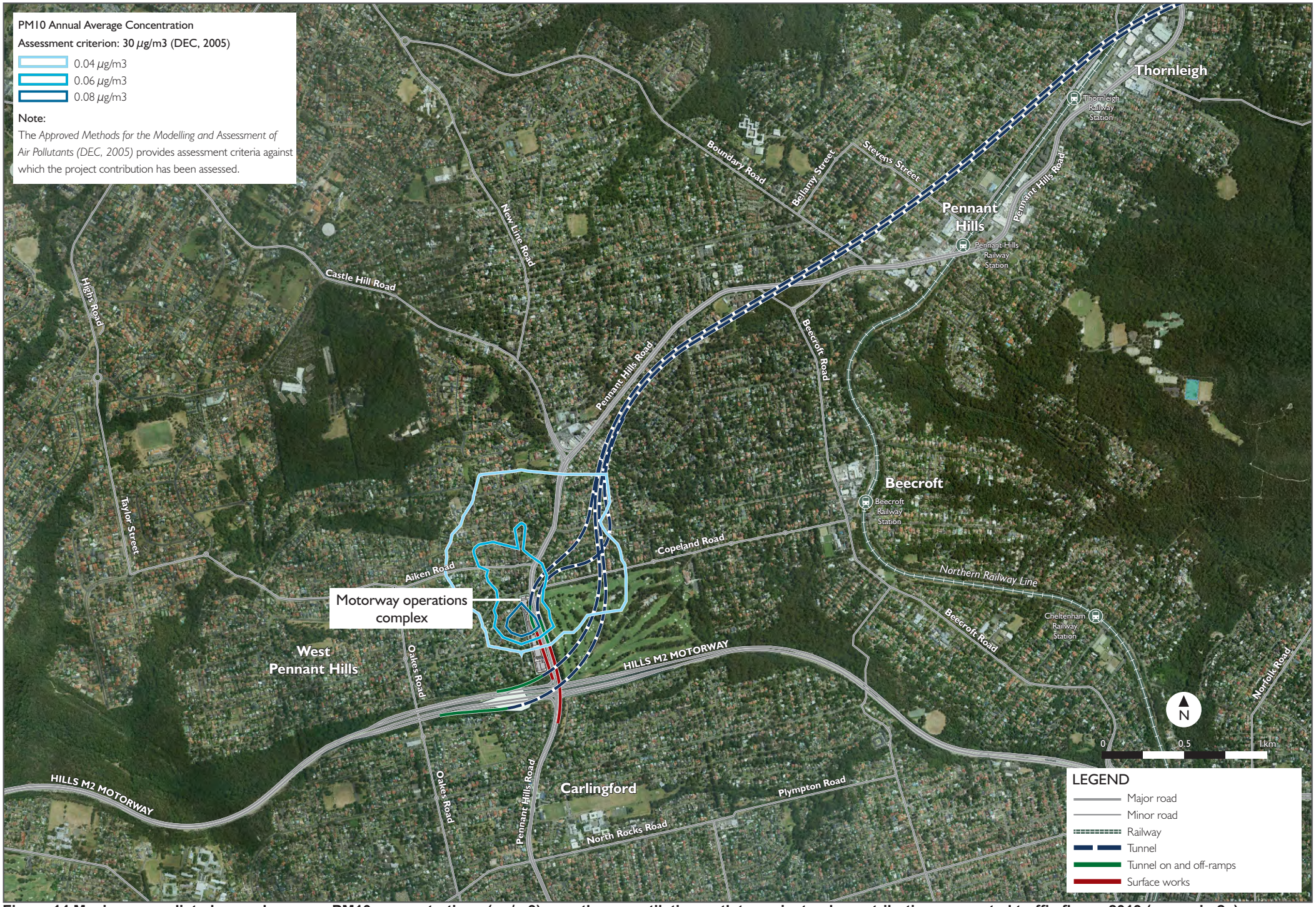

Figure 14 Maximum predicted annual average PM10 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

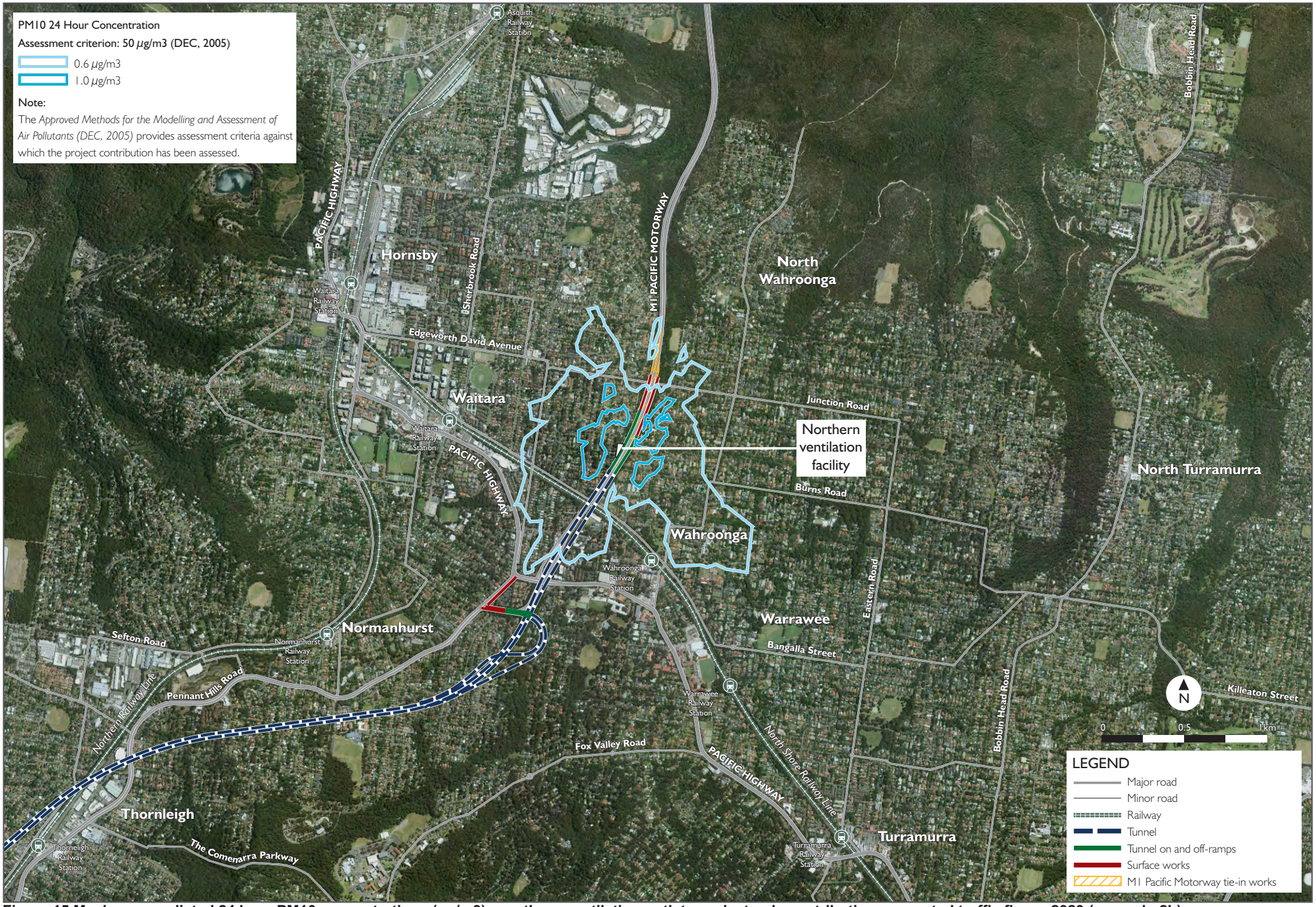

Figure 15 Maximum predicted 24 hour PM10 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

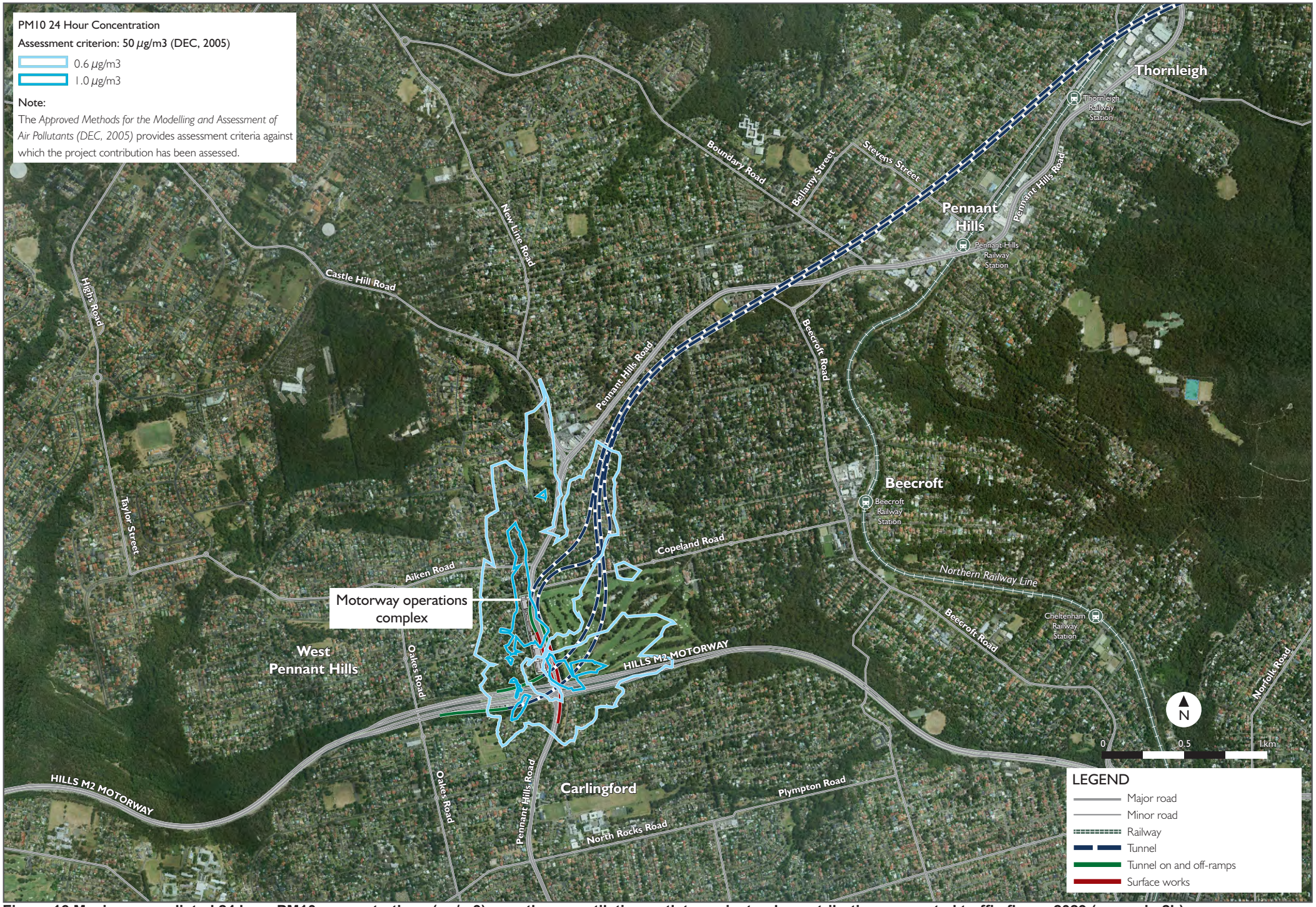

Figure 16 Maximum predicted 24 hour PM10 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

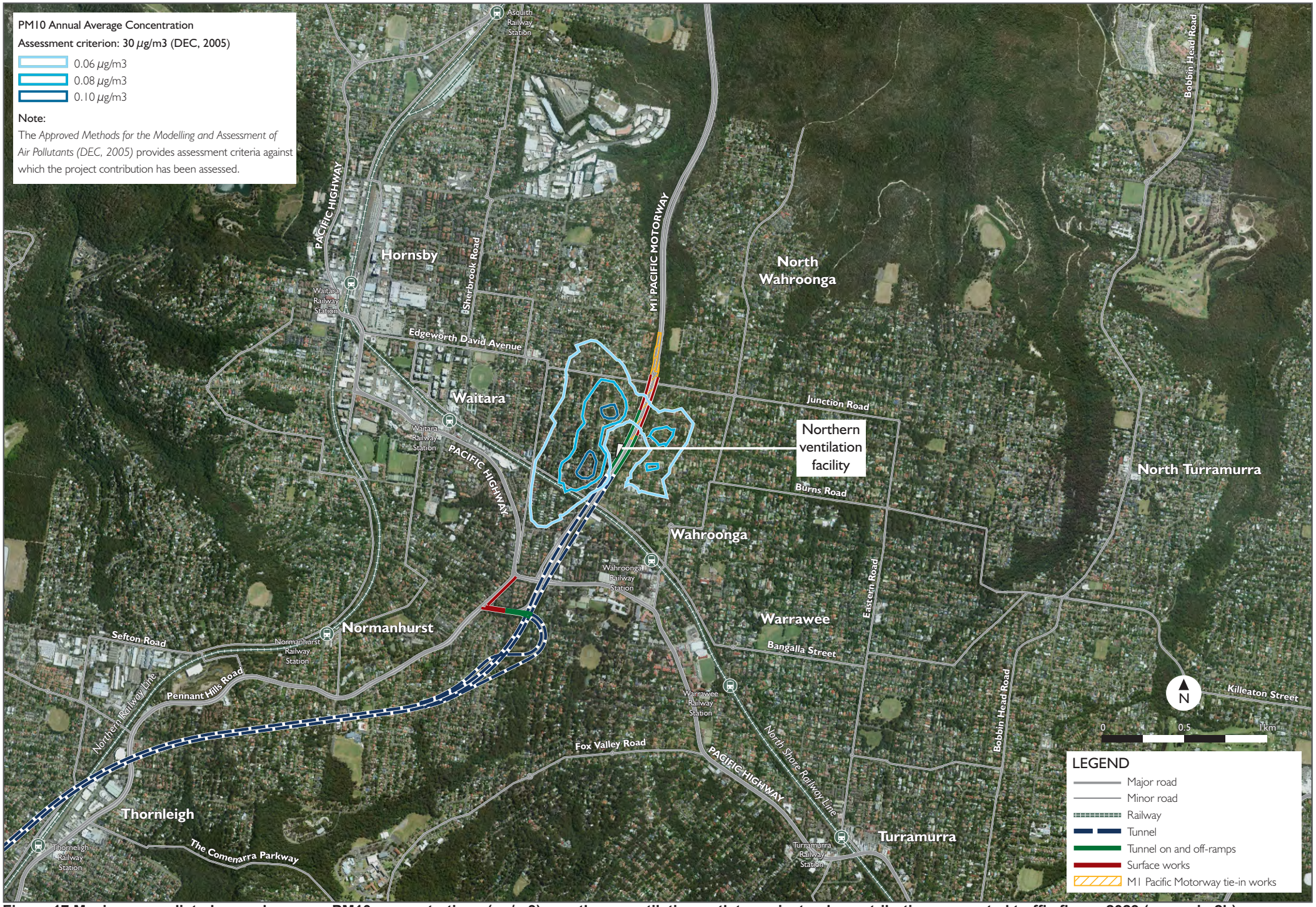

Figure 17 Maximum predicted annual average PM10 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

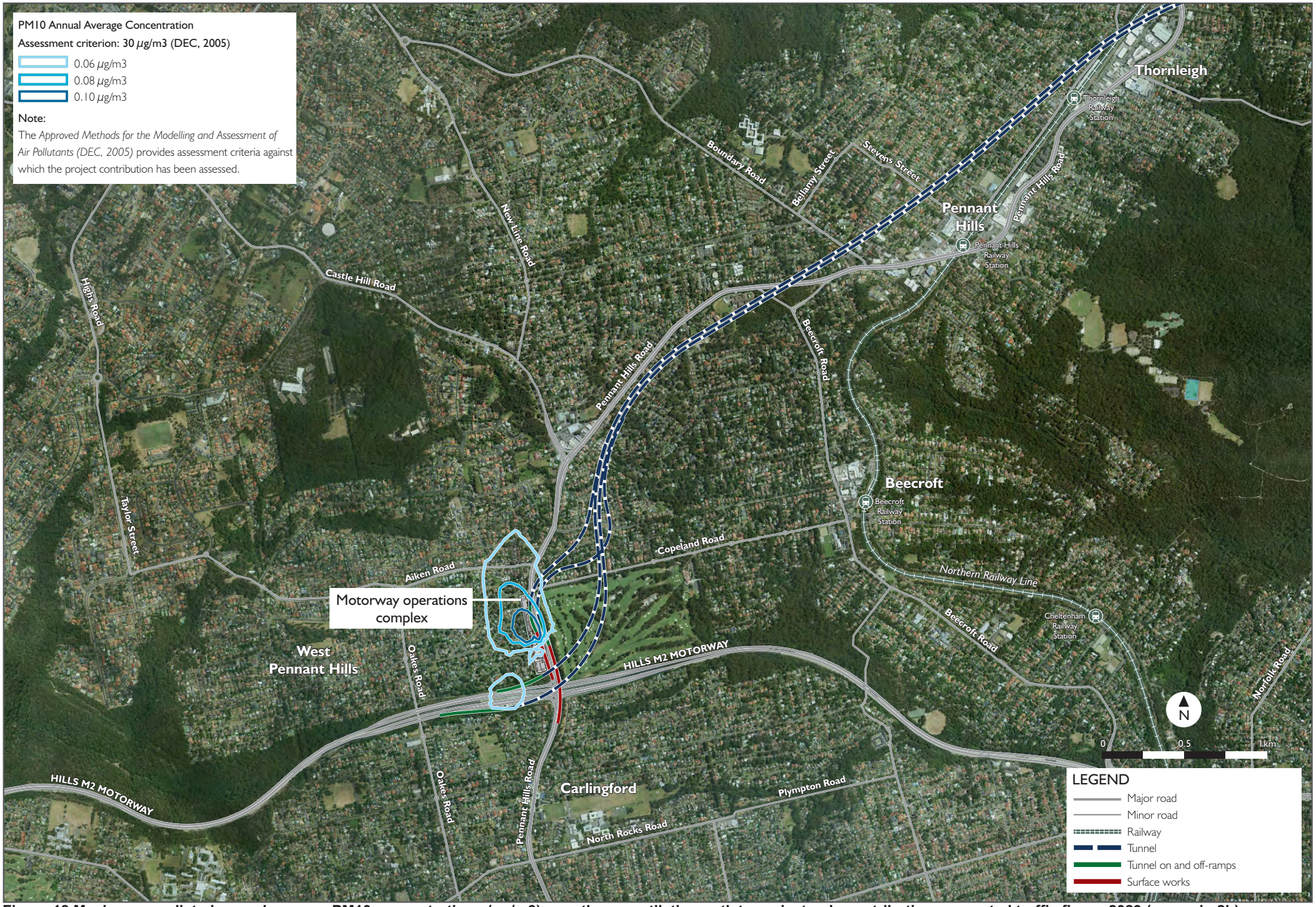

Figure 18 Maximum predicted annual average PM10 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

