

NorthConnex

Building for the future



Volume 2



Environmental Impact Statement

Submissions and Preferred Infrastructure Report
Chapters 5 - 7

November 2014

Roads and Maritime Services

NorthConnex

Submissions and preferred infrastructure report

NOVEMBER 2014

Prepared by

AECOM Australia Pty Ltd

Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia

T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com

ABN 20 093 846 925

AECOM in Australia and New Zealand is certified to the latest version of ISO9001, ISO14001, AS/NZS4801 and OHSAS18001.

© AECOM Australia Pty Ltd (AECOM). All rights reserved.

AECOM has prepared this document for the sole use of Roads and Maritime Services and for a specific purpose, each as expressly stated in the document. No other party should rely on this document without the prior written consent of AECOM. AECOM undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. This document has been prepared based on Roads and Maritime Services' description of its requirements and AECOM's experience, having regard to assumptions that AECOM can reasonably be expected to make in accordance with sound professional principles. AECOM may also have relied upon information provided by Roads and Maritime Services and other third parties to prepare this document, some of which may not have been verified. Subject to the above conditions, this document may be transmitted, reproduced or disseminated only in its entirety.

(blank page)

Contents

Volume 1

Glossary of terms and abbreviations.....	xi
Executive Summary	xxi
1 Introduction.....	41
1.1 The project	41
1.2 Statutory context	42
1.3 Purpose of the document.....	42
2 Clarifications – Air quality.....	47
2.1 Purpose of this chapter	47
2.2 Chapter outline	48
2.3 Changes since the exhibition of the environmental impact statement.....	51
2.4 Project description	51
2.4.1 Road grade and tunnel design	52
2.4.2 Ventilation system and facilities	52
2.5 Ventilation system design criteria	56
2.5.1 Design capacity of the project’s ventilation system.....	58
2.5.2 Compliance with design criteria and operational monitoring	63
2.6 Assessment philosophy and conservatism	63
2.6.1 Approach taken to the assessment	63
2.6.2 Assumptions and conservatism	65
2.7 Traffic volumes and assessment scenarios	75
2.7.1 Forecast traffic volumes.....	75
2.7.2 Scope of the operational air quality impact assessment	109
2.7.3 Assessment scenarios.....	121
2.8 Emissions inventories	129
2.8.1 Emission factors.....	129
2.8.2 Project tunnel emissions inventories	131
2.8.3 Surface road emissions inventories	168
2.9 In-tunnel air quality	168
2.9.1 Design and intended operation of the ventilation system	168
2.9.2 In-tunnel air quality for air quality impact assessment scenarios.....	170
2.9.3 Variability of in-tunnel air quality	177
2.10 Meteorological data and modelling.....	178
2.10.1 Set up of the MM5 and CALMET models	178
2.10.2 Wind data from the Sydney airport.....	185
2.10.3 Validation of the CALMET and MM5 models.....	189
2.10.4 Calm and low wind speed conditions	190
2.10.5 Sensitivity to calm and low wind speed conditions.....	195
2.10.6 Local meteorological monitoring data.....	196

2.11	Ambient air quality	206
2.11.1	Approach taken for the project	206
2.11.2	Approach to particulate matter concentrations (PM _{2.5})	211
2.11.3	Representativeness of background air quality data	213
2.12	Local and regional terrain.....	219
2.12.1	Terrain data used in the air quality impact assessment	219
2.12.2	Sensitivity analysis of terrain data.....	220
2.13	Dispersion modelling.....	222
2.13.1	Receiver location grids	222
2.13.2	Ventilation outlet modelling (CALPUFF).....	225
2.13.3	Surface road modelling (CAL3QHCR).....	232
2.14	Post-processing of model outputs	247
2.14.1	Cumulative impacts – consideration of background air quality.....	247
2.14.2	Atmospheric reactions – oxides of nitrogen.....	293
2.15	Operational impact assessment	303
2.15.1	Air quality modelling results (increased ventilation outlet height)	304
2.15.2	Further analysis of air quality modelling results (increased ventilation outlet height) 309	
2.15.3	Conclusions.....	343
2.16	Construction air quality	347
2.16.1	Overview of relevant construction activities.....	347
2.16.2	Tunnel excavation	348
2.16.3	Construction program	353
2.16.4	Construction plant and equipment.....	354
2.16.5	Spoil and waste disposal	355
2.16.6	Construction vehicles	356
2.16.7	Construction emission sources	356
2.16.8	Construction motor vehicles and plant	357
2.16.9	Earth moving, excavation and demolition.....	358
2.16.10	Construction water treatment.....	360
2.16.11	Construction air quality management.....	361
3	Clarifications – Ventilation system design	363
3.1	Availability and effectiveness of in-tunnel air treatment systems	363
3.1.1	Availability of in-tunnel air treatment technologies	363
3.1.2	International experience	366
3.1.3	Summary.....	369
3.2	Alternative ventilation design configurations	370
3.2.1	Options and alternatives	370
3.2.2	Scenario 1 – Changes in ventilation outlet height.....	372
3.2.3	Scenario 2 – Relocation of northern and southern ventilation outlets.....	389
3.2.4	Scenario 3 – Addition of intermediate ventilation outlet(s)	403
3.2.5	Scenario 4 – Changes in ventilation flow rates	423

3.2.6	Scenario 5 – Treatment of in-tunnel air or ventilation discharges	428
3.2.7	Summary of scenario analysis	436
4	Clarifications – Other issues.....	443
4.1	Use of generators to power road headers prior to mains power connection	443
4.1.1	Description	443
4.1.2	Environmental assessment.....	444
4.2	Southern ventilation offtake.....	445
4.2.1	Description	445
4.2.2	Environmental assessment.....	445
4.3	Storage of materials at the Darling Mills Creek construction compound (C2)	449
4.3.1	Description	449
4.3.2	Environmental assessment.....	449
4.4	Positioning of noise barriers near Coral Tree Drive.....	453
4.4.1	Description	453
4.4.2	Environmental assessment.....	454
4.5	Construction noise mitigation and management measures	465
4.5.1	Description	465
4.5.2	Environmental assessment.....	469

Volume 2

5	Community involvement	483
5.1	Consultation overview	483
5.2	Consultation activities	483
5.2.1	Static display of the environmental impact statement	484
5.2.2	Advertisements in local and regional publications	485
5.2.3	Community drop-in sessions.....	485
5.2.4	Air quality forum	486
5.2.5	Staffed static displays	486
5.2.6	Letters, emails and phone calls.....	487
5.2.7	1800 number and project email.....	487
5.2.8	Project overview document.....	488
5.2.9	Project fact sheets and brochures.....	488
5.2.10	Community updates.....	489
5.2.11	Website updates.....	489
5.2.12	Meetings with property owners	489
5.2.13	Meetings and briefings with stakeholders.....	489
5.2.14	Other consultation activities	491

5.3	Ongoing consultation during construction and commissioning	491
5.4	Ongoing consultation during operation	492
6	Submissions received	493
6.1	Respondents	493
6.2	Overview of the issues raised	493
6.2.1	Government agencies	494
6.2.2	Local councils.....	495
6.2.3	Other key stakeholders.....	496
6.2.4	Community	496
7	Responses to key stakeholder submissions.....	499
7.1	Government agencies.....	499
7.1.1	Environment Protection Authority.....	499
7.1.2	NSW Health	551
7.1.3	Fisheries NSW	587
7.1.4	Agriculture NSW.....	587
7.1.5	Crown Lands	587
7.1.6	NSW Office of Water	587
7.1.7	Office of Environment and Heritage	609
7.1.8	Office of Environment and Heritage – Heritage Council.....	615
7.2	Local councils.....	619
7.2.1	Hornsby Shire Council.....	619
7.2.2	The Hills Shire Council	667
7.2.3	Ku-ring-gai Council	675
7.3	Peak groups and advisory organisations	717
7.3.1	National Roads and Motorists' Association (NRMA).....	717
7.3.2	Public Health Association of Australia	719
7.3.3	Woolcock Institute of Medical Research.....	736
7.3.4	Asthma Foundation of NSW	754
7.4	Schools	761
7.4.1	Abbotsleigh	761
7.4.2	Loreto Normanhurst.....	762
7.4.3	Knox Grammar School	768
7.5	Churches and places of worship	769
7.5.1	Chinese and Australian Baptist Church.....	769
7.5.2	St Paul's Anglican Church	772
7.6	Hospitals and aged care facilities	774
7.6.1	Sydney Adventist Hospital	774
7.7	Elected representatives.....	781
7.7.1	The Hon Barry O'Farrell MP – State Member for Ku-ring-gai.....	781
7.7.2	Mr Matt Kean MP – State Member for Hornsby	785
7.7.3	Dr Mehreen Faruqi MLC – Member of the NSW Legislative Council.....	788
7.7.4	The Hon Philip Ruddock MP – Federal Member for Berowra.....	795

7.7.5	Mr Paul Fletcher MP – Federal Member for Bradfield.....	797
-------	---	-----

Volume 3

Response to community submissions	801
8.1 Strategic justification and project need	801
8.1.1 Need for the project	801
8.1.2 Justification	802
8.1.3 Project funding	806
8.1.4 Tolling and heavy vehicle regulation	812
8.2 Project development and alternatives.....	815
8.2.1 Strategic alternatives	815
8.2.2 Options development.....	818
8.2.3 Tender process and alternative tender designs	824
8.2.4 Preferred tender design refinements.....	826
8.2.5 Selection of surface infrastructure locations	837
8.2.6 Out of scope.....	844
8.3 Project.....	865
8.3.1 Construction program	865
8.3.2 Construction methods.....	866
8.3.3 Location and layout of construction compounds.....	868
8.3.4 Operational design	872
8.4 Planning and statutory requirements.....	877
8.4.1 Approval process.....	877
8.4.2 Adequacy and independence of the environmental impact statement.....	885
8.4.3 Statutory requirements and other approvals.....	897
8.5 Consultation	901
8.5.1 Level and quality of consultation	901
8.5.2 Consultation during exhibition.....	910
8.5.3 Future consultation.....	919
8.5.4 Endorsements of other submissions	922
8.6 Construction traffic.....	923
8.6.1 Traffic numbers and routes	923
8.6.2 Network performance	933
8.6.3 Public transport and emergency services.....	938
8.6.4 Impacts to pedestrians and cyclists.....	939
8.6.5 Traffic safety.....	943
8.7 Operational traffic	947
8.7.1 Traffic forecasts and modelling	947
8.7.2 Network performance	957
8.7.3 Pedestrians and cyclists	965
8.7.4 Traffic safety.....	968

8.7.5	Incident response	971
8.8	Construction noise and vibration	973
8.8.1	Airborne noise	973
8.8.2	Ground-borne noise.....	978
8.8.3	Vibration from surface works	979
8.8.4	Vibration from tunnelling works	980
8.8.5	Traffic noise.....	982
8.8.6	Noise from out of hours works	985
8.8.7	Traffic noise from out of hours works	989
8.8.8	Cumulative noise impacts.....	990
8.8.9	Property damage and existing condition surveys.....	991
8.9	Operational noise and vibration.....	993
8.9.1	Traffic noise.....	993
8.9.2	Vibration.....	997
8.9.3	Noise attenuation	998
8.9.4	Provision and location of noise barriers.....	999
8.9.5	At-property acoustic treatment	1006
8.9.6	Noise from ancillary facilities.....	1007
8.9.7	Modelling and assessment methodology.....	1010
8.10	Construction air quality	1018
8.10.1	Dust generation	1018
8.10.2	Emissions from plant and equipment	1019
8.10.3	Odour impacts during construction.....	1020
8.11	Operational air quality	1021
8.11.1	Assessment methodology	1021
8.11.2	Ventilation system	1043
8.11.3	Impacts around the northern ventilation outlet.....	1062
8.11.4	Impacts around the southern ventilation outlet	1065
8.11.5	Tunnel support facilities	1066
8.11.6	In-tunnel air quality	1067
8.11.7	Air quality improvements along Pennant Hills Road	1070
8.11.8	Air quality monitoring.....	1070
8.11.9	Odour impacts.....	1073
8.11.10	Impacts from surface roads	1074
8.12	Health.....	1077
8.12.1	Assessment methodology	1077
8.12.2	Impacts around the northern ventilation outlet.....	1084
8.12.3	Impacts around the southern ventilation outlet	1086
8.12.4	In-tunnel	1087
8.12.5	Asthma.....	1088
8.12.6	Benefits along Pennant Hills Road.....	1089

8.12.7	Noise and vibration.....	1089
8.12.8	General health impacts.....	1091
8.13	Urban design, landscape character and visual amenity	1099
8.13.1	Construction light spill.....	1099
8.13.2	Construction visual impact.....	1100
8.13.3	Operational landscape character impact	1101
8.13.4	Operational visual impact	1103
8.13.5	Operational urban design and landscaping	1109
8.13.6	Operational light spill	1114
8.14	Biodiversity	1117
8.14.1	Vegetation clearing.....	1117
8.14.2	Impacts to endangered ecological species.....	1119
8.14.3	Aquatic environment and changes to hydrology	1121
8.14.4	Indirect and other impacts.....	1122
8.14.5	Biodiversity management and offsets.....	1123
8.15	Social and economic.....	1125
8.15.1	Social and community impacts.....	1125
8.15.2	Construction amenity and traffic.....	1127
8.15.3	Operational amenity and traffic	1130
8.15.4	Impacts to economic output.....	1132
8.16	Hydrogeology and soils.....	1133
8.16.1	Construction erosion and sedimentation	1133
8.16.2	Construction groundwater impacts.....	1133
8.16.3	Settlement.....	1134
8.16.4	Operational groundwater impacts	1137
8.17	Surface water	1139
8.17.1	Construction water quality, treatment and discharge	1139
8.17.2	Construction hydrology and flooding	1139
8.17.3	Operational drainage infrastructure.....	1140
8.17.4	Operational water quality, treatment and discharge.....	1140
8.17.5	Operational hydrology and flooding.....	1142
8.18	Non-Aboriginal heritage	1143
8.18.1	Direct impacts to heritage items.....	1143
8.18.2	Impacts to heritage conservation areas.....	1144
8.18.3	Potential indirect impacts.....	1145
8.19	Aboriginal heritage.....	1149
8.19.1	Potential impacts to Aboriginal heritage items.....	1149
8.20	Land use and property	1153
8.20.1	Property acquisition.....	1153
8.20.2	Utility and local road impacts	1155
8.20.3	Future development impacts and opportunities	1157
8.20.4	Property values	1158

8.20.5	Compensation	1160
8.20.6	Property damage	1161
8.21	Hazards and risk	1163
8.21.1	Construction tunnelling risks	1163
8.21.2	Electric and magnetic fields	1164
8.21.3	Incidents in the tunnel	1164
8.21.4	Bushfires	1169
8.22	Resources and waste	1171
8.22.1	Construction spoil management and management	1171
8.22.2	Other construction waste	1173
8.22.3	Construction resource use	1173
8.22.4	Operational resource use	1174
8.22.5	Peak oil	1174
8.23	Greenhouse gas and climate change	1177
8.23.1	Construction greenhouse gas emissions	1177
8.23.2	Operational greenhouse gas emissions	1177

Volume 4

9	Preferred Infrastructure Report	1179
9.1	Overview	1179
9.2	Increased height of the ventilation outlets (plus five metres)	1181
9.2.1	Description of changes	1181
9.2.2	Environmental overview of changes	1181
9.2.3	Ambient air quality	1181
9.2.4	Human health	1199
9.2.5	Operational visual impacts	1201
9.3	Bus movements from the Pioneer Avenue compound (C8)	1219
9.3.1	Description of changes	1219
9.3.2	Environmental overview of changes	1219
9.3.3	Construction traffic and transport	1219
9.3.4	Construction traffic noise	1221
9.3.5	Summary and justification	1221
9.4	Amended construction haulage routes	1223
9.4.1	Description of changes	1223
9.4.2	Environmental overview of changes	1249
9.4.3	Construction traffic and transport	1249
9.4.4	Construction traffic noise	1263
9.4.5	Summary and justification	1277
9.5	Additional construction use at the Junction Road compound (C11)	1279
9.5.1	Description of changes	1279
9.5.2	Environmental overview of changes	1279

9.5.3	Construction traffic and transport	1279
9.5.4	Construction noise and vibration.....	1279
9.5.5	Summary and justification.....	1280
9.6	Additional property acquisition at the Wilson Road compound (C6)	1283
9.6.1	Description of changes	1283
9.6.2	Environmental overview of changes.....	1283
9.7	Conclusion.....	1284
10	Revised summary of mitigation measures	1285
11	Conclusion and next steps	1313
12	References	1315

Appendices

Appendix A	Stakeholder identification numbers
Appendix B	Wind roses

(blank page)

5 Community involvement

5.1 Consultation overview

The environmental impact statement was exhibited for 60 days from 15 July 2014 to 12 September 2014. During this time, a range of consultation activities were undertaken to engage with stakeholders and local communities on information in the environmental impact statement, to encourage participation in exhibition activities and to provide guidance on the submissions process. Submissions on the project were received by the Department of Planning and Environment during the exhibition period. Responses to issues raised in submissions received during the public exhibition are outlined in **Chapter 7** and **Chapter 8** of this report.

5.2 Consultation activities

The NorthConnex project team (including representatives from Roads and Maritime, Transurban, the Lend Lease Bouygues Joint Venture and technical and environmental consultants) supported the public exhibition of the environmental impact statement by undertaking a variety of consultation activities including holding community drop-in sessions, briefings and meetings, and distributing a range of information materials.

The following engagement methods, activities and communications materials were used to consult on the environmental impact statement:

- Toll free community information line (1800 997 057).
- Project email (enquiries@northconnex.com.au).
- Project website updates (www.northconnex.com.au).
- Interactive web-mapping tool (http://gisapps.aecomgis.com/northconnex/map_view.html).
- Advertisements in local and regional publications.
- Static displays of the environmental impact statement.
- Community drop-in sessions.
- Air quality forum (29 July 2014).
- Project overview document.
- Project fact sheets, brochures, community drop-in session invitations and display materials.
- Doorknocks to residents.
- Letters and emails to the project mailing list.
- Phone calls and meetings with property owners.
- Stakeholder meetings (including Members of Parliament), Councils, business groups, health care providers, places of worship and educational institutions).
- Targeted stakeholder group briefings (traffic and transport, industry and business, environment and community and real estate agents).
- Establishment of the NorthConnex Community Information Centre at Pennant Hills.
- Place Manager working with impacted residents, tenants and businesses.
- Project database to record correspondence relevant to the project, including contact details, enquiries and issues raised during the life of the project.

5.2.1 Static display of the environmental impact statement

The environmental impact statement and supporting materials were made available to view and download on the Department of Planning and Environment's website, the project website (www.northconnex.com.au) and at the following locations:

- **Department of Planning and Environment Information Centre**, 23-33 Bridge Street, Sydney.
- **NorthConnex Community Information Centre**, 354 – 356 Pennant Hills Road, Pennant Hills.
- **Roads and Maritime North Sydney office**, Level 9, 101 Miller Street, North Sydney.
- **Nature Conservation Council of NSW**, 2/5 Wilson Street, Newtown.
- **The Hills Shire Council**, 3 Columbia Court, Baulkham Hills.
- **Hornsby Shire Council**, 296 Pacific Highway, Hornsby.
- **Ku-ring-gai Council**, 818 Pacific Highway, Gordon.
- **Gosford City Council**, 49 Mann Street, Gosford.
- **Wyong Shire Council**, 2 Hely Street, Wyong.
- **Parramatta City Council**, 30 Darcy Street, Parramatta.
- **Turramurra Library**, 5 Ray Street, Turramurra.
- **Pennant Hills Library**, corner of Ramsey Road and Yarra Road, Pennant Hills.
- **Epping Library**, Chambers Court, Epping.
- **Hornsby Central Library**, 28-44 George Street, Hornsby.
- **Baulkham Hills Library**, Railway Street, Baulkham Hills.

In addition to the above display venues, static displays of the environmental impact statement were also set up at the following locations:

- **Local Members of Parliament electoral offices:**
 - The Hon Dominic Perrottet MP, State Member for Castle Hills, 287C Old Northern Road, Castle Hill.
 - The Hon Philip Ruddock MP, Federal Member for Berowra, Level 7 Tele Tech Building, Suite 701, 423 Pennant Hills Road Pennant Hills.
 - The Hon Barry O'Farrell MP, State Member for Ku-ring-gai, 27 Redleaf Avenue, Wahroonga.
 - Mr David Elliot MP, State Member for Baulkham Hills, Suite 125-33 Old Northern Road, Baulkham Hills.
 - Mr Matt Kean MP, State Member for Hornsby, Suite 5 The Madison 25-29 Hunter Street, Hornsby.
 - Mr Paul Fletcher MP, Federal Member for Bradfield, Level 2, 280 Pacific Highway, Linfield.
 - Mr Greg Smith MP, State Member for Epping, Suite 303, Level 3, 51 Rawson Street, Epping.
 - Mr John Alexander MP, Federal Member for Bennelong, 41-46 Oxford Street, Epping.
 - Mrs Lucy Wicks MP, Federal Member for Robertson, 91 Mann Street, Gosford.

- Mr Alex Hawke MP, Federal Member for Mitchell, 23 Terminus Street, Castle Hill.
- Mrs Karen McNamara MP, Federal Member for Dobell, Shop E1, Westfield Tuggerah, 50 Wyong Road, Tuggerah.

- **Local libraries:**

- North Ryde Library, 201 Coxs Road, North Ryde.
- Carlingford Library, Corner Lloyds Avenue and Boundary Road. Carlingford.
- Erina Library - The Hive, Erina Fair, Terrigal Drive, Erina.
- Tuggerah Library - Westfield Tuggerah, 50 Wyong Road, Tuggerah.

Electronic copies (on CD) were also made available to members of the public on request.

5.2.2 Advertisements in local and regional publications

Advertisements were placed to announce the environmental impact statement public exhibition period and to promote the community information sessions and air quality forum for the project. Advertisements were placed in local and metropolitan press, including:

- *Sydney Morning Herald.*
- *Sydney Daily Telegraph.*
- *North Shore Times.*
- *Hornsby Advocate.*
- *Northern District Times.*
- *Hill Shire District Times.*
- *Central Coast Express Advocate.*
- *Hills News.*
- *Newcastle Herald.*
- *Sing Tao Daily.*
- *Australian Chinese Daily.*
- *Bush Telegraph.*
- *The Sydney Korean Herald.*
- *Ho Ju Dong.*
- *The Indian Link.*

5.2.3 Community drop-in sessions

A total of five community drop-in sessions, attended by around 270 people in total, were held during the environmental impact statement public exhibition period. The community were informed of the drop-in sessions through project advertising, a community update, letters to interest groups who had registered with the project, email notification to registered stakeholders and information on the project website. These community events provided opportunities for members of the community to ask questions of the project team and help to further inform the development of formal submissions regarding the project. The session times and locations are outlined in **Table 5-1.**

Table 5-1 Community drop-in sessions

Location	Date	Time
Pennant Hills Golf Course	Wednesday 23 July 2014	6 pm to 9 pm
Pennant Hills Golf Course	Saturday 26 July 2014	1 pm to 4 pm
Muirfield Golf Course	Thursday 31 July 2014	6 pm to 9 pm
Hornsby RSL	Wednesday 6 August 2014	6 pm to 9 pm
Pennant Hills Community Centre	Saturday 9 August 2014	2 pm to 5 pm

5.2.4 Air quality forum

The project team recognise that potential air quality and associated human health impacts are issues of key interest to the community. This was reinforced through feedback received during the display of the preferred scheme in March 2014 and in preparation of the environmental impact statement. At that time, the commitment was made to hold an air quality specific forum as part of the environmental impact statement public exhibition period. This forum was held on Tuesday 29 July 2014 at Hornsby RSL. Around 700 members of the community and stakeholders attended the forum.

Key project representatives, technical specialists and an independent expert presented the findings of the air quality and human health assessments at the forum. These representatives and specialists were then available to answer questions from community members.

The air quality forum was filmed and the video was subsequently made available on the project website for the community and stakeholders who may not have been able to attend the forum.

5.2.5 Staffed static displays

Additional staffed static displays were provided in the central coast region during the environmental impact statement public exhibition. Staffed static displays provided the opportunity for residents of the Central Coast to engage with members of the project team face to face and to find out more about the project. The display times and locations are summarised in **Table 5-2**.

Table 5-2 Central coast staffed display schedule

Location	Date	Time
Erina Fair Shopping Centre, Erina	16 August 2014	2 pm to 5 pm
Deepwater Plaza Shopping Centre, Woy Woy	19 August 2014	9 am to 5 pm
Imperial Shopping Centre, Gosford	22 August 2014	9 am to 5 pm

5.2.6 Letters, emails and phone calls

Correspondence was distributed during the environmental impact statement public exhibition period to community members, registered stakeholders and interest groups. The correspondence provided a project updates, notifications of the public exhibition period, information on upcoming consultation activities, details on how provide feedback on the project through the submissions process and how to contact the project team for further information. This correspondence comprised:

- Eight email notifications sent during the public exhibition period to over 1,600 registered stakeholders.
- Around 780 letter notifications, sent through the post and email, to general interest groups such as community and environmental groups, transport providers, peak bodies, local places of worship, hospitals, aged care facilities and educational institutions.
- Around 250 invitations, sent through the post and email, for a briefing on the environmental impact statement sent to community, environment, business, industry and transport interest groups.

Further consultation was also conducted with key sensitive stakeholders via phone, email and post, notifying of the environmental impact statement public exhibition and offering a briefing with the project team. This included:

- Sixty-nine places of worship.
- One hundred and thirty educational institutions.
- Thirty-nine health providers and organisations.

Letters were also sent to raise awareness to residents who had been identified in the environmental impact statement as potentially eligible for consideration of at-property noise treatment, and those who may be impacted during construction and / or operation by changes to existing noise walls. Confirmation of the nature and extent of these potential impacts would be determined during the detailed design, which would include further consideration of potential operations noise impacts.

5.2.7 1800 number and project email

Various ongoing communication channels were also made available for the community and stakeholders to contact the project team for more information during the exhibition period. These included:

- Project free call number – 1800 997 057.
- Project email address – enquiries@northconnex.com.au.

Over 1,800 members of the community registered on the email distribution list to receive ongoing community updates by the close of the exhibition period.

The project 1800 number and email address were also monitored throughout the environmental impact statement public exhibition period. A summary of phone and email contacts is provided in **Table 5-3**.

Table 5-3 1800 number and email statistics 15 July 2014 – 12 September 2014

Activity	Total
Project 1800 phone calls received	275
Phone calls made	274
Project emails received	280
Emails sent by the project team	307

5.2.8 Project overview document

A project overview document was made available to coincide with the public exhibition period. The document presents an overview of the project, a summary of community consultation to date, some of the key findings of the environmental impact statement and the environmental impact assessment process. Readers were provided with details of how to view the full environmental impact statement and encouraged to make a submission.

The project overview document was posted on the project website and made available at the community information sessions and on request. Over 700 of these documents have been distributed.

5.2.9 Project fact sheets and brochures

Several project fact sheets and brochures were available during the environmental impact statement public exhibition process. These included:

- Northern interchange fact sheet.
- Southern interchange fact sheet.
- Trelawney Street construction compound fact sheet.
- Wilson Road construction compound fact sheet.
- Pioneer Avenue construction compound fact sheet.
- Junction Road construction compound fact sheet.
- Northern ventilation outlet fact sheet.
- Hills M2 Motorway integration fact sheet.
- Tunnelling near your home fact sheet.
- How to make a submission fact sheet.
- Air quality and the northern interchange at Wahroonga brochure.
- Air quality and the southern interchange at West Pennant Hills brochure.
- Air quality information brochure (provided at the air quality forum).

5.2.10 Community updates

Around 23,500 copies of the community updates were letterbox dropped to stakeholders and community members within the project footprint as follows:

- Community update No. 4 July 2014 – notification of the environmental impact statement public exhibition period and advertising community drop-in sessions.
- Community update No. 5 September 2014 – notification of the close of the environmental impact statement public exhibition and clarification regarding key issues raised during the public exhibition period.

5.2.11 Website updates

The NorthConnex project website (www.northconnex.com.au) was updated during the public exhibition period. Website links to the full environmental impact statement and the project summary document were posted on the website. The documents were broken down into multiple smaller files to assist the community and stakeholders in downloading sections of relevance and interest to their unique concerns. Information was also made available regarding the community drop-in sessions and visitors were provided with guidance on how to make a submission (electronic or hard copy) to the Department of Planning and Environment.

In addition, an interactive mapping tool was updated to assist community members and property owners in understanding more about the project and its proposed alignment. The tool shows an approximate depth and distance measure for properties within 50 metres to the outside of the proposed tunnel alignment.

5.2.12 Meetings with property owners

Potentially directly impacted property owners were offered a one-on-one meeting with Roads and Maritime project staff and members of the project team. Over 20 meetings were held during the exhibition period to discuss the environmental impact statement, potential impacts and other issues associated with the project.

Additionally, doorknocks to over 320 properties were conducted around the sites of proposed surface infrastructure to raise awareness of the project in these areas and to provide further information regarding the proposal, potential project benefits and impacts and the project approval process.

5.2.13 Meetings and briefings with stakeholders

During the exhibition period, a number of meetings and briefings were held with stakeholders. These provided stakeholders with an opportunity to obtain an overview of the environmental impact statement from the project team and to discuss issues of interest. During the meetings and briefings, stakeholders were also encouraged to make formal submissions to the Department Planning and Environment. **Table 5-4** lists the stakeholder meetings and briefings held during the public exhibition period.

Table 5-4 Stakeholder organisations consulted during the public exhibition period

Working group	Stakeholder	Meeting / briefing
State and Federal Government	State and Federal Members of Parliament (MP)	24 July 2014
	Mr Matt Kean MP	28 July 2014
	Mr David Elliott MP	8 August 2014
	Mrs Karen McNamara MP	12 September 2014
Local government	Ku-ring-gai Council (Councillors)	12 August 2014 2014
	Ku-ring-gai Council (council staff)	28 July 2014
	Hornsby Shire Council (Councillors)	30 July 2014
	Hornsby Shire Council (council staff)	4 August 2014
	The Hills Shire Council (Councillors)	5 August 2014
	The Hills Shire Council (council staff)	6 August 2014
	Wong Shire Council (Councillors)	27 August 2014
Environmental impact statement interest groups	General interest groups	30 July 2014
	Real estate agents	30 July 2014
Utility, industry and service providers	National Roads and Motorists Association (NRMA)	24 July 2014
	NSW Road Freight Industry Council	8 August 2014
	Colliers International Presentation – local businesses	14 August 2014
Local stakeholder organisations	Royal Institute for Deaf and Blind Children	25 July 2014
	NSW Public Schools Directors	30 July 2014
	Knox Grammar School	31 July 2014
	Loreto Normanhurst	11 August 2014
	Thornleigh Hillcrest Uniting Church	11 August 2014
	Abbotsleigh School	12 August 2014
	Asthma Australia (Asthma Foundation)	2 September 2014
	Association of Independent Retirees Ltd (Sydney Hills District Branch)	5 September 2014
	Community Against Polluting Stacks (CAPS)	11 September 2014
	Australian Medical Association	11 September 2014

5.2.14 Other consultation activities

NorthConnex project community information centre

The NorthConnex project community information centre is located at 354 – 356 Pennant Hills Road, Pennant Hills. During the environmental impact statement public exhibition period the information centre was opened three days per week from the 17 July 2014 through to 11 September 2014 as follows:

- Monday 9 am to 4 pm.
- Thursday 9 am to 4 pm.
- Saturday 10 am to 2 pm.

The information centre was staffed by members of the project team who were available to discuss the project and to answer enquiries.

A total of 365 members of the community attended the information centre during the exhibition period.

Place Manager

A Roads and Maritime Place Manager proactively engaged with individuals, businesses and community groups potentially impacted by the project's construction and operational sites through doorknocking, phone calls, emails and one-on-one meetings. The Place Manager attended the community information sessions to provide continuity in engagement with potentially impacted residents attending the sessions. The Place Manager also played an integral role in the property acquisition process.

5.3 Ongoing consultation during construction and commissioning

Consultation on the project will continue throughout the remainder of the planning process and into the construction period. The 1800 number and email address will continue to operate, and the website will be updated as the project progresses.

The Community Communications Framework in Appendix D of the environmental impact statement provides the basis for the Community Liaison Implementation Plan that would be developed and implemented for the project (subject to obtaining planning approval). This document would guide the consultation process during the design and construction phase of the project. The Community Communications Framework also provides information on consultation strategies around specific environmental and community issues. This includes:

- The formation of a Traffic and Transport Liaison Group to discuss traffic management and road safety matters during construction.
- Methods of disseminating changes in traffic conditions to the community and stakeholders.
- Consultation requirements during the development of the Urban Design and Landscape Plan.
- Targeted consultation in relation to out of hours works.

A public display centre, similar to the current community information centre, will also remain open (9 am to 5 pm Monday to Friday, excluding public holidays), offering all community and stakeholders the opportunity to drop in and speak with project team members for up to date information about the project.

Community relations staff will be the key point of contact between the project and the community. Their contact details will be available at all construction sites as well as via the project website.

Regular stakeholder meetings will also be held with councils, businesses and other groups.

The project team and its contractors will continue to work in partnership with communities during construction. The priority will be to ensure that people have an understanding of the proposed works and the points of contact for each of the proposed worksites.

During construction, stakeholders and the community will be kept informed of significant events or changes that might affect individual properties, residences and businesses, including:

- Significant milestones.
- Significant work method changes.
- Changes to traffic conditions and road access arrangements.
- Construction operations that could have a direct impact including noisy works, interruptions to utility services or work outside of normal hours.

5.4 Ongoing consultation during operation

Community liaison will continue during the operation phase of the project. Community consultation protocols will be established within an Operational Environmental Management Plan. This will include protocols for:

- Ongoing management of community complaints during operations.
- Community notifications prior to major maintenance activities.
- Wider notifications of major maintenance activities that require full tunnel carriageway closures.

6 Submissions received

6.1 Respondents

Submissions in response to the environmental impact statement were accepted by the Department of Planning and Environment during the public exhibition period (a period of 60 days from 15 July 2014 to 12 September 2014). Submissions were accepted by:

- Electronic submission (online) – www.majorprojects.planning.nsw.gov.au
- Email – plan_comment@planning.nsw.gov.au
- Fax – (02) 9228 6335
- Post – Major Projects Assessment, Department of Planning and Environment, GPO Box 39, Sydney, NSW, 2001

A total of 1,518 submissions were received in response to the environmental impact statement. The submissions were received from 1,251 different stakeholders, as summarised in **Table 6-1**.

Table 6-1 Summary of submissions received

Submission group type	Number of separate submitters*
Individual	1,206
State government agencies	5
Local councils	3
Interest groups/ organisations	29
Businesses	3
Elected representatives	5
Total	1,251

* Note that submitter details were withheld at the request of some submitters. In the absence of being able to identify each submitter, these submission statistics may overestimate the number of different submitters.

6.2 Overview of the issues raised

Each submission has been individually examined in detail to understand the issues being raised. The issues raised in each submission have been extracted and collated, and corresponding responses to the issues have been provided. Where similar issues have been raised in different submissions, these have been amalgamated together and only one response has been provided. Care has been taken in this process to preserve the specific details of each issue raised. In some cases, certain sections of submissions received were redacted by the Department of Planning and Environment prior to the submissions being provided to the proponent for analysis and response.

Submission authors have not been identified in this report (excluding agencies, councils and other key stakeholders). Submission authors have been assigned a unique identification number which is referred to in this report as a 'stakeholder identification number'. Letters have been sent to each submission author (where contact details have been provided) to advise of the author of its unique stakeholder identification number and the availability of this report. Approximately 563 submission authors selected to not disclose their contact information, therefore these individuals have not received a letter.

The issues that were raised most frequent in submissions were:

- Project development and alternatives.
- Health impacts.
- Planning and statutory requirements.
- Construction traffic impacts.
- Consultation.
- Urban design, landscape character and visual impacts.

6.2.1 Government agencies

Five government agencies made submissions, raising a range of issues relevant to their respective areas of interest and responsibility. Some recommendations for conditions of approval were also made. A high level summary of each agency's issues is provided below with detailed responses provided in **Chapter 7**.

Environment Protection Authority

The Environment Protection Authority raised issues relating to:

- The need for an environment protection licence during construction.
- Water quality and discharges during construction and operation.
- Operational air quality including clarifications of inputs and assumptions in the air dispersion modelling.
- Construction noise and vibration including consideration of further mitigation and management measures.
- Operational noise including clarifications of inputs to the noise modelling.

NSW Health

NSW Health raised issues relating to:

- In-tunnel air quality, including calculation of in-tunnel concentrations of vehicle emissions, health impacts of exposures to in-tunnel air and comparisons with the performance of other road tunnels.
- Ambient air quality including assumptions and inputs into the air dispersion modelling, and consequences for human health risks.
- The need to consider all feasible and reasonable measures to minimise in-tunnel and ambient exposures to vehicle emissions.

Department of Primary Industries

The Department of Primary Industries submission included responses from Fisheries NSW, Agriculture NSW, Crown Lands and the NSW Office of Water. Issues raised included:

- Potential for future operational stage licencing (water).
- Impacts associated with ongoing groundwater inflows in the project tunnels and the extent and impacts of groundwater drawdown.
- Impacts on surface water and groundwater sources, including potential loss of base flows in surface watercourses.
- Impacts on groundwater dependent ecosystems.

Office of Environment and Heritage

The Office of Environment and Heritage raised issues on biodiversity impacts of the project, Aboriginal heritage and potential flooding impacts. These included:

- Calculation of the biodiversity impacts and offset requirements for the project.
- Potential impacts on groundwater dependent ecosystems associated with groundwater drawdown.
- Consideration of protection of project infrastructure from the probable maximum flood level.