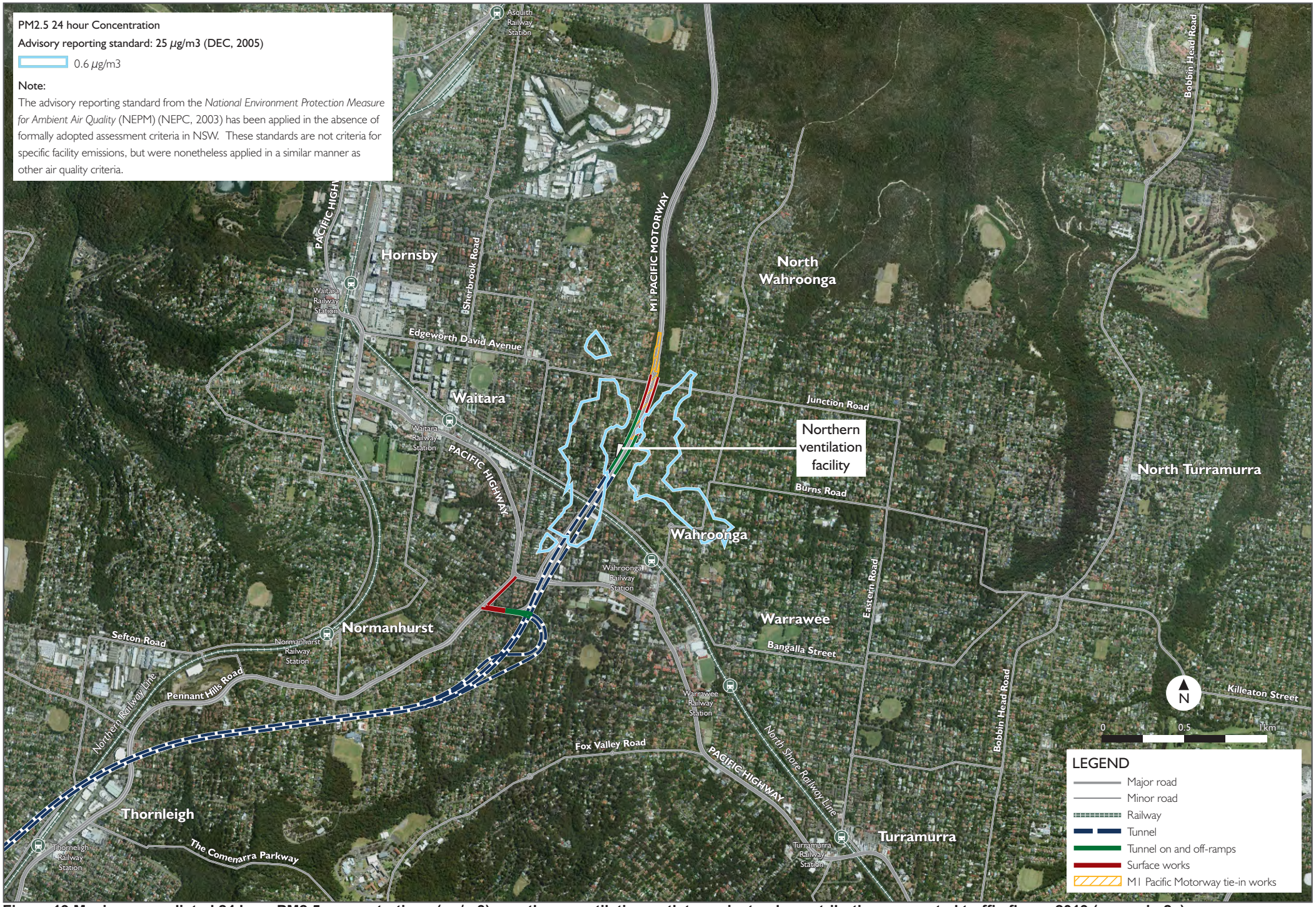

Figure 19 Maximum predicted 24 hour PM2.5 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

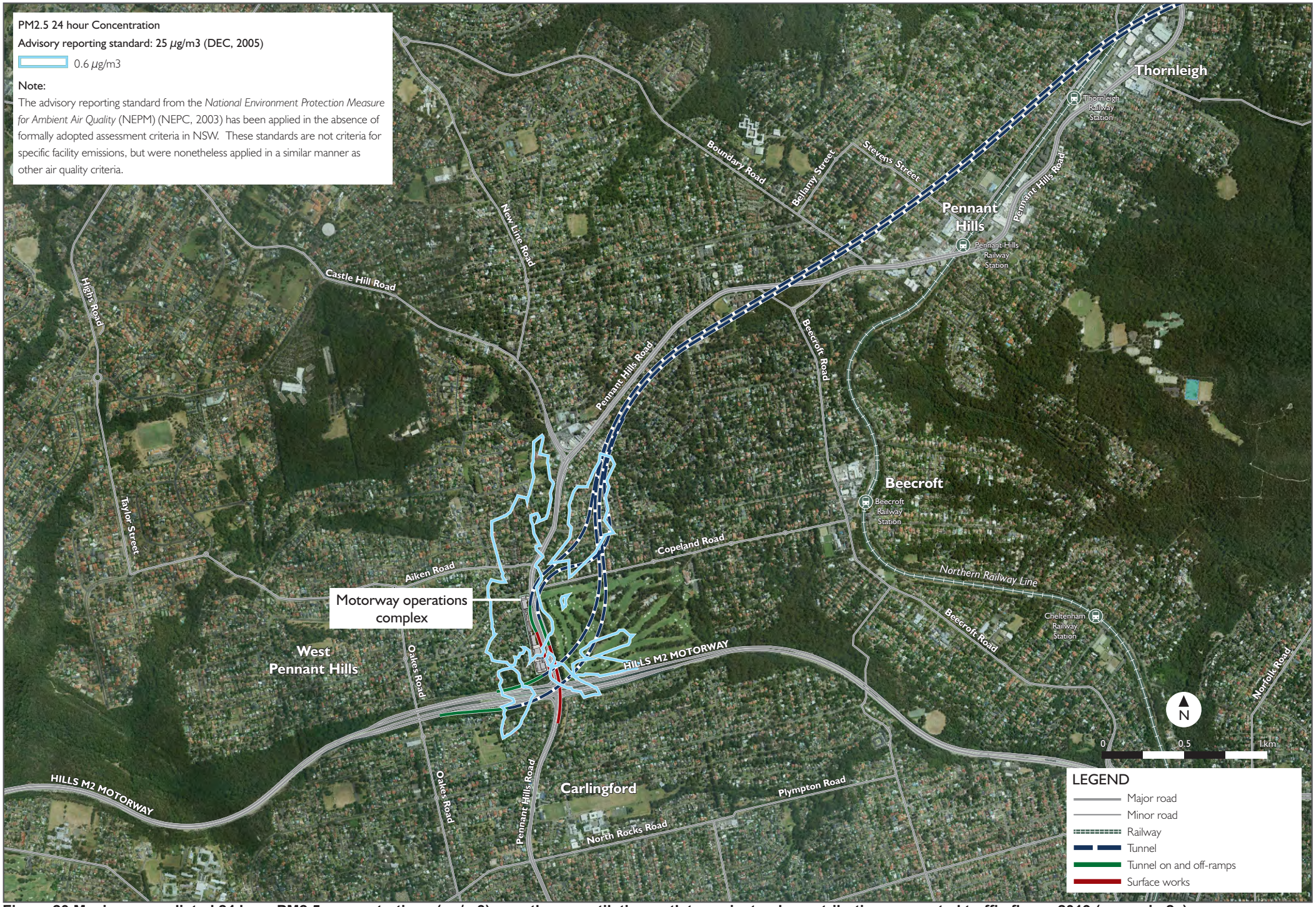

Figure 20 Maximum predicted 24 hour PM2.5 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

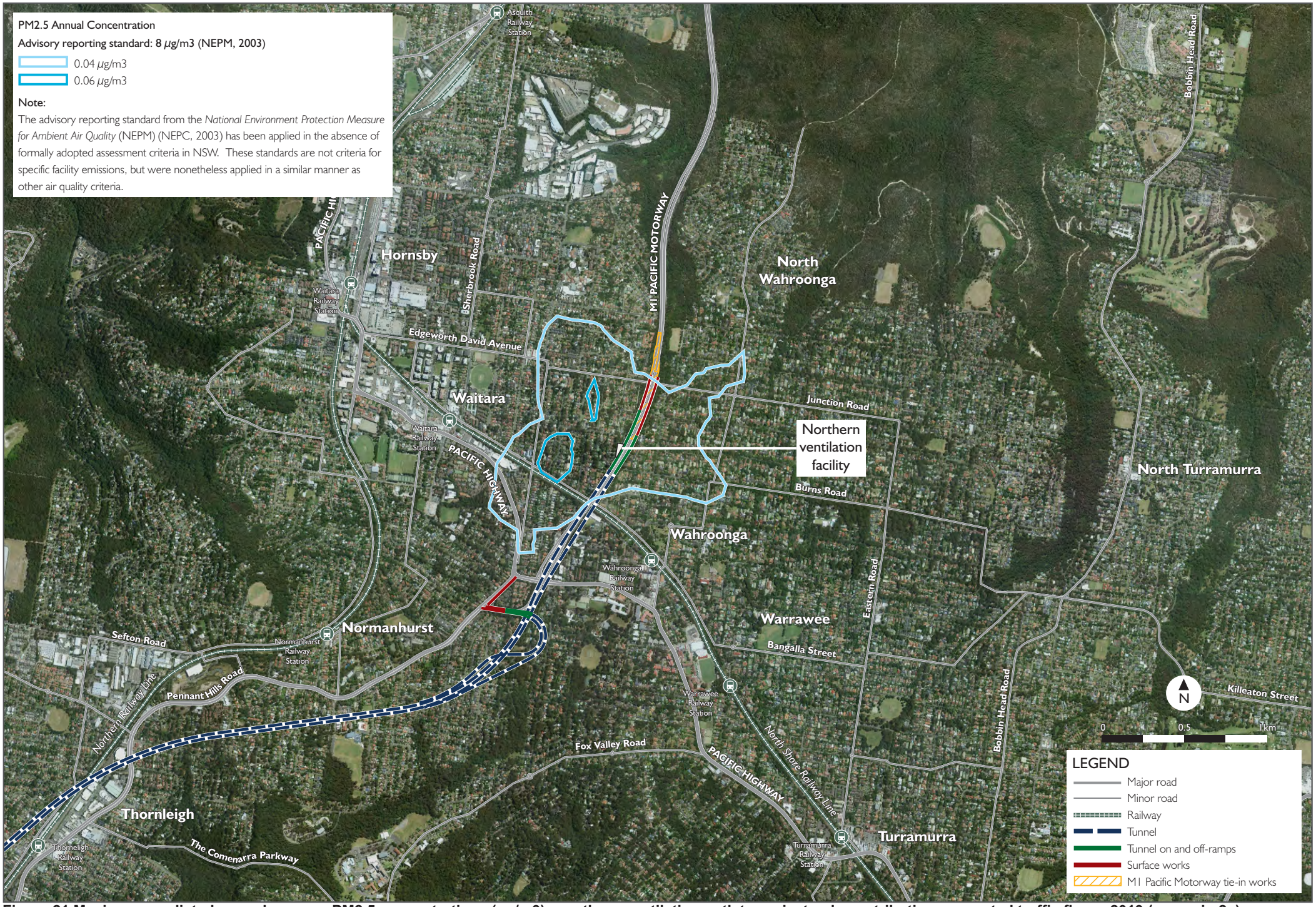

Figure 21 Maximum predicted annual average PM2.5 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

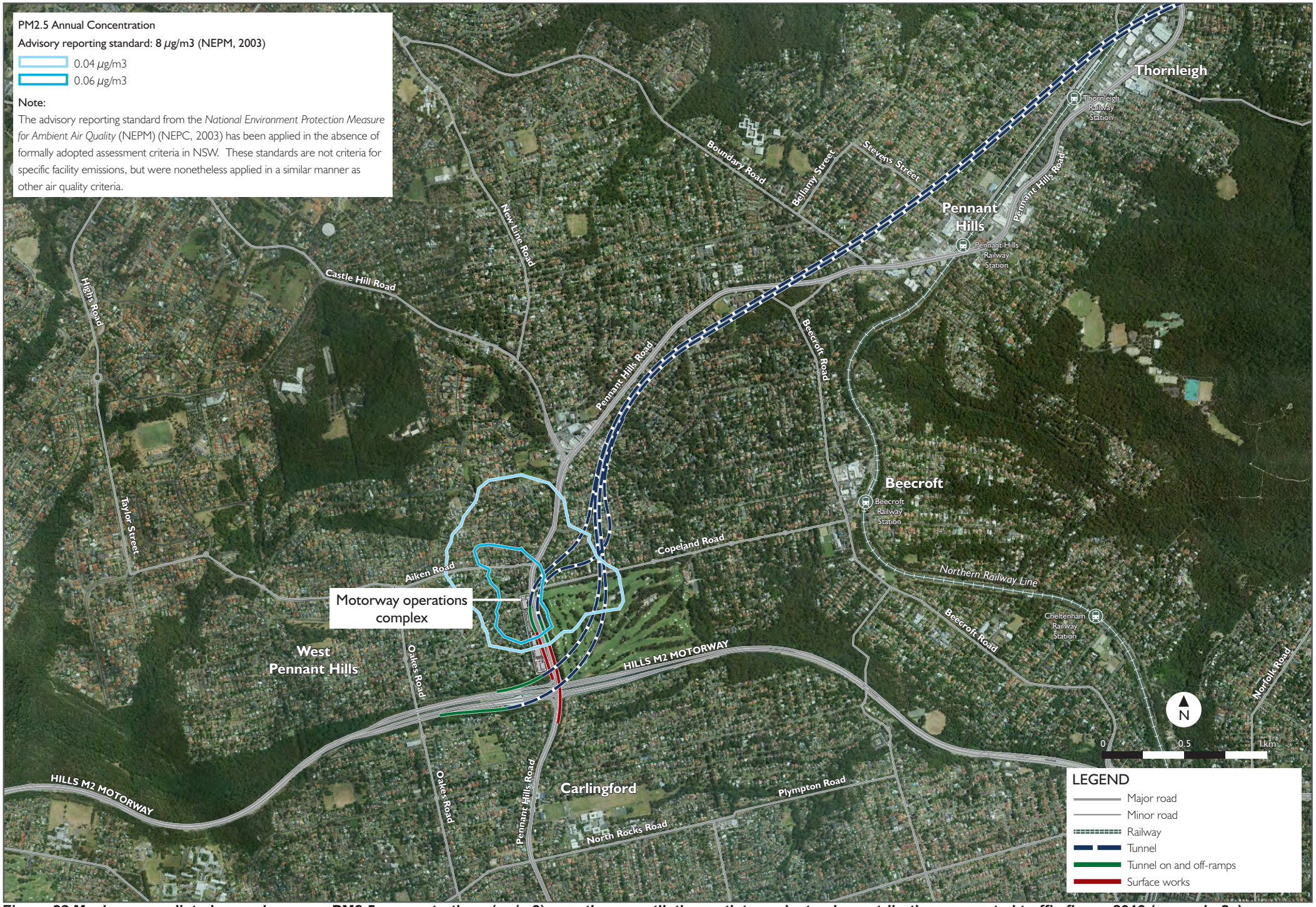

Figure 22 Maximum predicted annual average PM2.5 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

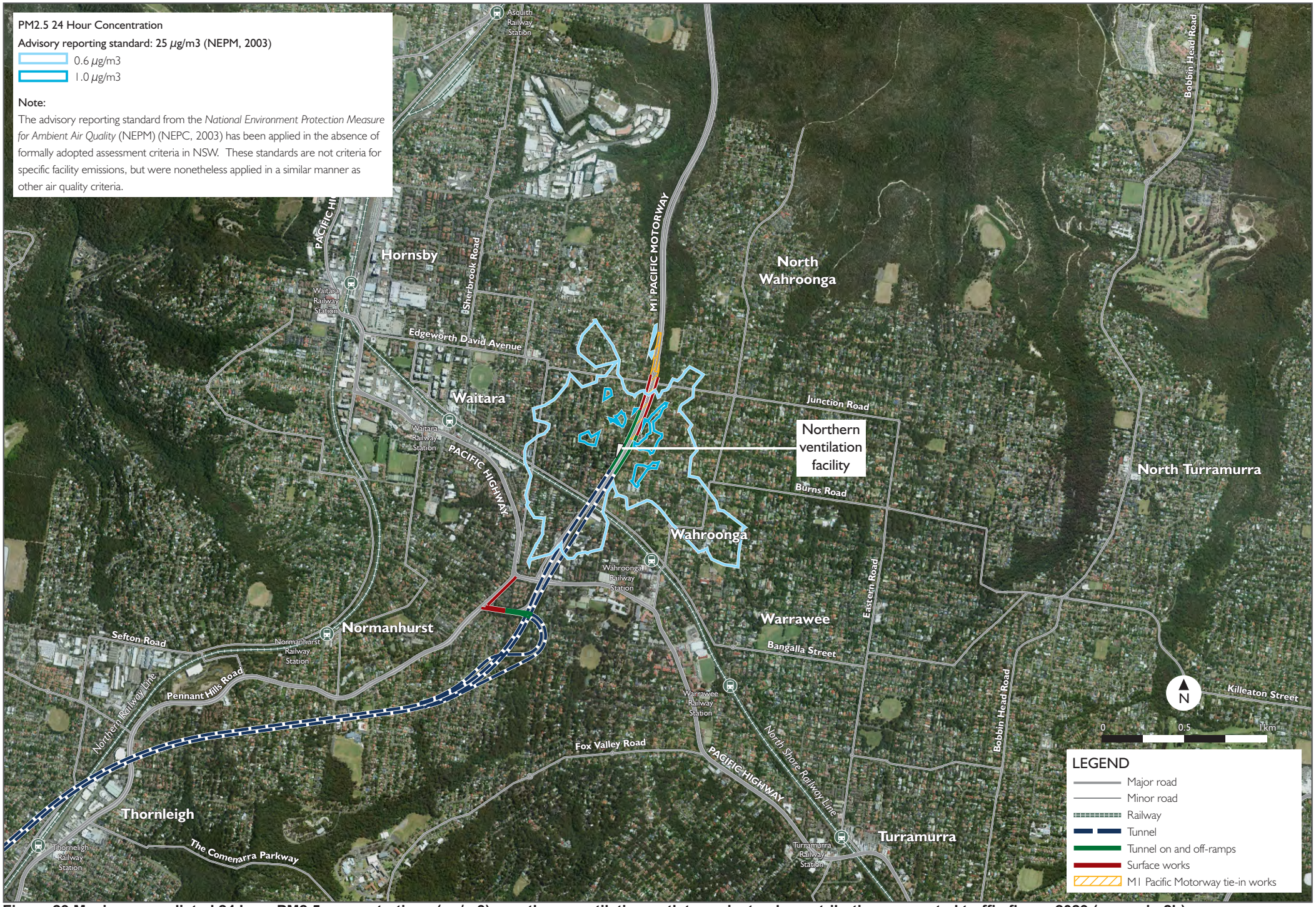

Figure 23 Maximum predicted 24 hour PM2.5 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