Heritage Council of NSW

The Heritage Council of NSW raised issues relating to:

- The potential impacts of acoustic treatments on heritage listed properties.
- Impacts associated with the former Thornleigh Maltworks site.

6.2.2 Local councils

Ku-ring-gai Council, Hills Shire Council and Hornsby Shire Council each made a submission which raised a range of issues, including:

- The need for ongoing consultation with local councils and the community.
- Construction traffic, especially haulage routes and the use of local roads.
- Operational traffic.
- Construction noise and vibration including impacts from works outside of standard construction hours.
- Operational noise from increased traffic volumes and from fixed infrastructure.
- Operational air quality including requesting clarification of the inputs to the air dispersion modelling, the consideration of filtration systems and the need for operational stage monitoring.
- The human health impacts associated with ambient and in-tunnel air quality.
- Visual impacts, including future landscape treatments and the urban design of fixed infrastructure.
- Surface water impacts especially associated with the discharge of treated groundwater during construction and operation.

- Non-Aboriginal heritage impacts associated with the former Thornleigh Maltworks site and potential impacts to locally listed non-Aboriginal heritage items.
- Biodiversity impacts and biodiversity offset requirements.
- Impacts to property values.

Detailed responses to the issues raised by local councils are provided in **Chapter 7**.

6.2.3 Other key stakeholders

Other key stakeholder included:

- Peak groups and advisory organisations, including the National Roads and Motorists' Association (NRMA), the Public Health Association of Australia (PHAA) and the Woolcock Institute for Medical Research.
- Schools, including Abbotsleigh, Loreto Normanhurst and Knox Grammar School.
- Churches and places of worship, including the Chinese and Australian Baptist Church and St Paul's Anglican Church.
- Elected representatives (State and Federal).

Detailed responses to the issues raised by these key stakeholders are provided in **Chapter 7**.

6.2.4 Community

Community submissions have raised a range of issues depending on the respondent's location in relation to the project, and the particular interests of the respondent. Community submissions include community groups. The main issues raised in community submissions include:

- Details of the project ventilation system.
- The operational air quality assessment methodology.
- The selection of surface infrastructure locations, especially the locations of the ventilation outlets.
- Human health impacts, mainly associated with operational air quality.
- The human health risk assessment methodology.

Responses to community submissions are provided in **Chapter 8**. Stakeholder identification numbers and the relevant section of the report where each stakeholder's issues are addressed are provided in **Appendix A**.

Petitions

Four petitions were received in response to the environmental impact statement. In summary the details of these petitions are:

- Petition 1 – containing 176 signatures from residents around the Trelawney Street site relating to construction traffic, construction worker parking in local streets, construction vehicle air pollution and noise impacts.
- Petition 2 – containing 42 signatures from residents of the Woniara Retirement Village relating to the location of the northern ventilation facility and potential impacts to human health.
- Petition 3 – containing 260 signatures from doctors in relation to the impacts of air pollution on human health.
- Petition 4 – containing 31 signatures on behalf of school children in the vicinity of the northern ventilation outlet relating to the location of the northern ventilation facility and potential impacts to human health.

Form letters

In total 605 individual form letters were received which constituted 15 different form letters.

Responses to the issues raised in these form letters are provided as part of the responses to community submissions in **Chapter 8**.

(blank page)

7 Responses to key stakeholder submissions

7.1 Government agencies

7.1.1 Environment Protection Authority

7.1.1.1 Environment protection licensing

Issue description

In accordance with Schedule 1 of the *Protection of the Environment Operations Act 1997*, the NorthConnex project will require an environment protection licence for construction. The proponent will need to make a separate application to the Environment Protection Authority for this licence if project approval is granted.

The Environment Protection Authority has met with the preferred tenderer and Roads and Maritime to discuss the potential environment protection licence and the Environment Protection Authority's expectations regarding:

- A Community Relations Strategy.
- Requirements for works outside of standard construction hours.
- Early formation and convening of an Environment Review Group (ERG) involving State agencies and local councils.

Response

The need to obtain an environment protection licence for construction of the NorthConnex project is identified in Section 2.4.1 of the environmental impact statement.

The development of a community liaison implementation plan for the construction phase of the project is identified in Section 6.6.1 of the environmental impact statement. Appendix D of the environmental impact statement provides the framework for this document. The plan includes a commitment to forming a government agency liaison group and a local council liaison group, as forums for ongoing consultation with those stakeholders.

The Environment Protection Authority would continue to be consulted in relation to an application for an environment protection licence for construction of the NorthConnex project.

7.1.1.2 Water quality

Issue description

The environmental impact statement does not state the relevant Water Quality Objectives and environmental values for the receiving waters of the project or any indicators and associated trigger values for these environmental values.

The Director-General's environmental assessment requirements for the project specified that *"The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000), and any applicable regional, local or site-specific guidelines"*.

It should also be noted that under section 45(f1) of the *Protection of the Environment Operations Act 1997*, the Environment Protection Authority is required to take the environmental values of receiving waters into consideration in its licensing decisions.

The Environment Protection Authority recommends that the assessment of the project take into account:

- A statement of the ambient Water Quality Objectives (WQOs) and the environmental values for the receiving waters relevant to the project. These refer to the community's agreed environmental values and human uses endorsed by the NSW Government as goals for ambient waters (<http://www.environment.nsw.gov.au/ieo/index.htm>).
- A statement of the indicators and associated trigger values or criteria for the identified environmental values.

Response

An assessment of potential surface water impacts is provided in Section 7.9 of the environmental impact statement. This assessment has considered the existing environment of the two main catchments being the Hawkesbury-Nepean Catchment and the Sydney Metropolitan Catchment, and the associated sub-catchments.

Further development of surface water management, including construction and operational water treatment requirements, specific discharge locations and detailed discharge designs would be conducted during the detailed design phase. Based on current design development, it is expected that treated construction and operational water would be discharged to the relevant local stormwater system, which would eventually drain into watercourses in the area. A summary of catchments and watercourses likely to be affected by project water discharges is provided in **Table 7-1**.

Table 7-1 Anticipated water discharges and affected catchments

Source	Catchment	Likely receiving watercourse
Construction phase		
Southern interchange compound (C5)	Sydney Metropolitan Catchment, Parramatta River Subcatchment	Blue Gum Creek/ Darling Mills Creek
Wilson Road compound (C6)	Hawkesbury-Nepean Catchment, Berowra Creek Subcatchment	Tedbury Creek/ Berowra Creek
Trelawney Street compound (C7)	Sydney Metropolitan Catchment, Lane Cove River Catchment	Coups Creek
Northern interchange compound (C9)	Sydney Metropolitan Catchment, Lane Cove River Catchment	Coups Creek
Operational phase		
Motorway operations complex	Sydney Metropolitan Catchment, Parramatta River Subcatchment	Blue Gum Creek/ Darling Mills Creek

The environmental impact statement identifies the expected volume and quality of point source discharges during the construction and operational phases of the project.

The proposed quality of water that would be discharged from water treatment plants during the construction and operation of the NorthConnex project has been determined with reference to the ecosystem protection levels outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). The environmental impact statement indicates that the project has been designed to:

- Achieve discharge water quality during construction up to the 80 per cent protection level for freshwater ecosystems (ANZECC, 2000).
- Achieve discharge water quality during operation up to the 95 per cent protection level for freshwater ecosystems (ANZECC, 2000).

For each catchment in New South Wales, the State government has endorsed the community's environmental values for water, known as 'Water Quality Objectives' (WQOs). The objectives comprise community-based environmental values and their associated national criteria drawn from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). The New South Wales Water Quality Objectives are the environmental values and long-term goals for consideration when assessing and managing the likely impacts of activities on waterways and are not intended to be applied directly as regulatory criteria, limits or conditions.

The Water Quality Objectives for the Hawkesbury-Nepean Catchment are contained in the final report of the Healthy Rivers Commission (HRC) on the Hawkesbury-Nepean River system (HRC, 1998). The report recommended Water Quality Objectives for nutrients in different regions of the Hawkesbury-Nepean Catchment and the values applicable to the region in which the NorthConnex project is located are presented below.

Table 7-2 Water Quality Objectives for the Hawkesbury-Nepean Catchment

Water quality indicator (µg/L)	Urban areas-main stream	Urban areas – tributary stream
Total phosphorus	30	~50
Total nitrogen	500	~1000
Chlorophyll-a	10-15	~20

The Healthy Rivers Commission process identified environmental values based on community goals and identified water quality objectives and these are outlined in the Hawkesbury-Nepean Catchment Management Action Plan 2007-2016. The environmental values for water in the Hawkesbury-Nepean catchment and its application to the NorthConnex project is presented in the table below.

Table 7-3 Environmental values for water in the Hawkesbury-Nepean Catchment

Location	Environmental values for water
Aquatic ecosystems	The design discharge water quality is based on ANZECC freshwater ecosystem protection levels. The water quality is high than the existing water quality of the receiving waters.
Suitable for primary contact	The immediate receiving waters are not currently used for primary contact recreation activities. The design discharge water quality would ensure that primary contact recreation activities in downstream waters are not affected.
Suitable for secondary contact	The immediate receiving waters are not currently used for secondary contact recreation activities. The design discharge water quality would ensure that secondary contact recreation activities in downstream waters are not affected.
Suitable for visual use	The immediate receiving waters do not currently possess high aesthetic qualities, nor are they located in a location in the landscape of aesthetic importance. The design discharge water quality would ensure that the aesthetic qualities of downstream waters are not diminished.

The Sydney Harbour and Parramatta River catchments have eleven Water Quality Objectives that are applicable for the drainage lines in the Sydney Metropolitan Catchment. These are presented in **Table 7-4**. The table also includes comments in relation to the application of these environmental values and Water Quality Objectives to the NorthConnex project.

By achieving discharge water quality levels applicable to the ANZECC freshwater ecosystem protection levels it is expected that the broader Water Quality Objectives for the Sydney Harbour and Parramatta River Catchments would be met.

As noted by the Environment Protection Authority, discharge quality water limits would be specified in an Environment Protection Licence issued under the *Protection of the Environment Operations Act 1997*. Trigger levels applicable to the licence are best determined by upstream and downstream monitoring of the discharge point or the work zone. Trigger levels would be determined on a case-by-case basis depending on differences in upstream and downstream readings.

Table 7-4 Environmental values and Water Quality Objectives for the Sydney Harbour and Parramatta River catchment

Environmental values	Water Quality Objective	Application to the NorthConnex project
Aquatic ecosystems	Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.	The design discharge water quality is based on ANZECC freshwater ecosystem protection levels. The water quality is high than the existing water quality of the receiving waters.
Visual amenity	Aesthetic qualities of waters	The immediate receiving waters do not currently possess high aesthetic qualities, nor are they located in a location in the landscape of aesthetic importance. The design discharge water quality would ensure that the aesthetic qualities of downstream waters are not diminished.
Secondary contact recreation	Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	The immediate receiving waters are not currently used for secondary contact recreation activities. The design discharge water quality would ensure that secondary contact recreation activities in downstream waters are not affected.
Primary contact recreation	Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.	The immediate receiving waters are not currently used for primary contact recreation activities. The design discharge water quality would ensure that primary contact recreation activities in downstream waters are not affected.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock	The water quality objective does not apply in the Sydney Harbour and Parramatta River Catchments
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	The immediate receiving waters and the downstream waters are not currently used as an irrigation water supply. Notwithstanding, the design discharge water quality would ensure that quality of downstream waters is not affected.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	The immediate receiving waters and the downstream waters are not currently used as homestead water supply. Notwithstanding, the design discharge water quality would ensure that quality of downstream waters is not affected.
Drinking water	Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment	The water quality objective does not apply in the Sydney Harbour and Parramatta River Catchments
Aquatic foods	Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.	The immediate receiving waters are not currently used for the production of aquatic foods. The design discharge water quality would ensure that quality of downstream waters where aquatic food production may take place is not affected. It is also noted that Sydney Harbour is currently closed to commercial fishing activities.

(blank page)

Issue description

The environmental impact statement has not provided any predicted water quality discharge concentrations during the construction and operational phases.

The Environment Protection Authority recommends that assessment be given to the following:

- Identification and estimation of the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point, including residual discharges after mitigation measures are implemented. This should be undertaken for construction and operational phases.
- Assessment of the significance of any identified impacts including consideration of the relevant ambient water quality outcomes. Demonstration of how the proposal will be designed and operated to:
 - Protect the Water Quality Objectives for receiving waters where they are currently being achieved.
 - Contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved.

Response

During the construction phase of the NorthConnex project, the project would discharge treated groundwater that inflows to the tunnel and captured surface water captured at construction sites.

With regard to water quality discharge concentrations for captured groundwater, the environmental impact statement indicates that the project has been designed to achieve discharge water quality concentrations in accordance with the 80 per cent protection level for freshwater ecosystems (ANZECC, 2000).

The concentrations of pollutants in surface water discharged from construction sites would be in accordance with the 100th percentile concentration limits in the environment protection licence for pH, total suspended solids and oil / grease. It is expected that, consistent with other major infrastructure projects, the limits in the environment protection licence would be:

- Oil and grease – none visible.
- pH – 6.5 to 8.5.
- Total suspended solids – 50 milligrams per litre.

During the operational phase of the NorthConnex project, the project would discharge treated groundwater that inflows to the tunnel. The project has been designed to achieve discharge water quality concentrations in accordance with the 95 per cent protection level for freshwater ecosystems (ANZECC, 2000).

The project would be designed and implemented to comply with these design specifications and with any discharge water criteria that may be specified in a planning approval or environment protection licence for the project.

Consideration of the relevant Water Quality Objectives is provided in the response above.

Issue description

The environmental impact statement states that it is anticipated that the discharge water quality requirements for the construction phase would be consistent with the 80 per cent protection level for freshwater ecosystems in accordance to the ANZECC Guidelines. The Environment Protection Authority does not consider the 80 per cent protection level appropriate for this project.

While it is understood that the proposed works are near highly disturbed waterways, the ANZECC Guidelines recommend that *"guideline trigger values for slightly-moderately disturbed systems also be applied to highly disturbed ecosystems wherever possible"*. The Guidelines state that *'the aim is to eventually restore highly disturbed systems to a slightly to moderately disturbed condition'*, and that *'it is not acceptable to allow poor environmental performance or water pollution, simply because a waterway is degraded'*. Additionally, many of the receiving waters drain to sensitive receiving environments (e.g. Ku-ring-gai Chase National Park, Lane Cove National Park and Bidjigal Reserve) through ephemeral streams where there is the potential for little or no dilution to occur before reaching the sensitive receiving environments. Furthermore, the Environment Protection Authority considers the construction phase of nearly four years a significant duration and does not consider the temporary nature of the construction works a valid reason to lower the protection level.

The Environment Protection Authority recommends that, as a minimum, the 95 per cent protection level is considered during the construction phase.

Response

The need for improvements in water quality in disturbed systems is accepted. The proposed discharge water quality is considered to be significantly higher than the current water quality of the receiving watercourses which would contribute to an ongoing improvement in water quality.

The proposal to treat and discharge construction water consistent with the 80 per cent protection level for freshwater ecosystems was determined based on a review of the condition and current water quality of the receiving waters. The review of available water quality data from local creeks was compared to the toxicant trigger levels for freshwater in Table 3.4.1 of the Guidelines. The review has shown that the receiving environments are highly disturbed ecosystems and the concentrations levels of the majority of toxicants are greater than the 80 per cent protection trigger levels that the project has been designed to achieve. As such, the discharge quality from the project would be better than that of the receiving environments and the project would contribute to an improvement of the water quality in the receiving environment.

Notwithstanding, the Environment Protection Authority would continue to be consulted in relation to appropriate discharge water quality criteria for construction and the project would comply with the discharge quality identified in an environment protection licence issued for the project. It is expected that, consistent with other major infrastructure projects, the limits in the environment protection licence would be

- Oil and grease – none visible.
- pH – 6.5 to 8.5.
- Total suspended solids – 50 milligrams per litre.

Issue description

During the construction phase, it is proposed that four water treatment plants would treat construction water, surface water runoff that drains into the tunnels and groundwater inflow and then discharge into receiving waters (stormwater and local waterways). The environmental impact statement has identified that the water treatment would typically involve: flocculation to remove total suspended solids, reverse osmosis to reduce salinity and dissolved solids; and correction of pH level.

The Environment Protection Authority considers it appropriate that assessment is undertaken on the potential, and a requirement to treat, hydrocarbons during the construction phase.

Response

The water treatment methods have been identified as an indication of what might be required in order to achieve an appropriate discharge water quality. This does not preclude other necessary treatments in order to meet the discharge criteria identified in an environment protection licence issued to the project. Hydrocarbons would be treated if identified as a concern during the construction phase.

Issue description

The typical water treatment methods proposed for the operational phase generally appear acceptable, however, consideration of the potential impacts of the use of a biocide in the water treatment plant is needed as additional treatment may be required.

The Environment Protection Authority recommends that assessment be given to the potential impact of the proposed biocide usage on the receiving environment associated with the operational phase water treatment plant.

Response

The water treatment methods have been identified as an indication of what might be required in order to achieve an appropriate discharge water quality. The exact nature of treatment would be determined during the detailed design of the water treatment plant and in consultation with the Environment Protection Authority in relation to the discharge quality.

The potential use and impact of biocide dosing would be further considered as part of this process.

Issue description

The environmental impact statement provides no detailed information about the environmental management measures relating to surface water and groundwater for the construction and operational phases of the project.

Response

Table 7-171 and Table 7-179 of the environmental impact statement provide a number of mitigation measures relevant to groundwater and surface water management during construction. These measures would be further detailed in the construction soil and water quality management plan.

Issue description

The Environment Protection Authority recommends that any conditions of approval include the following:

Prior to works commencing the Proponent must obtain the EPA's approval for a comprehensive Surface Water Management Plan (SWMP) to be developed in consultation with the EPA. The SWMP must include but not be limited to:

- a) *address construction and operation monitoring, management and response arrangements.*
- b) *specifications and design details of the Water Treatment Plants.*
- c) *identification and estimation of the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point for the construction and operation phases.*
- d) *an assessment of the potential impact of discharges on receiving surface waters and human health.*
- e) *a Surface Water Quality Monitoring Program (SWQMP).*
- f) *a Soil and Water Management Plan (SWMP) to cover soil erosion and sediment control measures for any areas that may be disturbed.*

The assessment of the potential impact of discharges on receiving waters must include but not be limited to:

- a) *detailed assessment of baseline data on current water quality in any receiving waters that could be affected by the project.*
- b) *a statement of the ambient Water Quality Objectives (WQOs) and the environmental values for the receiving waters relevant to the proposal.*
- c) *a statement of the indicators and associated trigger values or criteria for the identified environmental values.*
- d) *assessment of the significance of any identified impacts on surface waters including consideration of the relevant ambient water quality outcomes. Demonstration of how the proposal will be designed and operated to:*
 - a. *protect the WQOs for receiving waters where they are currently being achieved.*
 - b. *contribute towards achievement of the WQOs over time where they are not currently being achieved.*
 - c. *use of the appropriate level of protection for each contaminant (for example, contaminants that bioaccumulate should have a 99% protection level).*

The SWQMP must be prepared by a suitably qualified and experienced person and include but not be limited to:

- a) *a statement of the ambient Water Quality Objectives and environmental values for the receiving waters relevant to the proposal.*
- b) *a statement of the indicators and associated trigger values or criteria for the identified environmental values.*
- c) *trigger values for action and associated actions or mitigation measures if trigger values are exceeded.*

- d) *a water quality monitoring program with relevant analytes and with a sampling distribution and frequency appropriate to the nature and extent of potential pollution and activities being conducted onsite.*
- e) *location of discharge points and monitoring locations.*

The SWMP must be prepared by a suitably qualified and experienced person and include but not be limited to:

- a) *soil erosion and sediment control measures that comply with the practices and principles contained in Managing Urban Stormwater- Soils and Construction, Volume 1 (the Blue Book).*
- b) *design calculations and sizing for all clean water diversion bunds and sediment basin(s) on site.*
- c) *plan drawings showing the locations for soil erosion and sediment control practices for the site.*
- d) *written text detailing the installation, monitoring and maintenance requirements for all of the soil erosion and sediment control practices.*
- e) *drawings of any engineering structures such as sediment basin(s) and clean water diversion structures, including design standards and management regimes to return the system to design capacity following rainfall events.*

Response

The Environment Protection Authority's suggested conditions of approval are noted.

7.1.1.3 Air quality

The Environment Protection Authority has reviewed the air quality impact assessment completed for the NorthConnex project. The review has focused on those aspects of the assessment that could materially affect ambient air quality at local sensitive receivers.

Issue description

There are certain inputs into the air quality assessment, for example traffic modelling, where the Environment Protection Authority is an end user of this data and does not have relevant technical expertise to provide a meaningful review. For the purposes of the air quality impact assessment review, the Environment Protection Authority has assumed the traffic modelling completed for the project and adopted in the air quality assessment is accurate.

The Environment Protection Authority does not have sufficient expertise to provide comment on the traffic modelling in any detail.

Response

Robust and realistic traffic data is fundamental to the assessment of many aspects of the project, including in-tunnel air quality and potential ambient air quality impacts. It is recognised that regulatory authorities, the local community and other stakeholders need confidence that the project would be able to meet acceptable outcomes if situations differ from forecasts in the future. To provide confidence about the performance of the project under a range of potential traffic conditions, the environmental impact statement includes assessment of:

- **The expected situation in 2019.** The environmental impact statement includes assessments based on forecast traffic flows in 2019, being the expected year of opening of the project.
- **The expected situation in 2029.** The environmental impact statement includes assessments based on forecast traffic flows in 2029, being ten years after the expected opening of the project.
- **A credible worst case traffic scenario at any time.** This scenario is referred to 'design analysis A' in the environmental impact statement and is based on the maximum traffic design capacity of the project. A more detailed explanation of the derivation of 'design analysis A' is provided later in this section.

By assessing the project under forecast traffic volumes, and up to the maximum design capacity of the project, the full range of potential impacts of the project have been taken into account. This approach provides a high degree of confidence that if there is significant variance in traffic volumes away from forecasts in the future, then the project would still be capable of achieving acceptable environmental outcomes (including in relation to in-tunnel air quality and potential ambient air quality impacts).

To appreciate the implications of different traffic scenarios in the context of in-tunnel air quality and potential ambient air quality impacts, it is relevant to consider:

- The design criteria applied in the development of the project's ventilation system.
- The traffic design capacity of the project.
- The ventilation design capacity of the project.
- Traffic forecasts.

Ventilation system design criteria

The project's ventilation system has been designed to achieve specified in-tunnel air quality outcomes for traffic volumes up to and including the maximum traffic design capacity of the project's main alignment tunnels. The ventilation system design criteria are provided in Table 7-95 of the environmental impact statement and are reproduced below. **Table 7-5** provides additional explanatory comments to provide context to the likely operational mode of the project relative to average traffic speeds and ventilation system design criteria.

Table 7-5 Ventilation system design criteria

Average traffic speed (km/h)	Operational mode	CO design criteria (15 minute)	NO ₂ design criteria (15 minute)	Visibility (extinction coefficient)
80	Normal traffic conditions. Vehicles are moving freely with no congestion effects	50 ppm (57.5 mg/m ³)	0.5 ppm (0.94 mg/m ³)	<0.005 m ⁻¹
60		50 ppm (57.5 mg/m ³)	0.5 ppm (0.94 mg/m ³)	<0.005 m ⁻¹
40	Congested traffic conditions. Vehicles have slowed as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be implemented as average traffic speeds fall towards 40 km/h.	60 ppm (69 mg/m ³)	0.8 ppm (1.51 mg/m ³)	<0.005 m ⁻¹
0 to 20	Significantly congested traffic conditions. Vehicles have slowed significantly as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be in place.	87 ppm (100 mg/m ³)	1.0 ppm (1.88 mg/m ³)	<0.005 m ⁻¹

Traffic design capacity

The project has been designed to operate with two motorway standard traffic lanes in each direction (northbound and southbound). The design capacity of a motorway standard traffic lane is 2,000 passenger car units per hour under free flowing traffic conditions, which is equivalent to 4,000 passenger car units per hour for each of the main alignment tunnels.

'Passenger car units' is a standard, consistent basis for measuring the 'space' taken up by different size vehicles. For example:

- A standard passenger vehicle is one passenger car unit.
- An articulated truck is 2.9 passenger car units.
- A truck and dog is two passenger car units.

Figure 2-1 in **Chapter 2** of this report shows the relationship between the traffic design capacity of a motorway standard lane and average traffic speed. The figure shows that the maximum capacity of each lane would be achieved when average traffic speeds are around 60 km/h. At higher average speeds, the spacing between vehicles would increase to reflect increased stopping distances, with a commensurate reduction in lane capacity on a passenger car unit basis. Similarly, at lower average traffic speeds vehicles would tend to be spaced more widely (greater distance between vehicles) in response to increased vehicle densities (traffic congestion) and motorists' response to these traffic conditions. This, in addition to lower traffic throughput per hour (ie slower average traffic speeds), would lead to a significant reduction in the capacity of a traffic lane, particularly for average traffic speeds at or below 40 km/h.

An important observation to make from **Figure 2-1** is that under congested traffic conditions – when average traffic speeds are low – the physical capacity of the project's main alignment tunnels would be reduced. For example, the maximum traffic volumes that could be accommodate through the main alignment tunnels at an average traffic speed of 60 km/ h could not be occur at lower traffic speeds (congested traffic congestion) because of the physical constraints on the traffic lane design and spacing of vehicles (motorist response).

Ventilation design capacity

The project's ventilation system has been designed to achieve the ventilation design criteria summarised in **Table 7-5** for different average traffic speeds, taking into account the traffic throughput capacity of the project at different average traffic speeds (refer to **Figure 2-2**). Further details of how these ventilation design criteria have been applied are provided in **Section 2.5** of this report.

The forecast traffic volumes used as the basis for the assessments presented in the environmental impact statement are:

- In 2019:
 - Daily traffic of around 23,100 passenger car units in the southbound main alignment tunnel, with a peak of around 1,790 passenger car units (AM peak).
 - Daily traffic of around 22,900 passenger car units in the northbound main alignment tunnel, with a peak of around 1,930 passenger car units (PM peak).
 - Heavy vehicle volumes of around 28 per cent of total traffic volumes.
- In 2029:
 - Daily traffic of around 29,400 passenger car units in the southbound main alignment tunnel, with a peak of around 2,300 passenger car units (AM peak).
 - Daily traffic of around 28,950 passenger car units in the northbound main alignment tunnel, with a peak of around 2,360 passenger car units (PM peak).
 - Heavy vehicle volumes of around 25 per cent of total traffic volumes.

These forecast traffic data can be compared with the maximum traffic design capacity of a two lane motorway (refer to **Figure 2-1**) provided below. The comparison demonstrates that peak forecast traffic flows in 2019 and 2029 for both the southbound and the northbound main alignment tunnels would be comfortably below the maximum traffic design capacity down to an average traffic speed below 20 km/h.

- A maximum of 3,480 passenger car units per hour (two lanes) at 80 km/h.
- A maximum of 4,000 passenger car units per hour (two lanes) at 60 km/h.
- A maximum of 3,698 passenger car units per hour (two lanes) at 40 km/h.

Figure 7-1 shows the forecast traffic volumes for the project, as passenger car units, relative to the maximum traffic design capacity of the southbound and northbound main alignment tunnels in 2019 and 2029.

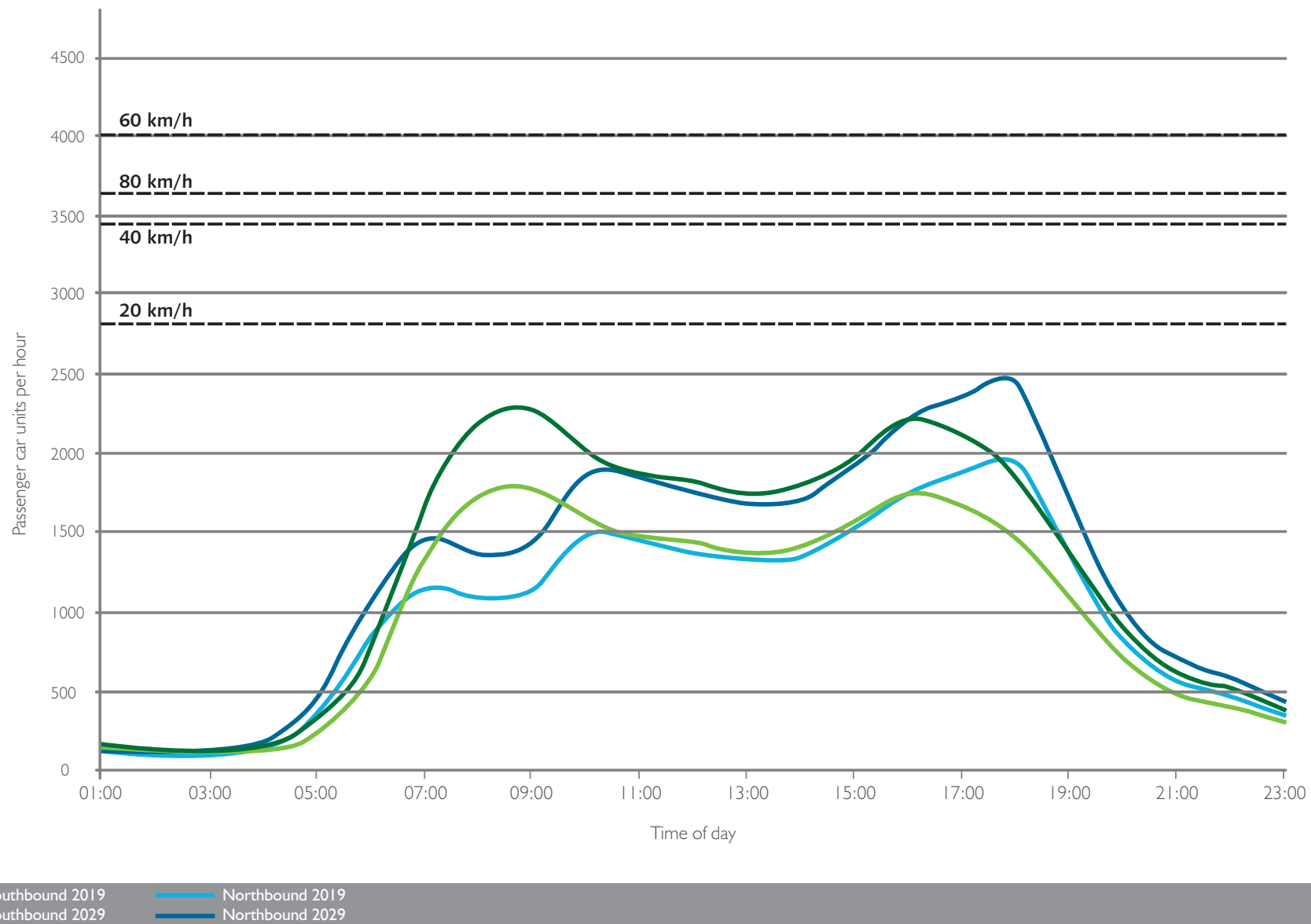


Figure 7-1 Forecast traffic volumes (PCU) relative to traffic design capacity

(blank page)

Traffic forecasts

Assessments presented in the environmental impact statement rely on forecast traffic data generated through a strategic transport model of Sydney's major road network using the Cube Voyager software platform. Cube is the most widely used software package in the world for transport planning.

The Cube model used to develop traffic forecast data for the NorthConnex project has taken into account factors including existing and future land use, anticipated changes to the major road network, existing and future travel demands, existing and future tolling structures, and motorist behaviours. Further details of these assumptions and inputs are provided in Section 5.2 of the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement).

While the traffic forecasts for the project are considered to be robust, it is recognised that regulatory authorities, the local community and other stakeholders need confidence that the project will be able to meet acceptable outcomes if the situation changes in the future. To provide confidence about the performance of the project in the event that actual traffic demand exceeds traffic forecasts in the future, the air quality impact assessment also considers 'design analysis A'.

Design analysis A has assumed that the maximum theoretical design capacity of 4,000 passenger car units in a main alignment tunnel would be reached during the peak hour. It is extremely unlikely that the maximum design capacity would be experienced for an entire 24-hour period, with traffic volumes likely to ebb and flow during the day around peak periods. A realistic traffic scenario for design analysis A was therefore established by:

- Comparing the maximum theoretical design capacity of each main alignment tunnel (4,000 passenger car units) with the expected peak hour traffic volumes in 2019, which were around 1,790 passenger car units in the southbound main alignment tunnel (morning peak) and around 1,930 passenger car units in the northbound main alignment tunnel (afternoon peak).
- Noting that the theoretical design capacity was around a factor of 2.1 times the maximum forecast peak in 2019 (ie 4,000 is around 2.1 times 1,930).
- Scaling the forecast traffic flows for 2019 by a factor of 2.1 for each hour of the day, to obtain the traffic flows used for design analysis A.

An equally valid approach would have been to use forecast traffic volumes in 2029 to derive design analysis A. However, given that the relative diurnal flows of traffic would be similar in 2019 and 2029 (refer to the shape of the diurnal flow curves in **Figure 7-1**), and scaling would be to the same maximum (4,000 passenger car units), there would be no significant difference in outcomes if traffic forecasts for 2029 had been used instead of data from 2019.

The total daily traffic volumes for design analysis A have therefore been established at around 48,000 passenger car units in each main alignment tunnel. This is considered to be a reasonable and realistic estimate of a worst case scenario (albeit highly unlikely) for operation of the project.

Figure 7-2 shows traffic volumes for design analysis A relative to the base traffic forecasts for 2019 for the northbound main alignment tunnel (forecaste to carry higher traffic volumes that the southbound tunnel). The figure shows that the peak hour traffic volumes for design analysis A could only be accommodated through the project's main alignment tunnels under free flowing traffic conditions (60 km/ h to 80 km/h) (ie with a throughput capacity of up to

4,000 passenger car units per main alignment tunnel). Congested traffic conditions in the project tunnels (40 km/h or less) would require a commensurate reduction in traffic volumes below the design analysis A peak hour figures, based on the physical capacity of the project tunnel lanes.

Taking the information in **Figure 7-1** and **Figure 7-2** into account, free flowing traffic conditions (60 km/h to 80 km/h) in the main alignment tunnels may not be achieved if:

- Traffic varies significantly from forecast traffic volumes. Actual traffic volumes would need to be more than double the forecast traffic volumes in 2019 to exceed the worst case traffic scenario (design analysis A) before the volume of traffic would lead to significant congestion and a reduction in average traffic speeds.
- A traffic accident or incident causes a reduction in main alignment tunnel capacity (for example, blocking a traffic lane temporarily until the incident had been moved to the adjacent breakdown lane).

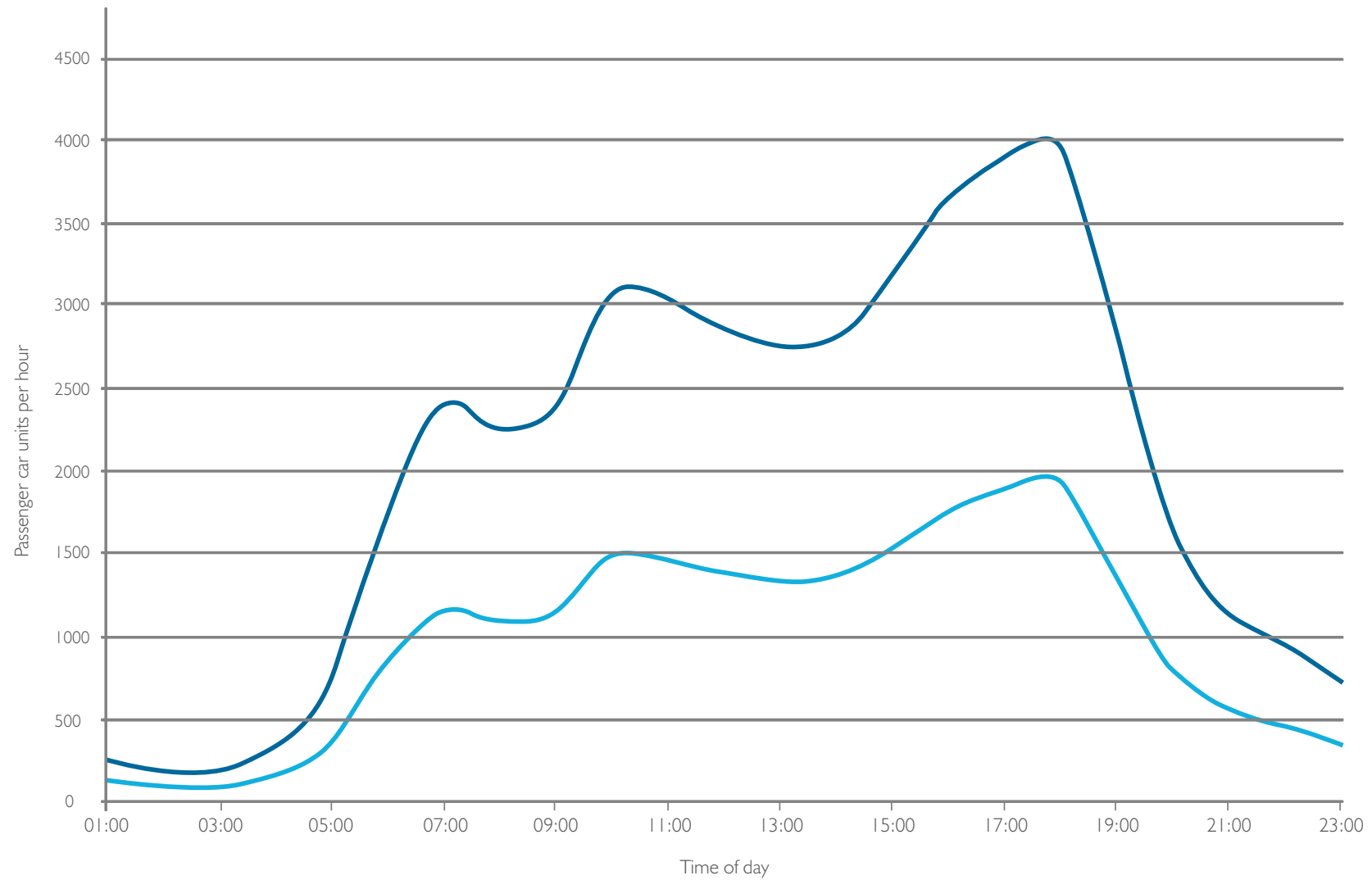


Figure 7-2 Comparison of northbound traffic – 2019 traffic forecasts and design analysis A

(blank page)

Issue description

With respect to the impact of vehicle speeds and operating conditions as they impact vehicle emissions, the predicted levels of service (LoS) in the tunnel are provided in Table 8-10 of the Technical Working Paper: Traffic and Transport (Appendix E to the environmental impact statement) and the travel times and implicit average speed in Table 8-12. For the purpose of its review, the Environment Protection Authority has assumed these factors to be correct.

Response

Table 8-10 of the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) provides levels of service for intersections along Pennant Hills Road in 2029, with and without the project. These levels of service do not relate to the project tunnels.

The travel times summarised in Table 8-10 of the Technical Working Paper: Traffic and Transport are average travel times through the project tunnels, taking into account expected distribution of vehicles through the project. For example, it takes into account vehicles that are expected to travel the full length of the main alignment tunnels, as well as vehicles that may enter or leave via on and off ramps without travelling the full length of the main alignment tunnels.

Issue description

The air quality impact assessment has generally been conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005).

The assessment predicts that the NorthConnex project will not result in any additional exceedances of the Environment Protection Authority's impact assessment criteria at the surrounding sensitive receivers for the operating scenarios assessed. This includes the worst case scenario of theoretical maximum design capacity during peak hour (4,000 passenger car units per hour in each main tunnel).

Response

The Environment Protection Authority's acknowledgement that the air quality impact assessment has been conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005) is noted. It is further noted that the Environment Protection Authority recognises that the NorthConnex project would not result in any additional exceedances of applicable impact assessment criteria.

The air quality impact assessment presented in the environmental impact statement demonstrates that the contributions from the project to the surrounding airshed are well within applicable ambient air quality criteria and advisory reporting standards. This includes scenarios based on forecast traffic volumes as well as 'design analysis A', which represents a maximum 'worst case' traffic scenario.

Issue description

The air quality impact assessment claims that a conservative approach to PM_{2.5}, PM₁₀ and NO₂ background concentrations has been adopted in the assessment. The assessment assumes that the maximum of the concentrations predicted by CAL3QHCR (surface road model) and those measured by the Office of Environment and Heritage at its Lindfield and

Prospect monitoring stations as the background concentration for each receiver for each hour of each modelling year.

The results of an analysis of the following datasets have been used to support the claim that the assumed background concentrations are conservative:

- Project road side monitoring data (Brickpit Park and Observatory Park) collected between December 2013 and March 2014 and predicted surface road modelling concentrations (using CAL3QHCR) at Brickpit Park and Observatory Park.
- Ambient monitoring data collected at the Office of Environment and Heritage's Prospect and Lindfield monitoring stations and ambient (background) project monitoring data (Headen Sports Park, James Park and Rainbow Farm Reserve) collected between December 2013 and March 2014.

The results of the statistical analysis are presented in Appendix C the Technical Working Paper: Air Quality (Appendix G of the environmental impact statement) and demonstrate the following:

- The Office of Environment and Heritage PM₁₀ monitoring data is higher than the project PM₁₀ ambient monitoring data for the majority of the time.
- Project NO₂ monitoring data is higher than the Office of Environment and Heritage NO₂ ambient monitoring data for the majority of the time.
- CAL3QHCR road modelling predictions (PM₁₀ and NO₂) are greater than the project road side monitoring data for the majority of the time.

Appendix C of the Technical Working Paper: Air Quality (Appendix G to the environmental impact statement) confirms that the CAL3QHCR road modelling predictions and the Office of Environment and Heritage PM₁₀ and PM_{2.5} monitoring data are conservative datasets and their use in the air quality assessment will result in conservative background concentrations.

The Office of Environment and Heritage NO₂ monitoring data, however, is not demonstrated to be conservative as the statistical analysis demonstrates the project NO₂ monitoring data is typically higher than the Office of Environment and Heritage NO₂ monitoring data. Appendix C of the Technical Working Paper: Air Quality acknowledges this result but states that as the average percentage difference between the two datasets was only 0.7 percent then the Office of Environment and Heritage data was considered satisfactory for use as background concentrations without any adjustment of the data.

The Environment Protection Authority considers that the assumed NO₂ background concentrations should have been adjusted to be able to claim that a conservative approach to background concentrations was adopted. The Environment Protection Authority recommends that conservative background NO₂ data is used in the assessment.

Response

Further information on the identification and application of background air quality data is provided in **Section 2.11** of this report.

The Environment Protection Authority has identified that there are times when the NO₂ data at the project monitoring stations will be higher than the data at the Prospect/ Lindfield monitoring stations. Conversely there will also be times that concentrations will be higher at the Prospect / Lindfield stations than the project monitoring stations. The analysis presented

in the Technical Working Paper: Air Quality concludes that the average difference between the two data sets over the period assessed is only 0.7 percent.

The intent of undertaking the comparison between the project monitoring stations and the Office of Environment and Heritage stations at Prospect and Lindfield was to determine if the overall data sets were similar and therefore appropriate for use in the air quality impact assessment. The average difference between the data sets of 0.7 per cent is considered negligible and, therefore, the data was considered appropriate for use in the assessment. Adjusting the background data by 0.7 per cent would have made an inconsequential change in the data and was not deemed necessary for the air quality impact assessment.

This issue can be further contextualised by considering the relative contributions of the project to ambient NO₂ concentrations, as distinct from the contributions made by background air quality. As an example, Chart 8 in the Technical Working Paper: Air Quality shows the ranked NO₂ (one hour average) contributions from the project at the most affected receiver location near the northern ventilation outlet in 2019. The data presented in Chart 8 can be summarised as provided **Table 7-6**. The table demonstrates that:

- The maximum project contribution of NO₂ (one hour average) at the most affected location near the northern ventilation outlet in 2019 would be an unusual and infrequent event. Only one hour in three years (around 0.004% of the time) is expected to reach this level of project contribution, with all other hours in the three year period predicted to be around no more than half of the maximum (ie less than 35 µg/m³).
- Over a three year period, the project is expected to contribute more than 4.1% of the applicable ambient air quality criterion for NO₂ (one hour average) for only three percent of the time. By corollary, this means that for 97% of the time, project contributions to the ambient airshed are less than 4.1%.

This information reinforces the conclusion drawn in the environmental impact statement that project contributions of NO₂ are low relative to applicable ambient air quality criteria, and for the majority of the time are very low. Taking into account background air quality, there is significant capacity to accommodate elevated background concentrations of NO₂ before compliance with ambient air quality criteria may be at jeopardy. Variance in background NO₂ data sets (project monitoring stations compared with Office of Environment and Heritage monitoring stations) could be accommodated within this significant capacity, even if the average difference were much greater than the calculated 0.7 per cent.

Table 7-6 Frequency of NO₂ (one hour average) project contributions at the most affected location – northern ventilation outlet, 2019.

Project contribution (NO ₂ , one hour) (µg/m ³)	Number of hours in three years	Percentage of hours in three years	Percentage of ambient air quality criterion
Maximum – 68.89 µg/m ³	1	0.004%	28.0%
35 µg/m ³ to 68.89 µg/m ³	0	0%	14.2% to 28.0%
30 µg/m ³ to 35 µg/m ³	48	0.18%	12.2% to 14.2%
20 µg/m ³ to 30 µg/m ³	280	1.07%	8.1% to 12.2%
10 µg/m ³ to 20 µg/m ³	461	1.75%	4.1% to 8.1%
Total	790	3.0%	>4.1%

Issue description

The CALPUFF modelling system was used in the air quality impact assessment and consists of three main components:

- CALMET: a meteorological model which develops hourly wind and temperature fields on a three dimensional gridded domain.
- CALPUFF: a transport and dispersion model, which advects puffs of material emitted from the modelled source simulating dispersion and transformation along the way using the fields generated by CALMET.
- CALPOST: processes the primary output files from CALPUFF of hourly concentrations or deposition fluxes at selected receiver locations.

The air quality dispersion modelling was undertaken for a three year period (meteorological data for January 2009 - December 2011). The following meteorological data were used as inputs to CALMET:

- Gridded hourly three dimensional MM5 data resolved at a 12 kilometre resolution to generate the 'initial guess' wind field in CALMET.
- Hourly observations from Lindfield, Terrey Hills, Richmond RAAF Base, Prospect and Sydney Airport to generate the final three dimensional wind fields for use in CALPUFF.

This methodology for incorporating the meteorological data in CALMET is referred to as the 'Hybrid Mode' in Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessment of Air Pollutants in NSW, Australia' (OEH, 2011). The meteorological data has been incorporated into CALMET as recommended in OEH (2011).

Using CALMET with observational data, as in the 'Hybrid Mode', requires the careful site specific assessment of seven critical parameters. These are: TERRAD, RMAX1, RMAX2, R1, R2, IEXTRP and BIAS. The air quality impact assessment presented in the environment impact statement does not detail the assumed values of these seven critical parameters.

The Environment Protection Authority recommends that the values for these seven critical parameters be provided and justified.

Response

Further information on meteorological monitoring and data used in the air quality impact assessment for the project is provided in **Section 2.10** of this report.

The seven critical parameters of the CALMET model and their values used in the air quality impact assessment for the project are:

- TERRAD – six kilometres.
- RMAX1 – four kilometres.
- RMAX2 – not used as prognostic data were used to determine the temperature field above 20 metres.
- R1 – 2.5 kilometres.
- R2 – not used as prognostic data were used to determine the temperature field above 20 metres.
- IEXTRP – no extrapolation was done.

- BIAS – no bias was done.

It should also be noted that ten vertical levels were used in CALMET, defined at 0, 20, 40, 80, 160, 320, 700, 1300, 1700, 2300 and 3000 metres above ground level. Cloud cover and cloud ceiling height were determined from the prognostic data (MM5).

The values described above have been chosen consistent with the guidance provided in in Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessment of Air Pollutants in NSW, Australia' (OEH, 2011). The final parameters used in the air quality impact assessment, as listed above, were determined following an iterative process of investigation of the effects of different values on the resultant wind fields. This iterative process considered parameters in the following ranges:

- TERRAD values between four kilometres and 10 kilometres.
- RMAX1 values between one kilometre and eight kilometres.
- R1 values between one kilometre and six kilometres.
- IEXTRP switched both on and off. For this air quality impact assessment, it was switched off due to confidence in the MM5 data in determining the initial guess wind fields.

Examples of resulting spatial wind fields under light wind speed conditions for onshore flow and offshore flow are shown in **Figure 2-6** and **Figure 2-7** of this report (refer to **Chapter 2**), respectively. In both figures, the wind speed varies between 1 m/s and 5m/s.

Issue description

It is important to undertake an evaluation of the CALMET modelling results as the CALMET module requires careful consideration of input data, modelling domain, grid resolution and the seven critical parameters referred to above. The air quality assessment presents a number of meteorological data evaluation studies:

- Comparison of Sydney Airport Bureau of Meteorology (BoM) data for the years 2009 to 2011 with longer term (30 year) statistics to establish the suitability of these years for the modelling assessment. The air quality impact assessment demonstrated that meteorological data for the years 2009 to 2011 are consistent with longer term averages and suitable for use. As Office of Environment and Heritage meteorological data was also used in the assessment, the five year statistics for the Prospect meteorological station were also compared to the years 2009 to 2011. This further analysis showed that the data from the years used in the modelling are very similar to the five year averages at the Prospect meteorological monitoring station and confirmed their suitability for use in the assessment.
- Statistical evaluation of MM5 data, used to generate an initial guess field in CALMET, versus observations for the years 2009 to 2011. The MM5 data was generally demonstrated to meet the relevant statistical benchmarks. The analyses showed a tendency for MM5 to over predict wind speed and some randomness in the wind direction data. This was expected given the 12 kilometre grid resolution.
- Analysis of CALMET generated stability class data at the Prospect and Sydney meteorological monitoring stations by hour of day and wind speed. This analysis generated the expected variation in stability class with hour of day and wind speed.
- Presentation of CALMET generated windroses for the northern and southern ventilation outlets and wind roses for each of the five observation stations for year 2009, 2010 and 2011. The air quality assessment does not provide an analysis of the

CALMET generated windroses for the northern and southern ventilation outlets or a discussion regarding the suitability of the CALMET generated wind speed and wind direction data in CALPUFF.

The Environment Protection Authority considers that the air quality impact assessment does not demonstrate the suitability of the CALMET generated wind speed and wind direction data. The Environment Protection Authority acknowledges that the issues regarding evaluation of CALMET generated meteorological data when observations are used to generate the data. There are, however, other wind speed and direction data available in the modelled domain that were not used to generate the modelled meteorological data and could be used to evaluate the suitability of the CALMET data.

The Environment Protection Authority recommends that an evaluation of the CALMET generated wind speed and wind direction data be provided to demonstrate that it is suitable for use in CALPUFF.

Response

Discussion of the representativeness of CALMET generated meteorological data for local meteorological conditions around the southern and northern ventilation outlets is provided in **Section 2.10** of this report. **Section 2.10.3** provides a validation/ evaluation of CALMET modelling outputs with observed meteorological data.

Issue description

Oxides of nitrogen (NO_x) are formed during high temperature combustion processes from the oxidation of the nitrogen in the air or fuel. NO_x from combustion consist largely of nitric oxide (NO) and partly of nitrogen dioxide (NO_2). After emission from a discharge point, NO is transformed to NO_2 through oxidation with atmospheric ozone.

The air quality impact assessment has applied the USEPA's ozone limiting method (OLM) to assess the oxidation of NO to NO_2 in the atmosphere. The ozone limiting method is listed in the Approved Methods for the Modelling and Assessment of Air Pollutants (DEC, 2005) as a method for assessing the oxidation of NO to NO_2 . The ozone limiting method applies the following equation to calculate the NO_2 concentration attributable to a project:

$$[\text{NO}_2]_{\text{project increment}} = 0.1[\text{NO}_x]_{\text{prediction}} + \text{MIN}\{0.9[\text{NO}_x]_{\text{prediction}} \text{ or } (46/48)[\text{O}_3]_{\text{background}}\}$$

Where:

$[\text{NO}_2]_{\text{project increment}}$ is the project contribution to ambient NO_2 concentrations at ground level.

$[\text{NO}_x]_{\text{prediction}}$ is the predicted concentration of NO_x from the project at ground level.

$[\text{O}_3]_{\text{background}}$ is the background concentration of ozone.

By default, the ozone limiting method assumes that approximately 10 per cent of the initial NO_x emissions are emitted as NO_2 and that all of the available ozone in the atmosphere will react with NO in the plume until either all of the ozone or all of the NO is used up.

The Environment Protection Authority estimates that the total fleet average NO_2 fraction ranges between 15 per cent and 17 per cent of total NO_x across the speed range. An

average of 16 per cent (not 10 per cent) of the initial NO_x emissions from the ventilation outlets could therefore be emitted as NO₂.

The ozone limiting method equation should therefore be adjusted to account for the site specific ratio of NO₂ / NO_x (at the point of discharge). That is, the 0.1 in the ozone limiting method equation above equation should be replaced with 0.16:

$$[NO_2]_{project\ increment} = 0.16[NO_x]_{prediction} + MIN\{0.9[NO_x]_{prediction} \text{ or } (46/48)[O_3]_{background}\}$$

The effect of the adjustment would be to increase the concentration of NO₂ directly emitted at the point of release (ventilation outlet) by 60 per cent, potentially increasing ground level concentration predictions under lower ambient ozone (O₃) conditions.

The air quality impact assessment presented in the environmental impact statement does not include sufficient information and data, such as all hourly NO_x predictions and all hourly O₃ values to comprehensively audit the effect of the methodological shortcoming on the overall project results.

The Environment Protection Authority has undertaken some preliminary calculations to determine the impact on the results of the air quality impact assessment. The Environment Protection Authority increased the entirety of the predicted project NO₂ increment by 60 per cent and the results are displayed in the table below. It can be seen that all scenarios except the worst case 'design analysis A' are predicted to still comply with the Environment Protection Authority's impact assessment criteria. The Environment Protection Authority anticipates that the proper implementation of the amended ozone limiting method equation above is likely to result in all scenarios still complying with the Environment Protection Authority's impact assessment criteria, however this should be verified and confirmed.

Table 7-7 Environment Protection Authority's NO₂ calculations based on amended ozone limiting method equation

Scenario	Peak project contribution (µg/m ³)	Peak project contribution + 60%	Background NO ₂ concentration (µg/m ³)	Peak cumulative NO ₂ concentration (µg/m ³)
Forecast traffic 2019 (northern ventilation outlet)	68.9	110.2	81.9	192.1
Forecast traffic 2029 (northern ventilation outlet)	74.6	119.4	84.7	204.1
Design analysis A (northern ventilation outlet)	114.8	183.7	67.2	250.9
Design analysis B (northern ventilation outlet)	96.4	154.2	84.7	238.9

Note: applicable NO₂ (one hour average) criterion is 246 µg/m³

The Environment Protection Authority recommends that the NO₂ impact assessment presented in the environmental impact statement be revised to use a site specific NO₂/ NO_x ratio that represents the expected NO₂/ NO_x ratio of the vehicle fleet based on a detailed analysis of fleet composition and fuel type. This revision should confirm that all scenarios are still predicted with comply with the Environment Protection Authority's impact assessment criteria.

Response

The air quality impact assessment presented in the environmental impact statement has been conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants (DEC, 2005), as specific in the Director-General's environmental assessment requirements for the project. This has included application of the ozone limiting method equation as published in the Approved Methods for the Modelling and Assessment of Air Pollutants.

Based on advice from the Environment Protection Authority that it has identified that the NO₂:NO_x ratio from the New South Wales Vehicle fleet is on average 0.16, it is accepted the ozone limiting method may underestimate the concentration of NO₂ at project ventilation outlets. This may have implications for predicted ground level concentrations of NO₂.

While the need for this methodological revision is acknowledged, the calculations presented by the Environment Protection Authority are not entirely correct:

1. The amended ozone limiting method equation presented by the Environment Protection Authority does not conserve the total quantity of NO_x. By increasing the proportion of NO_x present as NO₂ at the point of discharge, the total remaining NO_x available for atmospheric conversion would be reduced. This should be reflected in the amended equation presented by the Environment Protection Authority with an updated second term (emphasis added), as follows:

$$[NO_2]_{project\ increment} = 0.16[NO_x]_{prediction} + MIN\{0.84[NO_x]_{prediction} \text{ or } (46/48)[O_3]_{background}\}$$

2. The amended ozone limiting method equation would result in an increase in NO₂ of 60% at the point of discharge. However, in its calculations (as reproduced in **Table 7-8**), the Environment Protection Authority has increased the predicted ground level concentration of NO₂ by 60%. In effect, this approach increases both the concentration of NO₂ at the point of discharge and the NO₂ generated by atmospheric conversion. Only the NO₂ at the point of discharge should be altered. Coupled with the correction to the amended ozone limiting method equation outlined above, this is likely to have skewed the calculations conducted by the Environment Protection Authority.

A sensitivity analysis has been conducted to determine the potential effect of the amended ozone limiting method equation (as corrected above) on predicted ground level concentrations of NO₂. Ground level concentrations of NO₂ have been calculated for a series of NO_x and O₃ concentrations (up to around the NO₂ one hour average criterion of 246 µg/m³) using the ozone limiting method equation for both 10 per cent NO₂:NO_x and 16 per cent NO₂:NO_x at the point of discharge. These calculations are summarised in **Table 7-8**. Shaded cells indicate situations in which O₃ concentration is the limiting factor for NO₂ generation.

For context, background O₃ concentrations applied to the air quality impact assessment are summarised in **Section 2.11.2** and include:

- Maximum concentrations around 200 µg/m³ to 250 µg/m³.
- 95th percentile concentrations around 70 µg/m³ to 90 µg/m³.
- Average concentrations around 30 µg/m³ to 35 µg/m³.

Table 7-8 Comparison of ozone limiting method equation calculations

		Ozone concentration (one hour) ($\mu\text{g}/\text{m}^3$)					
		0	50	100	150	200	250
Total NO _x concentration (one hour) ($\mu\text{g}/\text{m}^3$)	Amended ozone limiting method equation (16% NO ₂)						
	50	8.0	50	50	50	50	50
	100	16.0	63.9	100	100	100	100
	150	24.0	71.9	119.8	150	150	150
	200	32.0	79.9	127.8	175.8	200	200
	250	40.0	87.9	135.8	183.8	231.7	250
	Original ozone limiting method equation (10% NO ₂)						
	50	5.0	50	50	50	50	50
	100	10.0	57.9	100	100	100	100
	150	15.0	62.9	110.8	150	150	150
	200	20.0	67.9	115.8	163.8	200	200
	250	25.0	72.9	120.8	168.8	216.7	250

Comparing the calculations presented in **Table 7-8**, the percentage change in predicted ground level NO₂ concentrations has been determined, as summarised in **Table 7-9**. The percentage values shown indicate the extent to which a 16 per cent NO₂:NO_x ratio exceeds a 10 per cent NO₂:NO_x ratio in terms of ground level NO₂ concentrations. The table indicates that:

- For situations where the NO_x concentration is limiting, rather than the O₃ concentration, there would be no difference in the air quality assessment outcomes for NO₂ based on differences in the ozone limiting method equation.
- The maximum difference resulting from amendment of the ozone limiting method equation is 60 per cent. This would occur when no O₃ is present which, although it may occur, is unlikely. Differences approaching 60 per cent would occur at low O₃ concentrations. However, under these conditions total NO₂ concentrations at ground level would be low (as indicated in **Table 7-8**) and would be dominated by the contribution of NO₂ at the point of discharge, rather than NO₂ generated through atmospheric conversion.
- Based on the air dispersion modelling present in the environmental impact statement, the project is expected to typically contribute peak ground level concentrations around 50 $\mu\text{g}/\text{m}^3$ to 150 $\mu\text{g}/\text{m}^3$. With most background air quality data indicating typical O₃ concentrations up to $\mu\text{g}/\text{m}^3$, the net effect of the amended ozone limiting method equation is expected to be around 10 to 15 per cent (as a change in ground level concentration).

The amended ozone limiting method equation has been applied to the further air dispersion modelling conducted for the five metre increase in ventilation outlet heights, as detailed in **Section 2.15** and **Section 9.2** of this report.

Table 7-9 Percentage difference between ozone limiting method equations

		Ozone concentration (one hour) (µg/m³)					
		0	50	100	150	200	250
Total NO _x concentration (one hour) (µg/m³)	50	60.0%	0%	0%	0%	0%	0%
	100	60.0%	10.4%	0%	0%	0%	0%
	150	60.0%	14.3%	8.1%	0%	0%	0%
	200	60.0%	17.8%	10.4%	7.3%	0%	0%
	250	60.0%	20.6%	12.4%	8.9%	6.9%	0%

Issue description

The air quality assessment predicts that the NorthConnex project would comply with the Environment Protection Authority's impact assessment criteria at all sensitive receivers.

Whilst compliance with the criteria is the Environment Protection Authority's benchmark for assessing the project, it is also prudent to review the project contribution to predicted ground level concentrations. A summary of the highest predicted contributions from the project as a percentage of the applicable ambient air quality criteria and advisory reporting standards is provided in **Table 7-10**.

Table 7-10 Maximum predicted project contributions

Pollutant	Averaging period	Maximum predicted ground level concentration as a percentage of applicable criteria (ventilation outlet)	
		Forecast traffic in 2029	Design analysis A
PM ₁₀	24 hour	4.2% (southern)	6% (southern)
	Annual	0.4% (southern)	0.9% (southern)
PM _{2.5}	24 hour	8.0% (southern)	12% (southern)
	Annual	1.6% (southern)	3% (southern)
NO ₂	1 hour	30% (northern)	47% (northern)
	Annual	3% (northern)	4% (northern)
CO	1 hour	0.36% (northern)	0.6% (northern)
	8 hour	0.58% (southern)	0.8% (southern)
Total VOCs	1 hour	19% (northern)	31% (southern)
PAHs	1 hour	0.23% (southern)	0.4% (southern)

It can be seen in the above table that the project is predicted to result in significant contributions to the one hour average NO₂ impact assessment criterion, including 30% under forecast traffic in 2029 and 47% for 'design analysis A'. The project is also predicted to contribute up to 8% of the 24 hour average PM_{2.5} advisory reporting standard for under forecast traffic in 2029 and 12% for 'design analysis A'.

Given the project is predicted to significantly contribute to the overall ground level concentrations at some sensitive receivers, options for reducing predicted impacts should be considered.

Predicted ground level concentrations due to emissions from the NorthConnex ventilation outlets could be reduced by improving the dispersion of emissions. Typical options for improving the dispersion of outlet emissions include increasing outlet height, decreasing outlet diameter and/or increasing outlet exit velocity. Each one of these would need to be evaluated for its practicability.

A reduction in the concentration of emissions from the ventilation outlets would also reduce predicted ground level concentrations. This could be achieved by increasing ventilation flow rate to further dilute the vehicle emissions, prior to discharging through the outlets or increasing the number of outlet used to discharge emissions.

The Environment Protection Authority recommends that an evaluation of the practicability of options for reducing predicted ground level concentrations be conducted, as the project is predicted to significantly contribute to the predicted ground level concentrations of NO₂ and particulate matter at sensitive receivers.

Response

An analysis of options and alternatives to minimise in-tunnel and ambient exposures to vehicle emissions managed within the project is provided in **Section 3.2** of this report.

The analysis presented by the Environment Protection Authority is based on two conservative assessment scenarios presented in the environmental impact statement:

- The forecast traffic scenario in 2029 has assumed that there would be no improvement in fuel quality or vehicle efficiency after 2020. In reality there is very likely to be continued improvement in these areas, and as such, the air quality impact assessment and predicted ground level contributions from the project are likely to be conservative and overestimates of actual performance. In the case of particulate matter, the environmental impact statement demonstrates that use of emissions factors published by the Permanent International Association of Road Congresses is likely to have overestimated particulate emission factors by a factor of up to two compared with the Environment Protection Authorities emission factors derived from the New South Wales Vehicle fleet.
- Design analysis A is a conservative, worst case estimate of project performance based on the maximum theoretical capacity of the main alignment tunnels. Based on traffic forecasts, this traffic scenario is highly unlikely to eventuate in the foreseeable future.

It is recognised that assessment of a project's contribution relative to applicable ambient air quality standards is an important consideration, particularly in the context of determining the capacity of the airshed to accommodate future developments. It is undesirable for a single project to contribute a significant proportion of air pollution relative to applicable air quality criteria because in addition to air quality and human health impacts, this may place a significant constraint on the ability for other developments to viably operate within a constrained airshed. However, it is also recognised in the case of the NorthConnex project that it will not generate emissions other than those already generated by road traffic. In fact, it is likely to facilitate a reduction in vehicle emissions through provision of a free flowing motorway connection without the congested stop-start conditions and road gradients experienced along Pennant Hills Road. Avoiding stop-start congested traffic congestions along Pennant Hills Road, a heavy vehicle would emit 80 to 86 per cent less carbon monoxide, 70 to 80 per cent less oxides of nitrogen and 71 to 78 per cent less particulate matter (as PM₁₀). The NorthConnex project is therefore not just better managing vehicle emissions – it is actually facilitating a reduction in total vehicle emissions along the Pennant Hills Road corridor.

Therefore, the potential for the NorthConnex project to contribute to or cause a constrained airshed by itself is negligible relative to existing air pollution sources in the region. The net effect of the NorthConnex project will be better management and dispersion of existing air pollution, rather than introduction of a new source of emissions.

As discussed earlier in relation to background concentrations of NO₂, the maximum contribution of NO₂ from the project occurs during one hour of the three years modelled for the air quality impact assessment (refer to **Table 7-6** of this report). At other times, ground level concentrations are less than half of the peak predictions.

Issue description

The overarching comment regarding the estimation of motor vehicle emissions is that the environmental impact statement does not provide a clear and explicit description of how the emissions were estimated. There is conflicting and confusing information spread widely throughout the document, which is poorly structured in terms of being able to find the relevant information or definitively understand how the emissions have been calculated.

Response

Section 2.8 of this report outlines how in-tunnel air quality has been calculated. The emissions inventory used in the ambient air quality impact assessment has also been used as an input into in-tunnel air quality calculations, as presented in Section 7.3 and Appendix G of the environmental impact statement.

Issue description

The Environment Protection Authority raises the following issues specific to assumptions around fleet composition and traffic mix:

- No clear and complete presentation is given in the environmental impact statement of the fleet composition assumed in the vehicle emissions modelling. The project traffic modelling presented in the environmental impact statement separates the fleet into light vehicle and heavy vehicles only (Table 7-26 of the environmental impact statement).
- The environmental impact statement assumes a constant eight per cent of passenger vehicles are diesel powered (refer to Appendix H of the Technical Working Paper: Air Quality), sourced from the 2013 Australian Bureau of Statistics (ABS) Motor Vehicle Census (MVC) for the entire Australian fleet. The environmental impact statement indicates that the ABS MVC shows a strong growth in the proportion of diesel passenger vehicles from 2008 to 2013, however then states that the 2013 diesel passenger vehicle proportion of eight per cent was used for the assessment in 2019 and 2029. This is considered a significant assessment weakness as sales data show a strong increase in the sales share of diesel passenger vehicles and diesel light commercial vehicles. Diesel vehicles have significantly higher NO_x, NO₂ and particle emissions than equivalent petrol vehicles. The Environment Protection Authority projections developed for the New South Wales Air Emissions Inventory estimate diesel passenger vehicles will comprise 17 per cent of the passenger vehicle fleet in 2019 and 27 per cent in 2029.
- No information is presented in the environmental impact statement on the proportion of light commercial vehicles in the light vehicle traffic that was used in the air dispersion modelling. In the absence of explicit information, it can only be assumed that the environmental impact statement has used the Permanent International Association of Road Congresses Australian assumption of 84 per cent passenger vehicles and 16 per cent light duty vehicles (light commercial vehicles (LCV)). The default Permanent International Association of Road Congresses figure appears reasonable in

comparison to Environment Protection Authority inventory models which estimate 18 to 20 per cent light commercial vehicles, depending on the road type and day of the week.

- No information is presented in the environmental impact statement on the proportion of diesel vehicles in the light commercial vehicle fleet that was used in the air dispersion modelling. In the absence of explicit information, it can only be assumed that the environmental impact statement has used the Permanent International Association of Road Congresses Australian default value of 50 per cent. New vehicles sales data indicates that similar to passenger vehicles, the sales share of diesel light commercial vehicles is increasing strongly. The Permanent International Association of Road Congresses estimate of 50 per cent is reasonable for 2019 but is likely to underestimate diesel light commercial vehicles in 2029 relative to the Environment Protection Authority's inventory models which estimate 63 per cent of light commercial vehicles will be diesel powered. Diesel powered light commercial vehicles have considerably higher NO_x, NO₂ and particle matter emission rates than equivalent petrol light commercial vehicles.
- No information is presented in the environmental impact statement on the heavy duty vehicle fleet composition used in the air dispersion modelling. The heavy duty fleet will comprise rigid trucks (no trailers) from 3.5 to 26 tonnes, articulated (semi-trailer) and heavy truck trailer combinations of approximately 25 to 42 tonnes, and long multi-trailer combinations (B-doubles) of 40 to 60 tonnes. In the absence of explicit information, it can only be assumed that the environmental impact statement has used the Permanent International Association of Road Congresses Australian default of 83 per cent 'single lorry' at 15 tonnes, and 17 per cent 'truck-trailer combinations/semitrailers' at 32 tonnes average, giving a combined average of 17.9 tonnes. This compares reasonably well with Roads and Maritime weigh-in-motion (WIM) data across all Sydney WIM sites for 2013 which gives an average of 16.6 tonnes.

The Environment Protection Authority recommends that the detailed fleet composition assumed in the assessment be provided. The assumed fleet composition should be provided by vehicle type and fuel type. Where the assumed fleet adopted in the current assessment cannot be adequately justified, a revised emissions inventory should be provided and, if necessary, a revised air quality impact assessment undertaken.

Response

Further discussion of fleet mix assumptions and sensitivity analyses is provided in **Section 2.8** of this report. That section also outlines other inputs and assumptions into the emissions inventory for the project.

The vehicle fleet composition applied to the calculation and assessment of in-tunnel air quality and potential ambient air quality impacts has been taken from the Australian Bureau of Statistics – Motor Vehicle Census (31 January 2013). This data has been reproduced in **Table 7-11**. For the purpose of the environmental impact statement, 'light vehicles' includes passenger vehicles and light duty vehicles.

Table 7-11 Vehicle fleet composition (ABS, 2013)

Vehicle type	Petrol (total)	Diesel	Other	All
Passenger vehicles				
Passenger vehicles	11,616,025	1,029,561	354,435	13,000,021
Campervans	17,635	34,164	2,302	54,101
Motorcycles	744,518	0	214	744,732
Light duty vehicles				
Light commercial vehicles	1,300,490	1,281,381	135,802	2,717,673
Non-freight vehicles	3,159	19,338	489	22,986
Heavy vehicles				
Light rigid trucks	9,116	120,044	1,987	131,147
Heavy rigid trucks	17,172	307,340	1,486	325,998
Articulated trucks	1,332	89,416	156	90,904
Buses	17,802	71,081	4,151	93,034

Based on these data, the light vehicle fleet composition (passenger vehicles and light duty vehicles) summarised in **Table 7-12** has been derived and applied to the air quality impact assessment for the project. The table shows that the assumed light vehicle fleet mix:

- Aligns well with default value published by the Permanent International Association of Road Congresses (ie 84 per cent passenger vehicles and 16 per cent light duty vehicles).
- Aligns well with the Environment Protection Authority's stated 18 to 20 per cent for light duty vehicles.

Table 7-12 Light vehicle fleet composition

Vehicle type	2013 data count (ABS)	Percentage
Cars	13,798,854	83.4%
Light duty vehicles	2,740,659	16.6%

The composition of the heavy vehicle fleet has also been derived from the Australian Bureau of Statistics data, as summarised in **Table 7-13**.

Table 7-13 Heavy vehicle fleet composition

Vehicle type	Petrol	Diesel	Other	All
Light rigid trucks	7.0%	91.5%	1.5%	20.5%
Heavy rigid trucks	5.3%	94.3%	0.5%	50.9%
Articulated trucks	1.5%	98.4%	0.2%	14.2%
Buses	19.1%	76.4%	4.5%	14.5%

Based on data from the Australian Bureau of Statistics, fuel mix has been derived for the 2013 fleet assuming that all vehicles are either fuelled with petrol or diesel. This is a conservative assumption because it does not make allowance for 'cleaner burning' fuels, such as liquefied petroleum gas (LPG). The derived 2013 fuel mix is summarised in **Table 7-14**.

A further conservative assumption was made for the purpose of the environmental impact statement, that all heavy vehicles would be diesel fuelled. As indicated in the environmental impact statement, the 2013 fuel mix for passenger vehicles (cars) and light duty vehicles was assumed to be constant into the future, whereas the proportion of alternative fuel vehicles is expected to continue to grow.

Table 7-14 Summary of fuel type (2013)

Vehicle type	Petrol	Diesel
Cars	92.1%	7.9%
Light duty vehicles	50.1%	49.9%
Heavy vehicles	7.2%	92.8%

The Environment Protection Authority's observation that the assumption that petrol/ diesel fuel mix would not change over time is not conservative is acknowledged.

To test the sensitivity of the air quality impact assessment, the mix of fuel types derived for 2013 (refer to **Table 7-12**) has been extrapolated based on an assumed constant linear trend in fuel types between the 2008 and 2013 data published by the Australian Bureau of Statistics. For example, between 2008 and 2013, the Australian Bureau of Statistics recorded a 104 per cent increase in diesel fuelled passenger vehicles but only a six per cent increase in petrol fuelled passenger vehicles over the same period.

Extrapolating changes in fuel mix in this manner has generated the fuel mix estimates in **Table 7-15** and **Table 7-16**, for 2019 and 2029, respectively.

Table 7-15 Summary of fuel type (2019)

Vehicle type	Petrol	Diesel
Cars	85.1%	14.9%
Light duty vehicles	34.4%	65.6%
Heavy vehicles	5.1%	94.9%

Table 7-16 Summary of fuel type (2029)

Vehicle type	Petrol	Diesel
Cars	77.1%	22.9%
Light duty vehicles	20.8%	79.2%
Heavy vehicles	2.6%	97.4%

These changes in fuel mix have been carried through the emissions inventory calculated for the project, and which was used as an input in the air quality impact assessment. Changes in the mass emission rate (g/s) of pollutants at the project's ventilation outlets as a consequence of these changes in fuel mix assumptions are summarised in **Table 7-17**. The table shows that with the change in fuel mix assumptions:

- Mass emission rates, and consequently ambient air quality impacts, would decrease for carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs) and total volatile organic compounds (VOCs).
- Mass emission rates for oxides of nitrogen (NO_x) and particulate matter (PM₁₀ and PM_{2.5}) would increase marginally – around one to two per cent in 2019, and around two to four per cent in 2029.

These changes in mass emission rates would not affect the outcomes of the air quality impact assessment presented in the environmental impact statement, and would have only a minor impact on modelled ground level concentrations of these pollutants. Notwithstanding, these updated fuel mix assumptions have been reflected in the additional air dispersion modelling conducted for the five metre increase in ventilation outlet heights (refer to **Section 2.15** and **Section 9.2** of this report).