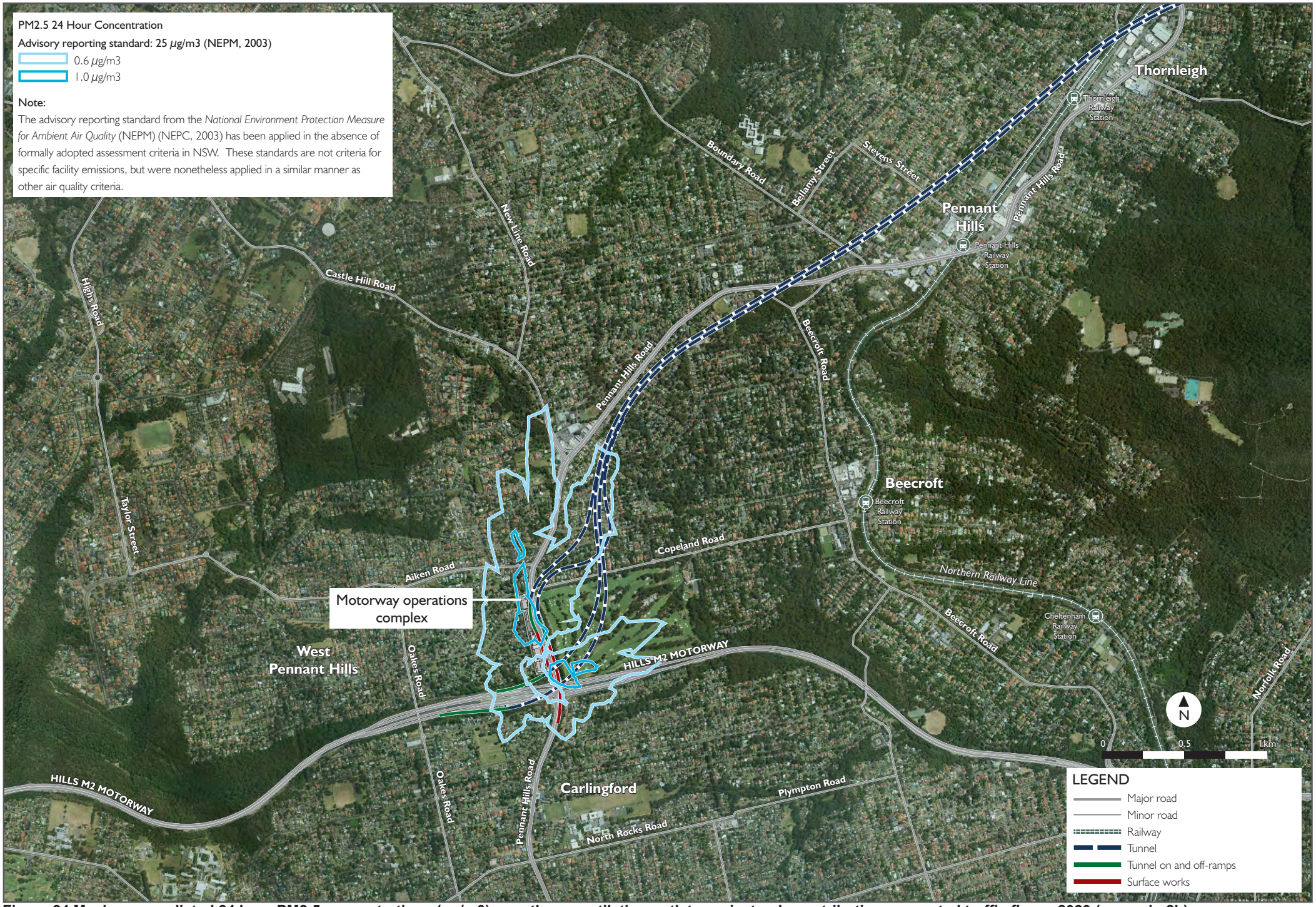

Figure 24 Maximum predicted 24 hour PM2.5 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

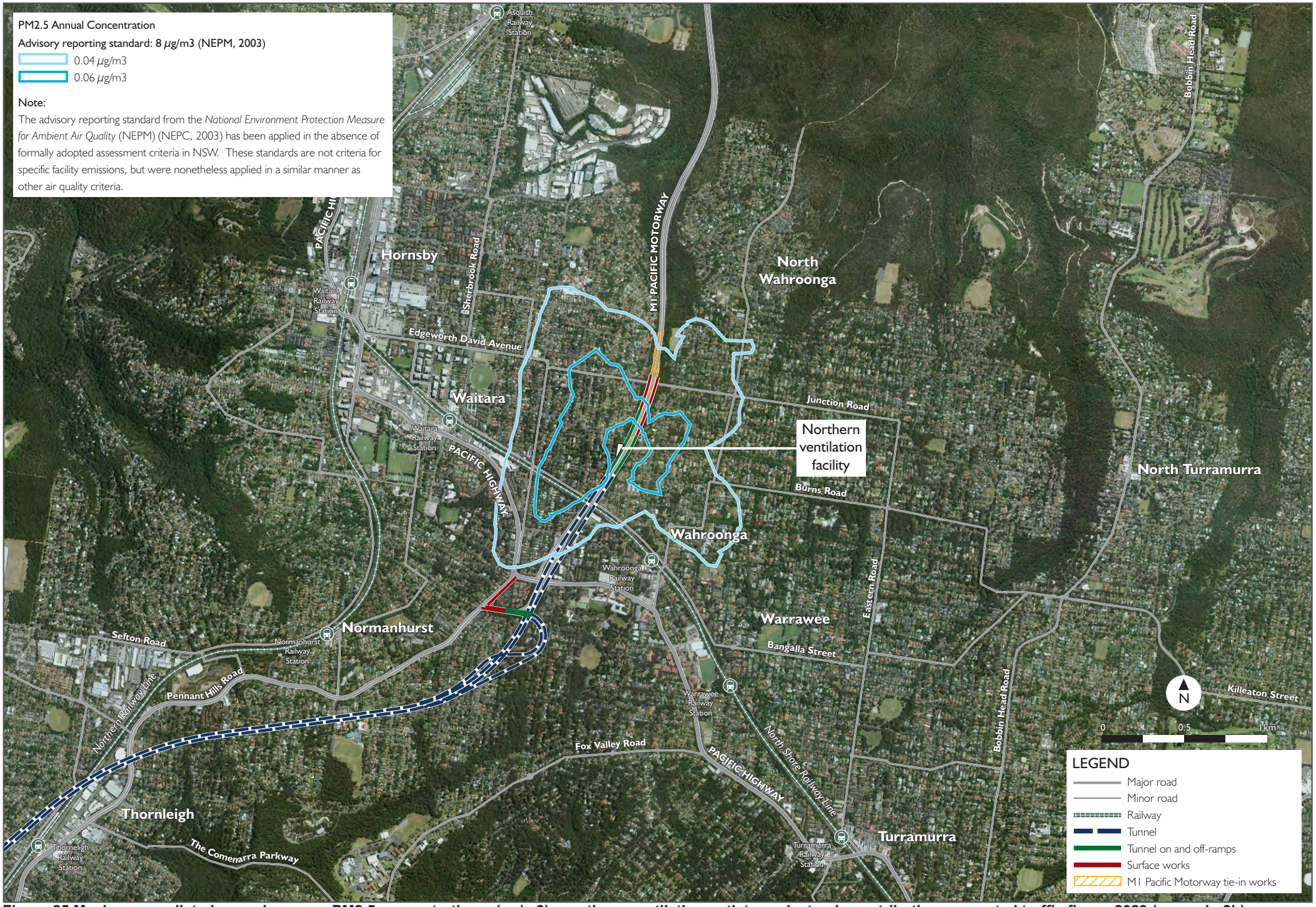

Figure 25 Maximum predicted annual average PM2.5 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

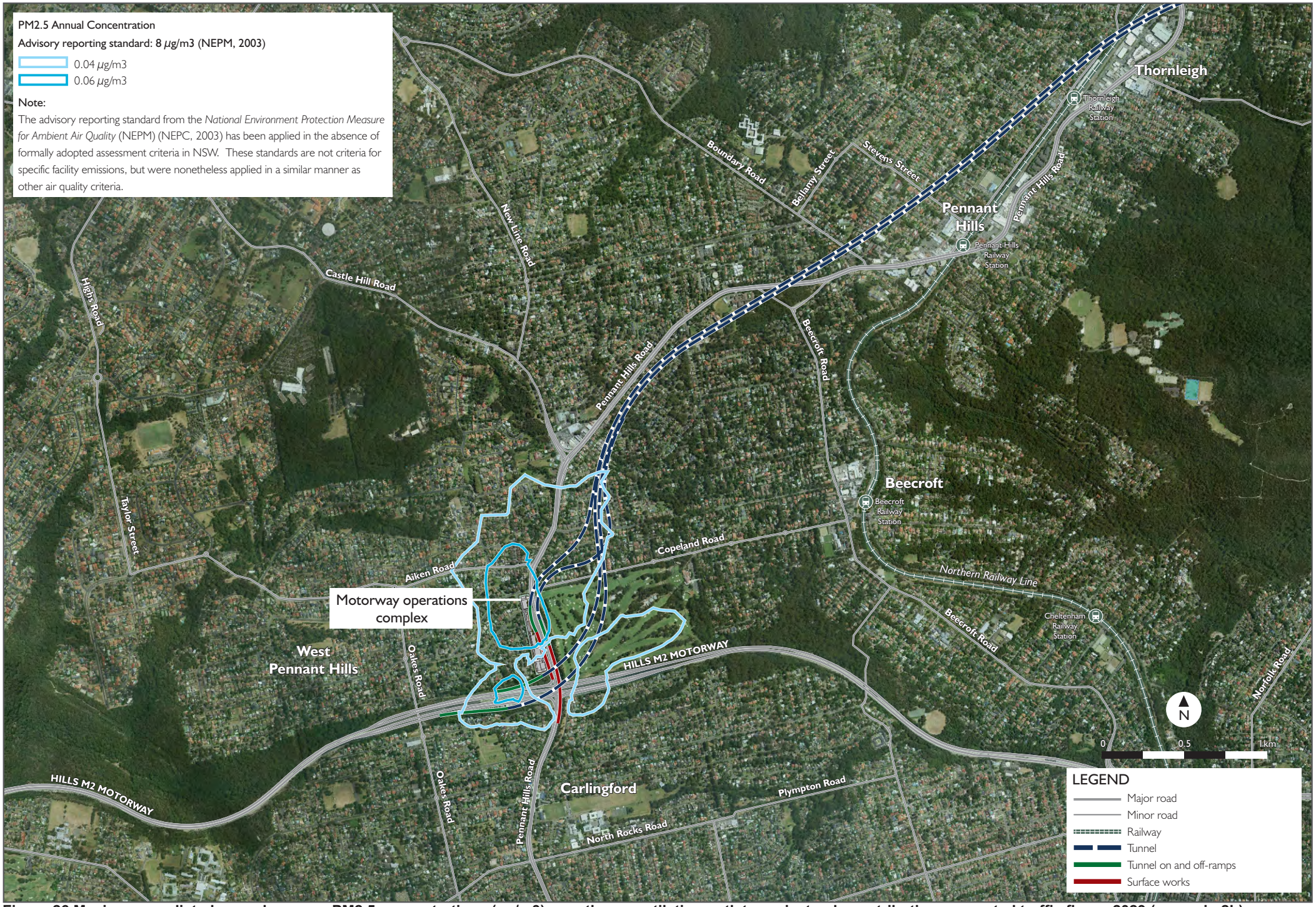

Figure 26 Maximum predicted annual average PM2.5 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

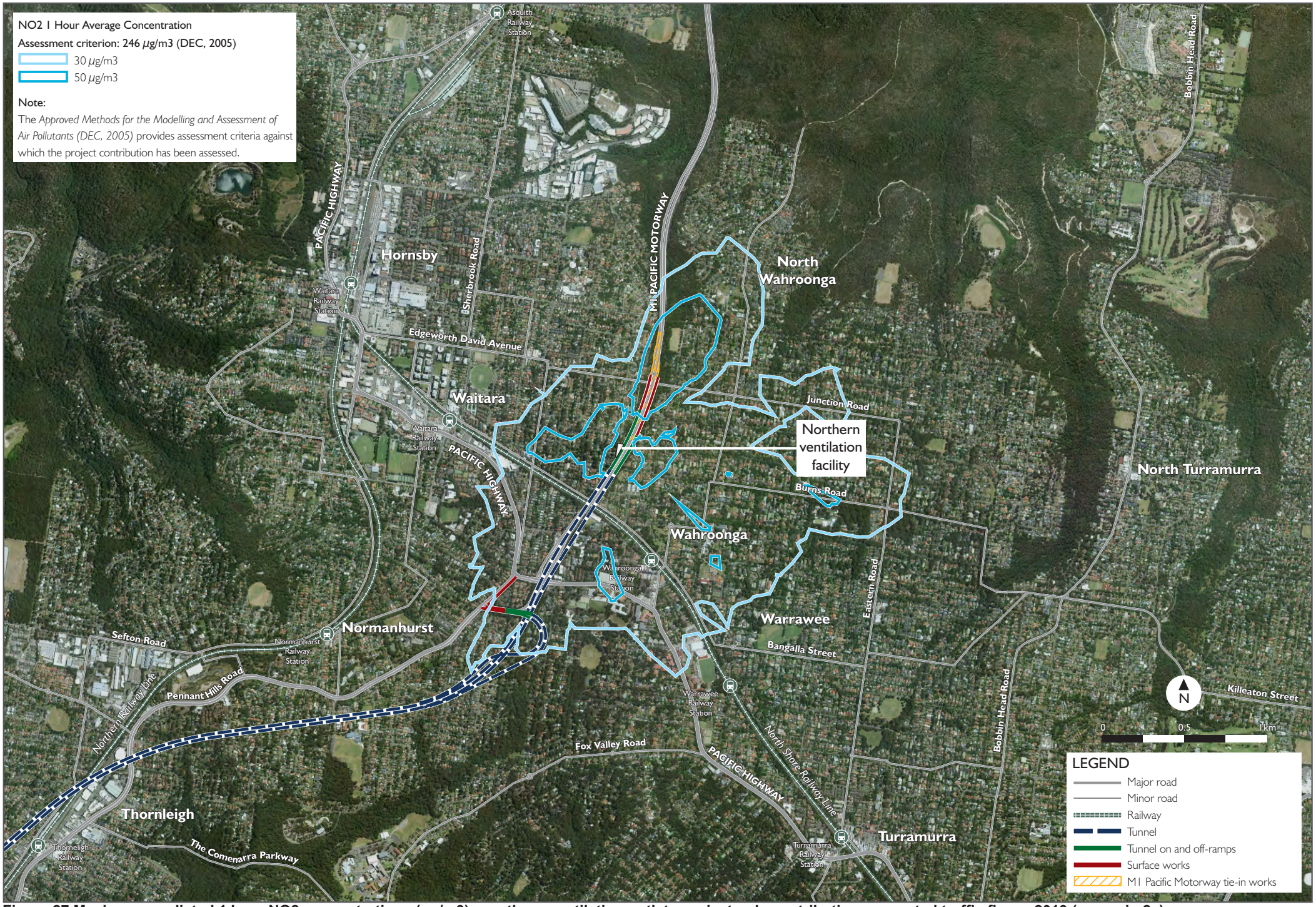

Figure 27 Maximum predicted 1 hour NO2 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

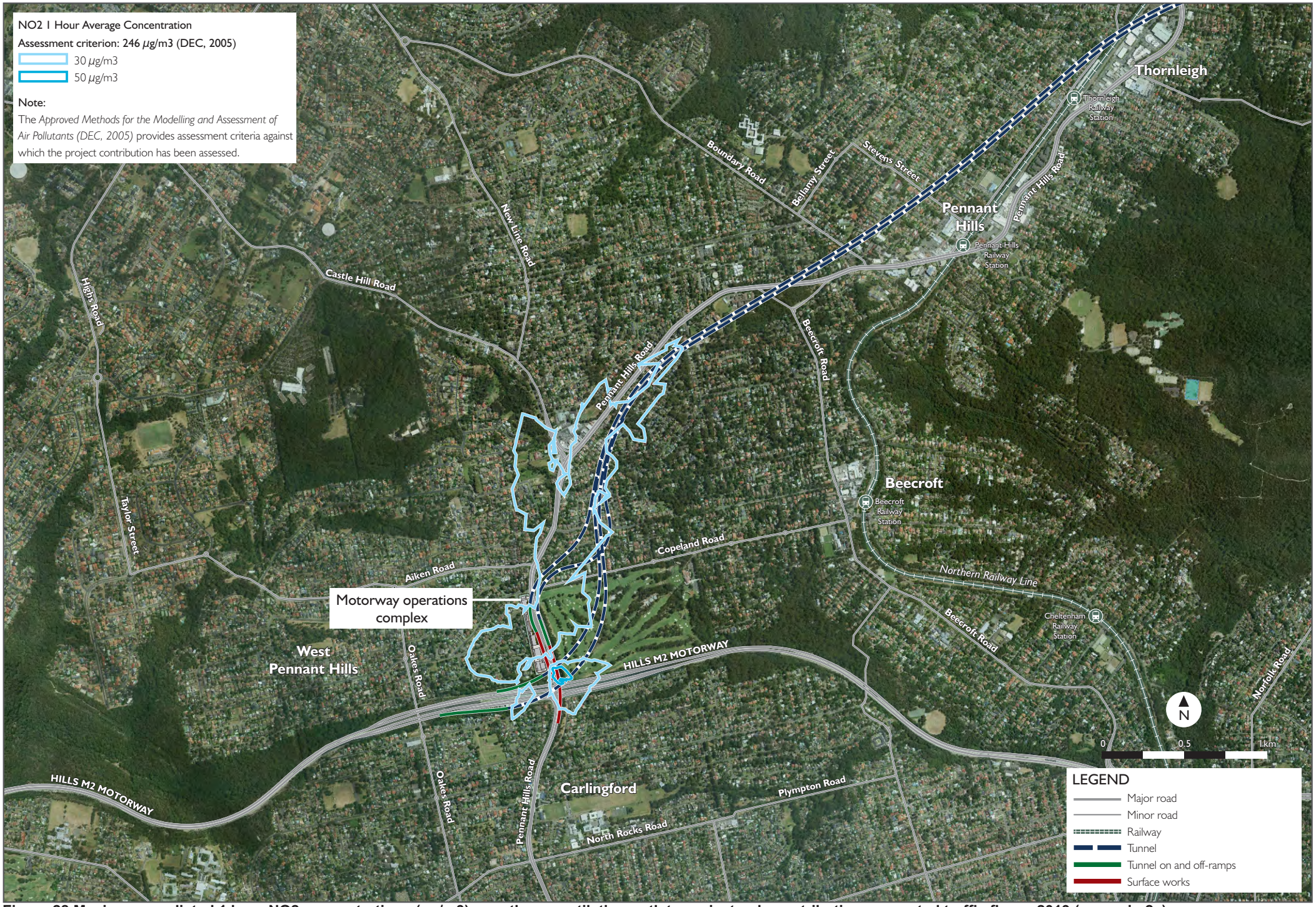

Figure 28 Maximum predicted 1 hour NO2 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

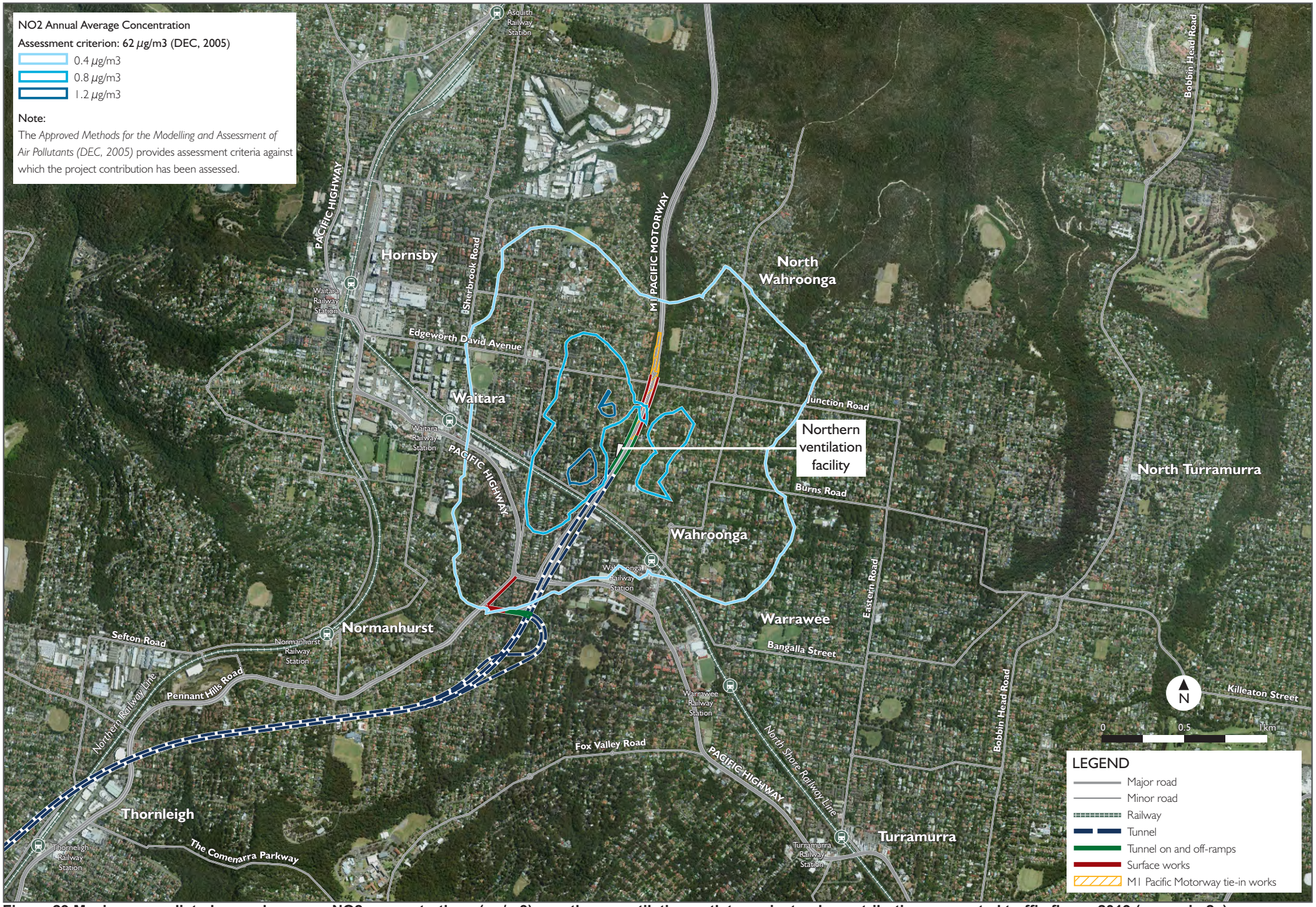

Figure 29 Maximum predicted annual average NO2 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

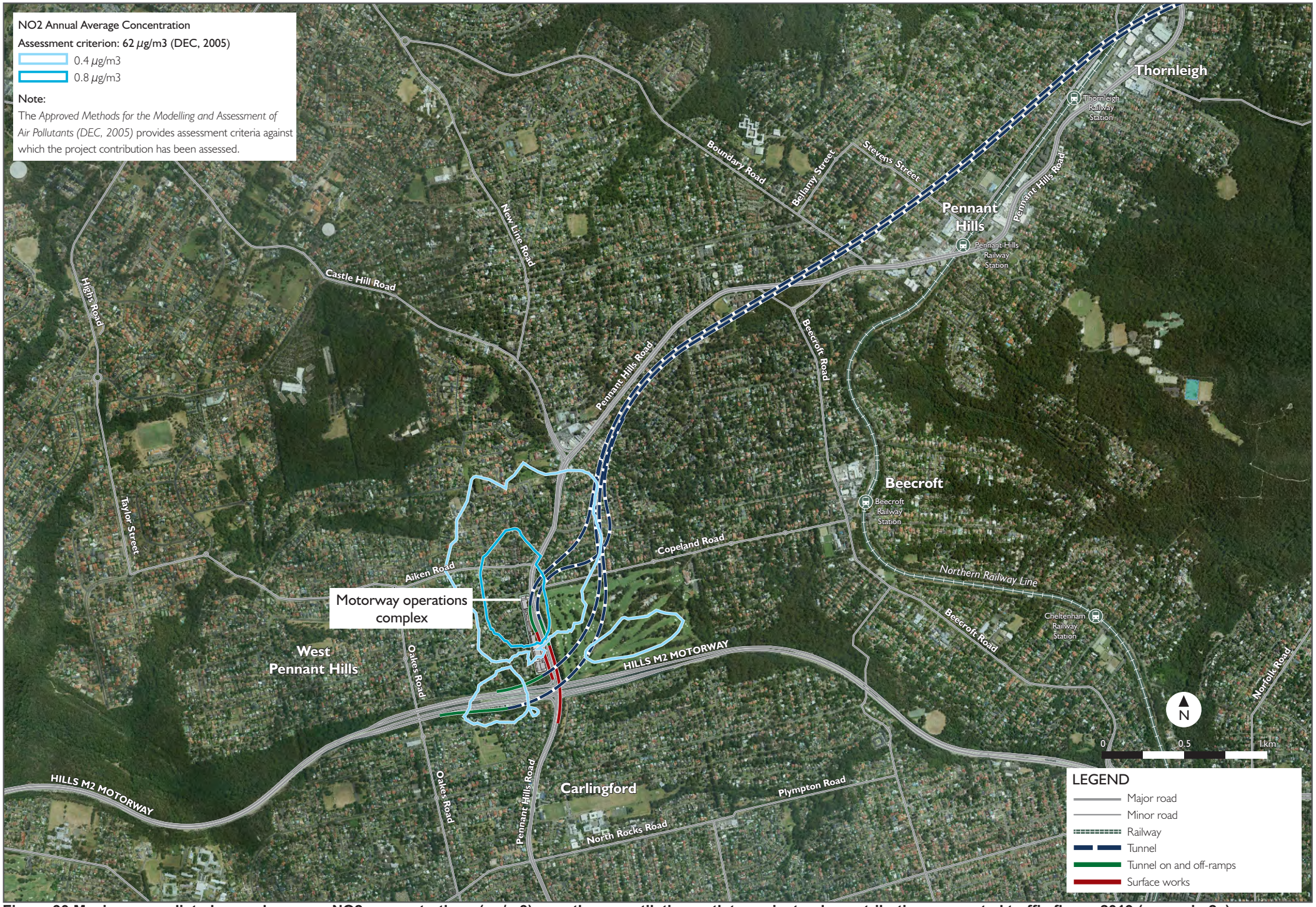

Figure 30 Maximum predicted annual average NO2 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2019 (scenario 2a)

This page has been left blank intentionally.

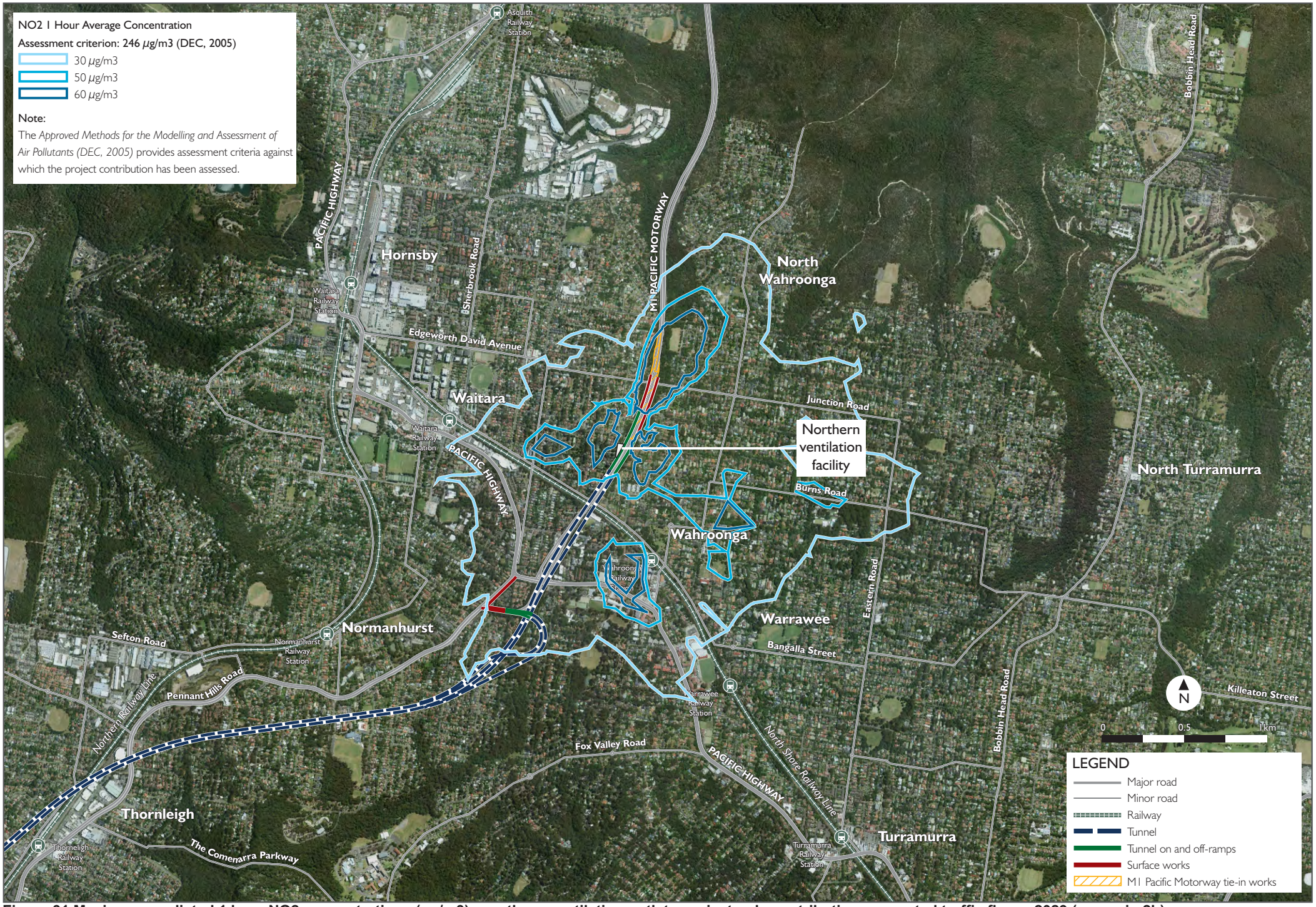

Figure 31 Maximum predicted 1 hour NO2 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

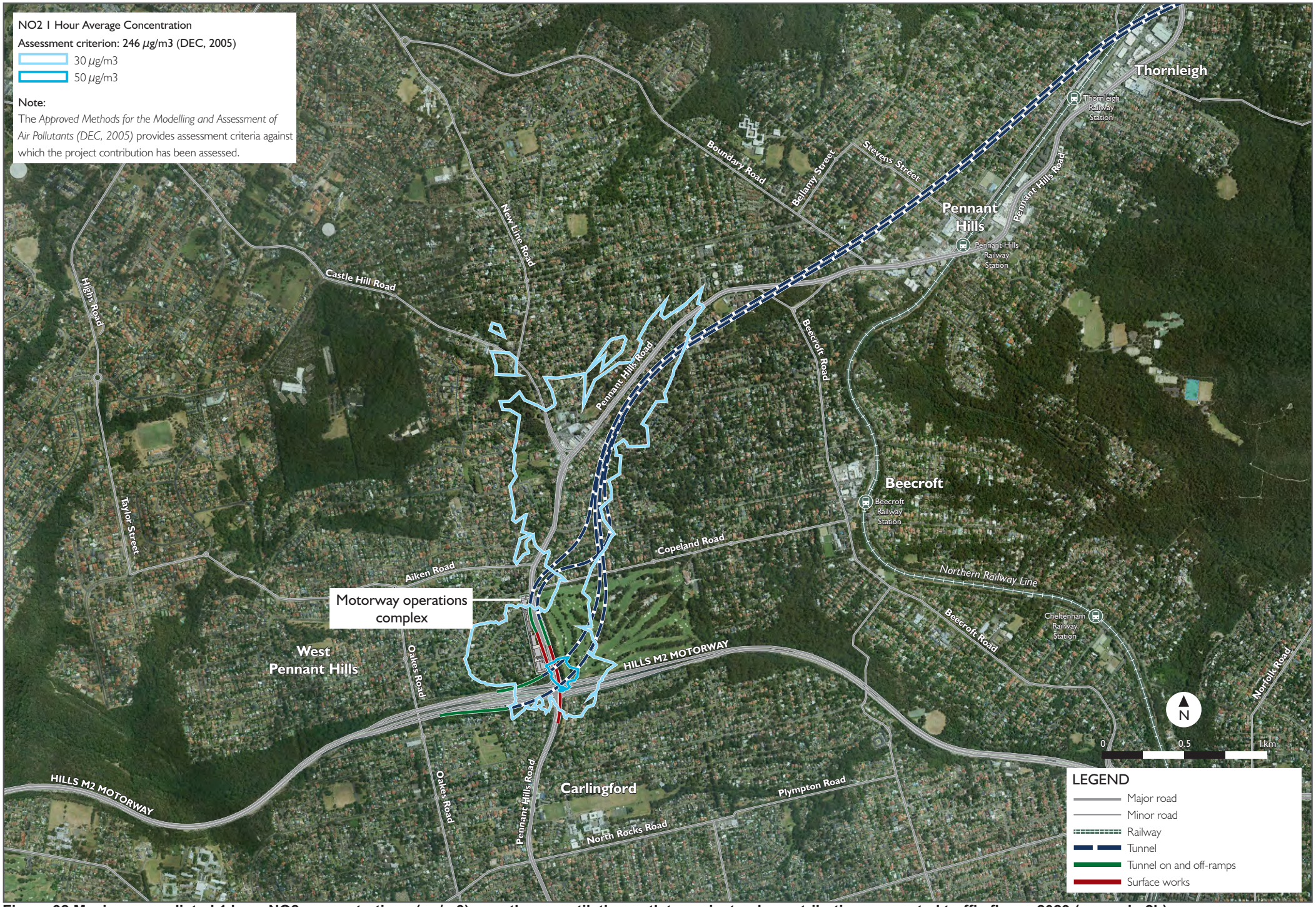

Figure 32 Maximum predicted 1 hour NO2 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

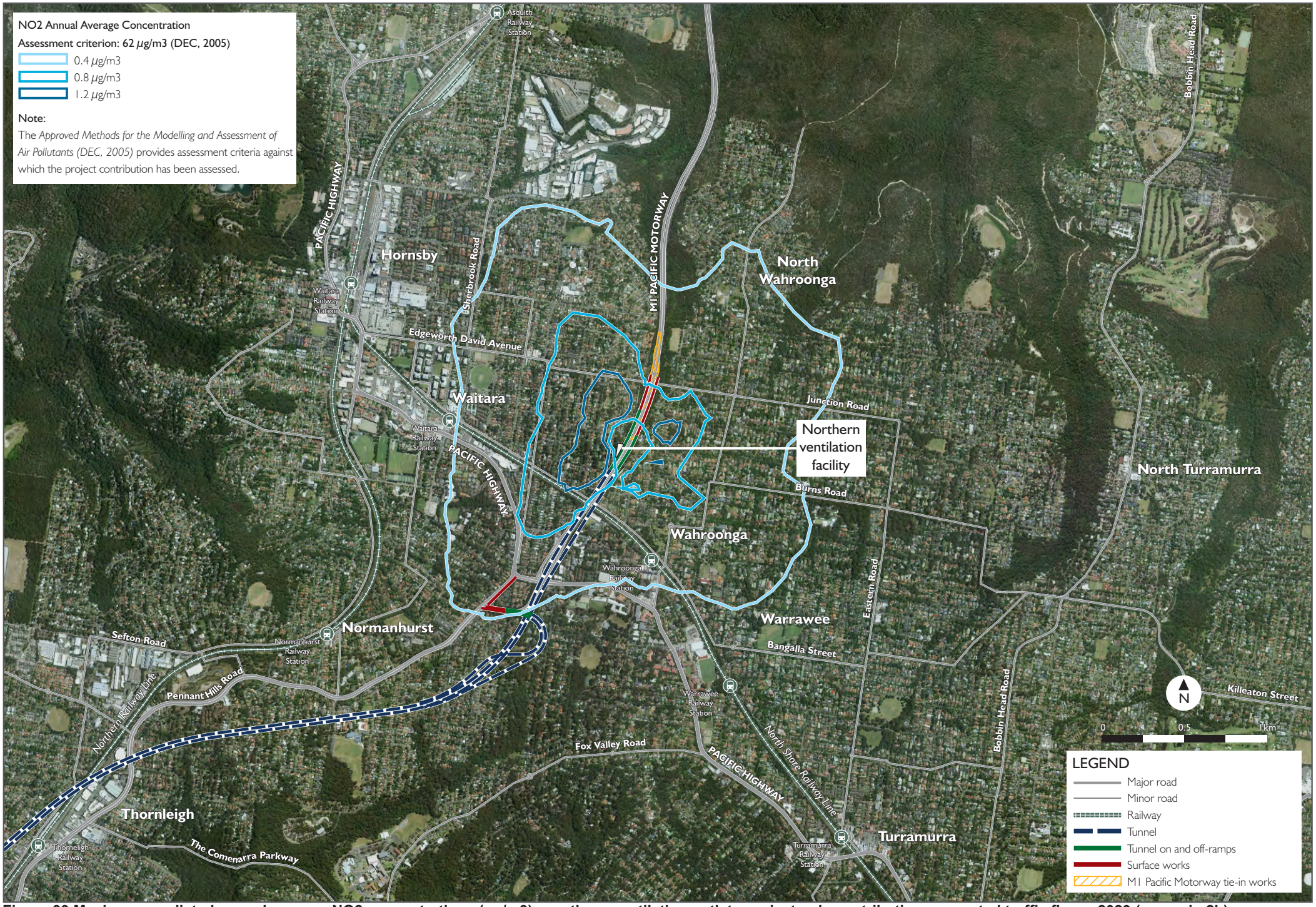

Figure 33 Maximum predicted annual average NO2 concentrations (ug/m3) - northern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