Table 7-17 Effect of changes in fuel mix assumptions (change in mass emission rate)

Pollutant	Change to 2019 emissions	Change to 2029 emissions
CO	-3.2% to -3.4%	-6.8% to -7.3%
NO _x	+1.1% to +1.3%	+2.9% to +3.3%
PM ₁₀	+1.2% to +1.8%	+2.7% to + 3.9%
PM _{2.5}	+1.2% to +1.7%	+2.6% to +3.9%
PAHs	-0.4% to -0.4%	-1.0% to -1.1%
Total VOCs	-2.3% to -2.5%	-5.2% to -5.5%

Issue description

The Environment Protection Authority raises the following issues specific to assumptions around particulate matter emissions and PM₁₀/ PM_{2.5} determination:

- It is not stated in the environmental impact statement how non-exhaust PM₁₀ emissions have been calculated from the Permanent International Association of Road Congresses PM_{2.5} non-exhaust emissions. The European EMEP/EEA emission inventory guidebook (2009) covering non-exhaust particulate matter emissions indicates that PM₁₀ emissions from these sources are around 70 to 80 per cent higher than PM_{2.5} emissions. The New South Wales Environment Protection Authority 2008 Air Emissions Inventory estimates that non-exhaust PM₁₀ emissions are nearly double non-exhaust PM_{2.5}, and in 2011, the non-exhaust PM₁₀ for the total fleet is 50 per cent higher than the exhaust source PM₁₀.

The EPA recommends that clarification of how non-exhaust PM₁₀ emissions have been calculated given that the Permanent International Association of Road Congresses only provides PM_{2.5} non-exhaust emissions. If emissions have been underestimated, a revised air quality impact assessment should be provided to account for any changes to the estimate of non-exhaust PM₁₀ emissions.

Response

Further information on the assumptions, inputs and methodology applied to the calculation of the emissions inventories for the project is provided in **Section 2.8** of this report.

Non exhaust particulate matter emissions have been calculated using emission factors published by the Permanent International Association of Road Congresses (2012). The emission factors (Table 27) are:

- 0.028 g/ km for passenger cars (as PM_{2.5}).
- 0.104 g/ km for heavy vehicles (as PM_{2.5}).

These emission factors have been used to calculate similar non exhaust emissions factors for PM₁₀ based on the same ratio of PM_{2.5} to PM₁₀ as vehicle emissions calculated using the National Pollutant Inventory (2008) emission factors for combustion (around 0.95). This has generated the following non exhaust PM₁₀ emission factors:

- 0.029 g/ km for passenger cars (as PM₁₀).
- 0.109 g/ km for heavy vehicles (as PM₁₀).

In comparison, the Air Emissions Inventory for the Greater Metropolitan Region in New South Wales: On-road Mobile Emissions: Results (EPA, 2008) provides the following non-exhaust PM₁₀ emission factors (Table 4-144, all sources, freeway/ motorway):

- 0.0215 g/ km for passenger cars (as PM₁₀).
- 0.0297 g/ km for light commercial vehicles (as PM₁₀).
- 0.0866 g/ km for rigid trucks (as PM₁₀).
- 0.1203 g/ km for articulated trucks (as PM₁₀).

Non exhaust PM₁₀ emission factors show a good correlation between data published by the Environment Protection Authority (2008) and data derived from the Permanent International Association of Road Congresses (2012).

The emission factors for PM₁₀ can be used to derive non exhaust emission factors for PM_{2.5} using Environment Protection Authority (2008) data (Table 4-145):

- 0.0114 g/ km for passenger cars (as PM_{2.5}).
- 0.0158 g/ km for light commercial vehicles (as PM_{2.5}).
- 0.0461 g/ km for rigid trucks (as PM_{2.5}).
- 0.0640 g/ km for articulated trucks (as PM_{2.5}).

These emission factors are significantly lower (around half) of the values published by the Permanent International Association of Road Congresses (2012) and applied to the air quality impact assessment of the project. This suggests that in-tunnel air quality concentrations and ambient air dispersion modelling results for PM_{2.5} presented in the environmental impact statement may be overstated. This is broadly consistent with observations made in Section 7.3 of the environmental impact statement that in-tunnel PM_{2.5} concentrations based on Permanent International Association of Road Congresses emission factors are up to twice the equivalent values obtained when applying emission factors published by the Environment Protection Authority (refer to Figure 7-30 and Figure 7-31 in the environmental impact statement).

Issue description

The Environment Protection Authority raises the following issues specific to assumptions around NO₂ emissions:

- The environmental impact does not appear to discuss how NO₂ emissions have been calculated. The only reference is a footnote to various tables such as Table 18 and Table 19 of the Technical Working Paper: Air Quality (Appendix G of the environmental impact statement), where it is stated that '*NO₂ has been assumed to be 10 per cent of total nitrogen oxides, consistent with PIARC (2012)*'. This implies that this ratio was applied to all vehicle types.
- Light duty diesel vehicles have significantly higher NO₂ emissions as a proportion of total NO_x. The Environment Protection Authority inventory uses information from the European EMEP/EEA emission inventory guidebook (2009) which gives Euro certification specific NO₂ fractions, which for light duty diesels range up to 55 per cent for Euro 4 to Euro 6. Using this data, the Environment Protection Authority inventory estimates in 2021 that the NO₂ fraction for diesel light duty vehicles would be around 54 per cent.

- The NO₂ fraction of petrol light duty vehicles in the Environment Protection Authority inventory is estimated to be three per cent while for heavy duty diesel vehicles a fraction of 11 to 12 per cent is estimated.
- The environmental impact statement assumes a NO₂ fraction of 10 per cent for all vehicles. The Environment Protection Authority model assigns technology specific NO₂ fractions by vehicle class from European models and data. The total fleet average NO₂ fraction estimated by the Environment Protection Authority ranges from 15 to 17 per cent across the speed range.

The Environment Protection Authority recommends that clarification be provided in relation to how NO₂ emissions have been estimated and, if necessary, revise the aggregated fleet NO₂/ NO_x emission estimate to be based on the detailed fleet composition data and best international data on vehicle technology specific NO₂ fractions. If necessary, a revised air quality impact assessment should be provided to account for any changes to the emissions inventory.

Response

The emissions inventory developed as an input into the air dispersion modelling for the project is based on Permanent International Association of Road Congresses (2012) emission factors. The emission factors are expressed in terms of oxides of nitrogen (NO_x).

For the purpose of the ambient air quality dispersion modelling, no assumptions about the relative concentrations of NO₂ and total NO_x have been made based on vehicle or fuel type within the project tunnels. As discussed early in this report in response to issues raised by the Environment Protection Authority, the ozone limiting method has been applied to ambient air quality dispersion modelling results to determine ground level concentrations of NO₂. The default ozone limiting method equation includes an inherent assumption that 10 per cent of NO_x at the point of discharge is NO₂. Consistent with advice from the Environment Protection Authority, the ozone limited method equation has been amended for application to the project to reflect a discharge concentration of NO₂ at 16 per cent of total NO_x. This updated equation has been applied to the further air quality impact assessment conducted for the five metre increase in ventilation outlet heights (refer to **Section 2.15** and **Section 9.2** of this report).

The issue of in-tunnel concentrations of NO₂ is complex, noting that NO₂ concentrations within a road tunnel are a function of traffic volumes and vehicle/ fuel mix, vehicle emissions (as NO_x and as NO₂) and background pollutant levels drawn into the tunnel, the extent of dilution provided by background air, ventilation flow rates and in-tunnel air residence times, and the amount of ozone present. The significance of each of these factors will depend on the specific context of the road tunnel under consideration. However, broad observations about the proportions of NO_x and NO₂ in typical emissions from an entire vehicle fleet therefore do not necessarily reflect or approximate conditions that may be experience within a road tunnel.

When considering NO₂ concentrations within the NorthConnex project tunnels, and particularly the percentage of NO_x present as NO₂, it is important to take into account:

- The design of the tunnel ventilation system, including ventilation design criteria.
- Factors affecting the NO_x:NO₂ ratio.
- Historical data on NO_x:NO₂ ratios in other Australian and international road tunnels.
- Management of in-tunnel air quality.

Tunnel ventilation design

As discussed early in this report, in response to issues raised by the Environment Protection Authority about traffic forecasts, the project's ventilation system has been designed to meet specified design criteria under a range of average traffic speeds and tunnel operational scenarios. As is typically the case with engineering design, a reasonable level of design conservatism has been applied to provide additional operational capacity if required.

The design of the project's ventilation system has been based on, among other things, guidance published by the Permanent International Association of Road Congresses (2012), which has been developed from extensive international experience in road tunnel design and operation. The guidance published by the Permanent International Association of Road Congresses is inherently conservative to ensure a robust approach to the design of road tunnel ventilation systems. The data relied on as part of the design of the project's ventilation system has used emission factors relevant to the Australian vehicle fleet (including for CO, NO_x and opacity) and takes into account vehicle types (passenger vehicles, light duty vehicles and heavy goods vehicles) as well as fuel type (petrol and diesel).

The total rate of NO_x emissions generated by the combined fleet composition expected to travel through the project has been calculated for forecast traffic volumes and for a worst case traffic scenario (design analysis A) over a diurnal cycle. This includes peak traffic periods for the northbound and southbound main alignment tunnels, which would correlate with peak in-tunnel vehicle emissions.

Consistent with the advice published by the Permanent International Association of Road Congresses (2012), the calculation of in-tunnel air quality has assumed that 10 per cent of NO_x within the project tunnels would be present as NO₂. Calculated NO₂ concentrations within the main alignment tunnels have been used to appropriately design the project's ventilation system, including sizing of ventilation fans, to achieve the ventilation design criteria under all conditions. The limiting design factor in this case is the maximum traffic design capacity of the main alignment tunnels, should it be achieved in the future (as distinct from forecast traffic volumes). This approach means that the project's ventilation system would have additional capacity to manage in-tunnel air quality above what would ordinarily be required for forecast traffic volumes.

Factors affecting the NO_x:NO₂ ratio

The ratio of NO₂:NO_x varies based on a range of factors, predominately the percentage of diesel vehicles within a road tunnel, the length of the tunnel, and operation of the ventilation system.

Heavy goods vehicles generate significantly higher NO₂ emissions as a proportion of total NO_x, and will often be higher than 10 per cent. In comparison, petrol fuelled passenger vehicles generate considerably less NO₂ as a proportion of NO_x. Short tunnels generally experience higher ratios of NO₂:NO_x.

The Permanent International Association of Road Congresses (2012) states that:

'While in previous years NO_x from combustion processes contained mostly NO (90 to 95% of the NO_x), the implementation of diesel vehicle exhaust gas after-treatment systems (oxygenation catalyst, DPF1, SCR2 systems) tend to significantly increase the primary emitted NO₂ percentages.'

In many European road tunnels, NO₂ can be around 20 to 30% of NO_x concentrations, which strongly depends on the share of diesel vehicles with exhaust gas after-treatment systems in the vehicle fleet and on the residence time of the NO_x in the tunnel air.'

Although the percentage of diesel passenger vehicles in New South Wales is rising, the percentage of diesel vehicles forecast to use the NorthConnex project is considerably lower than experienced in international road tunnels, particularly those in Europe. Taking this into account, the assumption of 10 per cent NO₂:NO_x is considered to be reasonable and sufficient for the design of the project's ventilation system, including sizing ventilation fans and maximum capacity, to accommodate a worst case traffic scenario. In doing so, additional capacity has been provided if required under forecast traffic scenarios.

Historical NO_x:NO₂ ratio data

Two studies have looked at the NO₂:NO_x ratios in Australian tunnels. One study, conducted by Holmes Air Science on the M5 East Motorway in 2004 showed values for the NO₂:NO_x ratio in that tunnel of around five to six per cent. The second study, conducted on the Lane Cove Tunnel, found a median NO₂:NO_x ratio of around seven per cent.

Several other studies have been conducted on international road tunnels. **Table 7-18** summarises the findings of these studies in relation to NO₂:NO_x ratios. It is important to note that the majority of these road tunnels do not actively and directly monitor in-tunnel concentrations of NO₂.

Table 7-18 supports the selection of a NO₂:NO_x ratio of 10 per cent as appropriate for design of the project's ventilation system under worst case traffic conditions.

Table 7-18 Reported NO₂:NO_x ratios in international road tunnels (O’Gorman and Gehrke, 2014)

Tunnel	Reported NO₂:NO_x ratio	Source
La Croix Rousse, France (1.8 kilometres, bi-directional)	Average: 7.3% to 9.2 % Daily peak: 8.7% to 9.6% Ratios of 20% have been measured during low NO _x periods (off peak)	Permanent International Association of Road Congresses (2000)
Careybeckx, Netherlands (1.6 kilometre, twin tube)	Average: 5%	De Fre, Bruynseraede and Kretzshmer (1994)
Tate’s Cairn, Hong Kong (4 kilometre, twin tube)	Average: 6% Peaks in areas of high ozone: 20%	Yao et al (2005)
Tai Lam (3.7 kilometre, twin tube)		
Hatfield, United Kingdom (1.1 kilometres, twin tube)	Peak in areas of high ozone: 25% Near exit portals: 12% to 14%	Boulter, McCrae and Green (2007)
Bell Common, United Kingdom (500 metres, twin tube)		
M5 East Motorway, Australia (4 kilometres, twin tube)	Average: 5% to 6%	National Health and Medical Research Council (2008)
Laerdal, Norway (24.5 kilometres, bi-directional)	Range: 10% to 30% Typical: 20%	Norwegian Public Roads Administration (2013)
Fodnes, Norway (6.6 kilometres, bi-directional)		
Knappe, Norway (2.5 kilometres, twin tube)		
Lane Cove Tunnel, Australia	Median: 7%	O’Gorman et al (2009)

Management of in-tunnel air quality

The actual ratio of NO₂:NO_x within the project tunnels is expected to fluctuate throughout the day. During off peak hours when traffic volumes are low and times when there is a higher percentage of heavy vehicles within the tunnels, the ratio of NO₂:NO_x may increase above 10 per cent. Although the ratio of NO₂:NO_x may increase during these periods, the total NO_x load would be considerably lower than during peak traffic periods.

Under all circumstances, the NorthConnex tunnels would continue to operate within the stipulated design criteria for NO₂. Air quality within the tunnels would be continuously monitored and the ventilation rate would be adjusted in response to traffic flows and real-time measurements for NO₂ concentrations taken within the project tunnels. This would maintain a safe environment for the tunnel users.

Notwithstanding the analysis presented in this section, in-tunnel air quality calculations have been conducted assuming both a 10 per cent and a 16 per cent NO₂ fraction of total nitrogen oxides in the project tunnels. This sensitivity analysis is provided in **Section 2.9**.

Issue description

The environmental impacts associated with off road diesel equipment can be a major source of fine particulate matter. The Environment Protection Authority recommends that an assessment of the environmental impacts associated with heavy vehicles be provided, including off road diesel equipment and plant used in the construction of the project. This should include but is not limited to:

- Compliance with relevant and current emission standards as prescribed in the Australian Design Rules for heavy duty engines and vehicles.
- Strategies for minimising air emissions from off road diesel equipment including but not limited to graders, bulldozers, loaders etc.
- Confirmation that all off road diesel equipment will meet best available diesel emissions standards or be fitted with an appropriate diesel exhaust treatment device where possible.

Response

All diesel fuelled plant and equipment used during the construction of the project would:

- Comply with relevant and current emission standards as prescribed in the Australian Design Rules for heavy duty engines and vehicles.
- Meet best available diesel emissions standards or be fitted with an appropriate diesel exhaust treatment devices where feasible and reasonable.

Site specific air quality mitigation and management measures would be developed for construction sites, construction activities and relevant plant and equipment during the detailed design of the project. The Environment Protection Authority would be consulted during the development of these measures. The Construction Environmental Management Plan(s) for project would detail site specific air quality mitigation and management measures, including measures to ensure minimisation of emissions where feasible and reasonable.

7.1.1.4 Construction noise and vibration

Issue description

Works are proposed outside of standard construction hours stated in the Interim Construction Noise Guideline (DECC, 2009), often without sufficient clarity as to their duration, location and extent. For example, the Technical Working Paper: Noise and Vibration states that rock hammering in the tunnel would be avoided between 10 pm and 7 am, but does not explain why this activity cannot be instead undertaken during standard hours only. Similarly, the Hills M2 Motorway integration works, bridge works and 'surface works supporting construction' are proposed on a 24 hour/ seven day basis without adequate justification for the potential impact or evidence of community consultation and support.

The Environment Protection considers that works should be restricted to the standard construction hours in the Interim Construction Noise Guideline unless clear justification is provided.

Response

There are three types of construction activities that cannot be feasibly or reasonably restricted to standard construction hours:

1. Underground tunnelling activities.
2. Surface activities supporting underground tunnelling activities.
3. Activities conducted within active road reserves.

Once commenced, it is not practical to start and stop tunnelling activities. The project tunnels would be constructed with principally with roadheaders with construction in some areas also employing surface miners. Significant time and resources are required to start-up and shut-down this equipment, which would introduce avoidable inefficiencies into the construction methodology and program if the project were limited to standard construction activities for tunnelling activities. Further, the current construction program which involves tunnelling activities over slightly less than three years (refer to Table 5-5 in the environmental impact statement) could be extended to include up to around eight to nine years of tunnelling works if standard construction hours were required for underground tunnelling. The environmental impact statement has demonstrated that, with some limited exceptions around tunnel portals, surface impacts as a result of underground tunnelling activities would be negligible.

Jack hammering underground may be required during tunnelling activities. Because this activity is noise intensity and poses an elevated risk of ground-borne noise and vibration, particularly around portal locations, a commitment has been made to avoid jack hammering at night. For the same reasons as outlined above in relation to tunnelling, further restrictions on rock hammering in the tunnel would not be practical.

Because tunnel works would be undertaken continuously, 24 hours per day and seven days per week,, tunnel support activities at the southern interchange compound (C5), the Wilson Road compound (C6), the Trelawney Street compound (C7) and the northern interchange compound (C9) are also likely to be required up to 24 hours per day and seven days per week. This is principally because of three factors:

- The total extent of land acquisition and surface disturbance required for the project has been minimised. As a consequence, there is limited space to stockpile spoil and a need to regularly remove spoil from tunnel support sites.
- Spreading traffic movements over a 24 hour period reduces peak impacts, with lower impacts on average for most receivers.
- The highly congested traffic situation along Pennant Hills Road during and around peak hours, and high traffic volumes at other times of the day limit the ability to remove spoil for large periods during day time hours.

Some of the Hills M2 Motorway integration works are also required to be conducted outside of standard construction hours. This is principally driven by the need to ensure construction safety and the continued operation of the Hills M2 Motorway with minimal disruption during construction works affecting or in proximity to live road carriageways.

The need to conduct construction works within road reserves outside of standard construction hours, such as for the Hills M2 Motorway integrations works, is different to conducting construction works on a 24 hour/ seven day basis. There is no suggestion in the environmental impact statement that construction activities associated with the Hills M2 Motorway would be required on a 24 hour/ seven day basis (only outside of standard construction hours). This approach is consistent with construction scheduling for the M2 Motorway Upgrade project, and for other major road and rail infrastructure projects where construction safety is an issue.

As outlined in the environmental impact statement, other construction activities may be conducted outside of standard construction hours where the works in question are minor/ low impact, required for emergency response or under statutory direction, or for which agreement has been reached with the affected receiver(s). These works, if required, would include:

- Construction activities that do not exceed the applicable Noise Management Level at the nearest sensitive receiver.
- Activities that required by the Police or other authorities for safety reasons.
- Activities that are required to avoid the loss of life, property and/ or to prevent environmental harm in the event of an emergency.
- Construction activities for which negotiated agreements are in place with the affected receivers.
- Construction activities otherwise authorised by an environment protection licence.

Consistent with the Interim Construction Noise Guideline, construction activities outside of standard construction hours have:

- Considered the nature of the project as a public infrastructure project.
- Included a focus on opportunities to minimise the total construction program and the duration of impacts on surrounding receivers.
- Been justified for reasons other than convenience.

As specified in the Interim Construction Noise Guideline, consultation required under the environmental impact assessment process has been conducted to allow '*community views to be considered when deciding whether the need to work outside standard hours has been adequately justified*'. Issues raised in community submissions relating to construction noise, and responses to those issues, are provided in **Section 8.8** of this report.

Issue description

Ground-borne noise from tunnelling is predicted to impact sensitive receivers at an internal level up to 45 dB(A), 24 hours a day for up to two days, with ground-borne noise discernible at each receiver for up to five days (refer to page 63 of the Technical Working Paper: Noise and Vibration). No mitigation measures are proposed for these receivers.

The Environment Protection Authority recommends that a strategy for dealing with regenerated noise impacts from tunnelling works is developed.

Response

During construction of the project, a Construction Noise and Vibration Management Plan(s) would be developed and implemented for each construction site/ activity, or each group of construction sites/ activities. These plans would detail site/ activity specific mitigation measures, taking into account the number and sensitivity of potentially affected receivers, the nature and duration of relevant construction activities, and the availability of feasible and reasonable mitigation measures.

An initial framework for a construction noise mitigation and management strategy has been developed consistent with the approach taken during the construction of the North West Rail Link and the Hills M2 Motorway Upgrade. This framework includes details of specific mitigation and management measures that would be applied, depending on the construction noise issue (including ground-borne noise) and the extent to which a receiver is anticipated to be impacted. Further details of the construction noise mitigation and management framework are provided in **Section 4.5** of this report.

Issue description

The construction traffic noise assessment in Section 7.2.4 of the environmental impact statement states that during the quietest periods of the night, construction traffic will increase local road noise by more than 2 dB(A), but is mitigated by the dominant noise effect of major roads (refer to page 422 of the environmental impact statement).

The Environment Protection Authority recommends that the expected worst-case construction traffic noise should be compared to measured overall road traffic noise levels to demonstrate this.

Response

Based on concerns raised in public submissions and through other community and stakeholder engagement mechanisms (refer to **Chapter 5** of this report), access arrangements to several construction compounds have been reviewed. This has included a review of heavy vehicle access arrangements to the southern interchange compound (C5), the Trelawney Street compound (C7) and the northern interchange compound (C9). As a result, heavy vehicle use of residential streets has been reduced further, with reductions in potential amenity impacts for local receivers.

Changes made to access arrangements at the southern interchange compound, the Trelawney Street compound and the northern interchange compound are detailed and assessed in **Section 9.4** of this report. In relation to traffic noise levels, this has resulted in a significant reduction in potential traffic noise increases during the more sensitive night time period.

Issue description

The cumulative construction noise assessment indicates that the reasonable worst case scenario for construction of this project alone may be 3 dB(A) or more above the predicted levels for each component in isolation (refer to page 425, Section 7.2.4 of the environmental impact statement and page 79 of the Technical Working Paper: Noise and Vibration).

The Environment Protection Authority recommends that mitigation measures for construction impacts should be chosen based on the reasonable worst case scenario for all components of this project and further detail provided on these mitigation measures and their effectiveness in reducing cumulative noise levels.

Response

The construction noise impact assessment presented in the environmental impact statement has been based on a conservative assumption that all plant and equipment within a construction site would be operating simultaneously and at the point closest to surrounding receivers. This inherent conservatism is likely to substantially, if not completely, offset the predicted 3 dB(A) increase in noise predictions associated with cumulative noise impacts.

The potential for cumulative noise impacts would be managed through the preparation and implementation of a Construction Noise and Vibration Plan(s), which would take into account the need for scheduling activities to minimise or avoid cumulative noise impacts, where feasible and reasonable. The plans would also detail site and receiver specific noise mitigation and management measures consistent with the Interim Construction Noise Guideline (DECC, 2005).

An initial framework for a construction noise mitigation and management strategy has been developed consistent with the approach taken during the construction of the North West Rail Link and the Hills M2 Motorway Upgrade. This framework includes details of specific mitigation and management measures that would be applied, depending on the construction noise issue (including ground-borne noise) and the extent to which a receiver is anticipated to be impacted. Further details of the construction noise mitigation and management framework are provided in **Section 4.5** of this report.

Issue description

The Technical Working Paper: Noise and Vibration (page 47) states that ' L_{A1} sound power levels are typically up to 8 dB(A) above L_{Aeq} sound power levels'. However some plant, for example excavators with rock hammers and piling rigs, may have a greater differential than the assumed 8 dB(A).

The Environment Protection Authority recommends that the differential should be justified by reference to appropriate literature or measurement values.

Response

Reference to the typical difference in L_{A1} sound power levels and L_{Aeq} sound power levels made in the Technical Working Paper: Noise and Vibration is a broad observation, and does not affect the assumptions or outcomes of the noise impact assessment. The observation is based on review of L_{Aeq} and L_{Amax} data provided in the UK Department for Environment Food and Rural Affairs (DEFRA) Update of Noise Database for Prediction of Noise on Construction and Open Sites (2005), which shows a typical difference of around 8 dB(A). It is recognised that some plant and equipment may exhibited a greater difference than this, while some plant and equipment may exhibit a lesser difference.

Issue description

The sleep disturbance impacts of construction traffic do not appear to have been assessed in accordance with guidance in the NSW Road Noise Policy (DECCW, 2011) and Environmental Noise Management Manual (RTA, 2001).

The Environment Protection Authority recommends that a strategy for dealing with construction traffic noise impacts, including sleep disturbance, is provided that will cater for the various routes that construction traffic will use throughout the project.

Response

There are currently no guidelines published by the Environment Protection Authority that require assessment of traffic-related sleep disturbance or that set criteria/ thresholds against which such impacts should be assessed. In particular, the NSW Road Noise Policy (DECCW, 2011) states that:

Triggers for, and effects of sleep disturbance from, exposure to intermittent noise such as noise from road traffic are still being studied. There appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. The NSW Roads and Traffic Authority's Practice Note 3 (NSW Roads and Traffic Authority 2008a) outlines a protocol for assessing and reporting on maximum noise levels and the potential for sleep disturbance.

[The Environment Protection Authority] will continue to review research on sleep disturbance as it becomes available.

Roads and Maritime has adopted a maximum noise/ sleep disturbance assessment policy as part of the Environmental Noise Management Manual (Practice Note III), but this applies to operational road traffic noise rather than to transient construction traffic noise of limited duration (ie not continuous and indefinite).

Based on concerns raised in public submissions and through other community and stakeholder engagement mechanisms (refer to **Chapter 5** of this report), access arrangements to several construction compounds have been reviewed. This has included a review of heavy vehicle access arrangements to the southern interchange compound (C5), the Trelawney Street compound (C7) and the northern interchange compound (C9). As a result, heavy vehicle use of residential streets has been reduced further, with reductions in potential amenity impacts for local receivers.

Changes made to access arrangements at the southern interchange compound, the Trelawney Street compound and the northern interchange compound are detailed and assessed in **Section 9.4** of this report. In relation to traffic noise levels, this has resulted in a significant reduction in potential traffic noise increases during the more sensitive night time period.

During construction of the project, a Construction Noise and Vibration Management Plan(s) would be developed and implemented for each construction site/ activity, or each group of construction sites/ activities. These plans would detail site/ activity specific mitigation measures, taking into account the number and sensitivity of potentially affected receivers, the nature and duration of relevant construction activities, and the availability of feasible and reasonable mitigation measures.

An initial framework for a construction noise mitigation and management strategy has been developed consistent with the approach taken during the construction of the North West Rail Link and the Hills M2 Motorway Upgrade. This framework includes details of specific mitigation and management measures that would be applied, depending on the construction noise issue (including ground-borne noise) and the extent to which a receiver is anticipated to be impacted. Further details of the construction noise mitigation and management framework are provided in **Section 4.5** of this report.

Issue description

With respect to mitigation, a Construction Noise and Vibration Management Plan (CNVMP) is proposed and a number of general methods to address construction noise impacts mentioned, but no specific measures have been assessed or committed to, nor has any assessment of their mitigation performance at sensitive receivers been carried out. Similarly with regard to construction vibration mitigation, a number of general measures are discussed, but no specific measures or their respective performance have been assessed or committed to.

Response

An initial framework for a construction noise mitigation and management strategy has been developed consistent with the approach taken during the construction of the North West Rail Link and the Hills M2 Motorway Upgrade. This framework includes details of specific mitigation and management measures that would be applied, depending on the construction noise issue (including ground-borne noise) and the extent to which a receiver is anticipated to be impacted. Further details of the construction noise mitigation and management framework are provided in **Section 4.5** of this report.

Issue description

The Environment Protection Authority considers that the noise and vibration modelling assumptions are generally reasonable, noting that:

- No temporary barriers have been assumed, which is a conservative assumption.
- All equipment has been considered to be operating concurrently, which is a conservative assumption.
- Acoustic sheds are proposed, with an insertion loss of '25'. Clarification should be provided that this is 25 dB(A).
- Equipment is considered to be operating at the closest location to receivers, which is a conservative assumption.

Underground construction equipment has not been modelled, which is reasonable, except when operating at or near portals/openings.

The Environment Protection Authority recommends that clarification should be provided on how the impacts of underground equipment have been accounted for in the modelling.

Response

The construction of the acoustic sheds has been assumed to have an insertion loss of 25 dB(A).

The construction noise impact assessment has assumed that works conducted underground near the tunnel portals would take place on the surface at that location. This is a conservative assessment which is likely to overestimate the potential noise impacts from these construction activities.

7.1.1.5 Operational noise and vibration**Issue description**

The environmental impact statement states that Stone Mastic Asphalt (SMA) is proposed for the motorway ramps, in accordance with the tender design.

The Environment Protection Authority recommends that consideration be given to the use of Open Graded Asphalt (OGA) to compare the additional noise benefit against the maintenance requirements.

Response

The noise reduction of Open Grade Asphalt in comparison to Stone Mastic Asphalt is typically around 1 dB(A). This noise reduction is not considered to be significant.

The operation life of Open Grade Asphalt is significantly less than Stone Mastic Asphalt. So although Open Grade Asphalt may offer minor reductions in noise impacts during operation, it would require more frequent pavement replacement with associated periods of construction related noise.

In the majority of locations where Stone Mastic Asphalt is proposed to be used, there are no receivers which trigger the need for consideration of potential at-property noise treatment. As such, consideration of a higher performing road pavement (with regard to noise performance) in these locations is not justified.

Issue description

A ground absorption factor of 0.75 has been used in the noise impact assessment, and is supported by calibration results. However, a lower figure may be more appropriate in an urban/suburban situation such as around the NorthConnex project.

The near-field calibration point results would not be a reliable indicator of the appropriateness of a particular absorption factor. The Environment Protection Authority considers that using a more conservative lower absorption factor would lead to higher predicted noise levels at distances from the road.

The Environment Protection Authority recommends assessment using a more conservative lower absorption factor.

Response

Noise logging has been conducted as far away as 120 metres from the M1 Pacific Motorway and 150 metres from the Hills M2 Motorway.

As observed by the Environment Protection Authority, data from these locations calibrated well with the noise model. The calibration factor has been chosen to ensure a suitable

calibration across the entire project. Using a more conservative calibration factor would have resulted in a noise model that would not calibrate appropriately. It is not considered appropriate to use a ground absorption factor that results in a model that cannot be calibrated.

Issue description

The scope for defining the noise impact assessment study area is different to the 600 metre envelope method used in the NSW Road Noise Policy (DECCW, 2011).

The Environment Protection Authority recommends that, while there has previously been discussions with Roads and Maritime regarding the differences between these two methods, the assessment should explicitly state that applying the 'highly urban' area approach will not result in diminished mitigation outcomes or increased noise impacts to the surrounding community.

Response

For the southern interchange and the Hills M2 Motorway integration works, the entire 600 metre catchment area has been modelled and assessed. Compared with the northern interchange and the M1 Pacific Motorway, this area has fewer competing (non-project) noise sources.

For the northern interchange and M1 Pacific Motorway tie-in, the noise impact assessment study area has been reduced from the 600 metres area by applying the 'highly urban' area approach. This approach has been adopted to address other significant sources of noise in this area, including major roads (such as the Pacific Highway) and railway lines.

Applying the 'highly urban' area approach has not resulted in diminished mitigation outcomes or increased noise impacts to the surrounding community.

Issue description

The modelling of traffic noise from tunnel portals has been carried out using a commercial software package using a recognised calculation method (SoundPLAN Nord2000). However, more detail on the values chosen for the input variables to the model, and its accuracy, is warranted in the assessment.

The Environment Protection Authority recommends that clarification be provided regarding the input values to the model and its accuracy.

Response

The sound power level is based on the road strings with which the tunnel portals intersect. Dimensions of the portal opening have been used, in addition to smooth concrete surface absorption characteristics. This would result in a conservative assessment of tunnel portal noise.

Issue description

Noise mitigation measures are proposed for a number of receivers, however no clear commitment to provision of mitigation measures has been made in the assessment.

The Environment Protection Authority recommends that the proponent provides detailed noise mitigation measures for affected receivers and a commitment to the provision of those measures.

Response

Operational mitigation measures in the form of low noise road pavement, noise barriers and at-property acoustic treatment have been identified in the environmental impact statement. The project would implement all of these measures, where relevant and feasible and reasonable. The scope and location of specific noise mitigation measures would be confirmed during the detailed design phase of the project.

Noise mitigation measures would be reviewed during detailed design to ensure that reasonable and feasible noise mitigation measures are provided, including noise barriers where appropriate, to meet the requirements of the NSW Road Noise Policy (DECCW, 2011) and the Environmental Noise Management Manual (RTA, 2005).

(blank page)

7.1.2 NSW Health

7.1.2.1 Human health risk assessment

Issue description

NSW Health is satisfied that the human health risk assessment has been generally undertaken in an appropriate manner. The human health risk assessment relies on data from air modelling and the comments provided in this letter are contingent upon the Environment Protection Authority's confirmation that the modelling approach is consistent with their Approved Methods.

It should be noted that the modelling is dependent on a number of assumptions, for example, future traffic flows.

Response

NSW Health's acceptance of the methodology applied to the human health risk assessment is noted.

The air quality impact assessment presented in Section 7.3 and Appendix G of the environmental impact statement, and on which the human health risk assessment has been based, has been conducted in accordance with the Approved Methods for the Modelling and Assessment in New South Wales (DEC, 2001).

Issues raised in the submission made by the Environment Protection Authority, including those specific to the air quality impact assessment, have been addressed in **Section 7.1.1** of this report. Clarifications of assumptions and inputs into the air quality modelling conducted for the project are also provided in **Chapter 2**.

Assessments presented in the environmental impact statement are based on forecast traffic data generated through a strategic transport model of Sydney's major road network using the Cube Voyager software platform. Cube is the most widely used software package in the world for transport planning.

The Cube model used to develop traffic forecast data for the NorthConnex project has taken into account factors including existing and future land use, anticipated changes to the major road network, existing and future travel demands, existing and future tolling structures, and motorist behaviours. Further details of these assumptions and inputs are provided in Section 5.2 of the Technical Working Paper: Traffic and Transport (Appendix E to the environmental impact statement).

While the traffic forecasts for the project robust, it is recognised that regulatory authorities, the local community and other stakeholders require confidence that the project will be able to meet acceptable outcomes if traffic conditions differ from forecasts. To provide confidence in the performance of the project in the event that actual traffic demand exceeds traffic forecasts in the future, the air quality impact assessment also considers 'design analysis A'.

Design analysis A assumes that the theoretical design capacity of 4,000 passenger car units would be reached during the peak hour. It is extremely unlikely that the maximum design capacity would be experienced for an entire 24-hour period, with traffic volumes likely to ebb and flow during the day around peak periods.

A realistic traffic scenario for design analysis A was therefore established by:

- Comparing the maximum theoretical design capacity of each main alignment tunnel (4,000 passenger car units) with the expected peak hour traffic volumes in 2019, which were around 1,790 passenger car units in the southbound main alignment tunnel (morning peak) and around 1,930 passenger car units in the northbound main alignment tunnel (afternoon peak).
- Noting that the theoretical design capacity was around a factor of 2.1 times the maximum forecast peak in 2019 (ie 4,000 is around 2.1 times 1,930).
- Scaling the forecast traffic flows for 2019 by a factor of 2.1 for each hour of the day, to obtain the traffic flows used for design analysis A.

Further information on the design basis for the maximum traffic capacity of the project, and the derivation of 'design analysis A' is provided in response to issues raised in the submission received from the Environment Protection Authority (refer to **Section 7.1.1.3**).

A comparison of forecast traffic volumes in 2019 and traffic volumes considered under design analysis A for the northbound main alignment tunnel is provided in **Figure 7-2**.

The total daily traffic volumes for design analysis A were therefore around 48,000 passenger car units in each main alignment tunnel. This is a reasonable and realistic estimate of a worst case scenario for operation of the NorthConnex project. The environmental impact statement demonstrates that design analysis A would meet applicable ambient air quality criteria.

Issue description

The human health risk assessment appropriately quantifies the incremental risk for local residents resulting from the predicted increased particulate matter exposure around both the northern and southern ventilation outlets. It should be emphasised that the exposure estimates used to undertake this assessment have been taken at face value.

Response

NSW Health's acceptance of the methodology applied to the human health risk assessment is noted, and that exposure estimates derived from air quality modelling have not been reviewed by NSW Health.

It is important that the NorthConnex project be considered as a whole, including both positive and negative impacts, and that the total population potentially affected by the project is also taken into account. With this in mind, the human health risk assessment presented in Section 7.4 and Appendix H of the environmental impact statement takes an holistic view of the project and the potentially affected population and demonstrates that, when considering the NorthConnex project as a whole, a net reduction in human health risks is expected across the potentially affected population.

As indicated in Table 5-7 of the Technical Working Paper: Human Health Risk Assessment (Appendix H to the environmental impact statement), the NorthConnex project would result in:

- A net reduction in the risk of mortality (≥ 30 years, all causes, long term) of 3×10^{-5} (three in 100,000) in both 2019 and 2029, when considering the project and the affected population as a whole.
- A net reduction in the risk of hospitalisations (≥ 65 years, cardiovascular, short term) of 8×10^{-5} (eight in 100,000) in 2019 and 9×10^{-5} (nine in 100,000) in 2029, when considering the project and the affected population as a whole.
- A net reduction in the risk of hospitalisations (≥ 65 years, respiratory, short term) of 2×10^{-5} (two in 100,000) in both 2019 and 2029, when considering the project and the affected population as a whole.

These net positive human health risk implications need to be considered in the context of a balanced, merit based assessment which also considers both the positive and negative impacts of the NorthConnex project in other areas, including traffic and transport, air quality, noise, ecology and heritage (among other issues, as detailed in the environmental impact statement).

Issue description

There are some discrepancies and internal inconsistencies within the Technical Working Paper: Air Quality that raise concerns about the robustness of the exposure inputs into the human health risk assessment.

An example is the tunnel outlet emission tables in Appendix H of the Technical Working Paper: Air Quality.

Response

A clarification of this issue is provided in **Section 2.8.2** of this report.

The emission rates used in the air dispersion modelling and impact assessment presented in Section 7.3 and Appendix G of the environmental impact statement are correct. This is despite these emission rates not being reflected in Appendix H to the Technical Working Paper: Air Quality, as published.

The inputs into the human health risk assessment, as derived from the outputs of the air quality dispersion modelling, are therefore also correct.

7.1.2.2 Calculation of in-tunnel air quality

Issue description

The human health risk assessment has been based primarily on a scenario where estimated expected traffic flows have been assumed. Given the expected growth in traffic for the corridor (as predicted by Scenario 2B (2029) and that the tunnels have been designed to have three traffic lanes in both directions) it would be prudent to consider scenarios with higher than predicted traffic flows. This has been done to some extent for external air quality (see Appendix E of human health risk assessment) but no similar assessment has been done for in-tunnel air quality.

In-tunnel air quality predictions made by the environmental impact have been based on the "most likely" traffic forecasts. It would be prudent to consider a more conservative scenario with higher traffic flows to provide greater surety in the assessment.

Pollutant concentrations increase along the tunnel and it would also be useful to clarify the location within the tunnel where [the criteria listed in Table 7-95 of the environmental impact statement] are to be applied (e.g. the mid-point, where there would be average concentrations or the distal end, where concentrations would be at their maximum).

It would be useful to clarify this (the assumption of free flowing traffic at 80km/h) and confirm the averaging period for the concentrations presented in the table.

Response

The current application for the NorthConnex project seeks approval for a road tunnel marked for two traffic lanes in each direction. Separate assessments would be conducted in the future, including air quality and human health risk assessments, if the project is to be expanded to more than two lanes in either or both directions.

The human health risk assessment presented in Section 7.4 and Appendix H of the environmental impact statement considers potential health impacts under forecast traffic scenarios in 2019 and 2029.

The forecast traffic volumes for the NorthConnex project are robust and realistic.

The project's ventilation system has been designed to achieve specified in-tunnel air quality outcomes for traffic volumes up to and including the maximum traffic throughput capacity of the project's main alignment tunnels. The ventilation system design criteria are provided in Table 7-95 of the environmental impact statement and are reproduced below. **Table 7-19** provides additional explanatory comments to provide context to the likely operational mode of the project relative to average traffic speeds and ventilation system design criteria.

Table 7-19 Ventilation system design criteria

Average traffic speed (km/h)	Operational mode	CO design criteria (15 minute)	NO ₂ design criteria (15 minute)	Visibility (extinction coefficient)
80	Normal traffic conditions. Vehicles are moving freely with no congestion effects	50 ppm (57.5 mg/m ³)	0.5 ppm (0.94 mg/m ³)	<0.005 m ⁻¹
60		50 ppm (57.5 mg/m ³)	0.5 ppm (0.94 mg/m ³)	<0.005 m ⁻¹
40	Congested traffic conditions. Vehicles have slowed as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be implemented as average traffic speeds fall towards 40 km/h.	60 ppm (69 mg/m ³)	0.8 ppm (1.51 mg/m ³)	<0.005 m ⁻¹
0 to 20	Significantly congested traffic conditions. Vehicles have slowed significantly as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be in place.	87 ppm (100 mg/m ³)	1.0 ppm (1.88 mg/m ³)	<0.005 m ⁻¹

In applying the ventilation system design criteria outlined in **Table 7-19**:

- The CO ventilation design criterion has been applied as a **15-minute exposure standard** for a motorist using the project tunnels (with no allowance made for the mitigating effects of closing vehicle windows or recirculating vehicle air). For likely average traffic speeds through the main alignment tunnels, in-tunnel exposure durations would be less than 15 minutes, and as such, exposure to ambient air before and/ or after travel through a main alignment tunnel has also been taken into account when assessing motorist exposures. In the case of CO, ambient air has been assumed to be 5 ppm CO (5.73 mg/m³ or equivalently 5,730 µg/m³), which is higher than monitored background air quality data (refer to **Section 2.11**). For an example of a motorist travelling at an average speed of 80 kilometres per hour (ie an in-tunnel journey of around 6.75 minutes), the motorist's exposure to CO would be:

 - Around 6.75 minutes within the main alignment tunnel, with gradually increasing in-tunnel concentrations of CO from the tunnel entry portal to the ventilation offtake near the tunnel exit portal. The concentrations of CO experienced by the motorist within the main alignment tunnel would depend on the traffic volumes/ traffic mix at the time of the tunnel journey.
 - The remaining 8.25 minutes (to total 15 minutes) with exposure to ambient air, being assumed to be a constant 5 ppm (5.73 mg/m³ or equivalently 5,730 µg/m³) for the design and sizing of the ventilation system.
- The NO₂ ventilation design criterion has also been applied as a **15-minute exposure standard**, and assessed in a similar way as outlined above for CO. For the purpose of taking into account background air quality, exposures prior to and following a journey through the project tunnels has been assumed to occur at 1 ppm NO_x (1.88 mg/m³ or equivalently 1,880 µg/m³). Comparison with the monitored background air quality data (refer to **Section 2.11**) shows that this assumption overestimates likely ambient concentrations of NO_x.

- The visibility design criterion has been applied as **an in-tunnel air quality standard**, applicable at all locations along the project tunnels, irrespective of potential motorist exposures.

As noted above, background concentrations of CO and NO_x outside the project tunnels have been assumed to be constant and above monitored background values. This is a conservative assumption because a higher assumed exposure to CO and NO_x outside the project tunnels means that a motorist must be exposed to lower concentrations in the project tunnels (than if a lower background concentration outside the project tunnels had been assumed) in order for the ventilation design criteria to be met (as exposure standards). This approach will have led to a slight over-design in the ventilation system capacity to maintain lower-than-required in-tunnel concentrations of CO and NO_x. This slight over-design provides additional latent ventilation capacity in the event that it is ever required and is considered to be a prudent approach to the design and management of a road tunnel ventilation system.

Assumed background concentrations of CO and NO_x have also been taken into account in the air drawn into the project portals (as vehicles enter the project tunnels) for the purpose of design and sizing the ventilation system. A similar approach was not applied to calculation of the project emissions inventory used in the ambient air quality modelling and assessment, as discussed further in **Section 2.8**. By overestimating the concentration of CO and NO_x likely to be drawn into the tunnel portals, a slight over-design of the project ventilation system has resulted. This slight overdesign provides further latent design capacity in the ventilation system if it is required.

As discussed in **Section 2.5.1** of this report, the total number of vehicles (measured as a standard passenger car unit) that can pass a fixed point in a motorway lane per hour is dependent on the average speed of traffic. 'Passenger car units' is a standard, consistent basis for measuring the 'space' taken up by different size vehicles. For example:

- A standard passenger vehicle is one passenger car unit.
- An articulated truck is 2.9 passenger car units.
- A truck and dog is two passenger car units.

This relationship between motorway lane 'throughput capacity' and average traffic speed is illustrated in **Figure 2-1** (refer to **Chapter 2**). The figure shows that:

- A maximum motorway lane capacity of 2,000 passenger car units per lane per hour is achievable at an average traffic speed of 60 km/h. This means that 2,000 passenger car units could pass a fixed monitoring point on a motorway lane every hour if traffic is travelling at 60 km/h.
- At an average traffic speed of 80 km/h per hour, a greater stopping distance is required between vehicles. Because of this, only 1,740 passenger car units would pass the same fixed point on a motorway lane per hour.
- At an average speed of 40 km/h, a shorter stopping is required between vehicles, but the vehicles are moving more slowly. Because of this, only 1,849 passenger car units would pass the same fixed point on a motorway lane per hour. For 20 km/h, this figure would drop further to only 1,419 passenger car units per hour.

For the two lane configuration of each of the project's main alignment tunnels, this means that for a fixed point, the following maximum vehicle throughputs could be accommodated:

- A maximum of 3,480 passenger car units per hour (two lanes) at 80 km/h.
- A maximum of 4,000 passenger car units per hour (two lanes) at 60 km/h.
- A maximum of 3,698 passenger car units per hour (two lanes) at 40 km/h.

By virtue of the physical capacity of a motorway lane to allow traffic to pass, the 'worst case' in-tunnel vehicle emissions scenarios for the project would occur whenever the maximum throughput of traffic is experienced at the relevant average traffic speed, as listed above. As part of the ventilation design process for the project, these 'worst case' vehicle emissions scenarios have been analysed and the ventilation system sized to provide sufficient air flow to ensure that in-tunnel concentrations of emissions do not exceed the design criteria specified in **Table 7-19**.

Table 7-20 summarises calculated in tunnel air quality (ventilation design calculations) at the ventilation offtake and at the tunnel mid point for the northbound and southbound main alignment tunnels for the maximum physical throughput capacity at each nominated average traffic speed.

The values shown in the table are in-tunnel concentrations at the relevant point (as distinct from motorist exposures). Therefore some of the concentrations listed in the table at the ventilation offtake are higher in magnitude than the ventilation system design criteria. The project ventilation would nonetheless comply with the ventilation system design criteria when factors including averaging period and the distinction between exposure standards and in-tunnel concentrations are taken into account.

The calculations conducted for the values presented in **Table 7-20** are:

- Based on the maximum physical throughput capacity of the main alignment tunnels at average traffic speeds of 80 km/h, 60 km/h and 40 km/h.
- Based on the project's ventilation design to achieve these criteria.
- Independent of year (as they are based in the maximum traffic throughput of a motorway lane), but have conservatively applied the Permanent International Association of Road Congresses (2012) emission factors for 2019 (rather than lower emissions factors for a later year). Emissions from vehicles after this year are expected to be no worse than in 2019, and likely to improve over time, based on current trends, with increased vehicle and fuel efficiency.

As noted in the environmental impact statement (page 515), vehicle throughput would be actively managed once traffic speeds fall to 40 km/h or lower in order to manage motorist exposure levels and to maintain in-tunnel air quality within acceptable limits. Based on ventilation design calculations, these traffic throughput thresholds would be:

- At an average speed of 40 km/h, around 3,700 passenger car units per hour (two lanes) (ie above the maximum throughput capacity of each main alignment tunnel, so the design throughput capacity would be limiting in this case).
- At an average speed of 30 km/h, around 3,400 passenger car units per hour (two lanes).

It is recognised that the vehicle numbers and vehicle types that may contribute to the passenger car unit thresholds listed above may change over time and from day to day. As such, it is proposed to develop a proactive and adaptive management approach to ensure that ventilation design criteria are not exceeded in the project tunnels. This approach would be developed during the detailed design phase of the project, and implemented from the commencement of operation.

Table 7-20 Ventilation design calculations – maximum lane throughput

Average traffic speed	Carbon monoxide			Nitrogen dioxide			Visibility (PM ₁₀)		
	Design criterion (15-minute)	Maximum concentration at ventilation offtake	Maximum concentration at tunnel mid point	Design criterion (15-minute)	Maximum concentration at ventilation offtake	Maximum concentration at tunnel mid point	Design criterion	Maximum concentration at ventilation offtake	Maximum concentration at tunnel mid point
Northbound main alignment tunnel									
80 km/h	50 ppm (57.3 mg/m ³)	11.8 ppm (13.5 mg/m ³)	8.4 ppm (9.6 mg/m ³)	0.5 ppm (0.94 mg/m ³)	0.78 ppm (1.47 mg/m ³)	0.40 ppm (0.75 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0045 m ⁻¹ (0.96 mg/m ³)	0.0026 m ⁻¹ (0.55 mg/m ³)
60 km/h	50 ppm (57.3 mg/m ³)	12.8 ppm (14.7 mg/m ³)	8.9 ppm (10.2 mg/m ³)	0.5 ppm (0.94 mg/m ³)	0.84 ppm (1.58 mg/m ³)	0.43 ppm (0.94 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0050 m ⁻¹ (1.06 mg/m ³)	0.0029 m ⁻¹ (0.62 mg/m ³)
40 km/h	60 ppm (68.7 mg/m ³)	13.1 ppm (15.0 mg/m ³)	10.1 ppm (11.6 mg/m ³)	0.8 ppm (1.51 mg/m ³)	0.83 ppm (1.56 mg/m ³)	0.51 ppm (0.96 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0050 m ⁻¹ (1.06 mg/m ³)	0.0034 m ⁻¹ (0.72 mg/m ³)
Southbound main alignment tunnel									
80 km/h	50 ppm (57.3 mg/m ³)	10.0 ppm (11.5 mg/m ³)	7.2 ppm (8.2 mg/m ³)	0.5 ppm (0.94 mg/m ³)	0.48 ppm (0.90 mg/m ³)	0.21 ppm (0.40 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0039 m ⁻¹ (0.83 mg/m ³)	0.0021 m ⁻¹ (0.57 mg/m ³)
60 km/h	50 ppm (57.3 mg/m ³)	12.0 ppm (13.7 mg/m ³)	8.3 ppm (9.5 mg/m ³)	0.5 ppm (0.94 mg/m ³)	0.61 ppm (1.14 mg/m ³)	0.27 ppm (0.51 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0050 m ⁻¹ (1.06 mg/m ³)	0.0027 m ⁻¹ (0.45 mg/m ³)
40 km/h	60 ppm (68.7 mg/m ³)	12.9 ppm (14.8 mg/m ³)	10.2 ppm (11.7 mg/m ³)	0.8 ppm (1.51 mg/m ³)	0.69 ppm (1.30 mg/m ³)	0.43 ppm (0.80 mg/m ³)	<0.005 m ⁻¹ (1.06 mg/m ³)	0.0050 m ⁻¹ (1.06 mg/m ³)	0.0035 m ⁻¹ (0.68 mg/m ³)

Note: in-tunnel air quality should be considered and assessed at the tunnel mid point. The maximum concentration at the ventilation offtake is relevant to and has been considered in the assessment of ambient air quality.

(blank page)

Operation of the tunnel ventilation system

During normal operation, the project's ventilation system would automatically operate and adjust the ventilation flow rates within the tunnel and at the ventilation outlets to maintain in-tunnel air quality within acceptable limits.

The ventilation system would have a fixed number of ventilation levels which would generally correspond with the number of exhaust fans (at the ventilation outlets) in combination with the supply fans (within the main alignment tunnels and ramps) in the system. For example, a 'level 1' operation may involve the operation of one exhaust fan, and a 'level 5' operation may involve the operation of four exhaust fans. The number of ventilation levels and fan operating combinations would be determined during the detailed design of the project.

Jet fans in the main alignment tunnels and ramps would operate to maintain longitudinal ventilation and to balance air flow in each tunnel section, such that in-tunnel air quality is maintained within acceptable limits.

The following key inputs will be used to determine the level of ventilation required at any given time and for any given traffic scenario:

- **Time of day** – The ventilation system would activate the level of ventilation required based on the time of day, increasing the level of ventilation in the tunnel in the lead up to peak hours, and reducing the level at off peak times such as during the night.
- **Traffic speed and density** – Vehicle detectors located within the roadway of the project tunnels and approaches would provide real-time input for traffic speed and traffic density in the project tunnels. This combination of vehicle speed and number of vehicles per hour would be used to select and confirm the level of ventilation required, possibly increasing above the level estimated by the 'time of day' schedule, if necessary. The combination of traffic speed, density and ventilation level would be pre-programmed into the ventilation system using an algorithm to ensure that acceptable in-tunnel air quality is maintained to prevent emissions from the project's portals.
- **Data from in-tunnel air quality monitoring sensors** - Air quality monitoring sensors would be located throughout the project tunnels to identify and provide a complete understanding of in-tunnel air quality during operation. As a minimum, these sensors would provide continuous monitoring for carbon monoxide, nitrogen dioxide, visibility and in-tunnel air flow.

If the air quality monitoring sensors detect that vehicle emissions concentrations are approaching the pre-set limits (ie actions triggers below maximum allowable in-tunnel air quality criteria to provide an 'early warning' and action system), feedback would be given to the ventilation system to increase the ventilation rate to the next ventilation level. This would continue in order to maintain in-tunnel air quality and to ensure compliance with the air quality criteria is always achieved.

- **Incident detection** – The project would be equipped with an automatic video incident detection (AVID) system. AVID is a close circuit television (CCTV) system but has the additional capability of detecting and actively alerting tunnel operators to incidents within the tunnel as they occur. The AVID system has the ability to detect a range of tunnel incidents including stopped vehicles, pedestrians or the presence of smoke in the project tunnels.

The AVID system would quickly alert the tunnel operators to an incident in the project tunnels, so that they can implement the appropriate incident management plan. For example, in the event of a stopped vehicle, the operators can quickly identify its location and respond by implementing a traffic management plan and increasing the level of ventilation if required. It would also assist them to address the driver through the public address system or motorist emergency telephone.

Unlike surface roads, road tunnels are constantly managed from a central control room with two operators to ensure that action can be taken quickly and effectively in the event of an alarm or incident. With respect to the emergency devices such as the deluge system, these would be automatically operated in the event of an incident.

Where there is a major incident such as a crash which results in the tunnel being blocked, the relevant tunnel would be closed and vehicles diverted to surface roads. The close tunnel would only be reopened once the incident is cleared. This action would be taken quickly (response time would be in minutes from alert) to minimise the number of vehicles in the tunnel.

In the event of a fire incident the whole tunnel in both directions would be closed and vehicles diverted to surface roads until the incident has been dealt with.

- **Traffic and ventilation management** - It is envisaged that congested, slow moving traffic conditions would be rare in the project. However, where average traffic speeds drop below 40km/h, the tunnel operators would have the ability to implement traffic management procedures as a further means to manage vehicle emissions and air quality within the tunnel, in conjunction with the tunnel ventilation system.

Subject to the conditions of approval that may be applied to the project by the Minister for Planning, the NorthConnex project would regularly report (real time) on the performance and compliance with the air quality criteria. This would include in-tunnel air quality, air discharged from the ventilation outlets and ambient air external to the project tunnels.

In-tunnel air quality reporting would provide a direct clear comparison between the actual monitored air quality exposure within the tunnel against the maximum allowable air quality criteria to demonstrate that compliance is achieved at all times.

Proposed monitoring and reporting methodology

It is recognised that a 15 minute exposure period for a motorist would be dependent on travel time through the project tunnels, the concentration of vehicle emissions in the tunnels and the ambient concentrations of pollutants prior to and after the journey through the tunnels.

For the purpose of providing a transparent means for reporting compliance with the NO₂, 15 minute exposure design criteria, it is proposed that concentrations of NO₂ measured at the tunnel mid points and at the northern and southern ventilation offtakes are used as reference points. Subject to detailed design, with sensors located along the tunnel an alternative would be to take the readings from each sensor and calculate an overall average level for the tunnel which would provide a more accurate reading than simply taking a single mid point reading.

For a longitudinally ventilated tunnel, the tunnel mid point concentration will provide a consistent reference to demonstrate average concentration of NO₂ in the tunnel and may be used to show compliance with the 15 minute exposure criteria. It is important to note that the tunnel mid-point concentration will provide an estimate of the average concentration within the tunnel, but would not include exposure to lower concentrations external to the tunnel, and therefore will not by itself represent a complete 15 minute exposure under all circumstances.

Issue description

In addition the Environment Protection Authority has advised NSW Health that using the assumptions in the environmental impact statement, NO₂ emission factors used in the assessment are approximately 25-35% lower than those predicted using the 2021 Environment Protection Authority emission factors.

Response

Table 19 in the Technical Working Paper: Air Quality (Appendix G to the environmental impact statement) compares in-tunnel concentrations of pollutants based on emission factors published by the Permanent International Association of Road Congresses (PIARC) (and used in the air quality impact assessment) and based on emission factors published by the Environment Protection Authority (EPA). Data in the table indicates that:

- In-tunnel concentrations based on PIARC emissions factors are around 16 to 37 per cent **lower** than those based on EPA emissions factors, depending on the location in the southbound main alignment tunnel during the peak hour in 2019.
- In-tunnel concentrations based on PIARC emissions factors are around 11 to 85 per cent **lower** than those based on EPA emissions factors, depending on the location in the northbound main alignment tunnel during the peak hour in 2019.
- In-tunnel concentrations based on PIARC emissions factors are around three to 21 per cent **higher** than those based on EPA emissions factors, depending on the location in the southbound main alignment tunnel during the peak hour in 2029.
- In-tunnel concentrations based on PIARC emissions factors are around 28 to 78 per cent **higher** than those based on EPA emissions factors, depending on the location in the northbound main alignment tunnel during the peak hour in 2029.

Unlike other pollutants, such as particulate matter and carbon monoxide, differences between emissions factors published by the Permanent International Association of Road Congresses and the Environment Protection Authority for NO₂ are highly variable. When compared with data from the Environment Protection Authority, 2019 traffic scenarios show lower in-tunnel concentrations while 2029 scenarios show higher in-tunnel concentrations of NO₂.

As can be seen from Table 7-97 of the environmental impact statement, air quality impacts are predicted to be greater in magnitude in 2029 than in 2019. Because emissions factors from the Permanent International Association of Road Congresses lead to higher in-tunnel concentrations than the Environment Protection Authority emissions factors in 2029 (in some cases up to 78 per cent more), it was decided, conservatively, to use the emissions inventory based on the Permanent International Association of Road Congresses in 2029. A similar approach was taken for the 2019 traffic scenario for consistency.

The environmental impact statement demonstrates that a more conservative approach taken for the 2029 forecast traffic scenario comfortably meets applicable ambient air quality criteria for NO₂. Similarly, the ambient air quality criteria for NO₂ would also be met in 2019 based on the assessment presented in the environmental impact statement, and if the Environment Protection Authority emissions factors had been applied.

Issue description

A key predictor of emissions is traffic speed and it is unclear what assumptions have been made by the model to produce exposure estimates upon which the human health risk assessment is based. This should be made explicit and a sensitivity analysis done to provide a firmer base for the human health risk assessment.

If traffic has been assumed to be travelling at 80 km/h (as stated on page 514 of the environmental impact statement) then there is a likelihood that the design criteria might feasibly be exceeded should traffic speeds be lower or if traffic forecasts underestimate the volume that actually occurs.

It would assist assessment of in-tunnel air quality if results were presented for traffic moving at the range of speeds for which design criteria have been established (i.e. 20, 40, 60 and 80km/h).

Response

Unless otherwise expressly stated (such as in the case of a breakdown incident), the environmental impact statement assesses the potential impacts of the project based on how it has been designed to operate for majority of the time. The project has been designed to operate with average traffic speeds around 80 km/h.

When considering a 'worst case' air quality scenario for the project, it is relevant to take into account two principal factors:

- The average speed of vehicles travelling through the tunnels, because lower average traffic speeds equate to more emissions. That is, traffic using the project tunnels will generate greater emissions at 40 km/ h than at 80 km/ h.
- The total volume of vehicles travelling through the tunnels, because more vehicles broadly equates to more emissions (the implications of changes in vehicle fleet and fuel mix are discussed in **Section 2.8**).

The data presented in **Table 7-19** of this report indicates that maximum traffic throughput capacity, traffic travelling at 40 km/ h would generate higher in-tunnel concentrations of vehicle emissions than for comparable scenarios at 60 km/h and 80 km/ h.

The project has been designed to operate with two motorway standard traffic lanes in each direction (northbound and southbound). The design capacity of a motorway standard traffic lane is 2,000 passenger car units per hour under free flowing traffic conditions (60 km/h), which is equivalent to 4,000 passenger car units per hour for each of the main alignment tunnels. As discussed in **Section 2.4.2** and shown in **Figure 2-1**, the two lane configuration of each main alignment tunnel has a design throughput capacity of vehicles (as passenger car units) at different average traffic speeds:

- A maximum of 3,480 passenger car units per hour (two lanes) at 80 km/h.
- A maximum of 4,000 passenger car units per hour (two lanes) at 60 km/h.
- A maximum of 3,698 passenger car units per hour (two lanes) at 40 km/h.

There are two potential scenarios that may lead to a decrease in average traffic speed through the main alignment tunnels:

- The patronage of the project exceeds the maximum theoretical design throughput capacity of the project tunnels (as listed above), generating congested traffic conditions and a reduction in average traffic speed.
- An incident in the tunnel(s) or downstream of the tunnel temporarily reduces the capacity of the tunnel (for example by blocking a lane, slowing traffic as a motorist reaction to the incident or causing a downstream obstruction that leads to traffic queuing).

Both of these scenarios have a low probability of occurrence based on the design and forecast performance of the project. The maximum theoretical traffic throughput of each main alignment tunnel is 4,000 passenger car units per hour. This is around 2.1 times the peak forecast traffic volumes in 2019 and around 1.6 times the peak forecast traffic volumes in 2029. This means that actual traffic volumes would need to be around 110 per cent higher than traffic forecasts in 2019 or around 60 per cent higher than traffic in forecasts in 2029. Based on traffic forecasts using the Cube strategic model, the triggers that may lead to this level of variance in traffic volumes (demography, land use, major additions to the road network, traffic generating developments) are not expected within the timeframes considered as part of the assessment of the project.

An incident in the project tunnels or downstream could involve:

- A minor incident, such as a vehicle breakdown.
- A major incident, such as a vehicle crash or fire.

Incidents in the project tunnels or downstream would be unlikely events. In the case of a major incident:

- Vehicle crashes on a motorway standard road have been estimated to occur at around 19.9 per 100 million vehicle kilometres (refer to the Technical Working Paper: Traffic and Transport in the environmental impact statement). This is equivalent to project 23 vehicle crashes in the project tunnels in 2029 (or around one every 15 days). This includes all crash types (fatal and injury).
- As discussed in **Section 2.7.2**, the frequency of fires in the project tunnels in 2029 has been estimated at 0.67 to 0.80 in 2029 (equivalent to one fire incident every 1.3 to 1.5 years).

The potential for incidents within the project tunnels would be actively monitored and managed. The project would be equipped with an automatic video incident detection (AVID) system. AVID is a close circuit television (CCTV) system but has the additional capability of detecting and actively alerting tunnel operators to incidents within the tunnel as they occur. The AVID system has the ability to detect a range of tunnel incidents including stopped vehicles, pedestrians or the presence of smoke in the project tunnels.

The AVID system would quickly alert the tunnel operators to an incident in the project tunnels, so that they can implement the appropriate incident management plan. For example, in the event of a stopped vehicle, the operators can quickly identify its location and respond by implementing a traffic management plan and increasing the level of ventilation if required. It would also assist them to address the driver through the public address system or motorist emergency telephone.

Unlike surface roads, road tunnels are constantly managed from a central control room with an operations team to ensure that action can be taken quickly and effectively in the event of an alarm or incident. With respect to the emergency devices such as the deluge system, these would be automatically operated in the event of an incident.

Where there is a major incident such as a crash which results in the tunnel being blocked, the relevant tunnel would be closed and vehicles diverted to surface roads. The closed tunnel would only be reopened once the incident is cleared. This action would be taken quickly (response time would be in minutes from alert) to minimise the number of vehicles in the tunnel.

In the event of a fire incident the whole tunnel in both directions would be closed and vehicles diverted to surface roads until the incident has been dealt with.

The low frequency of incidents, the design of the project and proactive monitoring and management of incidents means that the potential for extended periods of low average traffic speeds (around 40 km/ h or less) is very low. In the event that an incident, such as a breakdown or crash occurs, management measures would be in place to rapidly move any obstruction from the operational traffic lanes into the relevant breakdown lane, and to manage the entry of additional vehicles into the project tunnels so that congested traffic conditions do not eventuate (or are not exacerbated by continued traffic entry into the tunnels).

This approach is expected to resolve most incidents within the order of an hour or less. While there may be an increase in vehicle emissions in the project tunnels during this time if average traffic speeds drop, the ventilation system would be managed to maintain acceptable in-tunnel air quality. The potential implications for ambient air quality are unlikely to be material for any more than a short duration and at a low frequency. For these reasons, it is not considered appropriate to develop a low average traffic speed scenario (around 40 km/ h) as a worst-case scenario of the air quality impact assessment.

In the case of in-tunnel air quality impacts, for short duration reductions in average traffic speeds in the project tunnels, in-tunnel air quality may approach the calculated in-tunnel concentrations presented in **Table 7-20**.

Issue description

Significant congestion such as a breakdown scenario is described on page 503 of the environmental impact statement. Considering as part of this scenario there is the potential for motorists to be inside the tunnel for a significant period of time (up to 55 minutes), it would be prudent to model in-tunnel air quality under the breakdown scenario too.

Response

Mass emission rates for the assessed breakdown scenario are presented in **Table 2-47** of this report.

During a breakdown, the project's ventilation system would be operated to maintain acceptable in-tunnel air quality. Based on the design of the project's ventilation system to provide ventilation flow rates at the ventilation outlet typically from around 300 m³/s up to a maximum of 700 m³/s, this means that the peak in-tunnel concentrations of pollutants during a breakdown situation could be:

- For PM₁₀, from 314 µg/m³ (at 700 m³/s) to 733 µg/m³ (at 300 m³/s).
- For NO_x, from 4,928 µg/m³ (at 700 m³/s) to 11,500 µg/m³ (at 300 m³/s). Applying the NO_x:NO₂ ratio recommended by the Permanent International Association of Road Congress, this would equate to NO₂ concentrations of 493 µg/m³ and 1,150 µg/m³, respectively.
- For CO, from 4,429 µg/m³ (at 700 m³/s) to 10,333 µg/m³ (at 300 m³/s).

In the event of a worst case theoretical breakdown scenario, as was modelled and presented in the environmental impact statement, the concentrations listed above confirm that the project's ventilation system would need to be operated at or approaching maximum capacity.

7.1.2.3 Exposure to in-tunnel air

Issue description

The National Health and Medical Research Council (2008) has highlighted that 'concentrations of NO₂ which do or could arise in Australian tunnels present cause for concern' (page 120) based on a key tunnel exposure study of Svartengren et al 2000 'that showed a significantly increased allergenic response in asthmatics after exposure for 30 minutes to NO₂ at levels >300 µg/m³'.

In making this statement the National Health and Medical Research Council noted that transits in tunnels are likely to be less than 30 minutes but argued that a 15 minute or 30 minute exposure limit was appropriate given that 'tunnel pollutants are trapped inside vehicles if the windows are closed, extending exposure times well beyond tunnel transit times'.

It is noted that the models presented in the environmental impact statement suggest NO₂ concentrations in the NorthConnex will regularly exceed 300 µg/m³. Predicted exposures [to NO₂] in both tunnels of the NorthConnex project are greater than 300 µg/m³ (from five kilometres onwards for the northbound tunnel in 2029 and at the end of the southbound tunnel in 2029 (refer to Table 7-101 of the environmental impact statement) and hence there is the potential for sensitive individuals to experience adverse effects during transit.

Based on information documented in the National Health and Medical Research Council 2008 report, it is possible that sensitive users of the tunnel could experience adverse health effects following transit.

Response

Updated in-tunnel air quality calculations taking into account amendments to assumptions and inputs into the project's emission inventory calculations are provided in **Section 2.9** of this report.

There is currently no short duration exposure standard for NO₂ adopted for use in any Australian jurisdiction (for application to road tunnels or in other contexts). Where standards exist in other jurisdictions, they are generally inconsistent, reflecting scientific uncertainties and different precautionary stances (Advisory Committee on Tunnel Air Quality, 2014). In the absence of a current applicable standard, guidance published by the Permanent International Association of Road Congresses has been applied as design criteria for in-tunnel NO₂ concentrations, as detailed in 7.3 of the environmental impact statement.

The National Health and Medical Research Council (2008) has noted a Swedish study published in 2000 (Svartengren et al, 2000), which observed increased susceptibility to allergens in asthmatics following a 30-minute exposure to in-tunnel NO₂ above 300 µg/m³. The study conducted by Svartengren et al (2000) related to:

- Exposure to NO₂ at a concentration above 300 µg/m³ for 30 minutes. Travel times from the five kilometre point to the end of the northbound tunnel in 2029 would be around three minutes, which is significantly less than a 30 minute exposure. In the case of the southbound tunnel, the duration of exposure would be around 45 seconds. Exposures would be further reduced (by up to 70 to 75 per cent) if vehicle windows were closed and vehicle air recirculated, based on investigations conducted by NSW Health.
- Asthmatic individuals. The Svartengren et al (2000) study did not consider all sensitive individuals.
- Increased susceptibility of asthmatic individuals to allergen exposure following exposure to NO₂ above 300 µg/m³ for 30 minutes. The Svartengren et al (2000) study did not consider health effects during transit.

The study considered a relatively small sample size of 20 participants, and concluded that further investigations into the relationships between NO₂ and asthmatic response would be warranted. As noted in the Svartengren et al study (2000) and in the National Health and Medical Research Council report (2008), there have been several other studies looking into the connection between NO₂ exposure and asthmatic response. Although the studies all generally conclude that a relationship exists, there have been insufficient investigations conducted to date to accurately and conclusively define the relationship.

It is also important to recognise that the 300 µg/m³ value referred to in the Svartengren et al (2000) study relates to a 30-minute exposure. The in-tunnel air quality calculated for the project has been based on maximum hourly averages (refer to **Section 2.5** and **Section 2.9**). As such, a 30-minute exposure to a concentration of 300 µg/m³ (NO₂) is not directly comparable to the in-tunnel air quality calculations presented in the environmental impact assessment or this report without appropriate conversion of averaging periods, and taking into account the difference between an exposure standard and a concentration.

In terms of likely exposure times, the average motorist would spend around five to six minutes in the project tunnels, depending on the direction of travel. This takes into account the forecast distribution of traffic (with some vehicles entering or leaving without travelling the full length of the main alignment tunnels). For those motorists travelling the full nine kilometre length of a main alignment tunnel, the journey is anticipated to take around

6.75 minutes. A full 30-minute exposure in the project tunnels would occur at an average traffic speed of 18 km/h or less, which is well below the average traffic speed at which proactive management measures would be introduced to manage in-tunnel congestion (at 40 km/h or below).

As with NO₂, there is currently no applicable standard for particulate matter exposures over short durations, such as may be experienced by a road tunnel user. The Advisory Committee on Tunnel Air Quality (2014) has indicated that an appropriate level of protection from the effect of all road vehicle pollutants in-tunnel is provided through a combination of existing carbon monoxide and visibility standards. These visibility standards, as a proxy for particulate matter concentrations, have been applied to the design of the project. The NorthConnex project is expected to perform better than these visibility standards under free flowing traffic conditions, with a predicted extinction coefficient up to 0.003 m⁻¹, which is defined as a 'clear air' tunnel.

The source of the position quoted in the National Health and Medical Research Council (2008) that *"it is a common observation that motorists start to experience adverse health effects when particle levels exceed 500 µg/m³"* (page 121) is unclear. Given the context in which it is quoted, with reference to the Svartengren et al (2000) study, this may actually be a reference to NO₂. It is relevant to note here that the Svartengren et al (2000) study built on previous work by Strand et al (1998) in which a NO₂ threshold of 500 µg/m³ was considered. A later study by Barck et al (2002) also considered a 500 µg/m³ NO₂ exposure threshold.

Notwithstanding, it is relevant to consider typical motorist exposure levels based on transit times. As previously discussed, this is different to in-tunnel air quality data presented in the environmental impact statement and in **Section 2.9** of this report, which presents in-tunnel concentrations (rather than time-based exposures) at the end of the peak hour at various locations along the main alignment tunnels.

Issue description

Comparing the modelled [in-tunnel air quality] levels for the project (Table 7-101, page 516 of the environmental impact statement) with international guidelines indicates that the NorthConnex project would meet the French, Norwegian and Belgian guidelines for NO₂.

However, it should be noted that these guidelines are not necessarily health based (ie they may not be completely protective of health) and it is unclear what assumptions concerning the speed of vehicles has been made to arrive at the values in Table 7-101. If a relatively high speed of 80 km/h has been assumed and lower average speeds are encountered during peak hour then compliance with these guidelines may not be achieved.

Further, the Swedish NO₂ guideline is substantially lower than other jurisdictions (0.2 ppm or 410 µg/m³ averaged over one hour) and based on modelled in-tunnel air quality, NorthConnex is likely to exceed this guideline in the northbound tunnel.

Response

There is currently no short duration exposure standard for NO₂ applicable to any jurisdiction in Australia. Reference to standards applied elsewhere in the world has been provided for context, and does not imply that any of these standards is necessarily appropriate for domestic application.

As discussed earlier in this report, the project has been designed to provide free flowing motorway standard traffic conditions under forecast traffic volumes at an average traffic speed of 80 km/h. Low average traffic speeds and congested traffic conditions are not anticipated to be a feature of the project based on its design and forecast traffic volumes. Notwithstanding, the in-tunnel air quality calculations presented in **Section 2.9** indicate that, taking into account likely travel times (in-tunnel exposure times):

- The Norwegian NO₂ standards (1.4 mg/m³ at the tunnel mid point and 2.8 mg/m³ at the tunnel ends) are expected to be met under all assessed conditions.
- The Belgian NO₂ standard (0.9 mg/m³ for 20 minutes) is expected to be met under all assessed conditions, based on expected in-tunnel exposure times (less than 20 minutes).
- The French NO₂ standard (0.75 mg/m³ for 15 minutes) is expected to be met under most assessed conditions, but may be approached or exceeded in the northbound tunnel during the peak hour under congested traffic conditions. As discussed earlier this report and in the environmental impact statement, congestion management measures would be implemented if average traffic speeds fall to 40 km/h or lower, in order to ensure continued acceptable air quality in the project tunnels.