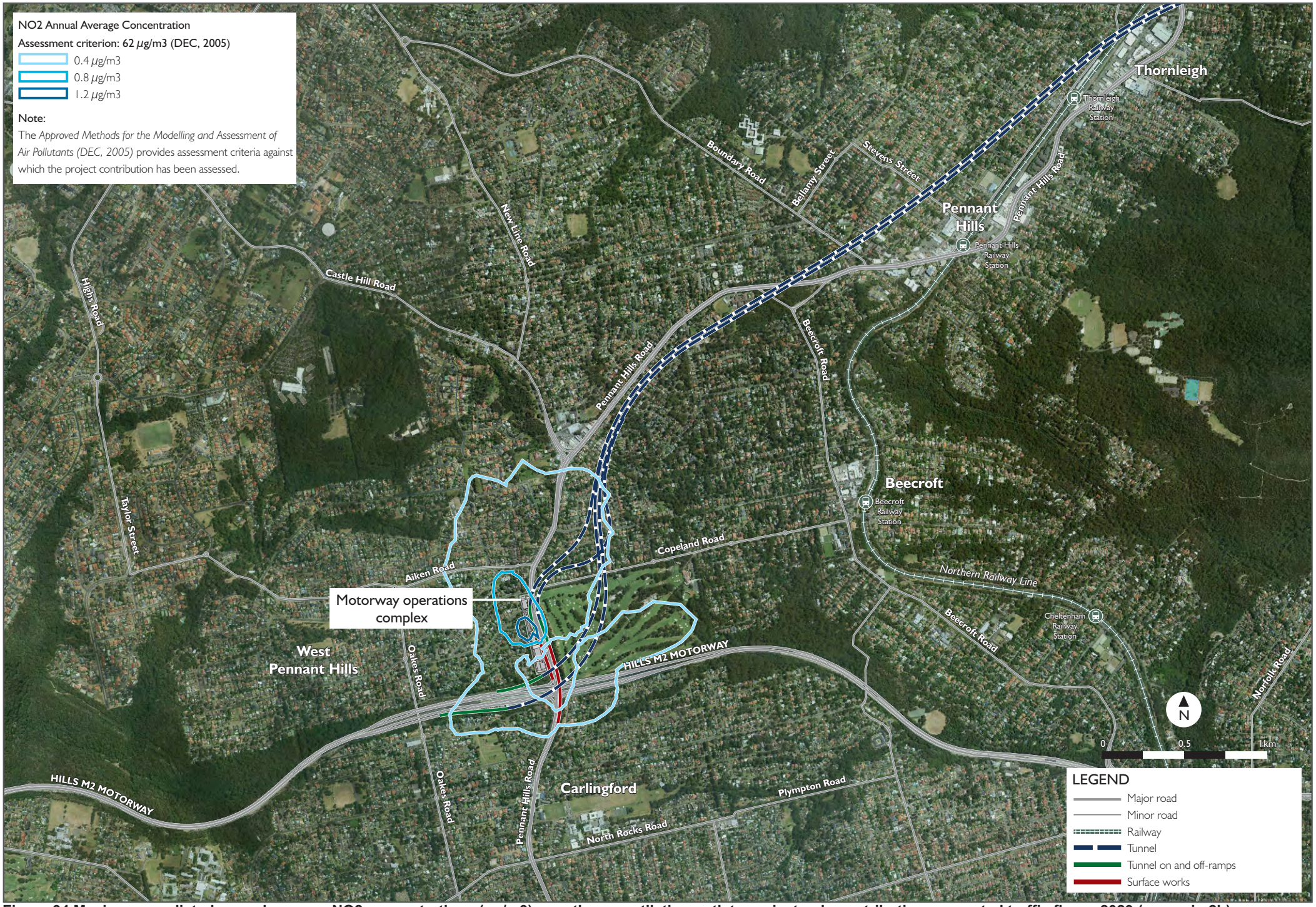

Figure 34 Maximum predicted annual average NO2 concentrations (ug/m3) - southern ventilation outlet - project only contribution - expected traffic flows, 2029 (scenario 2b)

This page has been left blank intentionally.

6.1.2 Cumulative assessment – With project – expected traffic flows – PM_{10} 24-hour average

Chart 4 and **Chart 5** show the project contributions and associated background concentrations for the modelling period for the 'with project – expected traffic flows' scenario for 2019 for the northern and southern ventilation outlets respectively, while **Chart 6** and **Chart 7** show the same data for 2029. The charts show the project contribution and the associated background concentration for each day of the modelling period for the receivers with the highest predicted project contributions (one receiver per chart). It should be noted that the maximum background concentrations are beyond the scale of the charts, and that the scales of the vertical axes were restricted so that the small project contributions could be seen. Even so, the project contributions are still barely visible, as the maximum project contributions were orders of magnitude lower than the background concentrations.

Table 34 provides further details of the contemporaneous assessment of the predicted 24 hour average PM_{10} concentrations, specifically:

- The top ten predicted cumulative concentrations (the project with background) for 'with project – expected traffic flows' in 2019 and 2029 (referred to as the maximum cumulative concentrations).
- The top ten predicted concentrations from each ventilation outlet for 'with project – expected traffic flows' in 2019 and 2029, and the cumulative concentration that would result (referred to as the maximum project concentrations).

As discussed in **Section 3.1**, nine exceedences of the PM_{10} 24 hour average criterion are present in the background OEH air quality data for 2009. These exceedences are likely to have resulted from bushfires or unusual short term natural events. These elevated concentrations are not considered representative of the area, with the average PM_{10} concentrations well below the relevant criteria.

The results of the contemporaneous analysis show:

- The maximum predicted contribution from the project would be 2.1 $\mu g/m^3$ ('with project – expected traffic flows' in 2029), which is substantially less than the applicable impact assessment criterion of 50 $\mu g/m^3$.
- The highest cumulative concentrations (background plus the project) occur at times where the maximum predicted project contributions for the assessed scenarios are all low (less than or equal to 0.3 $\mu g/m^3$) and well below the applicable impact assessment criterion of 50 $\mu g/m^3$.

This demonstrates that the predicted exceedences of the PM_{10} criterion would result from elevated background concentrations and would, therefore, be associated with other sources in the airshed. Furthermore, the cumulative assessment demonstrated that the project is not predicted to result in any additional exceedences of the 24 hour criterion (there were nine exceedences in the background data, and nine exceedences predicted by the dispersion modelling). As such, the project is predicted to have very little effect on local PM_{10} concentrations. The data were also ranked according to background concentrations; these are provided in **Appendix H**.

This page has been left blank intentionally.

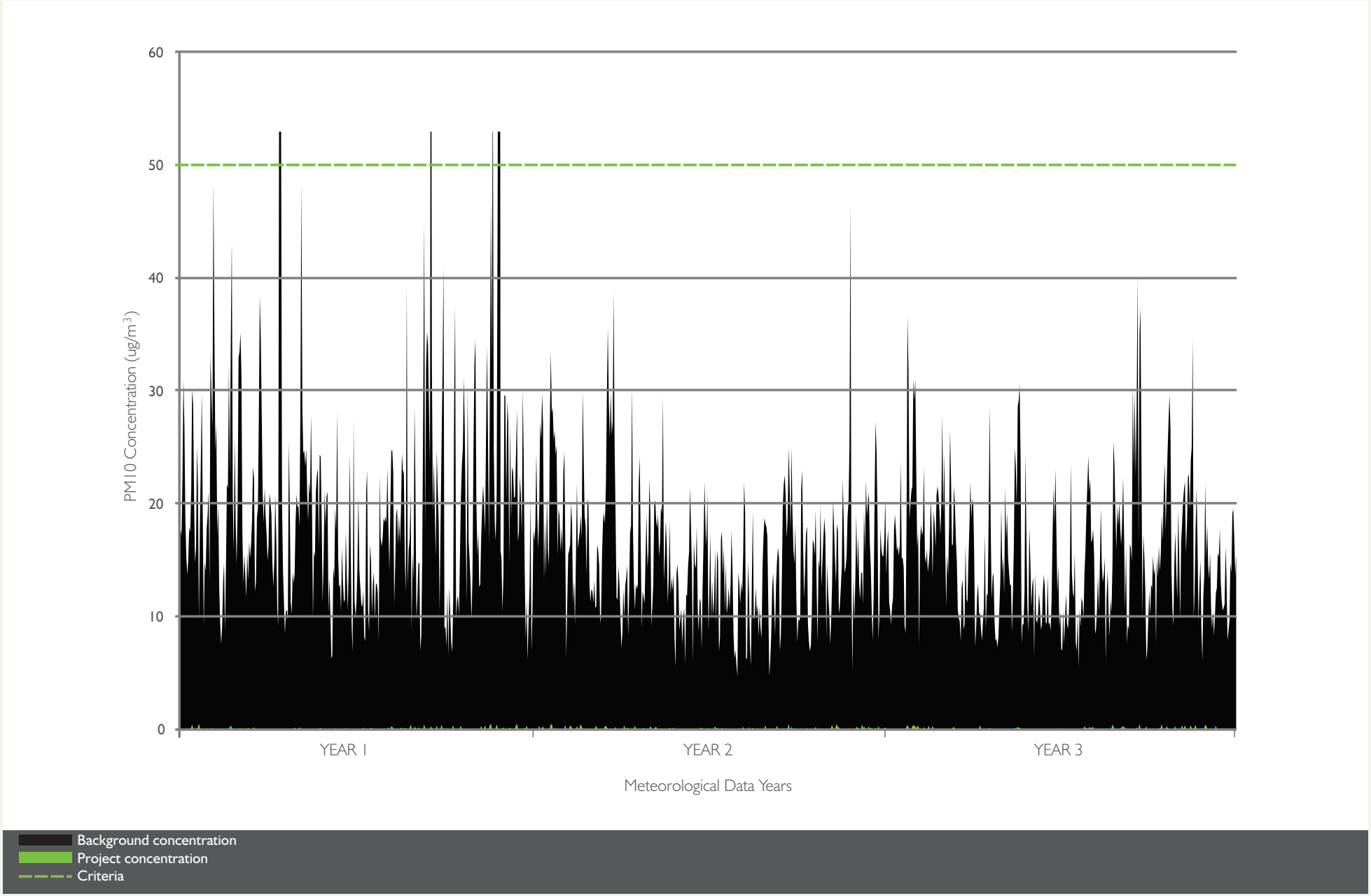

Chart 4 Predicted maximum cumulative PM10 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2019 – northern ventilation outlet

This page has been left blank intentionally.

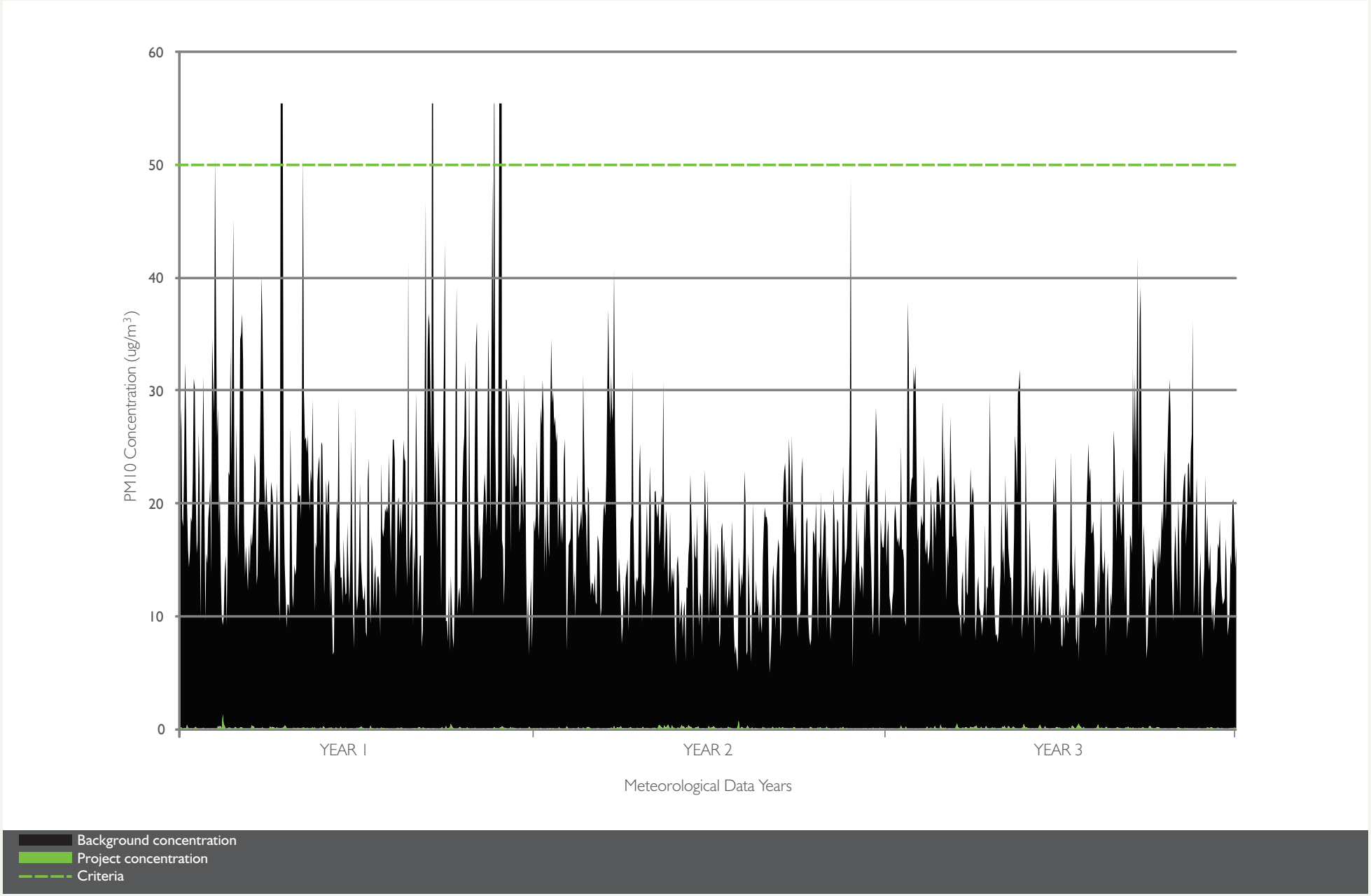

Chart 5 Predicted maximum cumulative PM10 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2019 – southern ventilation outlet

This page has been left blank intentionally.

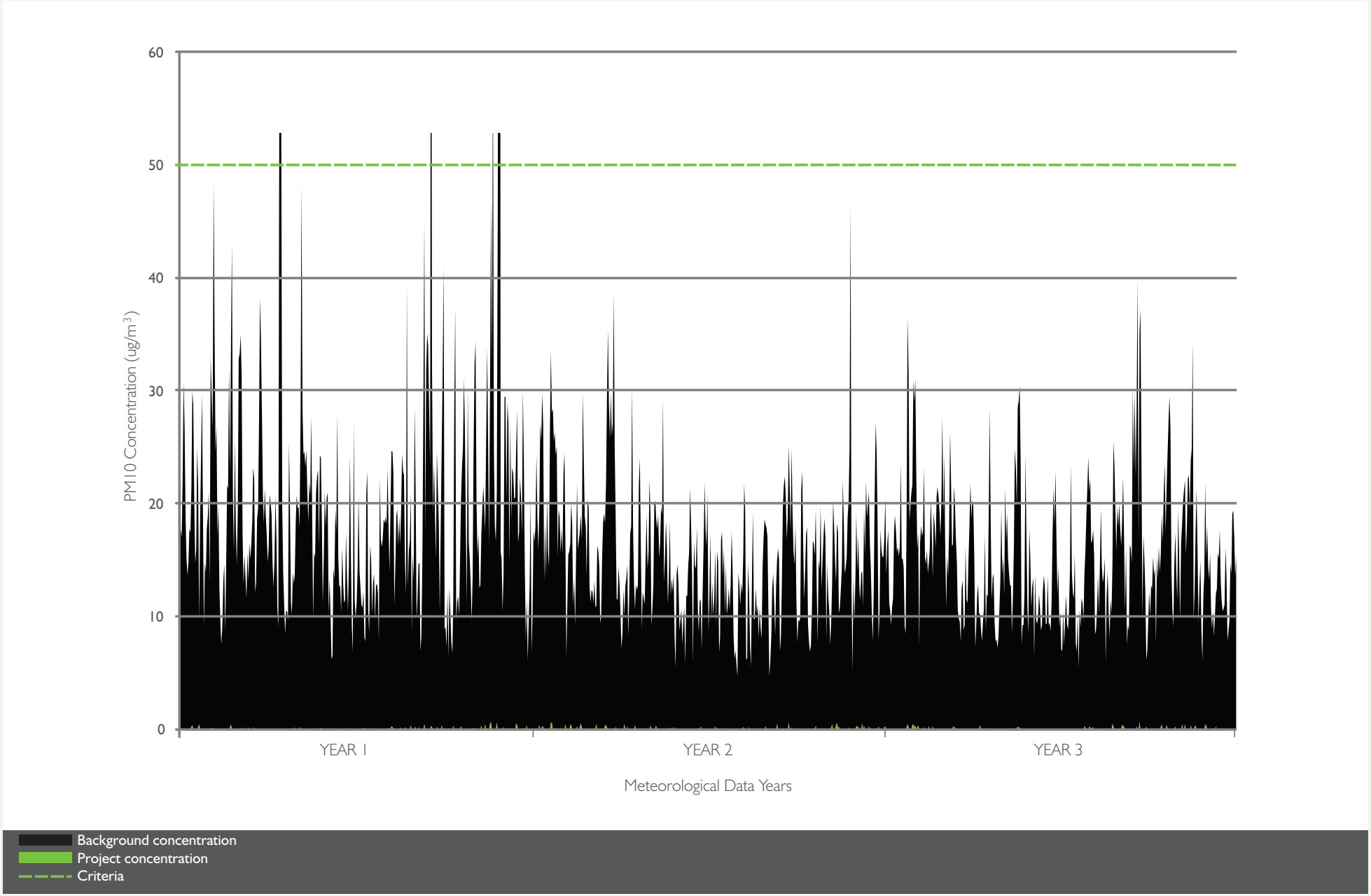

Chart 6 Predicted maximum cumulative PM10 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2029 – northern ventilation outlet

This page has been left blank intentionally.

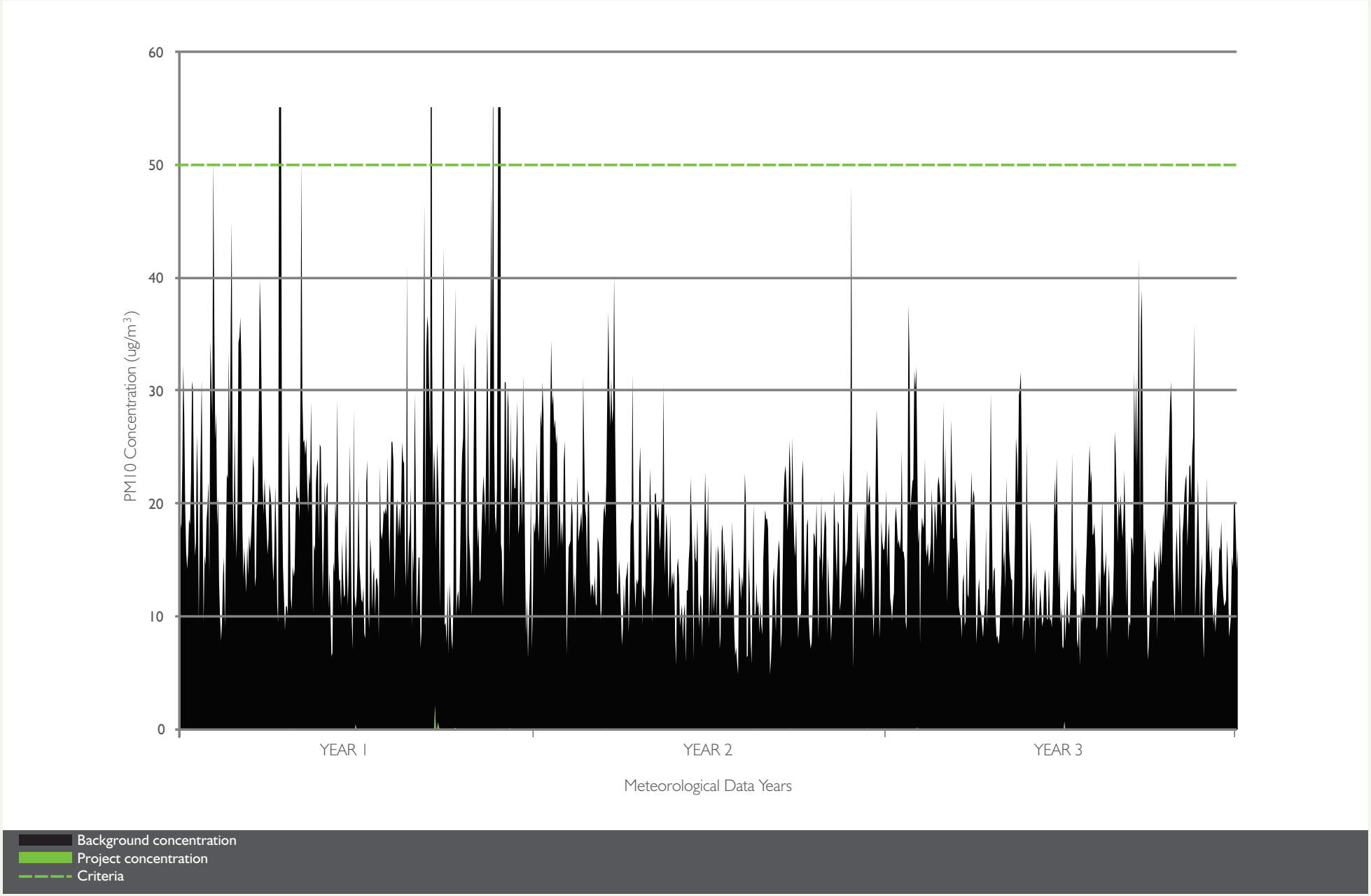

Chart 7 Predicted maximum cumulative PM10 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2029 – southern ventilation outlet

This page has been left blank intentionally.

Table 34 Predicted maximum cumulative PM_{10} concentrations (µg/m^3) – 24 hour averaging period – 'with project – expected traffic flows' in 2019 and 2029

Scenario	Outlet	Rank	Maximum cumulative concentration (µg/m^3)			Maximum project contribution (µg/m^3)		
			Cumulative concentration	Project contribution	Background contribution	Project contribution	Background contribution	Cumulative concentration
With project – expected traffic flows 2019 (Scenario 2a)	Northern ventilation outlet	1	221.8	0.2	221.6	1.0	11.1	12.1
		2	134.3	0.2	134.1	0.9	9.4	10.3
		3	92.0	0.3	91.7	0.9	11.9	12.8
		4	90.1	0.3	89.8	0.9	14.4	15.3
		5	61.3	0.2	61.1	0.9	20.2	21.1
		6	60.4	0.0	60.4	0.9	8.1	9.0
		7	56.3	0.3	56.0	0.9	19.6	20.4
		8	50.4	0.2	50.2	0.9	9.0	9.9
		9	50.2	0.0	50.2	0.9	21.0	21.9
		10	48.9	0.4	48.5	0.9	18.5	19.4
	Southern ventilation outlet	1	221.8	0.2	221.6	1.4	11.1	12.5
		2	134.4	0.3	134.1	1.3	17.8	19.1
		3	92.2	0.5	91.7	1.2	7.8	9.0
		4	90.0	0.3	89.8	1.2	15.0	16.2
		5	61.5	0.4	61.1	1.2	17.5	18.6
		6	60.4	0.3	60.1	1.1	8.9	10.0
		7	56.4	0.4	56.0	1.1	20.2	21.3
		8	50.7	0.5	50.2	1.1	13.3	14.4
		9	50.3	0.2	50.1	1.1	17.1	18.2
		10	49.0	0.5	48.5	1.0	19.8	20.9

Scenario	Outlet	Rank	Maximum cumulative concentration (µg/m³)			Maximum project contribution (µg/m³)		
			Cumulative concentration	Project contribution	Background contribution	Project contribution	Background contribution	Cumulative concentration
With project – expected traffic flows 2029 (Scenario 2b)	North ventilation outlet	1	221.8	0.2	221.6	1.4	20.2	21.5
		2	134.4	0.2	134.1	1.2	9.4	10.6
		3	92.1	0.4	91.7	1.2	11.6	12.8
		4	90.1	0.3	89.8	1.2	11.1	12.3
		5	61.3	0.2	61.1	1.2	18.5	19.7
		6	60.5	0.0	60.5	1.2	15.2	16.4
		7	56.3	0.3	56.0	1.2	21.0	22.2
		8	50.4	0.2	50.2	1.2	14.3	15.5
		9	50.3	0.2	50.1	1.2	19.2	20.3
		10	49.0	0.5	48.5	1.2	8.1	9.3
	South ventilation outlet	1	221.8	0.3	221.6	2.1	20.2	22.3
		2	134.5	0.3	134.1	1.8	7.8	9.6
		3	92.3	0.7	91.7	1.7	22.3	24.0
		4	90.1	0.4	89.8	1.6	11.1	12.7
		5	61.5	0.4	61.1	1.5	17.5	19.0
		6	60.5	0.4	60.1	1.5	10.2	11.8
		7	56.5	0.5	56.0	1.4	17.8	19.2
		8	50.9	0.7	50.2	1.3	15.0	16.4
		9	50.4	0.3	50.1	1.3	21.0	22.3
		10	49.1	0.6	48.5	1.3	18.3	19.6

6.1.3 Cumulative assessment – With project – expected traffic flows – $PM_{2.5}$ 24-hour average –

Chart 8 and **Chart 9** show the project contributions and associated background concentrations for the modelling period for the 'with project – expected traffic flows' scenario for 2019 for the northern and southern ventilation outlets respectively. The 2029 data are shown in **Chart 10** and **Chart 11** respectively. The charts again show the project contribution and the associated background concentration for each day of the modelling period for the receivers with the highest predicted project contributions (one receiver per chart). The vertical axes were again restricted to enable the project contributions to be seen. As was evident for PM_{10}, the project contributions of $PM_{2.5}$ were orders of magnitude lower than the background concentrations, and are barely visible compared to the background concentrations.

Table 35 presents further details of the contemporaneous assessment of the predicted 24 hour average $PM_{2.5}$ concentrations, specifically:

- The top five predicted cumulative concentrations (the project with background) for 'with project – expected traffic flows' in 2019 and 2029 (the maximum cumulative concentrations).
- The top five predicted concentrations from each ventilation outlet for 'with project – expected traffic flows' in 2019 and 2029, and the cumulative concentration that would result (the maximum project concentrations).

There were four exceedences of the $PM_{2.5}$ 24 hour average advisory reporting standard in 2009 in the background $PM_{2.5}$ concentrations (which were derived from the PM_{10} data). As with PM_{10}, these exceedences are likely to have been caused by infrequent, unusual events such as bushfires.

The results of the contemporaneous analysis show:

- The maximum predicted contributions from the project would be 2.0 $\mu g/m^3$ for 'with project – expected traffic flows' in 2019 and 2029, which is substantially lower than the $PM_{2.5}$ 24 hour average advisory reporting standard of 25 $\mu g/m^3$.
- The highest cumulative concentrations (background plus the project) were predicted to occur at times where the maximum predicted project contributions for the assessed scenarios are all low (below 0.8 $\mu g/m^3$) and well below the advisory reporting standard of 25 $\mu g/m^3$.

This demonstrates that the predicted exceedences of the $PM_{2.5}$ 24 hour average advisory reporting standard would result from elevated background concentrations and would be associated with other sources in the airshed. Furthermore, the project would not result in any additional exceedences of the 24 hour advisory reporting standard (there were four exceedences of the criterion in the background data, and four predicted to occur by the dispersion modelling). The project is, therefore, predicted to have very little effect on local $PM_{2.5}$ concentrations.

This page has been left blank intentionally.

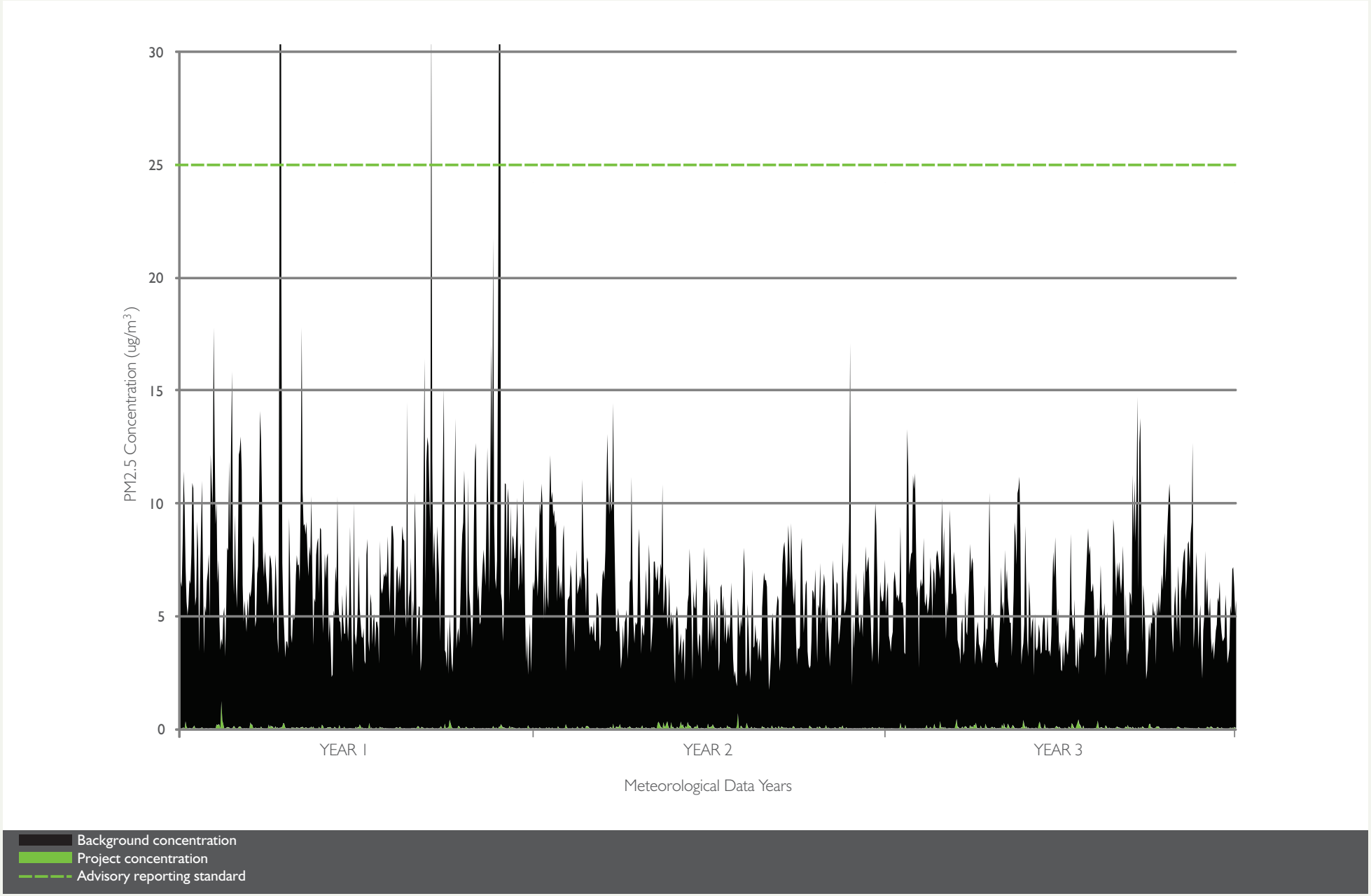

Chart 8 Predicted maximum cumulative PM2.5 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2019 – northern ventilation outlet

This page has been left blank intentionally.

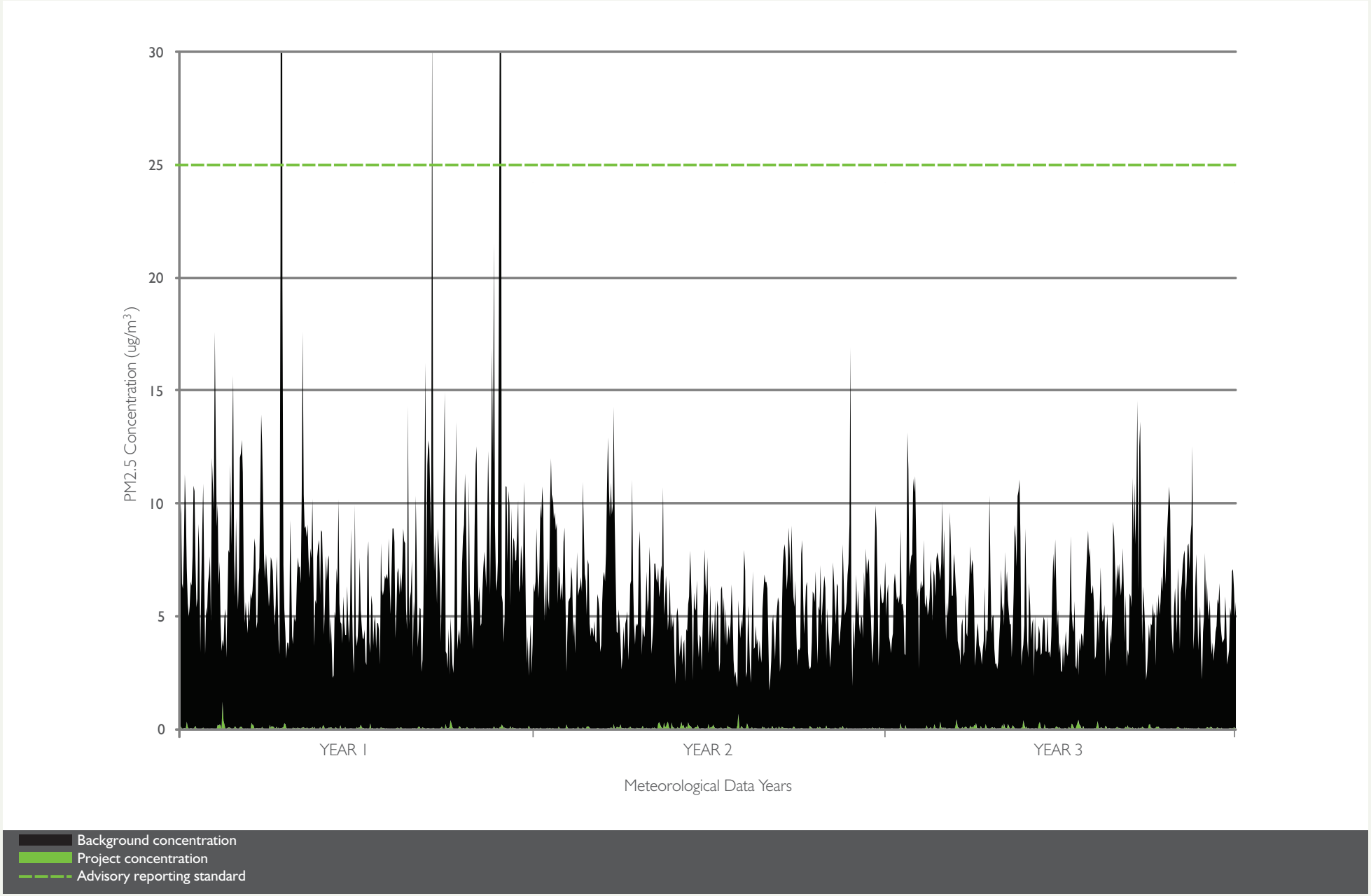

Chart 9 Predicted maximum cumulative PM2.5 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2019 – southern ventilation outlet

This page has been left blank intentionally.