With respect to the Swedish NO₂ standard, it is relevant to note that the standard is based on a one hour exposure. Taking into account that a motorist would spend around 6.75 minutes in the main alignment tunnel at 80 km/h (and around 13.5 minutes at 40 km/h), it is expected that the Swedish NO₂ standard could be achieved except in heavily congested conditions. As discussed earlier in response to issues raised by NSW Health, the project has been design and would be operated to ensure that the likelihood of such heavily congested conditions is very low.

Issue description

The National Health and Medical Research Council has also stated that "motorists start to experience adverse health effects when particles exceed 500 µg/m³", a level predicted to be reached at the end of the northbound tunnel.

The National Health and Medical Research Council has stated that compared to NO₂, the issue of protecting users from the effects of particulate matter is more controversial. It has concluded that there is insufficient evidence to define exposure limits but remarks that 'it is a common observation that motorists start to experience adverse health effects when particle levels exceed 500 µg/m³' (refer to page 120 of NHMRC (2008)). Predicted levels of PM_{2.5} approach and exceed this level at the end of the northern tunnel of the NorthConnex project and consequently adverse health effects cannot be discounted for users of the tunnel.

Based on information documented in the National Health and Medical Research Council 2008 report, it is possible that sensitive users of the tunnel could experience adverse health effects following transit.

Response

The source of the position quoted in the National Health and Medical Research Council (2008) that *“it is a common observation that motorists start to experience adverse health effects when particle levels exceed 500 µg/m³”* (page 121) is unclear. This position does not appear to be supported by or sourced from the relevant health studies considered in the report, and given its connection with the Svartengren et al (2000) study may in fact be an erroneous reference to NO₂ exposures rather than particulate matter. It is relevant to note here that the Svartengren et al (2000) study built on previous work by Strand et al (1998) in which a NO₂ threshold of 500 µg/m³ was considered. A later study by Barck et al (2002) also considered a 500 µg/m³ NO₂ exposure threshold.

Notwithstanding, it is relevant to consider typical motorist exposure levels based on transit times. As previously discussed, this is different to in-tunnel air quality data presented in the environmental impact statement and in **Section 2.9** of this report, which present in-tunnel concentrations (rather than time-based exposures) at the end of the peak hour at various locations along the main alignment tunnels.

7.1.2.4 Comparison with other road tunnels

The NorthConnex project should be assessed on its merits as an individual project, independent of the history, performance and requirements applied to other road tunnels. This assessment should be based on the legislation, environmental standards and assessment policies applicable in New South Wales.

Notwithstanding, if the NorthConnex project is to be compared to other road tunnels, the comparison needs to be made on a consistent basis. Differences between road tunnels need to be taken into account if such a comparison is to be made.

Issue description

Modelling presented in the environmental impact statement suggests that PM_{2.5} and NO₂ levels in the NorthConnex tunnels could be equal to or higher than other tunnels in operation in Australia and overseas.

The National Health and Medical Research Council (2008) reports that most concentrations of in-tunnel NO₂ are in the range 50 to 150 ppb with high emissions or congestion raising concentrations towards 300 ppb. The levels predicted for the NorthConnex project are in excess of 300 µg/m³ (approximately 150 ppb) for more than half of the northbound tunnel of the NorthConnex project.

The predicted range of PM_{2.5} levels for the northern tunnel of the NorthConnex project in 2029 (6pm) is from 0.037 to 0.553 mg/m³ with a level of 0.305 mg/m³ (or 305 µg/m³) predicted for mid tunnel. These levels would be among the highest, if not higher than all those reported by the National Health and Medical Research Council.

Figure 7-31 (page 523 in the environmental impact statement) describes predicted PM_{2.5} levels substantially higher than those recorded in the M5 East tunnel when PIARC emission factors are used.

In view of the above it would be reasonable to state that the predicted air quality within the NorthConnex tunnels is equal to, if not poorer than many of the tunnels described in the National Health and Medical Research Council document.

Response

The National Health and Medical Research Council report (2008) states:

'As [this report] makes clear, multiple variables influence road tunnel air quality. This makes it impossible to directly compare concentrations of air pollutants recorded in one tunnel with another without considering the differences between the tunnels. A lack of data has prevented this review from systematically analysing and disaggregating these multiple influences' (page 18).

The report goes on to state – in relation to CO, but with similar implications for other pollutants – that:

'[The data presented in this report] are plotted together, but it must be reiterated that the data cannot be intercompared in any way. These data are presented here only to provide an overview of the range of reported concentrations' (page 30).

As alluded to in the National Health and Medical Research Council report, concentrations of vehicle emissions in road tunnels will be influenced by several factors. These factors include:

- Traffic volumes and traffic mix (light vehicles and heavy vehicles).
- Traffic flow conditions (free flowing or congested).
- Fuel quality and fuel mix (petroleum, diesel or liquefied petroleum gas (LPG)).
- Fleet age.
- Tunnel design, including tunnel cross section, length and gradient.
- Ventilation design, including the nature and rate of ventilation through the tunnel.
- Ambient conditions, including temperature, humidity and background concentrations of pollutants (such as ozone).

The in-tunnel air quality data presented by the National Health and Medical Research Council (2008) does not take these factors into account (nor does it purport to), and the information it presents therefore needs to be carefully interpreted in the context of comparing fundamentally different road tunnels.

Other factors that preclude direct comparison of the data presented by the National Research and Medical Research Council (2008) with predictions made for in-tunnel air quality in the NorthConnex tunnels include:

- With the exception of the M5 East Motorway tunnels, all of the international tunnels referenced by the National Research and Medical Research Council operate in different jurisdictions. The specific legislation, environmental standards and assessment policies applicable to those tunnels is therefore different to the NorthConnex tunnel, and may require operation of road tunnels in very different ways.
- The data for international tunnels has been gathered from various studies from 1991 to 2006. The predictions made for the NorthConnex tunnel have been made for forecast traffic in 2019 and 2029. This difference in time period needs to be taken into account, particularly noting that conditions in the reference international tunnels are likely to significantly change over the 13 to 38 year period until 2019/ 2029.
- The data for international tunnels is based on average in-tunnel concentrations. The studies referenced by the National Health and Medical Research Council in Table 3.5

of its report (2008) imply that these are daily average values (over a 24-hour period, as distinct from a spatial average along the tunnel length in any hour of the day). Equivalent averaging periods for NorthConnex in-tunnel air quality data need to be compared, rather than selecting maximum predicted in-tunnel concentrations from environmental impact statement for the NorthConnex project for comparison.

- Most of the data for international tunnels has been gathered over a limited duration (in some cases as little as four days). Therefore, the data may not be representative of in-tunnel air quality conditions in operating tunnels under all circumstances.
- The data for international tunnels is actual monitoring data during tunnel operation. In contrast, the NorthConnex in-tunnel air quality data are predicted values based on forecast traffic volumes and conservative ventilation design emission factors provided the Permanent International Association of Road Congresses (PIARC).

With respect to NO₂, the National Health and Medical Research Council (2008) mentions reported in-tunnel concentrations in the range 50 to 150 ppb (around 105 to 310 µg/m³) and up to 300 ppb (around 620 µg/m³) under high emission or congested conditions. Importantly, it states that these concentrations do not include data for 'exceptionally long' road tunnels, being:

- The Høyanger tunnel in Norway (7.5 kilometres in length), which has reported NO₂ concentrations of 730 ppb (around 1,497 µg/m³) in Spring 1994 and 220 ppb (around 450 µg/m³) in Spring 1995.
- The Mont Blanc tunnel in France (11.6 kilometres in length) which has reported an NO₂ concentration of 500 ppb (around 1,025 µg/m³)

On the basis of length alone, the Høyanger and Mont Blanc tunnels are more relevant to the NorthConnex project.

The distribution of reported NO₂ concentrations in other road tunnels provided in the National Health and Medical Research Council report (2008) can be plotted with similar calculated concentrations for NorthConnex project to illustrate the variability and range of international road tunnel performance (rather than for the purpose of direct comparison, as noted above). **Figure 7-3** shows the National Health and Medical Research data, and includes calculated average NO₂ concentrations on a similar 24 average basis at the main alignment tunnel mid points in 2019 and 2029.

The examples of the Landy tunnel (Paris) and the Croix Rousse tunnel (Lyons) demonstrate the particular challenges of comparing in-tunnel air quality performance across fundamentally different tunnel operations. The Landy tunnel (1.3 kilometres), for example, is one of the busiest tunnels in Europe (with four lanes in each direction) and carries around 220,000 vehicles per day, including around 17,000 heavy vehicles. Its elevated in-tunnel NO₂ concentrations are largely driven by high traffic volumes. In contrast, the Croix Rousse tunnel (1.8 kilometres) is low speed (50 km/h) and is weight limited (vehicles less than 3.5 tonnes). Its elevated in-tunnel NO₂ concentrations are largely driven by long air residence times in the tunnel (maximising the conversion of oxides of nitrogen into NO₂). Both of these tunnels are relatively short in length (both less than two kilometres), but their reported in-tunnel concentrations of NO₂ are comparable to tunnels referred to by the National Health and Medical Research Council as 'exceptionally long'.

(blank page)

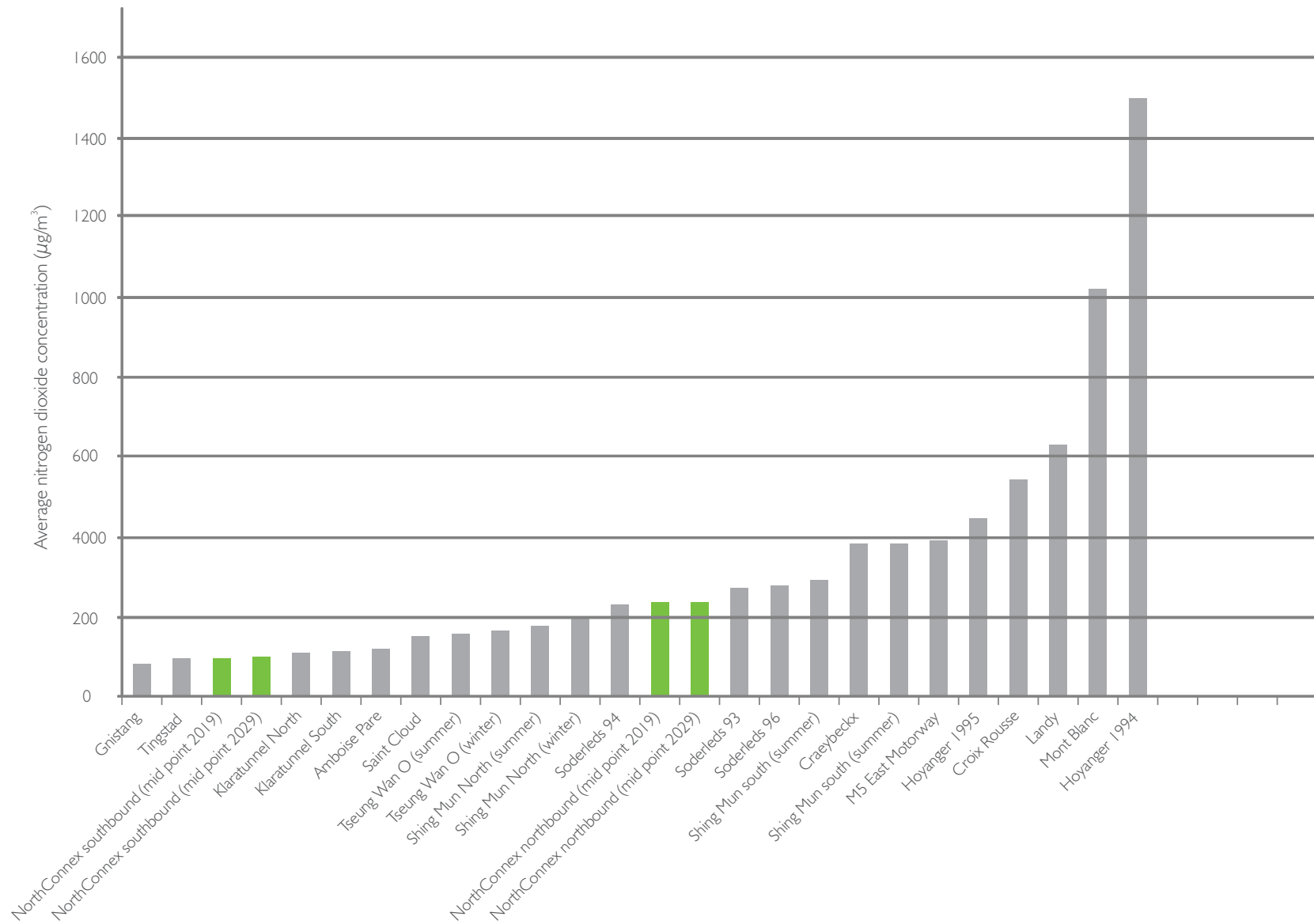


Figure 7-3 Average in-tunnel NO_2 concentrations for various international road tunnels (NHMRC, 2008 and RMS, 2014)

(blank page)

Figure 7-4 presents similar data showing the distribution and range of PM_{2.5} data presented in the National Health and Medical Research report (2008) and calculated in-tunnel concentrations calculated for the NorthConnex project on a similar 24 average basis at the main alignment tunnel mid points in 2019 and 2029. Importantly, all of the tunnels shown in **Figure 7-4** and considerably shorter than the NorthConnex project, with the longest – the Shing Mun tunnels – being only 2.7 kilometres in length. The Söderleds tunnel in Stockholm, which was used for the Svartengren et al (2000) study is 1.5 kilometres in length. All other tunnels shown in the figure are less than one kilometre long. The M5 East Motorway tunnel PM_{2.5} concentration (388 µg/m³) referred to in the National Health and Medical Research report (2008) is not shown in **Figure 7-4** because it is a transect (drive through) value, and is therefore not on a comparable basis to other data in the figure (mean concentration from a fixed point monitor).

Figure 7-5 shows National Health and Medical Research (2008) and NorthConnex calculations for PM₁₀, as a more complete set of data for particulate matter than the limited information for PM_{2.5}. In road tunnels, PM₁₀ concentrations are typically slightly higher than PM_{2.5} concentrations and offer a potential proxy for considering PM_{2.5} (subject to taking into account particulate size distributions for the relevant vehicle fleet and fuel combinations in each context).

As explained in the environmental impact statement, in-tunnel concentrations of pollutants have been based on conservative emission factors published by the Permanent International Association of Road Congresses. These emission factors have been specifically design for the purpose of ventilation design, and are therefore likely to over-predict actual in-tunnel concentrations of pollutants (to ensure adequate redundant ventilation capacity). The environmental impact statement also demonstrates that if more realistic emission factors published by the Environment Protection Authority are used, then in-tunnel concentrations of particulate matter are approximately halved. Taking this into account, the NorthConnex project is expected to perform at a similar or better level in terms on in-tunnel particulate matter concentrations than other road tunnels presented in the National Health and Medical Research Council report (2008).

Consistent with the advice presented in the National Health and Medical Research Council (2008) and the discussion provided above, it is not appropriate to directly compare the NorthConnex project with the M5 East Motorway tunnels without taking into the very different contexts of the two tunnels. Key factors influencing the air quality in these two road tunnels are summarised in **Table 7-21**.

Table 7-21 Comparison of key factors affecting in-tunnel air quality in the M5 East Motorway and the NorthConnex project

Key factor	M5 East Motorway	NorthConnex project
Tunnel length	Four kilometres	Nine kilometres
Daily traffic	Around 90,000 to 100,000 vehicles (two directions)	Forecast to be around 30,000 vehicles in 2019 and around 40,000 in 2029.
Heavy vehicles	Around 15 to 20 percent.	Forecast to be 25 to 30 per cent.
Ventilation	Longitudinal with cross ventilation between road tunnels	Longitudinal with no cross ventilation between road tunnels
Ventilation flow rate	Up to 900 m ³ /s, through one ventilation outlet	Up to 700 m ³ /s, through each of two ventilation outlets
Maximum grade	Around eight per cent at the westbound exit.	Four per cent at the southbound exit.
In-tunnel air quality assessment method	Actual monitoring data from the tunnel	Ventilation design estimates based on the Permanent International Association of Road Congresses

(blank page)

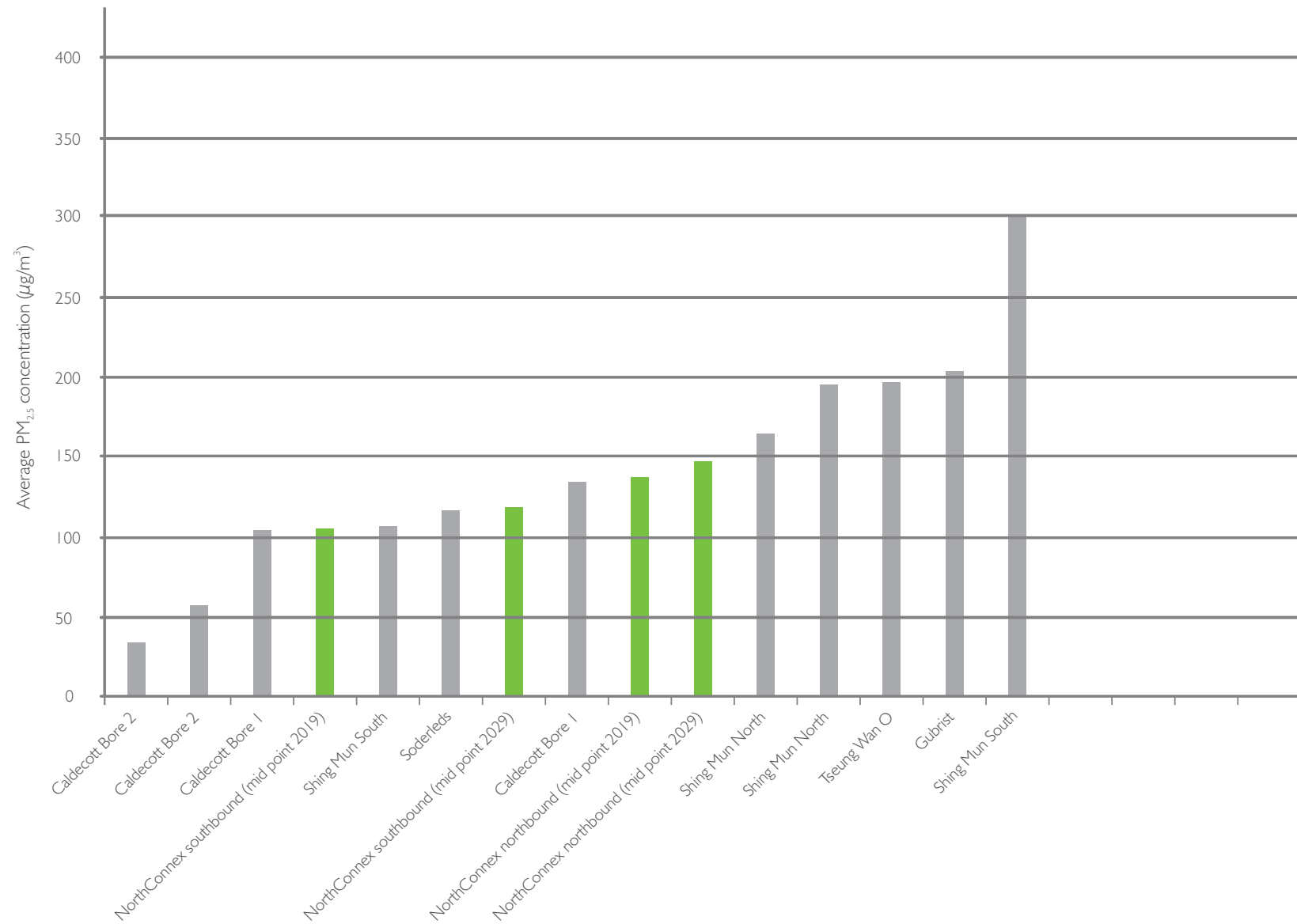


Figure 7-4 Average in-tunnel $PM_{2.5}$ concentrations for various international road tunnels (NHMRC, 2008 and RMS, 2014)

(blank page)

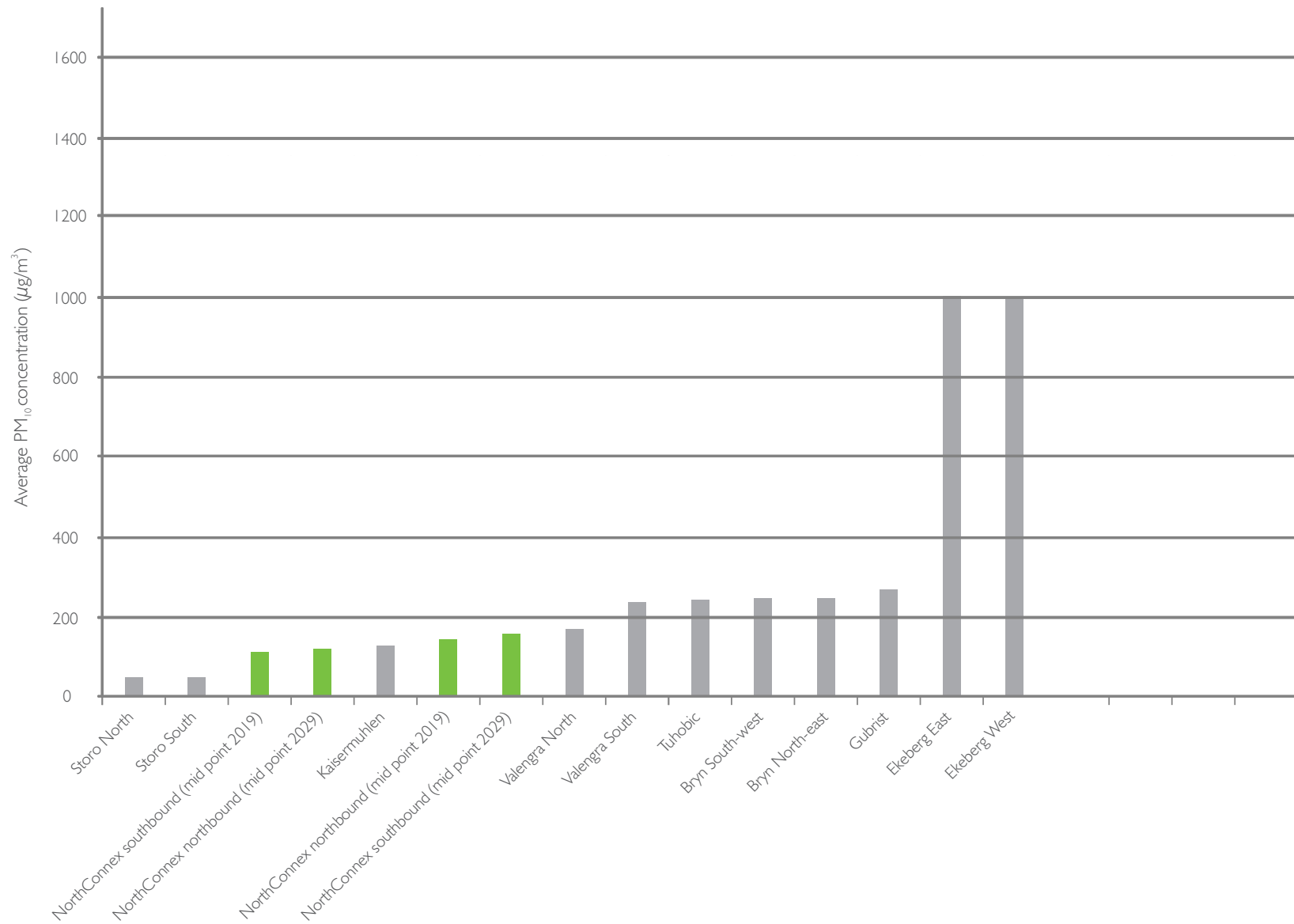


Figure 7-5 Average in-tunnel PM_{10} concentrations for various international road tunnels (NHMRC, 2008 and RMS, 2014)

(blank page)

7.1.2.5 Ventilation design and optimisation

Issue description

Carbon monoxide (CO) and nitrogen dioxide (NO₂) ventilation system design criteria levels are described on pages 475 and 476 and in Table 7-95 of the environmental impact statement. The criteria are based on the recommendations of PIARC (2012). It should be noted that PIARC is not a health authority and this level is not necessarily completely protective of human health.

Response

It is acknowledged that the Permanent International Association of Road Congresses (PIARC) is not a health authority. The environmental impact statement makes no assertion to the contrary.

The criteria presented in Table 7-95 of the environmental impact statement (and reproduced in **Table 7-17** earlier in this report in response to issues raised by NSW Health) are the parameters applied to the engineering design of the project. The acceptability of the air quality (including in-tunnel air quality) impacts and the human health risks posed by the project are to be determined through the environmental impact assessment process currently underway, in accordance with the *Environmental Planning and Assessment Act 1979*. The Minister for Planning may apply conditions of approval to the project relating to in-tunnel air quality, if the project is approved.

With respect to the engineering criteria used in the design of the project, the environmental impact statement explains that the criterion for carbon monoxide (CO) has been based on the World Health Organization Guidelines for Indoor Air Quality (2010). These guidelines recommend a maximum short-term exposure (15-minutes) of 100 mg/m³. A design criterion of 100 mg/m³ of CO has been applied in the event of significantly congested traffic conditions (0-20 km/h), with more stringent design criteria applied at higher average traffic speeds (from 57.5 mg/m³ to 69 mg/m³ of CO).

In the absence of applicable in-tunnel air quality criteria for nitrogen dioxide (NO₂) or particulate matter (measured as a concentration or in terms of visibility) in any Australian jurisdiction, and without a consistent, internationally recognised short-term exposure standard for these pollutants, the guidance provided by the Permanent International Association of Road Congresses has been applied.

The project has been designed to meet existing CO and visibility (as a proxy for particulate matter) limits, and:

- In the case of CO, more stringent design criteria have been applied at higher average traffic speeds.
- In the case of visibility (as a proxy for particulate matter), the project is expected to perform better than the minimum standard of 0.005 m⁻¹ for peak fluid traffic, with in-tunnel air quality predicted to be consistent with a 'clear air tunnel' (0.003 m⁻¹).

The New South Wales Advisory Committee on Tunnel Air Quality has recommended that a short-term exposure standard be developed for NO₂ in the medium to long term. The applicability and implications for the project of such a standard would be considered once it is developed and adopted for use in New South Wales. The New South Wales Advisory Committee on Tunnel Air Quality is chaired by the Chief Scientist and Engineer, and includes representation from NSW Health, the Environment Protection Authority and the Department of Planning and Environment.

Issue description

Exposure to traffic related air pollution has been shown in epidemiological and clinical studies to be associated with a range of cardiovascular and respiratory health outcomes.

Importantly, there is little evidence of any threshold below which exposure to components of traffic related air pollution are not associated with adverse health effects. Consistent with this, the National Health and Medical Research Council (NHMRC) 2008 report, air quality in and around traffic tunnels concludes that it is good practice to limit exposure and to strengthen measures to ensure in-tunnel and external air quality impacts are continually minimised.

The National Health and Medical Research Council has stated that *"This may seem unacceptable, especially if those living near the point sources do not gain as much from the transport benefits of the tunnel. However, this is not the case if the point sources (and their impact zones) can be located in areas of reduced or zero population density, or dispersion can be designed in such a way that the increased burden is negligibly small. This should be the goal of good tunnel design"*. (NHMRC 2008, page 127).

In order to assess whether the NorthConnex proposal has achieved the above goal it would be necessary to evaluate the design options considered. Although ventilation outlet location, ventilation outlet height, ventilation outlet volumetric flow rates, outlet diameter and outlet velocity flow rates are presented for the project, there is no presentation of how modifying these variables might decrease the impact emissions will have on the local external air quality around the ventilation outlets.

The Environment Protection Authority has advised NSW Health that predicted ground level concentrations due to emissions from the NorthConnex ventilation outlets could be reduced by improving the dispersion of emissions. Typical options for improving the dispersion of emissions include increasing outlet height, decreasing outlet diameter and/or increasing outlet exit velocity, although each one of these would need to be evaluated for its practicability.

NSW Health supports this position and recommends that all reasonable measures are taken to minimise exposure to air pollution both inside and outside the tunnel.

Response

Details of ventilation system design options and alternatives are presented in **Section 3.2** of this report. Review of options and alternatives has been conducted with the aim of verifying that all feasible and reasonable ventilation design measures have been applied to the project to minimise exposure to air pollution, and consequently to minimise potential human health risks, both within the project tunnels and in the ambient environment. Broadly, the review of options and alternatives has considered:

- Changes in the height of ventilation outlets.
- Relocation of ventilation outlets.
- Provision of additional ventilation outlets.
- Changes in ventilation flow rates.
- Application of air treatment technology.

It is important to recognise that the NorthConnex project would not introduce new or increased air emissions. The emissions from the NorthConnex ventilation outlets already occur along Pennant Hills Road and would continue to occur in the future in the absence of the NorthConnex project. The NorthConnex project offers an opportunity to reduce the overall quantity of vehicle emissions along the corridor and to manage air pollution in a control way, with resultant net improvements in air quality and human health outcomes, as demonstrated in the environmental impact statement.

Managing emissions from vehicles and exposure to those emissions through road tunnel design and operation (for the NorthConnex project and for other road tunnels) is only one component in a necessary broader suite of initiatives to reduce the air quality and human health impacts associated with emissions from the road transport sector. These initiatives are detailed in Action for Air (EPA, 1998) and the most recent updated of that strategy released in 2009, including actions to:

- Use cleaner fuels, vehicles and fleet.
- Reduce vehicle use.
- Improve and influence transport choice.

Issue description

The air quality impact assessment presented in the environmental impact statement shows limited areas of increased PM_{2.5} exposure adjacent to the project's ventilation outlets.

There is a theoretical increase in the risk of the primary health outcomes of interest (mortality and admissions to hospital). This is to be expected for a pollutant with no threshold of effect.

The human health risk assessment predicts a very small increased risk of hospitalisation and mortality (to a maximum of 10⁻⁵ to 10⁻⁶ per annum) for residents who experience an increase in PM_{2.5} exposure.

According to the framework outlined in the human health risk assessment, the predicted levels described would not normally be considered to be negligible and might fall within the acceptable or tolerable risk category. As such an investigation should be made into all reasonable and feasible measures to minimise this risk and in the context of a tunnel these measures should be focused at maximising dispersion.

Based on this assessment, it is recommended that there is further exploration of all feasible and reasonable measures to reduce ground level concentrations in those areas currently predicted to experience an increase. Measures that should be considered include the number of outlets, heights of outlets, outlet velocity flow of emissions from outlets and the location of outlets. The environmental impact statement as it currently stands does not provide detail about how these issues were explored and the effect that alterations to the current design might have.

Response

Details of ventilation system design options and alternatives are presented in **Section 3.2** of this report. Review of options and alternatives has been conducted with the aim of verify that all feasible and reasonable ventilation design measures have been applied to the project to minimise exposure to air pollution, and consequently to minimise potential human health risks, both within the project tunnels and in the ambient environment.

When assessing a development or activity under the *Environmental Planning and Assessment Act 1979*, it is necessary to take a balance, merit-based approach which takes into account all of the relevant positive and negative implications of the development or activity. In the case of human health risks, it is therefore important to consider both areas of increased and decreased risks as a result of the NorthConnex project. This is particularly important in the case of human health where impacts and benefits are relevant at a population scale, rather than at the scale of individual receivers.

The human health risk assessment presented in Section 7.4 and Appendix H of the environmental impact statement demonstrates that, when considering the NorthConnex project as a whole, a net reduction in human health risks is expected across the complete, potentially affected population. As indicated in Table 5-7 of the Technical Working Paper: Human Health Risk Assessment (Appendix H to the environmental impact statement), the NorthConnex project would result in:

- A net reduction in the risk of mortality (≥ 30 years, all causes, long term) of 3×10^{-5} (three in 100,000) in both 2019 and 2029, when considering the project and the affected population as a whole.
- A net reduction in the risk of hospitalisations (≥ 65 years, cardiovascular, short term) of 8×10^{-5} in 2019 (eight in 100,000) and 9×10^{-5} (nine in 100,000) in 2029, when considering the project and the affected population as a whole.
- A net reduction in the risk of hospitalisations (≥ 65 years, respiratory, short term) of 2×10^{-5} (two in 100,000) in both 2019 and 2029, when considering the project and the affected population as a whole.

These net positive human health risk implications need to be considered in the context of a balanced, merit based assessment which also considers both the positive and negative impacts of the NorthConnex project in other areas, including traffic and transport, air quality, noise, ecology and heritage (among other issues, as detailed in the environmental impact statement).

7.1.3 Fisheries NSW

Issue description

Fisheries NSW has reviewed the environmental impact statement for the NorthConnex project and has no objection to these works, subject to implementation of the environmental mitigation measures relating to aquatic biodiversity, hydrogeology and soils, and surface water, outlined in Chapter 9 of the environmental impact statement.

Response

Mitigation measures identified in Chapter 9 of the environmental impact statement would be implemented by the NorthConnex project.

7.1.4 Agriculture NSW

Issue description

Agriculture NSW advises that the commitment made in the environmental impact statement to manage weeds is adequate.

Response

Agriculture NSW's comment is noted.

7.1.5 Crown Lands

Issue description

Crown Lands advises that it has no issue with the NorthConnex project.

Response

Crown Lands' comment is noted.

7.1.6 NSW Office of Water

7.1.6.1 Impacts to groundwater resources

Issue description

The NorthConnex tunnels are proposed to be constructed as drained tunnels, with ongoing groundwater inflow, capture and discharge. The environmental impact statement predicts that 2 gigalitres of groundwater will need to be abstracted and discharged during the five year construction period, with ongoing abstractions of 170 to 700 megalitres per year during operation. By virtue of clause 18 and Schedule 5, clause 2 of the *Water Management (General) Regulation 2011* roads authorities are currently exempt from the requirement to hold a water access licence to account for water taken for road construction and maintenance.

Ongoing licensing arrangements for road infrastructure are currently under development in consultation with the Roads and Maritime. The NSW Office of Water will not currently require licensing for water taken by a roads authority for this project, however requests a commitment from Roads and Maritime to liaise with the NSW Office of Water and ensure any necessary licences are held once these arrangements are finalised.

Response

Roads and Maritime would continue to consult with the NSW Office and Water in relation to licensing arrangements for the NorthConnex project and other road infrastructure in the future.

Issue description

The NSW Office of Water notes that groundwater inflows into the project tunnels is proposed to be limited to one litre per second per kilometre through engineering means, such as grouting.

Response

The limit of groundwater inflow into the tunnel to one litre per second per kilometre is a design requirement of the project. This is a reasonable limit to achieve through design based on the hydrogeological characteristics of the Hawkesbury Sandstone. The environmental impact assessment has been completed on this basis.

This groundwater inflow limit is not unusual and is similar to the approach taken for other drained tunnels in Sydney. Examples of measured groundwater inflow rates into other Sydney tunnels are provided in **Table 7-22**.

Table 7-22 Measured drainage rates in other Sydney tunnels

Tunnel	Type	Width (m)	Length (km)	Inflow rate (L/s/km)	Reference
Eastern Distributor Tunnel	Three lane road tunnel	12 (double deck)	1.7	1	Hewitt, 2005
Cross City Tunnel	Twin two lane road tunnels	8 (twin)	2.1	<3	Best and Parker, 2005
M5 East Motorway Tunnel	Twin two lane road tunnels	8 (twin)	3.8	0.9	Tammetta and Hewitt, 2004
Epping to Chatswood Rail Tunnel	Twin rail tunnels	7.2	13	0.9	Best and Parker, 2005
Lane Cove Tunnel	Twin three lane road tunnels	9 (twin)	3.6	0.6/1.7*	Coffey, 2012
Northside Storage Tunnel	Sewer storage tunnel	6	20	0.9	Coffey, 2012

* measured inflow in Lane Cove Tunnel varied from 0.6 L/s/km (2011) to 1.7 L/s/km (2001 - mid 2004)

Inflow rates from other Sydney road tunnels, as summarised in **Table 7-22** vary from around 0.9 litres per second per kilometre to less than three litres per second per kilometre. In all cases (including the Cross City Tunnel and Lane Cove Tunnel where inflows have been measured at times to exceed one litre per second per kilometre) there are no known adverse environmental impacts from groundwater drawdown caused by tunnel inflow. This includes tunnels that pass directly under watercourses such as the Epping to Chatswood Rail Tunnel which passes under the Lane Cove River and the Lane Cove Tunnel which passes under Stringybark Creek.

Historically, the one litre per second per kilometre limit has been set as an average across the length of the tunnel. This means that a single kilometre of the tunnel could exceed the one litre per second per kilometre criterion, although the average along the entire tunnel may not. In order to drive improved design outcomes, for NorthConnex project has applied this limit as an average measured across any kilometre of the tunnel.

Issue description

Details of the hydrogeological investigations completed to support the design of the tunnels have not been provided, making it difficult to confirm the validity or otherwise of the hydrogeological inferences underpinning the design.

Response

Section 7.8 of the environmental impact statement presents a summary of relevant geological and hydrogeological information used to inform the assessment of the project. Sufficient information is provided to support and inform the analysis presented in the environmental impact statement.

Information summarised in the environmental impact statement is based on data gathered from 23 boreholes along the project alignment. The locations of these boreholes are shown in **Figure 7-6**, with a summary of borehole parameters provided in **Table 7-23**.