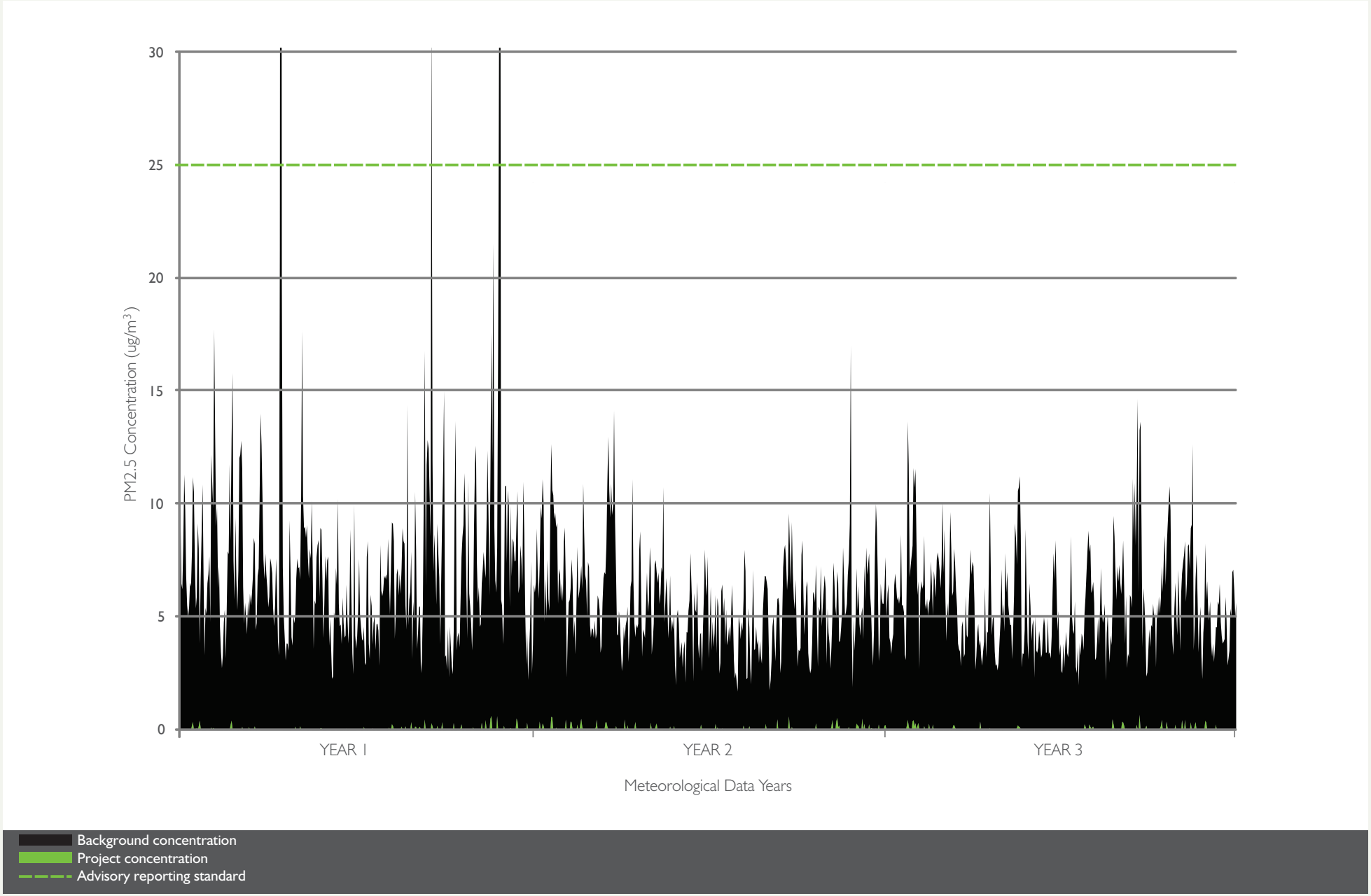

Chart 10 Predicted maximum cumulative PM2.5 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2029 – northern ventilation outlet

This page has been left blank intentionally.

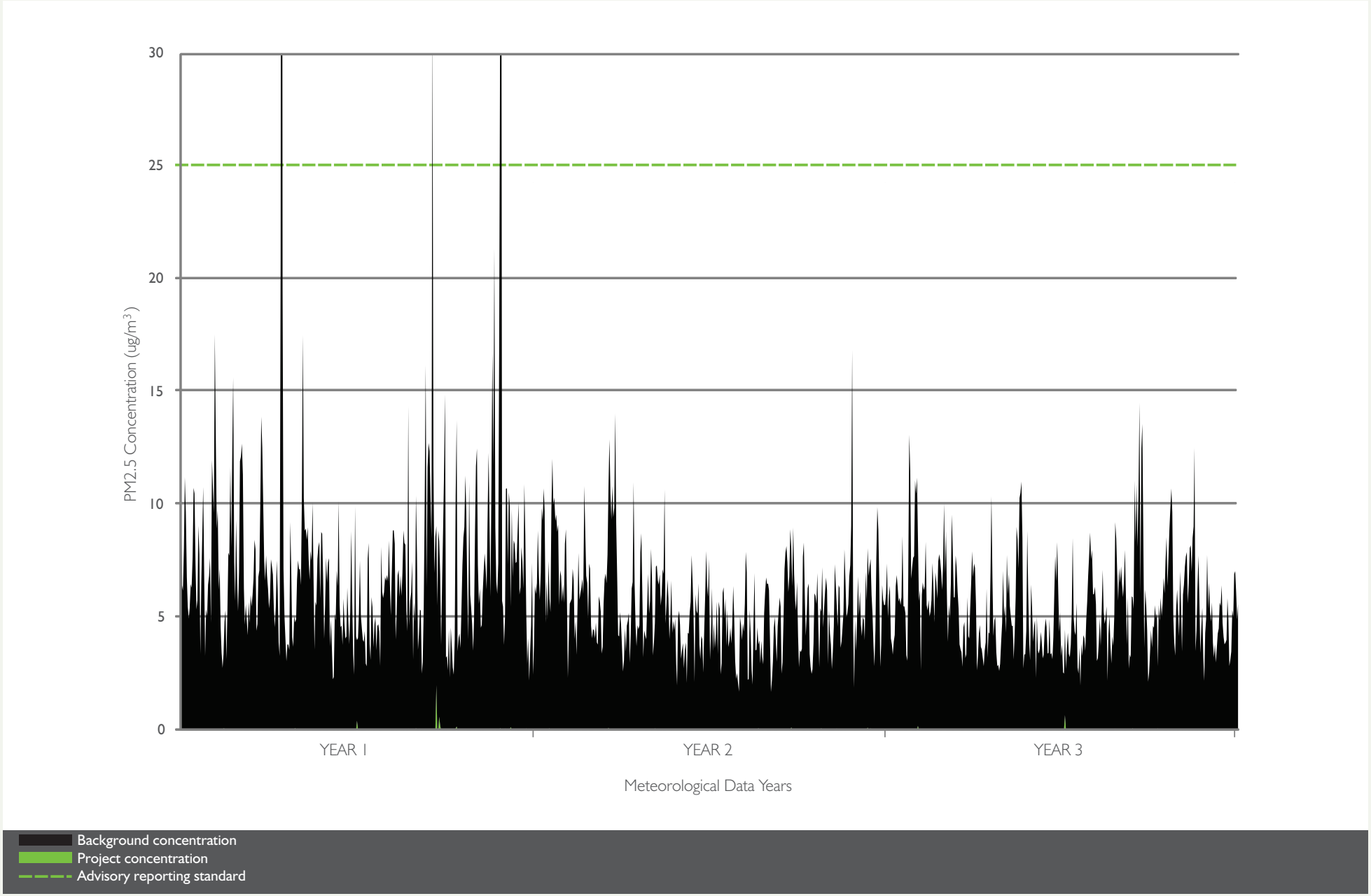

Chart 11 Predicted maximum cumulative PM2.5 concentrations (ug/m3) – 24 hour averaging period – 'with project – expected traffic flows' in 2029 – southern ventilation outlet

This page has been left blank intentionally.

Table 35 Predicted maximum cumulative $PM_{2.5}$ concentrations (µg/m^3) – 24 hour averaging period – 'with project – expected traffic flows' (Scenario 2)

Scenario	Outlet	Rank	Maximum cumulative concentrations (µg/m^3)			Maximum project contributions (µg/m^3)		
			Background concentration	Project contribution	Cumulative concentration	Project contribution	Background concentration	Cumulative concentration
With project – expected traffic flows 2019 (Scenario 2a)	Northern ventilation outlet	1	77.6	0.2	77.8	1.0	11.1	12.1
		2	46.9	0.3	47.3	0.9	9.4	10.3
		3	32.1	0.6	32.6	0.9	11.9	12.8
		4	31.4	0.4	31.8	0.9	14.4	15.3
		5	21.4	0.2	21.6	0.9	20.2	21.1
	Southern ventilation outlet	1	77.6	0.2	77.8	1.4	11.1	12.5
		2	47.0	0.2	47.2	1.3	17.8	19.1
		3	32.1	0.5	32.5	1.2	7.8	9.0
		4	31.4	0.2	31.7	1.2	15.0	16.2
		5	21.4	0.3	21.7	1.2	17.5	18.6
With project – expected traffic flows 2029 (Scenario 2b)	Northern ventilation outlet	1	77.6	0.2	77.8	1.3	7.1	8.4
		2	47.0	0.4	47.4	1.2	3.3	4.5
		3	32.1	0.8	32.9	1.1	4.1	5.2
		4	31.4	0.5	31.9	1.1	6.5	7.6
		5	21.4	0.3	21.7	1.1	5.3	6.4
	Southern ventilation outlet	1	77.6	0.2	77.8	2.0	7.1	9.1
		2	47.0	0.3	47.2	1.7	5.7	7.4
		3	32.1	0.6	32.7	1.6	7.8	9.4
		4	31.4	0.3	31.8	1.5	3.9	5.4
		5	21.4	0.4	21.8	1.4	6.1	7.6

This page has been left blank intentionally.

6.1.4 Nitrogen dioxide

The predicted cumulative concentrations of 1 hour NO_2 were all well below the impact assessment criterion. For example, the maximum project contribution for the 'with project – expected operation, 2019' scenario was predicted to be 68.9 µg/m^3, which is around 28 per cent of the criterion level. **Chart 8** shows the predicted NO_2 contributions for the receiver with the maximum predicted contributions over the course of the modelling period for this scenario, which are ranked in order of size. As shown, the project contributions are at a negligible level for around 70 per cent of the modelling period. The NO_2 contributions associated with the other assessed scenarios followed the same trend. This demonstrates that predicted project contributions of NO_2 are expected to be minimal for most of the time.

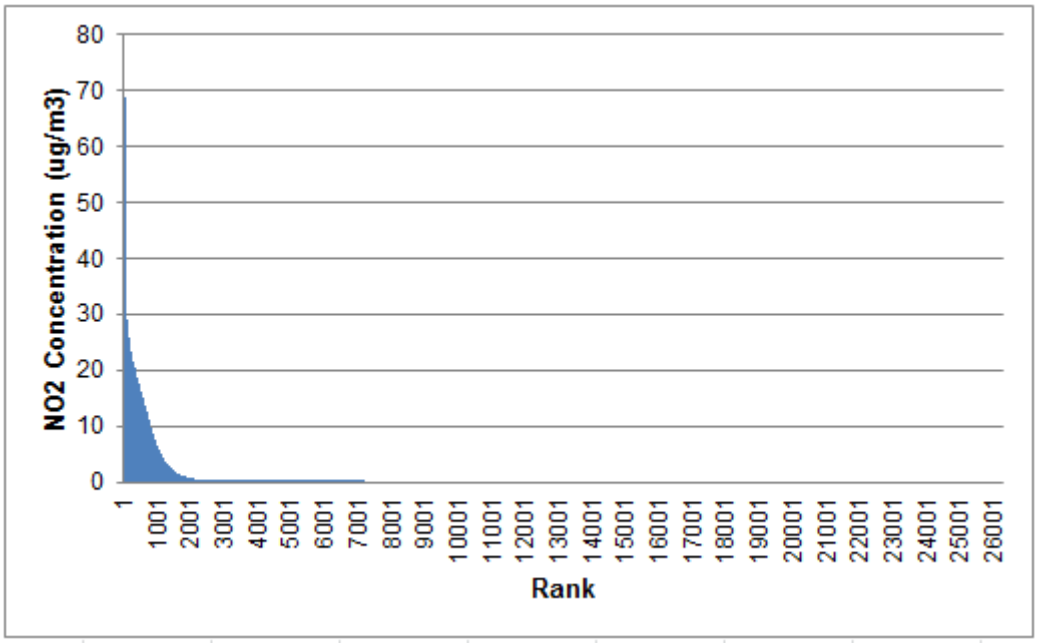

Chart 8 Ranked NO_2 concentrations at the receiver with the maximum predicted project contribution, 'with project – expected operation, 2019

6.1.5 VOCs

The total VOC concentrations from **Table 22** were speciated using the profile provided in OEH (2012) and the mass fraction for the project fleet determined by the health risk assessment for the project (refer to technical working paper: human health risk assessment). As shown in **Table 36**, the predicted concentrations of individual VOC species were all orders of magnitude below the applicable impact assessment criteria for the individual compounds.

This page has been left blank intentionally.

Table 36 Predicted concentration of speciated VOCs (µg/m^3) (project contribution) – 'with project – expected traffic flows' in 2019 and 2029

Pollutant	Averaging Period	Predicted concentrations of speciated VOCs (µg/m^3)				Impact assessment criteria (µg/m^3)
		With project – expected traffic flows 2019 (Scenario 2a)		With project – expected traffic flows 2029 (Scenario 2b)		
		Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
Total VOCs	1 hour 99.9%	4.1	3.7	5.4	5.4	-
1,3-butadiene	1 hour 99.9%	0.04	0.03	0.05	0.05	40
Acetaldehyde	1 hour 99.9%	0.09	0.08	0.09	0.09	42
Benzene	1 hour 99.9%	0.13	0.12	0.20	0.20	29
Formaldehyde	1 hour 99.9%	0.20	0.18	0.21	0.21	20
Xylenes	1 hour 99.9%	0.19	0.17	0.30	0.29	190
Toluene	1 hour 99.9%	0.23	0.21	0.36	0.36	360

This page has been left blank intentionally.

6.1.6 Without project – Pennant Hills Road

The 'without project' scenario (Scenario 1) assessed the expected future pollutant concentrations along the main surface roads considered in the assessment in the absence of the project. These results were compared to the surface road modelling results for the 'with project – expected traffic flows' (Scenario 2a and 2b) along the road corridor, and are presented in **Table 37**.

It should be noted that the road emissions do not form part of the predicted emissions from the project; rather, they essentially reflect background pollutant concentrations. The results do, however, demonstrate that the project would result in lower levels of PM_{10}, VOCs and PAHs in the short term, while levels of CO are not expected to change substantially, and are expected to remain orders of magnitude lower than the applicable impact assessment criteria.

Table 37 Comparison of without and with project along the road corridor

Pollutant	Averaging period	Condition	Maximum predicted concentrations (µg/m³) 2019	2029	Criteria (µg/m³)
PM_{10}	24 hour	Without project (Scenario 1)	27.1	32.8	50
		With project (Scenario 2a / 2b)	19.8	20.4	
	Annual	Without project (Scenario 1)	13.3	16.1	30
		With project (Scenario 2a / 2b)	10.6	10.8	
$PM_{2.5}$	24 hour	Without project (Scenario 1)	25.7	31.2	25*
		With project (Scenario 2a / 2b)	18.8	19.4	
	Annual	Without project (Scenario 1)	12.6	15.3	8*
		With project (Scenario 2a / 2b)	10.1	10.2	
NO_2	1 hour	Without project (Scenario 1)	183	207	246
		With project (Scenario 2a / 2b)	165	167	
	Annual	Without project (Scenario 1)	45	49	62
		With project (Scenario 2a / 2b)	39	44	
CO	1 hour	Without project (Scenario 1)	583	647	30,000
		With project (Scenario 2a / 2b)	575	643	
	8 hour	Without project (Scenario 1)	406	462	10,000
		With project (Scenario 2a / 2b)	414	459	
Total VOCs	1 hour	Without project (Scenario 1)	44.4	49.3	-
		With project (Scenario 2a / 2b)	42.0	45.9	
PAHs	1 hour	Without project (Scenario 1)	0.026	0.007	0.4
		With project (Scenario 2a / 2b)	0.005	0.005	

* Advisory reporting standards

6.1.7 Project air quality benefits (combined effects)

Vehicles using the project in preference to Pennant Hills Road would avoid 21 sets of traffic lights, and would have an estimated travel time of around five to six minutes. This would offer significant travel time savings over the alternative of using Pennant Hills Road or if the project was not constructed (refer to technical working paper: traffic and transport (AECOM, 2014)). In addition to the reduced travel times, the project tunnels would capture vehicle emissions, which would then be released in a controlled and efficient manner via the tunnel ventilation outlets, facilitating effective pollutant dispersion.

The results of dispersion modelling and pollutant monitoring studies of existing road tunnels generally show that the pollutant concentrations associated with outlet emissions are indistinguishable from pollutant concentrations from all other surrounding sources (such as emissions from surface roads, industrial sources, domestic sources, and natural sources). An extensive literature review by the National Health and Medical Research Council (2008) determined that the effects of road tunnel emissions on local air quality are very small compared to the effects from other sources, particularly local surface roads, and that monitoring is often unable to distinguish emissions from road tunnels from background pollutant sources.

The project is expected to improve traffic flows along Pennant Hills Road, which would be expected to improve air quality along that road corridor. Further, the capture and dispersion of emissions from the diverted traffic through ventilation outlets would improve the dispersion of pollutants.

In order to evaluate the total effect of the project on local air quality, the incremental increases from the ventilation stations and the relative decreases in pollutant concentration along the road corridor were combined, using the predicted concentrations for $PM_{2.5}$ (annual average and 24 hour average).

Figure 35 to **Figure 38** show the relative change in $PM_{2.5}$ concentrations along the Pennant Hills Road corridor as a percentage of the 8 µg/m^3 (annual average) and 25 µg/m^3 (24-hour average) advisory reporting standards, respectively, for the 'with project – expected traffic volumes' for 2019 and 2029. The contour labels represent the change in concentration as a percentage of the advisory reporting standard. Due to the scale of the figures, it is only possible to clearly shown changes up to ten per cent.

The assessment found that:

- In the case of both 24-hour average and annual average $PM_{2.5}$ concentrations, the project's ventilation outlets would effectively disperse emissions to very low levels in the surrounding environment. The peak $PM_{2.5}$ contributions from the project would be around five to 10 per cent (24-hour average) and one to five per cent (annual average) of the advisory reporting standards for $PM_{2.5}$. Both of these percentages are well within the normal variability in background $PM_{2.5}$ concentrations measured at existing regional monitoring stations managed by the Office of Environment and Heritage, and as recorded at monitoring stations established along the Pennant Hills Road corridor for the project.
- Substantial reductions in annual average $PM_{2.5}$ concentrations are expected along the Pennant Hills Road corridor (refer to **Figure 35** and **Figure 37**). These improvements in air quality are expected to peak at up to 40 percent of the 8 µg/m^3 (annual average) advisory reporting standard for $PM_{2.5}$ within the Pennant Hills road reserve. Receivers along the road corridor are predicted to benefit from improvements in $PM_{2.5}$ concentrations (annual average) of between around around five to 35 per cent as a result of the project.
- Substantial reductions in 24-hour average $PM_{2.5}$ concentrations are expected along the Pennant Hills Road corridor (refer to **Figure 36** and **Figure 38**). These improvements in air quality are expected to peak at up to 25 percent of the 25 µg/m^3 (24-hour average) advisory reporting standard for $PM_{2.5}$ within the Pennant Hills road reserve. Receivers along the road corridor are expected to benefit from improvements in $PM_{2.5}$ concentrations (24 hour average average) of between five to 35 per cent as a result of the project.
- The project is expected to result in a net improvement in air quality, taking into account the predicted substantial improvements in air quality along the Pennant Hills Road corridor balanced with less extensive, very low increases in $PM_{2.5}$ concentrations around the northern and southern ventilation outlets.