In summary, investigations conducted for the NorthConnex project included:

- A total of 23 geotechnical boreholes drilled to depths between 9.1 metres and 81.6 metres by Terratest Pty. Ltd. and Macquarie Drilling Pty. Ltd. between 1 July 2013 and 26 July 2013. This included:
 - The drilling comprised 947 metres of core drilling and 118 metres of other than rock (OTR) drilling.
 - The boreholes were drilled using 110 mm diameter solid augers in soil and extremely weathered rock and HQ3 (wireline) 96 millimetre / 63.5 millimetre diameter coring in competent rock.
 - Target borehole depths were based on the concept design and the materials expected at each location, and ranged from nine metres to 80 metres below ground level.
 - Standard Penetration Tests (SPTs) were typically completed at 1.5 metre depth intervals.
 - A long chain polymer viscosifier was added in some of the boreholes to improve core recovery.
 - All boreholes were vertical, with the exception of borehole BH032 which was drilled at an angle of 60° with the horizontal and on a bearing of 152° relative to grid north.
 - Standpipe piezometers were installed in 12 of the boreholes.
- Borehole water pressure testing was conducted within 11 of the boreholes at various depth intervals. This included:
 - A total of 31 borehole water pressure tests between depths of 8.8 metres and 75.6 metres using a single packer.
 - A double packer was used in borehole BH024 as a result of a bladder malfunction with the single packer.

In addition to data gathered from the 23 boreholes for the NorthConnex project, geotechnical and hydrogeological data gathered for the North West Rail Link project and the Hills M2 Motorway Upgrade project was used to inform the design of the project and relevant parts of the environmental impact statement.

Geological stratigraphy determined from the 23 project boreholes is summarised in **Table 7-24**.

Groundwater levels have been measured in 12 boreholes (measurements taken on 23 July 2013, 26-29 July 2013 and 7 August 2013). This data is summarised in **Table 7-25**.

Groundwater quality monitoring has also been conducted in 12 boreholes. Groundwater quality data for key parameters monitored at each of the 12 boreholes is summarised in **Table 7-26**. In addition to these key parameters, testing has been conducted for a suite of hydrocarbons, including organochlorine and organophosphate pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons.

Further groundwater and surface water monitoring is currently being undertaken, in addition to data already collected along the project corridor and information sourced from the North West Rail Link project and the Hills M2 Motorway Upgrade project. This data will be used to inform the detailed design of the project and further development of the mitigation, monitoring and management measures listed in Table 7-171 and Table 7-179 of the environmental impact statement. Importantly, groundwater data will be used to develop a three dimensional, numerical groundwater model to verify that the final detailed design of the project would perform within or better than the predictions made in the environmental impact statement. This would include further modelling of:

- Likely long-term inflow rates into the main alignment tunnels.
- The zone in which changes in groundwater levels above and adjacent to the project tunnels are likely to occur at tunnel operation stage.

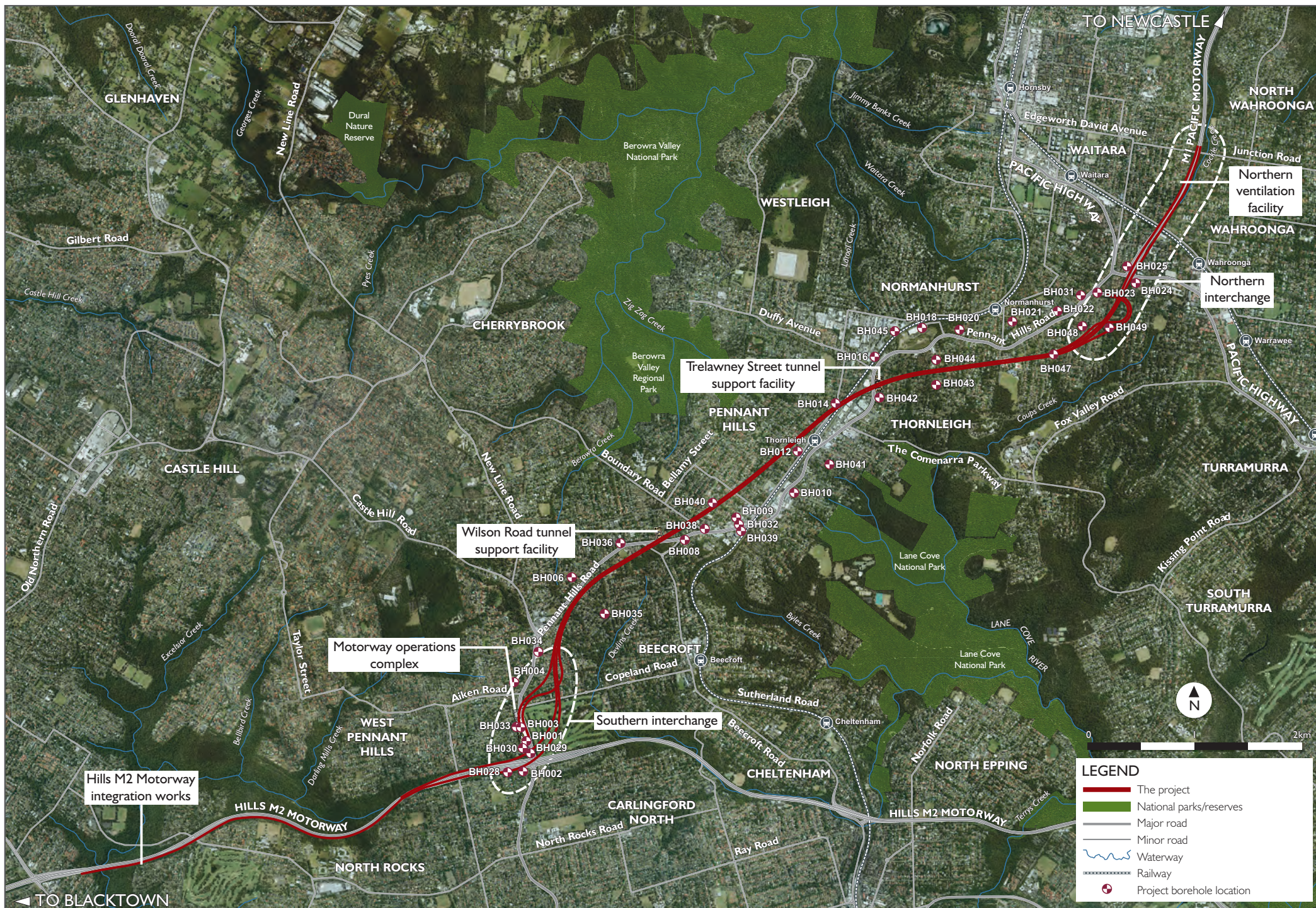


Figure 7-6 Location of project boreholes

(blank page)

Table 7-23 Details of project boreholes

Borehole number	Location	MGA coordinates		Ground surface level AHD)	Depth of borehole (m)	Inclination (bearing)	End borehole elevation (m AHD)	Depth of non-destructive digging (m)	Date completed
		Easting (m)	Northing (m)						
BH001	Pennant Hills Road, West Pennant Hills	319240.91	6263098.11	126.78	44.00	90°	82.78	1.5	20 July 2013
BH002	Coral Tree Drive, Carlingford	319210.19	6262801.01	127.52	48.00	90°	79.52	1.5	5 July 2013
BH003	Pennant Hills Road, West Pennant Hills	319188.40	6263228.68	133.58	32.00	90°	101.58	1.4	15 July 2013
BH004	Eaton Road, West Pennant Hills	319120.70	6263321.63	137.87	36.00	90°	101.87	1.5	9 August 2013
BH005	Grace Avenue, West Pennant Hills	319352.81	6263920.62	162.29	56.98	90°	105.31	1.5	9 July 2013
BH006	Boyd Avenue, West Pennant Hills	319665.85	6264618.46	167.20	59.00	90°	108.20	1.5	12 July 2013
BH008	Lilla Road, Pennant Hills	320724.80	6264969.71	188.76	81.60	90°	107.16	1.3	3 July 2013
BH009	Fisher Avenue, Pennant Hills	321206.55	6265178.16	167.87	55.00	90°	112.87	1.5	16 July 2013
BH010	Albion Street, Pennant Hills	321753.69	6265417.58	170.87	47.00	90°	123.87	1.5	6 May 2013
BH012	Pritchard Street, Thornleigh	321784.54	6265795.77	172.61	50.00	90°	123.87	1.5	18 July 2013
BH014	Janet Avenue, Thornleigh	322136.60	6266248.81	162.59	40.00	90°	122.59	1.5	12 July 2013

Borehole number	Location	MGA coordinates		Ground surface level AHD)	Depth of borehole (m)	Inclination (bearing)	End borehole elevation (m AHD)	Depth of non-destructive digging (m)	Date completed
		Easting (m)	Northing (m)						
BH016	Pioneer Avenue, Thornleigh	322506.07	6266685.06	173.08	43.00	90°	122.59	1.5	10 July 2013
BH018	Dartford Road, Thornleigh	322940.24	6266955.39	174.63	43.00	90°	131.63	1.5	17 July 2013
BH020	Kenley Road, Normanhurst	323297.27	6266938.95	169.82	35.10	90°	134.72	1.5	8 July 2013
BH021	Fraser Road, Normanhurst	323792.71	6267015.25	173.92	40.00	90°	133.92	1.5	18 July 2013
BH022	Jasmine Road, Normanhurst	324214.44	6267118.68	181.75	50.00	90°	131.75	1.5	11 July 2013
BH023	Aaron Place, Wahroonga	324594.60	6267306.47	188.51	41.00	90°	147.51	0.54	15 July 2013
BH024	Lucinda Avenue, Wahroonga	324942.66	6267375.63	200.24	42.00	90°	158.24	1.4	5 July 2013
BH025	Isis Street, Wahroonga	324871.34	6267532.94	192.46	29.00	90°	163.46	1.5	17 July 2013
BH029	Pennant Hills Road, West Pennant Hills	319260.68	6262988.20	130.17	47.10	90°	83.07	1.5	19 July 2013
BH030	Pennant Hills Road, West Pennant Hills	319215.62	6263022.10	123.66	9.05	90°	114.61	1.5	22 July 2013
BH031	Edwards Road, Wahroonga	324433.72	6267286.36	183.52	56.00	90°	127.52	1.3	17 July 2013
BH032	Fisher Avenue, Pennant Hills	321227.30	6265139.66	170.31	80.00	60° (152° grid north)	90.31	1.5	26 July 2013

Table 7-24 Stratigraphy of project boreholes

Borehole number	Depth of top layer where confirmed by inspection of rock core (metres below ground level)							
	Residual soil	Volcanic breccia	Ashfield Shale, Mulgoa Laminite member	Ashfield Shale, Regentville Siltstone member	Ashfield Shale, Kellyville Laminite member	Ashfield Shale, Rouse Hill Siltstone member	Mittagong Formation	Hawkesbury Sandstone
BH001				*	15.00	21.10	27.49	28.86
BH002	1.5		*	18.00	26.00	34.40	39.50	42.40
BH003				*	15.90	23.70	28.47	30.60
BH004	1.5		*	6.42	18.80	25.00	31.09	32.09
BH005	1.5		*	6.31	21.50	28.00	33.50	45.00
BH006				*	6.65	16.33	20.35	24.65
BH008			*	4.50	20.00	28.10	33.70	37.70
BH009		*						
BH010				*	7.70	16.00	20.55	22.74
BH012						*	13.53	15.65
BH014								*
BH016					*	15.00	20.05	21.80
BH018					*	12.30	19.15	21.09
BH020					*	12.00	19.50	21.10
BH021					*	12.57	16.82	17.05
BH022						*	12.00	14.50
BH023							10.50	11.11
BH024				*	14.61	18.20	26.45	29.74
BH025						*	13.80	16.70
BH029				*	20.15	27.00	33.50	36.40

Borehole number	Depth of top layer where confirmed by inspection of rock core (metres below ground level)							
	Residual soil	Volcanic breccia	Ashfield Shale, Mulgoa Laminite member	Ashfield Shale, Regentville Siltstone member	Ashfield Shale, Kellyville Laminite member	Ashfield Shale, Rouse Hill Siltstone member	Mittagong Formation	Hawkesbury Sandstone
BH030				*				
BH031					*	6.84	13.10	16.30
BH032		*						

* denotes weathered rock in upper section (tope of unit/ layer not determined)

Table 7-25 Standing water levels in project boreholes

Borehole number	Standing water level (23 July 2013)		Standing water level (26 July 2013)		Standing water level (7 August 2013)	
	Metres below top of casing	Metres AHD	Metres below top of casing	Metres AHD	Metres below top of casing	Metres AHD
BH001	6.1	120.7	2.11 (*)	124.7	2.2	124.6
BH002	6.2	121.3	17.7	106.8	10.1	117.4
BH003					4.7	128.9
BH004	5.4	132.5	15.5 (*)	132.5	7.6	130.3
BH005	13.5	149.4	34.1	128.2	19.8	142.5
BH006	16.8	150.4	46.1	121.1	42.7	124.5
BH008	11.6	177.2	Not measured	124.7	52.5	136.3
BH009					Not measured	Not measured
BH010					6.1	164.8
BH012	31.5	141.1	33.1	139.5	32.8	139.8
BH014	24.1	138.5	24.4	123.2	24.6	138.0
BH016					13.8	159.3
BH018	23.3	151.3	24.1	150.6	24.0	150.6
BH020					8.0	161.8
BH021	15.5	158.4	26.0	147.9	26.2	147.7
BH022					8.2	173.6
BH023	6.3	188.2	14.3	174.2	9.5	179.0
BH024					9.4	190.8
BH025	5.2	187.3	4.9	187.5	5.0	187.5
BH029					17.4	112.8
BH030					2.7	121.0
BH031					13.9	169.6

Borehole number	Standing water level (23 July 2013)		Standing water level (26 July 2013)		Standing water level (7 August 2013)	
	Metres below top of casing	Metres AHD	Metres below top of casing	Metres AHD	Metres below top of casing	Metres AHD
BH032					Not measured	Not measured

* these measurements were recorded on 29 July 2013

Table 7-26 Water quality in project boreholes

Parameter	BH001	BH002	BH004	BH005	BH006	BH008	Bh012	BH014	BH018	BH021	BH023	BH025
Sample date	29/07/13	29/07/13	29/07/13	30/07/13	30/07/13	30/07/13	29/07/13	29/07/13	30/07/13	30/07/13	30/07/13	30/07/13
Conductivity (µS/cm)	1,380	1,800	2,710	11,600	4,420	3,310	1,290	1,480	2,230	1,680	1,060	4,850
pH	8.06	7.26	5.98	5.60	6.97	7.28	7.52	6.89	8.16	8.72	7.23	8.71
Resistivity (ohm.cm)	725	556	369	86	226	302	775	676	448	595	943	206
Hydroxide alkalinity (as CaCO ₃ mg/L)	<1	<1	<1	1,190	<1	<1	<1	<1	<1	115	<1	<1
Carbonate alkalinity (as CaCO ₃ mg/L)	<1	<1	<1	68	<1	<1	<1	<1	289	76	<1	<1
Bicarbonate alkalinity (as CaCO ₃ mg/L)	213	345	1,120	<1	309	455	315	192	63	<1	160	<1
Total alkalinity (as CaCO ₃)	213	345	1,120	1,260	209	455	315	192	352	191	160	<1
Sulfate (as SO ₄ mg/L)	229	279	163	239	402	260	146	81	221	135	76	68
Chloride (mg/L)	112	168	126	1,640	958	630	90	282	346	186	167	1,320
Calcium (mg/L)	13	51	297	638	110	37	30	61	5	1	18	3
Magnesium (mg/L)	10	14	6	<1	50	76	11	27	25	<1	13	88
Sodium (mg/L)	225	280	378	1,150	819	616	230	203	440	242	160	676
Potassium (mg/L)	8	20	26	96	27	29	28	16	49	63	8	6
Arsenic (mg/L)	<0.001	<0.001	0.002	<0.001	0.001	<0.001	0.001	<0.001	0.018	0.004	<0.001	0.001
Cadmium (mg/L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003
Chromium (mg/L)	<0.001	0.070	0.007	0.206	<0.001	<0.001	<0.001	<0.001	0.057	0.077	<0.001	0.001
Copper (mg/L)	<0.001	0.003	0.009	0.006	0.001	0.006	0.002	0.001	0.003	0.003	<0.001	0.061

Parameter	BH001	BH002	BH004	BH005	BH006	BH008	Bh012	BH014	BH018	BH021	BH023	BH025
Nickel (mg/L)	0.032	0.102	0.114	<0.001	0.026	0.018	0.082	0.091	0.029	<0.001	0.040	0.055
Lead (mg/L)	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.003
Zinc (mg/L)	0.036	0.106	0.098	0.032	0.031	0.053	0.030	0.017	<0.005	<0.005	0.020	0.097
Mercury (mg/L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ferrous iron (mg/L)		<0.05		<0.05				<0.05	<0.05			
Ferric iron (mg/L)		<0.05		<0.05				<0.05	<0.05			
Nitrate and nitrite (as N mg/L)		0.13		0.13				0.02	<0.01			
Total Kjeldahl nitrogen (as N mg/L)		0.9		1.8				0.9	17.8			
Total nitrogen (as N mg/L)		1.0		1.9				0.9	17.8			
Total phosphorous (as P mg/L)		0.13		<0.01				<0.05	<0.01			
Total anions (meq/L)	12.2	17.4	29.3	76.4	41.6	32.3	11.9	13.5	21.4	11.9	9.49	38.6
Total cations (meq/L)	11.5	16.4	32.4	84.3	45.9	35.6	13.1	14.5	22.7	12.2	9.13	37.0
Ionic balance (%)	3.08	3.14	4.98	4.92	4.96	4.92	4.97	3.67	2.92	1.28	1.95	2.27

Issue description

The assessments of groundwater behaviour and the impacts associated with dewatering caused by the tunnels lack rigour and detail.

Response

The level of assessment of groundwater impacts have been undertaken in accordance with the NSW Office of Water Aquifer Interference Policy. An empirical assessment of the lateral extent of potential groundwater drawdown in the Hawkesbury Sandstone as a result of groundwater into the project tunnels has been conducted using the Perrochet and Musy (1992) empirical method. The assessment shows a long-term quasi steady state drawdown scenario. Based on this model, the environmental impact statement considers the potential impacts of potential groundwater drawdown in Section 7.8.

The model outcomes on which the environmental impact statement is based can be seen in **Figure 7-7**. The figure shows the predicted lateral extent of groundwater drawdown in the Hawkesbury Sandstone.

The lateral extent of drawdown in the north is lower than in the south due to the shallower level tunnel and deeper incised watercourses, compared to the south with a deeper tunnel and shallower incised watercourses. Groundwater outflow to creeks through springs (if they are present), would not be affected outside the lateral extent of drawdown.

Figure 7-7 shows that the lateral extent of groundwater drawdown intersects a number of surface watercourses in their headwaters. These include:

- Three un-named creeks around Normanhurst.
- Tedbury Creek.
- Berowra Creek.
- Devlins Creek.

With the exception of Devlin's Creek, these surface watercourses are all concrete lined, or concrete piped systems where the lateral extent of groundwater drawdown intersects the watercourse. As such, drawdown impacts on these watercourses would not be anticipated.

Devlins Creek retains somewhat of a natural channel where the lateral extent of groundwater drawdown intersects the watercourse. Due to the relatively low hydraulic conductivity within the Hawkesbury Sandstone, the base flow in Devlins Creek would not be reliant on the surface expression of groundwater. Any baseflow within Devlins Creek fed by groundwater flows is anticipated to be negligible.

Additionally, as identified in the Technical Working Paper: Biodiversity (Appendix J to the environmental impact statement), there are no groundwater dependent ecosystems within this section of Devlins Creek, and there are no ecosystems along downstream sections of Devlins Creek which are reliant on the surface expression of groundwater. This suggests that the vast majority of water flow within Devlins Creek is from overland flow paths. As the NorthConnex project is located predominantly underground, there would be no change to overland flow paths.

Issue description

The potential impacts of most interest are the baseflow impacts in the tributaries of the Hawkesbury River northwest of the tunnel and of Lane Cove River to the south and east. These tributaries lie within the Berowra Valley Regional/ National Park and Lane Cove National Park respectively, both of which are inferred in Geoscience Australia's Groundwater Dependent Ecosystems Atlas to contain flora with varying potential for groundwater interaction.

Response

The Groundwater Dependent Ecosystem Atlas identifies some areas of vegetation within the Berowra Valley Regional/ National Park and the Lane Cove National Park which are reliant on groundwater to various degrees. The Atlas does not identify any vegetation which is reliant on the surface expression of groundwater (ie baseflows of watercourses fed by groundwater). There is no direct connection between potential impacts on baseflows and these groundwater dependent ecosystems.

It is also relevant to note that the principal regulatory instrument – the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources prepared and published by the NSW Office of Water – does not identify any groundwater dependent ecosystems in either the Berowra Valley Regional/ National Park or the Lane Cove National Park. The closest groundwater dependent ecosystems to the project that are identified in the Water Sharing Plan are at Windsor (around 20 to 30 kilometres from the project at the closest point) and within the Botany Sands Aquifer (around 25 kilometres from the project and separated by Sydney Harbour). Both of these areas of groundwater dependent ecosystems mapped in the Water Sharing Plan are well beyond the area potentially affected by the project.

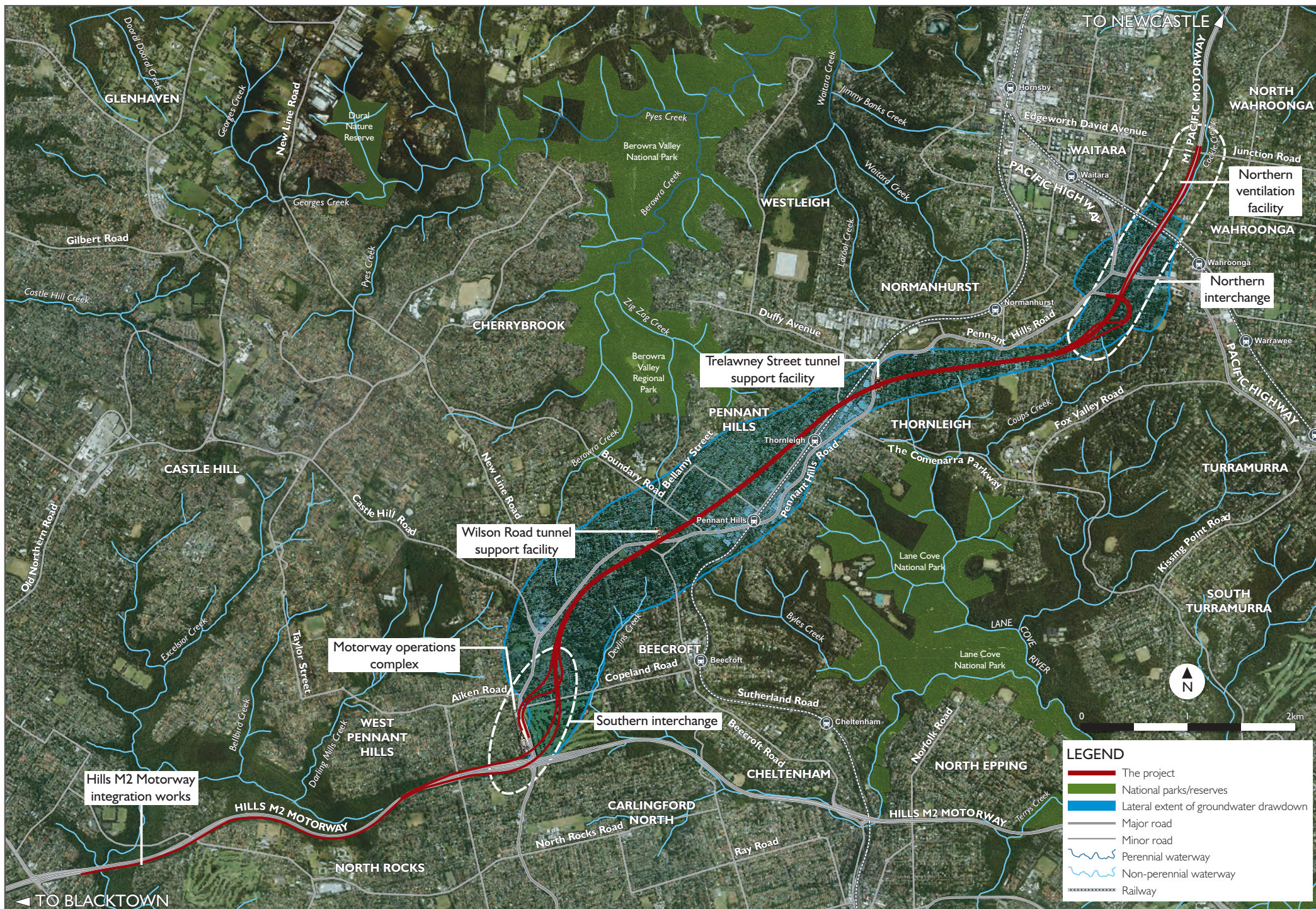


Figure 7-7 Lateral extent of groundwater drawdown

(blank page)

Issue description

Potential baseflow impacts in the tributaries of the Hawkesbury River and the Lane Cove River, which lie outside the construction corridors and thus the nominated study areas, do not appear to be considered or addressed either within the environmental impact statement or in Appendix J (Technical Working Paper: Biodiversity). Additional information is included in the supplementary information provided by Roads and Maritime to the NSW Office of Water during the public exhibition period but assessment of these potential impacts remains limited.

Response

The assessments presented in the environmental impact statement, and the responses to issues raised by the NSW Office of Water above, indicate that:

- The lateral extent of groundwater drawdown around the project tunnels would intersect several concrete lined or concrete piped watercourses. The only unlined watercourse potentially affected by groundwater drawdown is Devlins Creek, which does not support groundwater dependent ecosystems that are reliant on the surface expression of groundwater (including downstream of the project).
- Due to the relatively low hydraulic conductivity within the Hawkesbury Sandstone, the base flow in Devlins Creek would not be reliant on the surface expression of groundwater. Any baseflow within Devlins Creek fed by groundwater flows are anticipated to be negligible.
- Mapping of groundwater dependent ecosystems by Geoscience Australia and by the NSW Office of Water does not indicate any groundwater dependent ecosystems which are dependent on the surface expression of groundwater and are within areas potentially affected by groundwater drawdown from the project.

Due to the proposed restriction in groundwater inflow into the project tunnels, the generally low hydraulic conductivity of the Hawkesbury Sandstone and the avoidance of impacts to existing overland flow paths to the tributaries of the Hawkesbury River and the Lane Cove River, the potential for change in baseflow of these watercourses is considered to be minimal.

Issue description

Advice should be sought from the Office of Environment and Heritage about the specific values and impacts in relation to the tributaries of the Hawkesbury River and the Lane Cove River.

Response

The Office of Environment and Heritage has reviewed the environmental impact statement, and has made a separate submission on the project. Responses to issues raised by the Office of Environment and Heritage are provided in **Section 7.1.7** of this report.

7.1.6.2 Impacts to surface water resources

Issue description

Potential impacts to surface water resources as a result of the project include impacts to flow regimes, water quality and disturbance of waterfront land during construction, and impacts due to the discharge of captured construction water, stormwater and groundwater to receiving surface waters during construction and operation.

Section 7.9.4 of the environmental impact statement outlines proposed environmental management measures to mitigate the potential impacts arising from the project. These measures are generally considered adequate to manage potential impacts to surface water resources and should be incorporated into the project approval, should approval be granted.

Response

The potential impacts to surface water resources have been assessed in Section 7.9 of the environmental impact statement.

Mitigation measures identified in Section 7.9.4 of the environmental impact statement will be implemented by the project.

7.1.6.3 Recommendations

Issue description

A condition of approval should require that groundwater inflows be limited to one litre per second per kilometre. This limit is to be applied over any given kilometre of tunnel rather than as an average value.

Response

The limit of groundwater inflow into the tunnel to one litre per second per kilometre is a design requirement of the project and is applied over any given kilometre of the tunnels. This is a more stringent application of the design requirement than has occurred on previous Sydney road tunnels which the one litre per second was applied as an average over the entire tunnel. The environmental impact assessment has been completed on this basis.

Issue description

Specific advice should be sought from the Office of Environment and Heritage about the values and importance of the various ecosystems which may be affected by potential baseflow losses (including spring discharges) arising from tunnel groundwater inflows, whether any potential biodiversity impacts would be of concern if realised, and appropriate mitigation and response measures to address potential impacts.

Response

As detailed in the responses to issues raised by the NSW Office of Water above, there are no ecosystems in proximity to the project that may be affected by loss of baseflows. Further, the potential for loss of baseflows in surface watercourses near the project would be minimal due to the proposed restriction in groundwater inflow into the project tunnels, the generally low hydraulic conductivity of the Hawkesbury

Sandstone, the avoidance of impacts to existing overland flow paths to surface watercourses and the concentric lines or piped nature of the majority of these watercourses.

The Office of Environment and Heritage has reviewed the environmental impact statement, and has made a separate submission on the project. Responses to issues raised by the Office of Environment and Heritage are provided in **Section 7.1.7** of this report.

Issue description

A Groundwater Management Plan should be developed which takes account of the risks associated with potential baseflow reduction impacts caused by dewatering. The plan should include:

- A protocol for the measurement of groundwater inflows to the tunnels during construction and operation.
- Mitigation and response measures to be implemented to maintain groundwater inflows within the prescribed limit of one litre per second per kilometre.
- A procedure for the investigation and evaluation of the risks to groundwater and surface water resources and dependent ecosystems as a result of potential baseflow reduction impacts caused by dewatering.
- Monitoring, impact trigger definition and response actions to mitigate and manage potential impacts to groundwater and surface water resources and dependent ecosystems from both construction and ongoing dewatering caused by the drained tunnel.
- "Make good" provisions to be implemented in the event of adverse impacts to nearby groundwater users from both construction and ongoing dewatering caused by the drained tunnel.
- A protocol for ongoing communication with the NSW Office of Water regarding licensing requirements for the operational take of groundwater.

Response

As identified in Table 7-171 of the environmental impact statement, the project would develop a Construction Soil and Water Quality Management Plan. This plan would detail the management measures in relation to potential surface water and groundwater impacts. Mitigation measure HS8 in Table 7-171 also identifies that the project would develop a groundwater monitoring plan for the construction phase.

Roads and Maritime would continue to consult with the NSW Office of Water in relation to licensing arrangements for road infrastructure in the future.

Issue description

A commitment is required from the proponent to continue to liaise with the NSW Office of Water regarding licensing the long-term operational take of groundwater.

Response

Roads and Maritime would continue to consult with the NSW Office of Water in relation to licensing arrangements for road infrastructure in the future.

Issue description

A Surface Water Management Plan should be developed and include:

- Implementation of the environmental management measures outlined in Table 7-179 of the environmental impact statement.
- Monitoring, impact trigger definition and response actions for all watercourses and riparian land potentially impacted by the project.

Response

As identified in Table 7-179 of the environmental impact statement, the project would develop a Construction Soil and Water Quality Management Plan. This plan would detail the management measures in relation to potential surface water and groundwater impacts. Mitigation measure SW20 in Table 7-179 also identifies that the project would develop a surface water monitoring plan for the construction phase.

Issue description

By virtue of section 115ZG of the *Environmental Planning and Assessment Act 1979*, state significant infrastructure projects are currently exempt from the requirement to obtain controlled activity approvals in accordance with section 91 of the *Water Management Act 2000*. Notwithstanding, all activities taking place in, on or under waterfront land, as defined in the *Water Management Act 2000* should be conducted in accordance with the NSW Office of Water's Guidelines for Controlled Activities available at www.water.nsw.gov.au.

Response

The requirements of the NSW Office of Water's Guidelines for Controlled Activities would be considered in relation to any activities taking place in, on or under waterfront land.

7.1.7 Office of Environment and Heritage

7.1.7.1 Biodiversity – direct impacts

Issue description

This project will entail the clearing of at least 5.9 hectares of native vegetation including 2.8 hectares of the Blue Gum High Forest critically endangered ecological community.

To address these and other unavoidable biodiversity impacts, offsets have been calculated using the Biobanking Assessment Methodology.

To calculate ecosystem credits, the Office of Environment and Heritage notes that three mapped vegetation communities were merged into the '*Sydney Peppermint — Smooth-barked Apple — Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin*' biometric vegetation type. This was done because the areas of these communities are smaller than the required minimum vegetation zone size of 0.25 hectares as defined in the Biobanking Assessment Methodology.

While the rationale for this approach is supported, the Office of Environment and Heritage considers two of the mapped communities have been incorrectly merged. Based on assemblage similarity, the Office of Environment and Heritage recommends that:

- The Coastal Enriched Sandstone Moist Forest community be merged with the Sydney Turpentine-Ironbark Forest which should then be assessed as the '*Turpentine — Grey Ironbark Open Forest in the lower Blue Mountains*' biometric vegetation type.
- The Coastal Enriched Sandstone Dry Forest community be merged with the '*Smooth-barked Apple — Red Bloodwood — Sydney Peppermint heathy open forest in sandstone gullies, eastern Sydney Basin*' biometric vegetation type.

The Office of Environment and Heritage also notes that 0.08 hectares of unconfirmed Blue Gum individuals, 0.1 hectares of unconfirmed Sydney Turpentine-Ironbark Forest and 4.04 hectares of unsurveyed vegetation were excluded from the Biobanking Assessment Methodology assessment.

The Office of Environment and Heritage recommends a re-assessment of required offsets using the Biobanking Assessment Methodology be undertaken following confirmation of the vegetation communities in unsurveyed areas and to address the vegetation merging issues detailed above.

Response

The Office of Environment and Heritage's comments are noted.

The environmental impact statement identifies that the offset calculation would be reviewed and refined in consultation with the Office of Environment and Heritage and the Department of Planning and Environment as part of the Biodiversity Offset Strategy. Previously unsurveyed areas would be surveyed, then offset calculations would be refined based on that additional information, plus potential reduction in vegetation disturbance due to a refinement of the detailed design and construction methodologies.

Issue description

The Office of Environment and Heritage is concerned that it may be difficult to secure currently unprotected vegetation to satisfy the offset requirements for this development, particularly in relation to Blue Gum High Forest credits. The Office of Environment and Heritage therefore recommends the proposed Biodiversity Offset Strategy be prepared and approved as part of the overall project approval.

Response

The scarcity of Blue Gum High Forest is recognised, and is a key reason for committing to careful review of opportunities to further reduce vegetation disturbance during the detailed design process.

Roads and Maritime would continue to consult with the Office of Environment and Heritage in relation to the identification of suitable offset sites or other offset measures. The NorthConnex project is committed to the development of a Biodiversity Offset Strategy and subsequent Biodiversity Offset Package post planning approval, consistent with the approach on similar infrastructure projects.

Issue description

In relation to other direct impact biodiversity issues:

- The Office of Environment and Heritage notes that 1,767 species credits would be required to offset the removal of 106 *Epacris purpurascens* var. *purpurascens* individuals. It is unclear if these credits are intended to be purchased or the impacts would be offset by translocation. The Office of Environment and Heritage recommends a Translocation Plan be prepared should the latter be chosen.
- The Office of Environment and Heritage supports the measure to prepare a Microbat Management Plan to manage any potential impacts on threatened microbats.
- The Office of Environment and Heritage supports the measure to develop a Flora and Fauna Management Plan for the construction phase of the project. The Office of Environment and Heritage recommends this Plan be extended (or a succeeding Plan be developed) to address management following construction. The Office of Environment and Heritage considers an appropriate duration of an extended (or succeeding) plan would be until vegetation condition is restored to pre-construction condition and, if any *Epacris purpurascens* var. *purpurascens* is translocated, until this has been proven successful.

Response

It is proposed at this stage is to offset *Epacris purpurascens* var. *purpurascens* individuals by translocation. A Translocation Plan would be produced or details of the translocation measures would be documented within suitable other plans, eg as part of the Biodiversity Offset Strategy and Biodiversity Offset Package. Appropriate measures of success for the translocation of *Epacris purpurascens* var. *purpurascens* individuals would be included as part of the plan.

Mitigation measure B14 in Table 7-156 of the environmental impact statement identifies that the project would develop a Microbat Management Plan.

Mitigation measure OpB1 identifies that a management plan would be developed to identify and manage biodiversity impacts during operation including weed management, maintenance of nest boxes and the ongoing maintenance of the riparian areas.

7.1.7.2 Biodiversity – indirect impacts

Issue description

The environmental impact statement assesses the potential indirect biodiversity impacts arising from the project. For the majority of impacts, the assessment undertaken and the range of mitigation measures proposed appears appropriate.

Response

The Office of Environment and Heritage's comments are noted.

Issue description

The Office of Environment and Heritage is concerned with the assessment of indirect biodiversity impacts as a result of the proposed arrangements for intercepting and discharging up to 700 megalitres of groundwater per annum.

The Office of Environment and Heritage notes the 'discharge of treated groundwater would change the flow in downstream watercourses, including Blue Gum Creek and Darling Mills Creek, from ephemeral to perennial flow regimes'. Groundwater regimes in other waterways will logically be impacted by reduced flows although the relative scale of these changes is unclear. In addressing hydrology and aquatic ecology impacts, the environmental impact statement and the Technical Working Paper: Biodiversity (Appendix J of the environmental impact statement) state:

- The potential impacts to aquatic fauna in the upper reaches of watercourses near the development 'are likely to be limited given the degraded condition of these environments and the lack of habitats' (page 757 of the environmental impact statement).
- 'Higher quality environments further downstream' could be affected by the potential for increased bank erosion, sedimentation and algal blooms which may reduce the availability of habitat for macroinvertebrates (page 757 of the environmental impact statement).
- The increased and permanent base flow in Darling Mills and Blue Gum Creeks is 'unlikely to have a significant impact on aquatic ecology' (page 764 of the environmental impact statement).
- The aquatic biodiversity impacts of increased water volume in the impacted waterways could be negative or positive depending on whether 'quality is adequately controlled and discharge rates do not exceed habitat requirements of aquatic taxa' (page 99 of the Technical Working Paper: Biodiversity).

A number of measures are proposed to ameliorate hydrology and aquatic ecology impacts. The Office of Environment and Heritage notes these appear to be confined to the management of surface water.