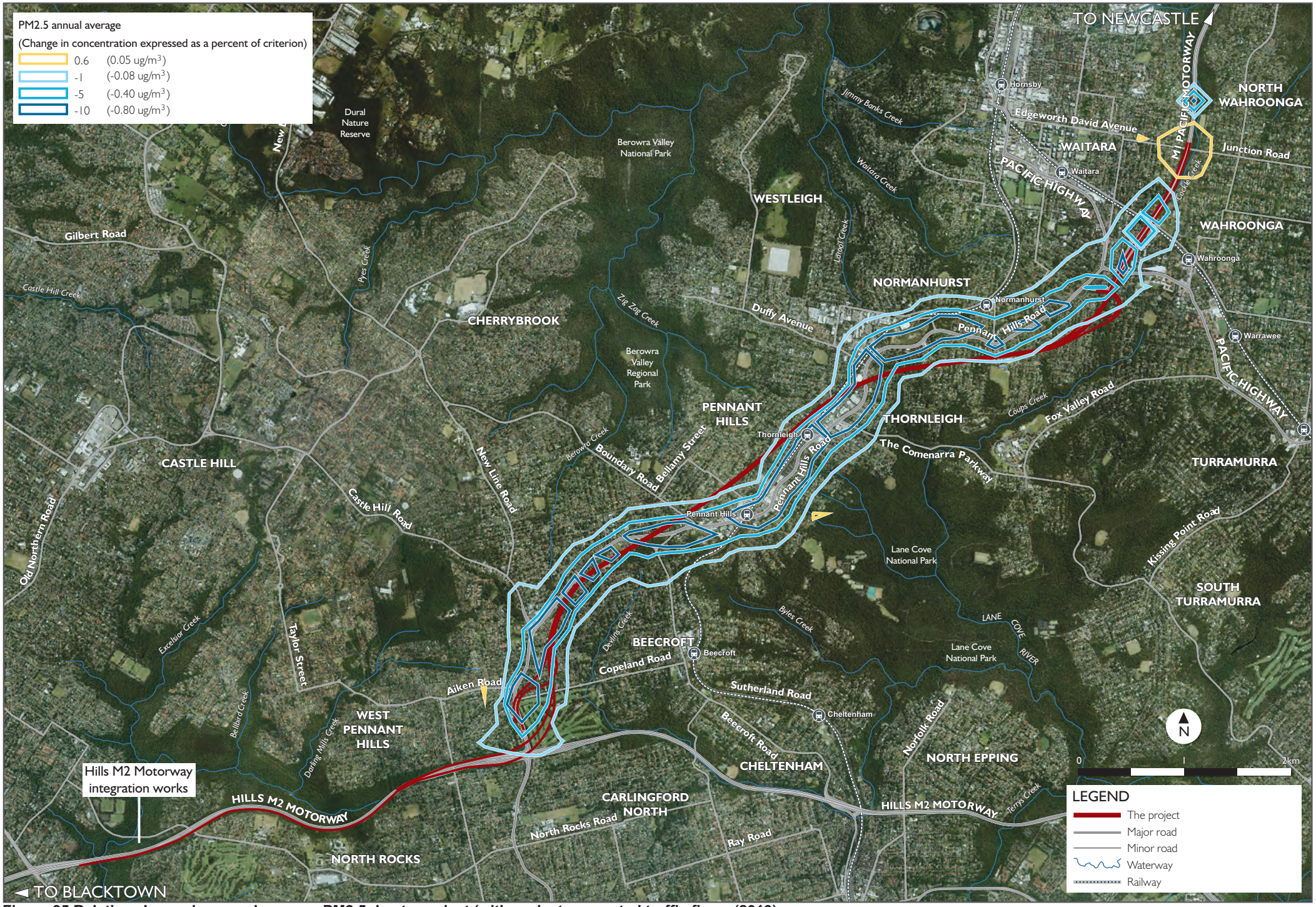

Figure 35 Relative change in annual average PM2.5 due to project (with project - expected traffic flows (2019)

This page has been left blank intentionally.

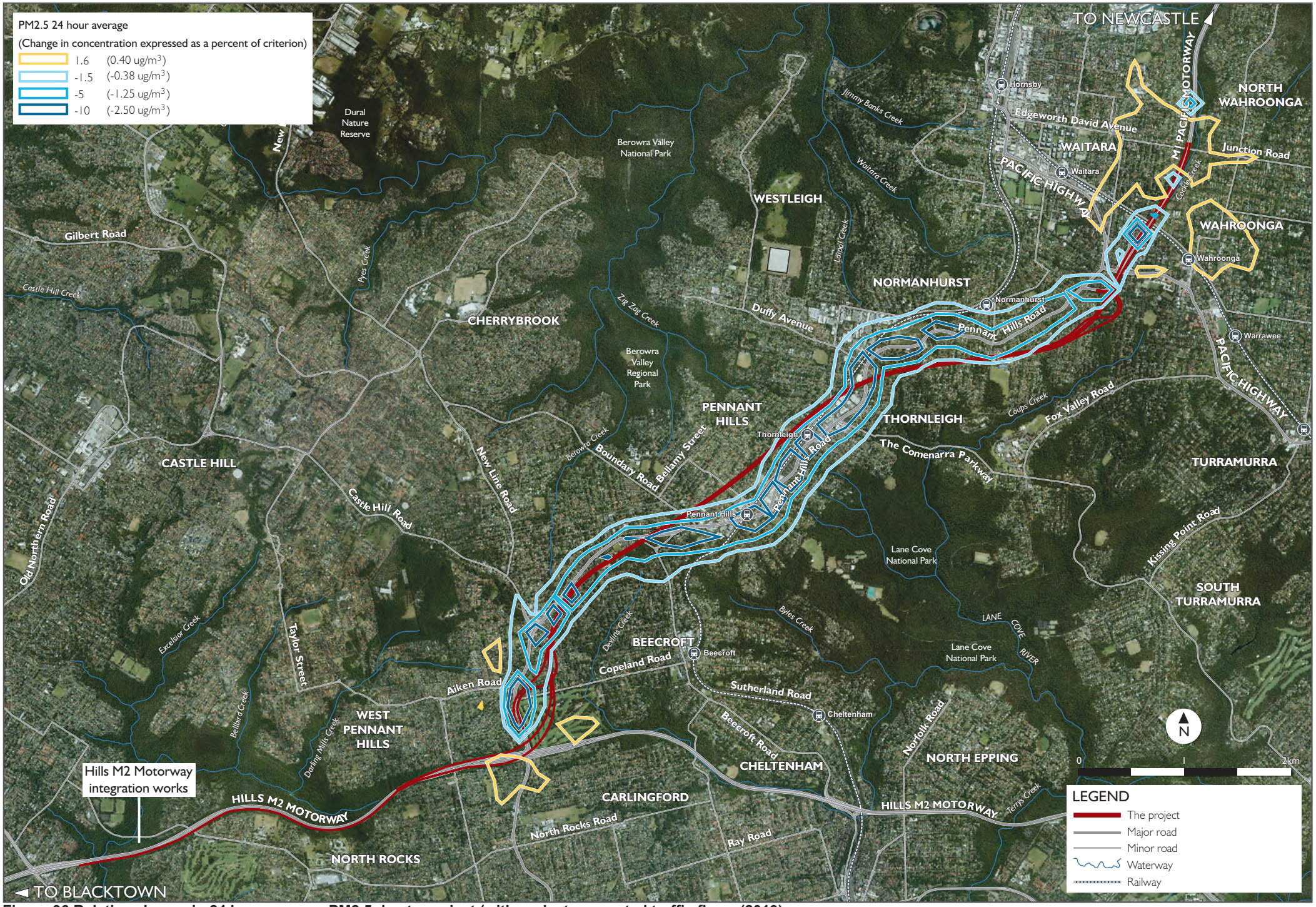

Figure 36 Relative change in 24 hour average PM2.5 due to project (with project - expected traffic flows (2019)

This page has been left blank intentionally.

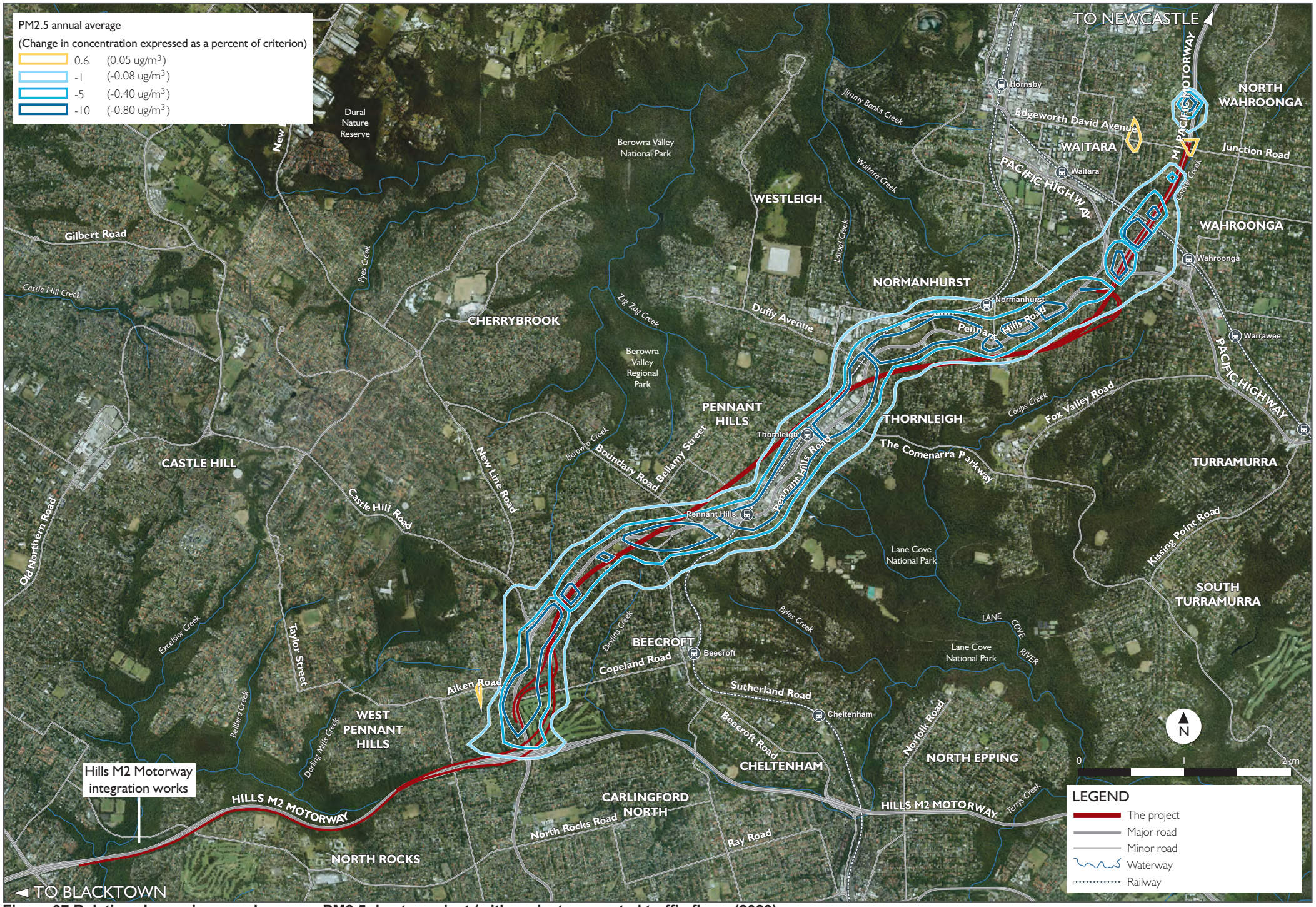

Figure 37 Relative change in annual average PM2.5 due to project (with project - expected traffic flows (2029)

This page has been left blank intentionally.

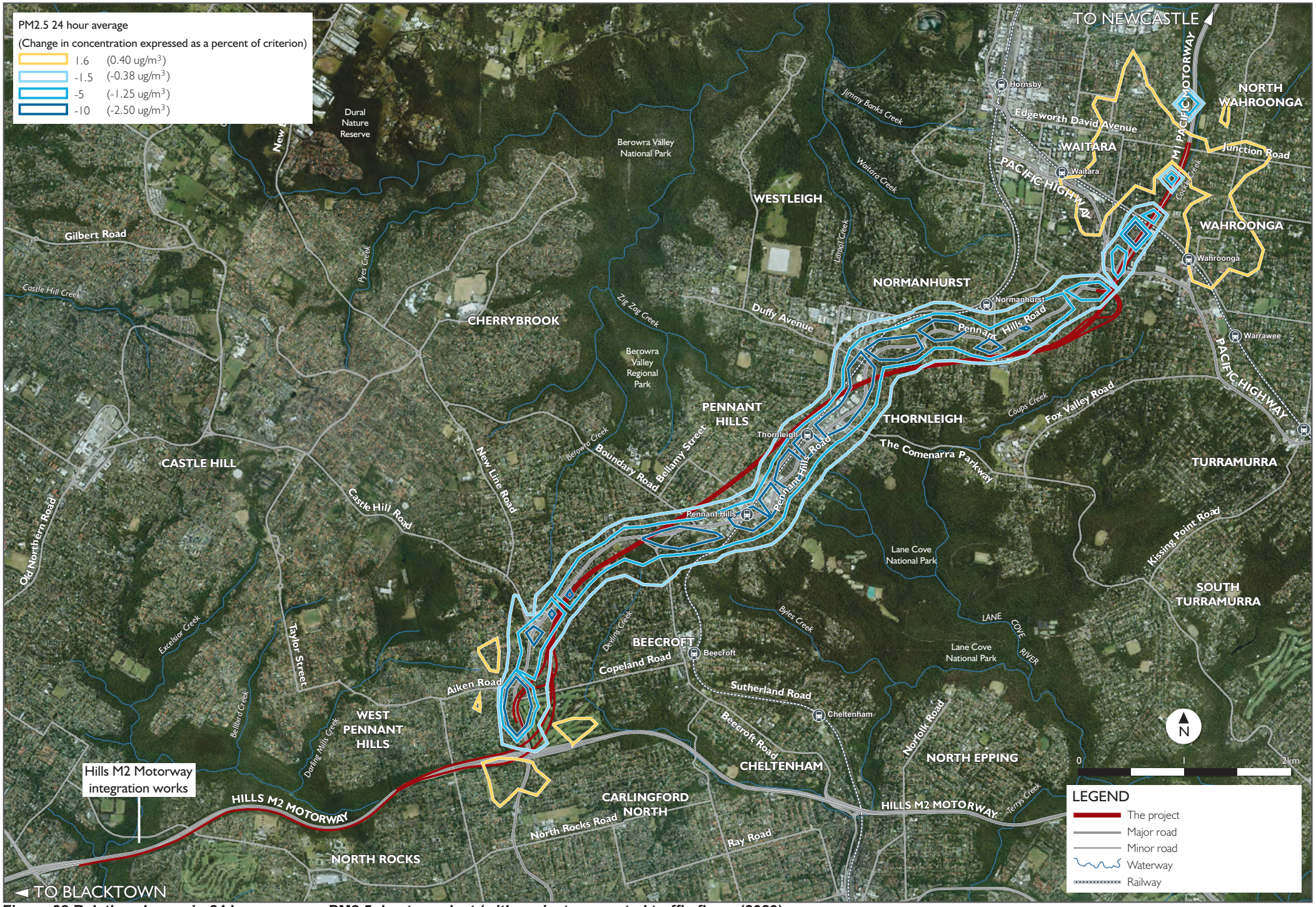

Figure 38 Relative change in 24 hour average PM2.5 due to project (with project - expected traffic flows (2029)

This page has been left blank intentionally.

6.1.8 Design analysis A

For design analysis A, which assessed the maximum design capacity of the main alignment tunnels during peak hours, the results of the dispersion modelling predicted that:

- The peak incremental contribution of PM_{10} (24-hour average) from the project would be 3.1 µg/m^3, which is around six per cent of the 50 µg/m^3 assessment criterion.
- The peak incremental contribution of PM_{10} (annual average) from the project would be 0.26 µg/m^3, which is less than one per cent of the 30 µg/m^3 assessment criterion.
- The peak incremental contribution of $PM_{2.5}$ (24-hour average) from the project would be 3.0 µg/m^3, which is around 12 per cent of the 25 µg/m^3 advisory reporting standard.
- The peak incremental contribution of $PM_{2.5}$ (annual average) from the project would be 0.25 µg/m^3, which is around three per cent of the 8 µg/m^3 advisory reporting standard.
- The peak incremental contribution of NO_2 (24-hour average) from the project would be 114.8 µg/m^3, which is around 47 per cent of the 246 µg/m^3 assessment criterion.
- The peak incremental contribution of NO_2 (annual average) from the project would be 2.5 µg/m^3, which is around four per cent of the 62 µg/m^3 assessment criterion.

The predicted concentrations of $PM_{2.5}$, which is considered to be the primary pollutant of interest for this project, for design analysis A are shown in **Table 38** and **Table 39**. Results of the modelling of other pollutants for this scenario are provided in **Appendix G**. In all cases, the contributions from the project to the surrounding airshed were predicted to be well below applicable air quality assessment criteria.

Table 38 Predicted concentrations of $PM_{2.5}$ – Design analysis A (µg/m^3)

Source	Averaging period	Predicted maximum concentrations (µg/m^3) (Design Analysis A)		Impact assessment criteria (µg/m^3)
		Northern ventilation outlet	Southern ventilation outlet	
Peak project contribution	24 hour maximum	2.2	3.1	-
	Annual average	0.2	0.3	-
Peak cumulative concentration (project plus background)	24 hour maximum	Refer to **Table 33**		25
	Annual average	**8.73**	**10.30**	8
Project contribution (% of criteria)	24 hour maximum	8.4 %	12.0 %	-
	Annual average	2.0 %	3.1 %	-
Exceedences denoted in **bold type**.				

This page has been left blank intentionally.

Table 39 Predicted maximum cumulative $PM_{2.5}$ concentrations (µg/m3) – 24 hour averaging period – Design analysis A

Outlet	Rank	Maximum cumulative concentration (µg/m^3)			Maximum project contribution (µg/m^3)		
		Background concentration	Project contribution	Cumulative concentration	Project contribution	Background concentration	Cumulative concentration
Northern ventilation outlet	1	77.6	0.4	77.9	2.1	7.1	9.2
	2	47.0	0.7	47.7	1.8	2.8	4.7
	3	32.1	1.2	33.2	1.8	6.8	8.6
	4	31.4	0.6	32.1	1.8	3.9	5.6
	5	21.0	0.9	22.0	1.7	6.7	8.5
Southern ventilation outlet	1	77.6	0.4	78.0	3.0	3.9	6.9
	2	47.0	0.5	47.5	2.8	6.2	9.1
	3	32.1	1.1	33.2	2.7	5.4	8.1
	4	31.4	0.6	32.0	2.7	5.3	7.9
	5	21.4	0.8	22.1	2.6	7.8	10.4

This page has been left blank intentionally.