The Office of Environment and Heritage notes that the Director-General's environmental assessment requirements in relation to biodiversity and is concerned that the assessment of the proposed changed groundwater regimes on the biodiversity values within sensitive receiving catchments, such as the Lane Cove River and Berowra Valley National Parks, is limited and/or unclear. The Office of Environment and Heritage considers that the environmental impact statement provides limited assessment on the relative importance of the current groundwater regime in supporting existing downstream biodiversity values.

The Office of Environment and Heritage recommends that additional assessment be undertaken to clarify or more clearly detail the relationship between the existing and proposed groundwater regime and the aquatic and terrestrial biodiversity of the water catchments within the project. Additional measures to avoid, minimise and mitigate adverse indirect biodiversity impacts should be developed if necessary.

Response

Further information on potential groundwater drawdown and impacts on groundwater dependent ecosystems is provided in responses to the submission made by the NSW Office of Water (refer to **Section 7.1.6** of this report).

The project has set design requirements to limit of groundwater inflow into the tunnel to one litre per second per kilometre (measured over any given kilometre of the tunnels). This design requirement is more stringent than other Sydney road tunnels. This would be achieved by grouting of any significant water bearing features intercepted by the project. Apart from these water bearing features, the hydraulic conductivity of the Hawkesbury Sandstone is relatively low.

The Groundwater Dependent Ecosystem Atlas identifies some areas of vegetation within the Berowra Valley Regional/National Park and Lane Cove National Park which are reliant on groundwater to various degrees. The Atlas does not identify any vegetation in proximity to the project which is reliant on the surface expression of groundwater (ie baseflows of watercourses fed by groundwater).

Due to the proposed restriction in groundwater inflow into the tunnels, the generally low hydraulic conductivity of the Hawkesbury Sandstone and the avoidance of any impacts to existing overland flow paths to these watercourses, the potential for change in baseflow of these watercourses is considered to be minimal.

Further consideration of potential for groundwater drawdown would be undertaken during the detailed design stage of the project. This would include the identification of additional mitigation and management measures if required.

7.1.7.3 Aboriginal cultural heritage

Issue description

The Office of Environment and Heritage has reviewed the Technical Working Paper: Aboriginal Cultural Heritage (Appendix M to the environmental impact statement) and considers the assessment sufficiently addresses the Director-General's environmental assessment requirements in relation to the potential impacts the development may have on any Aboriginal objects.

The Office of Environment and Heritage concurs with the recommendations of the Technical Working Paper: Aboriginal Cultural Heritage, particularly in relation to the ongoing monitoring of the potential effects from vibration on rockshelter sites and overhangs.

The Office of Environment and Heritage considers that a protocol for this monitoring should be established early and consideration must be made of appropriate management and rehabilitation if negative effects from vibration are identified. The Office of Environment and Heritage further recommends that impacts to Archaeological Sensitivity Area 1 (ASA1) and Archaeological Sensitivity Area 2 (ASA2) are avoided.

Response

Protocols for monitoring would be developed as part of the construction environmental management documentation. This would include appropriate notification and management protocols in the event on unexpected impacts.

The project would avoid direct impacts to ASA1 and ASA2. In the unlikely event that detailed design identifies direct impacts to these areas, further assessment and consultation with Aboriginal stakeholders and the Office of Environment and Heritage would be undertaken.

Issue description

With regard to Aboriginal community consultation, the methodology for the identification of the Aboriginal representatives who provided input has not been specified. Neither has it been articulated how the consultation complies with the Director-General's environmental assessment requirements.

The Office of Environment and Heritage considers that the Director-General's environmental assessment requirements are somewhat unclear about what form consultation with the Aboriginal community should take, as they state that the assessment of the potential Aboriginal cultural heritage impacts must be undertaken in accordance with the Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community consultation, 2005. Additionally, the Director-General's environmental assessment requirements require the proponent to 'demonstrate effective community consultation with Aboriginal communities...'.

The Office of Environment and Heritage recommends that the Department of Planning and Environment clarify the form of Aboriginal community consultation required for this project.

Response

The Aboriginal heritage assessment was carried out generally in accordance with the Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC, July 2005) and the Director-General's environmental assessment requirements.

Consultation with Aboriginal stakeholders is described in Section 3.1 of the Technical Working Paper: Aboriginal Heritage (Appendix M of the environmental impact statement).

Consultation with Aboriginal stakeholder has been undertaken in accordance with Stage 2 of the Roads and Maritime Procedure for Aboriginal Cultural Heritage Consultation and Investigation (RTA, 2011) which aligns with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (DECCW, 2010).

Engagement with Aboriginal stakeholders in relation to the NorthConnex project has included consultation and field surveys with the Metropolitan Local Aboriginal Land Council and the Guringai Tribal Link Aboriginal Corporation. Representatives of both organisations have provided verbal feedback during the field inspections, which was considered in the assessment presented in the environmental impact statement. The representatives were invited to provide a report or comments detailing their findings from the inspections for consideration in the assessment of the potential impacts of the project.

As the Aboriginal heritage assessment concluded that no impacts to Aboriginal objects, places or cultural features would occur as a result of the project, no further consultation or investigation was required. This is consistent with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (DECCW, 2010).

7.1.7.4 Floodplain risk management

Issue description

The Office of Environment and Heritage notes that due to the location of the project along a ridgeline, mainstream flooding has not been identified as a major design constraint. The environmental impact statement advises that local flooding would have limited impacts to surrounding receivers and infrastructure.

Environmental management measures proposed to address impacts associated with the project on flooding include the augmentation of existing infrastructure and the construction of new mitigation measures. Further assessment of these measures is proposed at the operational and detailed design stages.

The environmental impact statement advises that flooding from external catchments and during a Probable Maximum Flood is unlikely to inundate the southern tunnel portals. No advice is provided in relation to the northern tunnel portals. The Office of Environment and Heritage recommends further investigation be undertaken to ensure tunnel portals are located above the Probable Maximum Flood level.

The Office of Environment and Heritage advises that it is prudent to investigate the need for an emergency management plan to manage extreme local flooding in consultation with the State Emergency Service. This investigation can be undertaken at an appropriate time during development of the project.

The Office of Environment and Heritage also recommends considering the potential future impacts of increased rainfall intensity due to climate change.

Response

Section 7.9.3 of the environmental impact statement identifies that the tunnel portals would be designed to prevent the ingress floodwaters up to the probable maximum flood. This statement is relevant for all tunnel portals.

The NorthConnex project team has undertaken consultation with Fire and Rescue NSW in relation to emergency management requirements of the project. This consultation, and consultation with other emergency services, would continue during the development of the design.

A climate change risk assessment, including risks associated with increased rainfall intensity has been considered in Table 8-36 of the environmental impact statement. This would continue to be considered during the development of the detailed design of the project.

7.1.8 Office of Environment and Heritage – Heritage Council

7.1.8.1 Non-Aboriginal heritage – mitigation and management measures

Issue description

Section 9.0 of the Technical Working Paper: Non-Aboriginal heritage (Appendix L to the environmental impact statement) outlines recommended mitigation and management measures to address the loss of heritage value. The report recommends that the measures be further developed and clearly defined on an item by item basis once the final areas and level of disturbance have been defined during detailed design. The measures would be detailed within the construction management plan.

The Heritage Council recommends the following conditions:

- In accordance with Section 9.0 of the Technical Working Paper: Non-Aboriginal heritage (Appendix L to the environmental impact statement), the proponent must develop mitigation and management measures to be implemented for every heritage item within the study area, and any heritage item in the vicinity that may be affected by the project. This includes archaeological items, heritage conservation areas, and draft heritage items.
- The mitigation and management measures must also address the impacts of any necessary acoustic treatment to heritage items to ensure that it is carried out in a sympathetic manner. Prior to any acoustic treatment, the proponent must obtain advice from an appropriately experienced and qualified heritage consultant and obtain the relevant approvals to ensure that the works undertaken have minimal impact on fabric and does not detract from the significance of the heritage item.

Response

Appropriate mitigation and management measures would be developed for heritage items which have the potential to be directly or indirectly impacted by the project. As identified in Section 9 of the Technical Working Paper: non-Aboriginal heritage

(Appendix L of the environmental impact statement) consideration of indirect impacts would include consideration of ground settlement, vibration and visual impacts.

Section 7.10.3 of the environmental impact statement provides consideration of potential acoustic treatment and heritage items. This section identifies that the need for acoustic treatment at each property would be confirmed during detailed design, in consultation with landowners, and with consideration of potential impacts to heritage values.

Should at-property acoustic treatment be required for listed heritage items, this may result in impacts to the fabric of these items. Treatment would be sympathetic to the heritage values of each item and would be undertaken in accordance with the Burra Charter, which stipulates that changes which reduce cultural significance should be reversible.

Any necessary approvals which are not required for State significant infrastructure projects would be obtained. It is noted that an approval under Part 4, or an excavation permit under section 139, of the *Heritage Act 1977* do not apply to the NorthConnex project.

7.1.8.2 Non-Aboriginal heritage – archaeology

Issue description

The Technical Working Paper: Non-Aboriginal heritage (Appendix L to the environmental impact statement) identifies that the Thornleigh Maltworks site is listed for its archaeological value and makes the recommendation that an archaeological test excavation program is to be undertaken.

The Heritage Council recommends the following conditions:

- Archaeological test excavation at the Maltworks is to be undertaken in accordance with the recommendations of the Technical Working Paper: Non-Aboriginal heritage (Appendix L to the environmental impact statement) for the Thornleigh Maltworks.
- The Excavation Direction must comply with the Heritage Council's Excavation Director Guidelines for archaeology of local significance. The final report on the archaeological excavation must be submitted to the Heritage Council within one year of the archaeological program.
- Where substantial intact archaeological relics of State or local significance are discovered during excavation, work must cease in the affected area and the Heritage Council must be notified in writing in accordance with section 146 of the *Heritage Act 1977*.

Response

Mitigation measure NAH8 in Table 7-186 of the environmental impact statement identifies mitigation and management measures in relation to the Thornleigh Maltworks site. This would include:

- A structural assessment of the germination structure would be conducted to ascertain the possible impact of the demolition of adjacent structures and to identify suitable mitigation methods to ensure the germination structure remains intact. Additional measures would be identified and implemented, if

required, to treat the newly exposed surfaces of the germination structure to protect it from the elements as a result of the demolition of adjacent structures.

- Archival recording of the industrial site would be undertaken to record the connection of the original structures to the modern upgraded structures.
- A program of archaeological test excavation would also be undertaken to assess the archaeological potential of identifying evidence of the early malting industry in this area, the relationship of the industrial site to the urban site and evidence of the occupation of the Manager's House by the Chilvers family.

In the event that substantial intact archaeological relics of State or local significance are discovered during excavation, work would cease in the affected area and the Heritage Council would be notified in writing in accordance with section 146 of the *Heritage Act 1977*.

(blank page)

7.2 Local councils

7.2.1 Hornsby Shire Council

7.2.1.1 Air quality

Issue description

The conclusions and modelling revolving around air quality are based on previous traffic modelling. If the traffic modelling is found to be flawed in the future it is noted that this will in turn disqualify many of the assumptions entered into the air quality model.

Response

Assessments presented in the environmental impact statement rely on forecast traffic data generated through a strategic transport model of Sydney's major road network using the Cube Voyager software platform. Cube is the most widely used software package in the world for transport planning.

The Cube model used to develop traffic forecast data for the NorthConnex project has taken into account factors including existing and future land use, anticipated changes to the major road network, existing and future travel demands, existing and future tolling structures, and motorist behaviours. Further details of these assumptions and inputs are provided in Section 5.2 of the Technical Working Paper: Traffic and Transport (Appendix E to the environmental impact statement).

A significant investment is proposed in the NorthConnex project. The commercial viability of this investment is dependent on forecast traffic volumes expected to use the project being reasonable and realistic. Because of this, the Cube model and its outputs have been interrogated in detail to confirm that the project is viable prior to seeking design and construct tenders or lodging an application for environmental planning approval.

The air quality impact assessment presented in Section 7.4 and Appendix G of the environmental impact statement has as its principal focus, modelling and assessment of potential air quality impacts under forecast traffic flows in 2019 and 2029 (derived from the Cube model). To provide confidence about the performance of the project in the event that actual traffic demand exceeds traffic forecasts in the future, the air quality impact assessment also considers 'design analysis A'. This design analysis is based on the project operating at its maximum theoretical design capacity during the peak hour (4,000 passenger car units). Design analysis A therefore represents a credible upper limit to the potential operation of the project. Although it is considered unlikely that design analysis A would eventuate in reality, based on traffic forecasting, it provides a 'worst-case' scenario for the purpose of assessment potential air quality impacts. The environmental impact statement demonstrates that design analysis A would meet applicable ambient air quality criteria.

Further discussion of traffic forecasts, implications for the design of the project tunnels and ventilation system, and derivation of a worst case traffic scenario ('design analysis A') is provided in response to the submission received from the Environment Protection Authority (refer to **Section 7.1.1.3** of this report).

Issue description

Council believes that tunnel portal emissions have not been quantified. The environmental impact statement states that *'The project does not currently propose portal emissions from the main alignment tunnels. This approach may, however, be considered in the future, but would be subject to appropriate assessment and approval at the relevant time'*.

It is noted that portal emissions at the southern interchange will be minimal as the ventilation facility is approximately 50 metres from the portal, resulting in approximately 50 metres of uncaptured tunnel air being discharged from the portal.

It is noted that the northern ventilation facility is approximately one kilometre from the tunnel portal and therefore there may exist the potential for significant emissions to be experienced at this location, which have not been quantified.

Council requests the Department of Planning and Environment to seek clarification regarding the potential for tunnel portal emissions from the tunnel portals.

Response

The northern ventilation facility is located directly above the northbound main alignment tunnel portal and around one kilometre from the Pennant Hills Road off-ramp at the northern interchange.

The project does not propose any emissions from the tunnel portals under normal operating conditions.

The project's ventilation system has been designed to operate with a pressure differential between the ventilation off-take and the portal. This pressure differential will act to draw air close to the tunnel portals back into the tunnel for collection and management with other tunnel air, via the relevant ventilation off-take and associated ventilation facility. This operational principle has been applied to both main alignment tunnel and off-ramp tunnel portals. This is a common management approach in road tunnels where portal emissions are prohibited.

Further details regarding the operation of the project ventilation system is provided in Section 5.2.5 of the environmental impact statement.

Issue description

Dispersion modelling has been performed using nested receivers (that is, a receiver grid of varying resolution, with receiver spacing decreasing for those areas closest to the emission points). To assess the impact from the tunnel ventilation outlets, the following receiver grids have been used:

- A uniform Cartesian receiver grid over the 10 kilometre x 17 kilometre modelling domain with an unspecified resolution (receiver spacing), although this is inferred from Figure 8 of the environmental impact statement to be 300 metres.
- A uniform Cartesian receiver grid over two 5 kilometre x 5 kilometre areas centred around each of the tunnel ventilation outlets with a resolution of 150 metres.
- To assess the road traffic emissions, receivers were spaced at various distances (10 metres to 225 metres from the road centreline).

The 'fine' receiver grid spacing of 150 metres is considered to be too coarse for a 15 metre ventilation outlet emission point. Given that the ventilation outlet height is proposed to be 15 metres, a grid resolution of approximately 15 metres to 45 metres would be expected (around one to three times the height of the ventilation outlet).

Merely based on a desktop mapping exercise, there are a significant number of residential properties located within a 150 metre diameter of the outlet that might be inadequately assessed in the current modelling configuration.

Given that significant impacts are expected in near-field locations, using such a refined grid would enable a detailed assessment of the concentrations at and immediately beyond the ventilation facility boundary to be assessed.

A similar limitation occurs between the 150 metre receiver locations, with the concentrations between those receiver points interpolated.

The point of maximum impact in reality may therefore not coincide with the 150 metre grid, and the maximum impacts under-assessed.

There are discrepancies between the text presented in Section 4.2.6 of the environmental impact statement and those presented in Table 17 of the Technical Working Paper: Air Quality, specifically, the extents of the modelling domain (Table 17 of the environmental impact statement refers to a 15 kilometre x 10 kilometre modelling domain).

Council requests that the Department of Planning and Environment ensure that it is satisfied that the correct data has been used and the report author corrects the report for consistency. Council believes that should the 'correctly quoted' receiver resolution be as presented in Table 17 of the Technical Working Paper: Air Quality, then the observations above would be exacerbated.

Response

The CALMET meteorological modelling conducted in the air quality impact assessment employed a 60 kilometre by 62.5 kilometre modelling domain, with 250 metre resolution.

The CALPUFF air dispersion modelling conducted in the air quality impact assessment employed a 17 kilometre by 10 kilometre modelling domain. A 250 metre grid spacing was used to match the CALPUFF model with the CALMET model. Within that 250 metre grid spacing, finer modelling grids were applied for the purpose of modelling ground level concentrations of air emissions for relevant receivers.

Relevant receivers for the purpose of the air dispersion modelling, which were indicative locations rather than specific individual premises, were determined through the use of variable grid sizes depending on distance from a project ventilation outlet or a major road (Pennant Hills Road, the Hills M2 Motorway or the M1 Pacific Motorway).

As indicated in Section 4.2.6 of the environmental impact statement, a high density receiver grid of 150 metre spacing was applied to a five kilometre by five kilometre area around each of the project ventilation outlets. Outside this area (more than 2.5

kilometres from each ventilation outlet) a receiver grid with 300 metre spacing was applied.

For receivers along major road corridors, receiver locations were spaced at 10 metres, 35 metres, 105 metres, 160 metres and 225 metres from the road centreline.

In total, 6,919 receiver locations were considered in the air quality impact assessment. Figure 8 in the Technical Working Paper: Air Quality shows the receiver locations considered in the assessment.

The resolution of the receiver grids applied as part of the air quality impact was developed having regard to the guidance document Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia (OEH, 2011). One of the authors of that document, who is an internationally-recognised meteorological and air dispersion modelling specialist, peer reviewed and endorsed the CALMET and CALPUFF parameters used in the air quality assessment for the project. This included the receiver grid resolution.

As noted in Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia (OEH, 2011), the best receiver grid spacing for each modelling project is dependent on the size of the modelling domain and the complexity of the terrain within the domain. The guidance document states that typical CALMET applications should include between 100 and 300 grid cells in both the x and y directions (OEH, 2011, page 18). Furthermore, it states that near-field applications may require modelling grid spacings of about 250 metres, while grid spacings of 150 metres may be required to resolve dominant terrain features (OEH, 2011, page 18).

Modelling domains and receiver grid resolutions for the air quality impact assessment have been developed consistent with the direction provided in the abovementioned guidance document. The CALMET meteorological modelling domain had 240 by 250 cells with a 250 metre spacing, while the CALPUFF air dispersion modelling domain had a grid spacing of 150 metres around the ventilation outlets to accommodate near-field effects. The terrain around the ventilation outlets is undulating, but was not considered to be complex with dominant terrain features. Based on advice provided in the guidance document (OEH, 2011), the project location and the project scale, the meteorological and air dispersion modelling grids were considered appropriate.

In addition the base receiver grids applied to the air quality impact assessment, a further 60 receiver locations were included in the air quality modelling. These receiver locations were health sensitive sites, including schools, hospitals, aged care and nursery care centres. Air quality modelling outcomes for these 60 locations were used to inform specific health risk assessments for those locations as part of the broader human health risk assessment presented in Section 7.4 and Appendix H of the environmental impact statement.

Although a 150 metre grid spacing around the project ventilation outlets is considered to be appropriate, a further screening level analysis has been conducted to demonstrate the potential effect of a reduced grid spacing. The screening level assessment has been based on:

- A 150 metre and a 25 metre receiver grid around the northern ventilation outlet.
- Forecast traffic flows in 2019.
- One year of meteorological data.
- Annual and 24 hour average PM_{2.5} concentrations.

Table 7-27 summarises the outcomes of the screening level assessment. It presents the maximum value modelled in the domain around the northern ventilation outlet, as well as the average value across the modelling domain. The table shows that:

- On average across the modelling domain around the northern ventilation outlet, a 25 metre grid spacing produces a slightly higher 24 hour average and annual average value PM_{2.5} concentration. However, the increase in the average value across the modelling domain is less than 0.5% of the advisory reporting standard in both cases.
- The peak 24 hour average and annual average PM_{2.5} concentrations are both higher with a 150 metre grid spacing than with the application of a 25 metre spacing. In the case of the 24 hour average, the relative difference is two percent of the advisory reporting standard. The difference in the annual average is less, at only 0.13%.

This demonstrates that the difference in the modelling domain grid spacing has a negligible impact on predicted ground level concentrations, on average. However, the use of a 150 metre grid spacing in the air quality impact assessment for the project is likely to have led to an overestimation of impacts at the most affected receiver location. This overestimation is negligible in the case of the annual average PM_{2.5} concentration, but up to two percent of the advisory reporting standard for the 24 hour average. This supports the conclusion that a 150 metre grid spacing is appropriate, and may in fact be conservative for shorter duration averaging periods.

Table 7-27 Comparison of 150 metre and 25 metre receiver grid spacings

Pollutant	Statistic	Ground level concentrations and percentage of advisory standard				Relative change (% of standard)
		150 metre grid	% of standard	25 metre grid	% of standard	
PM _{2.5} (24 hour average)	Average across domain	0.21 µg/m ³	0.84%	0.33 µg/m ³	1.32%	+0.48%
	Peak value	1.21 µg/m ³	4.84%	0.71 µg/m ³	2.84%	-2.0%
PM _{2.5} (annual average)	Average across domain	0.014 µg/m ³	0.18%	0.026 µg/m ³	0.33%	+0.15%
	Peak value	0.075 µg/m ³	0.94%	0.065 µg/m ³	0.81%	-0.13%

Issue description

With respect to Section 4.2.8, Section 4.2.9 and Appendix H of the environmental impact statement, there is very little auditable data presented to cross-check the emission estimations. It is acknowledged that the emission factors are derived from referenced material and the range of assumptions/ road factors is presented, but there is no tabulated emission inventory that is auditable, and therefore the emission estimation and results are being asked to be taken on faith. For a project of this nature, it would be expected that the emissions inventory would be presented in a format that was auditable.

Council requests the Department of Planning and Environment to seek additional information to demonstrate that emissions calculations have been performed satisfactorily.

Section 4.2.8, Section 4.2.9 and Appendix H of the environmental impact statement present an 'example' emission calculation but that appears to be incorrectly calculated. Based on the data and the assumptions presented, the combined passenger car (PC) plus light duty vehicle (LDV) emission factor is calculated to be 28.2 g/h, compared against the 26.4 g/h presented in the report.

It is acknowledged that this is merely an example, but given the lack of auditable emissions calculations Council believes that it does not infer confidence that the emissions estimations are correct.

Response

Further information on how in-tunnel air quality and the emissions inventory for the ambient air quality dispersion modelling were conducted is provided in **Chapter 2** of this report.

Issue description

Table 7-88 in the environmental impact statement (page 449) discusses the need for emergency smoke extraction facilities at two locations, on the corner of Wilson Road and Pennant Hills Road and on the corner of Trelawney Street and Pennant Hills Road. Council assumes that these facilities will be required during accidents/ fires.

The Department of Planning and Environment may wish to clarify how often it is anticipated that these emergency extraction outlets would need to be utilised and the increased risk posed by the extraction of polluted air at ground level on the surrounding environment.

In relation to low speed traffic conditions (refer to page 450 of the environmental impact statement), Council believes there is a need for real time air-quality monitoring in the tunnel and the environmental impact should clarify that this will be the case.

Response

Further information on the likelihood and potential consequences of an in-tunnel fire incident are provided in **Section 2.7.2** of this report.

Issue description

In relation to low speed traffic conditions in the environmental impact statement (page 450), Council believes that there is a need for real time air-quality monitoring in the tunnel and the environmental impact should clarify that this will be the case.

Response

The environmental impact statement commits to conducting in-tunnel air quality monitoring. Further details of the proposed monitoring are provided in Table 7-104 and Table 9-1 of the environmental impact statement.

Issue description

A report of a visit by a delegation from the then New South Wales Roads and Traffic Authority to Japan from 30th of September to 10th of October 2003 (February 2004)", makes the following statement in its discussion:

"There would be some logistical advantages in considering incorporating ESPs [electrostatic precipitators] and NO₂ removal technology for a pilot in a new tunnel, where bypass passages and ESPs could be included in the design submitted for planning approval."

Council believes this key report from the New South Wales State Government (the then RTA) supports the installation of air-quality treatment at the design phase and even mentions the possibility of including such in the forecast NorthConnex project (formerly F3 to M2).

Response

The report of a visit by a delegation from the the New South Wales Roads and Traffic Authority to Japan from 30 September 2003 to 10 October 2003 (published in February 2004) does identify the consideration of incorporating electrostatic precipitators and nitrogen dioxide removal technology for a pilot trial in a new tunnel. The report also noted that timeframes for construction of a new tunnel were unclear at that point in time.

Since the report by the visiting delegation was written, a decision was made to undertake a filtration trial on the M5 East Motorway tunnels in lieu of the pilot proposed by the report. The trial involved both use of an electrostatic precipitator and removal of NO₂. The outcomes of the M5 East Motorway filtration trial are summarised in Section 7.3.1 of the environmental impact statement. Studies undertaken in relation to the filtration trial support the conclusion that there are many other measures available to reduce emissions of particulate matter to the atmosphere that are more effective (on a total mass basis) and up to ten times less costly than tunnel air filtration.

Reports confirming the results of the M5 East Motorway tunnel air filtration trial may be found on the Roads and Maritime website.

Further discussion of the availability and efficacy of in-tunnel air treatment systems is provided in **Section 3.1** of this report. Discussion of the potential application of these systems to the project is provided in **Section 3.2**.

Issue description

The environmental impact statement (page 451) suggests that the M5 East Motorway filtration trial was not successful for a variety of reasons. These reasons were dominated by cost and efficiency of the pollutant removal technologies.

The CSIRO produced two reports analysing the M5 East Motorway filtration trial, neither of these two reports are directly referenced in the environmental impact statement:

- Air Filtration Plant of the M5 Tunnel: Determination of Particle Removal Efficiencies – Report No. EP 117216 (November 2011).
- Air Filtration Plant of the M5 Tunnel: Determination of Nitric Oxide and Nitrogen Dioxide Removal Efficiencies – Report No. EP 117222 (November 2011).

These reports determined that the particulate matter removal efficiency of the M5 East Motorway treatment plant was:

- $PM_{2.5} = 69\% \pm 3\%$.
- $PM_{10} = 70\% \pm 2\%$.

Further, the NO_2 removal efficiency of the activated carbon system was determined to be 99% or greater over a wide range of gas flow rates.

It is clear from assessing the AMOG 2012 reference that one of the main reasons contributing to the inefficiency of the treatment plant was the fact that it needed to be retrospectively fitted to a system not designed for its installation.

It is therefore suggested that if the air filtration system had been designed into the M5 East Motorway at the beginning, the cost/ efficiency of the plant would have been much greater.

The environmental impact statement also concludes that current background pollution levels are relatively high compared to the relatively low pollutant levels from the NorthConnex project and therefore there is no need to fit pollution reduction systems. This does not take into account the cumulative effects of pollution. This project will produce new point sources of pollution which need to be dealt with to avoid cumulative effects from this pollution through time (refer to Figure 7-20 on page 487 of the environmental impact statement).

Having regard to the findings of the M5 East Motorway study, which noted the inefficiencies of retrospectively fitting air quality treatment systems, Council believes that:

- Air quality treatment systems should be incorporated into the design of the NorthConnex project.
- If not incorporated then the NorthConnex project should be designed to include allowance for the retrospective fitting of such treatment systems in the future, if required.

Response

The environmental impact statement includes an analysis of the potential costs and benefits of tunnel filtration systems and explains why such systems are not warranted (refer to Section 7.3.1 of the environmental impact statement). The environmental impact statement demonstrates that the NorthConnex project would meet ambient air quality criteria and would pose a very low risk to human health. In this context, there is no basis to justify installation of filtration systems.

The analysis of filtration systems presented in the environmental impact statement considered international studies undertaken by the New Zealand Transport Agency and the French Government as well as the results of the M5 East Motorway filtration trial.

The use of filtration systems within the tunnel ventilation outlets is not warranted. These systems have been proven to be costly and inefficient. Greater improvements in air quality could be achieved through investment in programs targeting other emission sources that contribute higher levels of pollution to the surrounding environment. For example, improvements have been demonstrated through the smoky vehicle strategy instigated by Roads and Maritime and the Environment Protection on the M5 East Motorway. Further details of the effectiveness of this strategy are provided in Section 7.3.1 of the environmental impact statement.

The published results of the M5 East Motorway air filtration trial represent the most robust and independent assessment of the efficiency of tunnel air filtration systems. There is very little comparable independent system verification data for other tunnel air filtration installations. Manufacturers have not yet provided robust independent assessments to demonstrate that their claimed system efficiencies have been realised.

Had a filtration system been specific as part of the original design of the M5 East Motorway, then it is likely that efficiencies in construction may have resulted in lower capital expenditure. However, operational expenditure and maintenance costs would be unlikely to have changed significantly, whether the filtration system was included in the original design, or retrofitted to the tunnels. Therefore, when presenting a comparison of programs targeting emissions sources, Roads and Maritime has been keen to compare both the capital expenditure and the operational costs of filtration. This has demonstrated that greater improvements in air quality could be achieved through investment in programs targeting other emissions sources that contribute higher levels of air pollution to the surrounding environment.

Further discussion of the availability and efficacy of in-tunnel air treatment systems is provided in **Section 3.1** of this report. Discussion of the potential application of these systems to the project is provided in **Section 3.2**.

Issue description

The environmental impact statement (Table 7-89 on page 451), outlines various sources of air pollution and the predicted impact from those sources e.g. wood fires etc. Council believes that sources of other air pollution are irrelevant to the current environmental impact statement and that this particular study needs to deal with the construction of new pollution point sources which need to be managed into the future. Any argument regarding its scale compared to other polluting sources is of little consequence as the effects from the current project are what need to be dealt with here.

Council asks the Department of Planning and Environment to satisfy itself that the current project is objectively assessed using relevant criteria.

Response

The NorthConnex project will not generate additional air pollution. Instead, it will collect, manage and effectively disperse vehicle emissions that are currently released at ground level along Pennant Hills Road. When considering the project as a whole, the environmental impact statement shows that there would be overall improvements to regional air quality from the project.

Action for Air (EPA, 1998) – the Government's 25 year air quality management plan – and the updates to that strategy in 2002, 2006 and 2009, recognise that managing and improving air quality in New South Wales requires a multi-layered approach and an 'integrated attack on air pollution'. Action for Air recognises that all stakeholders and pollution sources need to play a role in maintaining and managing air quality.

In the spirit of Action for Air, it is appropriate to focus the broader task of air quality management and improvement over time on those areas where the greatest benefit could be feasibly and reasonably achieved through the most cost effective means. Action for Air includes a series of targets and focus areas, including the transport, commercial and industrial and domestic sectors, through which improvements in air quality could be achieved.

The environmental impact statement for the NorthConnex project, including Table 7-89 and the discussion of filtration technology, is consistent with and reinforces the underlying focus of Action for Air. That is, there are several opportunities that have been identified which have the potential to significantly reduce particulate matter loads in the Sydney airshed at much less cost per tonne of reduction than would be achieved through road tunnel filtration. If the focus is to be on improving air quality in Sydney as a whole, then these opportunities would provide a more efficient and cost effective means to do so than road tunnel filtration. By comparison, road tunnel filtration is a relatively costly and uneconomic means to remove a comparatively small mass of particulate matter from the Sydney airshed.

Issue description

The environmental impact statement (page 451) references a report by PAEHolmes (2013) regarding the health benefits of removing certain amounts of PM_{2.5} from the Sydney airshed. On examining this referenced report it becomes clear that it is based almost entirely on work conducted in the United Kingdom.

Of the work conducted in the United Kingdom, one significant report, Quantification of the Health Effects of Air Pollution in the UK for Revised PM₁₀ Objective Analysis (Steadman et al 2002) clearly outlines that meteorological conditions play an extremely important role in determining particle concentrations in the atmosphere by:

- Extended periods of low wind speeds can reduce dispersion and lead to a build-up of high concentrations of all pollutants.
- In the UK, easterly air flows increase the contribution from secondary particles formed from sulfur and nitrogen oxide emissions in Europe.
- Low temperatures or increasingly high temperatures can lead to increased energy demand for heating or for air-conditioning which increases emissions.

- This UK report clearly demonstrates how important meteorological conditions are to the human health effects of air pollution.

Council asks the Department of Planning and Environment to ensure that local meteorological data is obtained and used to improve the findings applicability to the Sydney environment.

Response

The PAEHolmes (2013) report referred to in the environmental impact statement is in relation to the development of a valuation methodology associated with the reduction in particulate matter from the atmosphere. The valuation methodology considered in the PAEHolmes report is independent of meteorological conditions. It is an implicit assumption of the PAEHolmes report that the valuation methodology would be applied to air quality information relevant to a particular local context.

Further information on meteorological modelling and assumptions used in the air quality impact assessment for the project are provided in **Section 2.10** of this report.

The potential for accumulation of emissions would general be relevant under light wind conditions combined with a temperature inversion. In these circumstances, emissions could be released in the atmosphere below the temperature inversion layer, and in the absence of good dispersion (under light wind conditions) could accumulate in the local area.

Analysis of temperature profiles around the northern and southern ventilation outlets during summer and winter (based on 2009 meteorological data) shows that surface based inversions are not a common occurrence during either season. This can be seen in **Figure 7-8** and **Figure 7-9**, which show the temperature profiles during summer for the southern and northern ventilation outlets, and **Figure 7-10** and **Figure 7-11** which show the temperature profiles during winter. Temperature profile data is summarised in **Table 7-28**.

The absence of surface based inversions is not an unexpected observation due to the significant mechanical mixing that would occur at the surface as a result of obstacles, trees and suburban structures.

Raised temperature inversions would be a more common occurrence at both ventilation outlets, but only during the winter months and only at night time. These inversions would develop at night and would be strongest between 30 metres and 60 metres above ground level. They may sometimes persist at up to 240 metres above ground level. Only between 3 am and 5 am would these temperature inversions reach ground level, and then only weakly (refer to **Figure 7-8** and **Figure 7-9**). During summer, only very weak shallow inversions occur aloft at around 30 metres and only at night time (refer to **Figure 7-10** and **Figure 7-11**).

Wind speed increases with increasing height above the ground. Flow near the surface encounters obstacles that reduce the wind speed and introduce random vertical and horizontal velocity components at right angles to the main direction of the wind flow. The vertical wind speed profiles for around the northern and southern ventilation outlets are shown in **Figure 7-12** and **Figure 7-13** for summer (January) and in **Figure 7-14** and **Figure 7-15** for winter (July). As can be seen in the figures, the wind gradient is greatest in the first few hundred metres above ground level, after

which the flow is relatively uniform up until around 3,000 metres, after which it steadily increases.

The wind speed profiles are different between summer and winter. In winter the overall wind speed gradient is steeper and the depth of gradient is larger than in summer. The daytime wind speed profiles, especially in summer are low in comparison to the night time and early morning profiles when the atmosphere is stable.

Table 7-28 Temperature profiles near the southern and northern ventilation outlets in winter and summer

Time	Vertical height (m)									
	10	30	60	120	240	510	1000	2000	2650	3000
Southern ventilation outlet (July)										
Midnight	11.8 °C	11.7 °C	12.2 °C	12.2 °C	11.5 °C	9.4 °C	5.8 °C	2.6 °C	0.1 °C	-2.9 °C
6 am	9.2 °C	8.8 °C	9.5 °C	10.1 °C	10.2 °C	8.7 °C	5.7 °C	2.8 °C	0.4 °C	-2.2 °C
10 am	7.9 °C	7.7 °C	8.5 °C	9.2 °C	9.6 °C	8.3 °C	5.5 °C	2.7 °C	0.3 °C	-2.3 °C
2 pm	14.7 °C	14.5 °C	14.2 °C	13.6 °C	12.4 °C	9.8 °C	5.5 °C	2.5 °C	0.2 °C	-2.6 °C
6 pm	16.3 °C	16.1 °C	15.8 °C	15.2 °C	14.0 °C	11.4 °C	6.7 °C	2.4 °C	0.0 °C	-2.8 °C
Northern ventilation outlet (July)										
Midnight	9.2 °C	9.0 °C	9.6 °C	10.1 °C	10.1 °C	8.7 °C	5.6 °C	2.7 °C	0.4 °C	-2.3 °C
6 am	8.0 °C	7.8 °C	8.5 °C	9.2 °C	9.5 °C	8.3 °C	5.5 °C	2.6 °C	0.3 °C	-2.4 °C
10 am	14.6 °C	14.4 °C	14.1 °C	13.5 °C	12.3 °C	9.6 °C	5.4 °C	2.4 °C	0.2 °C	-2.6 °C
2 pm	16.1 °C	15.9 °C	15.6 °C	15.0 °C	13.8 °C	11.2 °C	6.6 °C	2.3 °C	0.0 °C	-2.8 °C
6 pm	11.6 °C	11.6 °C	12.1 °C	12.1 °C	11.4 °C	9.3 °C	5.8 °C	2.5 °C	0.1 °C	-2.9 °C
Southern ventilation outlet (January)										
Midnight	19.6 °C	19.0 °C	19.2 °C	19.0 °C	18.2 °C	16.2 °C	13.4 °C	11.2 °C	9.1 °C	6.9 °C
6 am	21.0 °C	20.8 °C	20.5 °C	19.9 °C	17.9 °C	15.7 °C	13.0 °C	11.0 °C	9.1 °C	6.8 °C
10 am	26.8 °C	26.6 °C	26.3 °C	25.8 °C	24.6 °C	21.9 °C	16.2 °C	10.8 °C	8.8 °C	6.6 °C
2 pm	27.3 °C	27.1 °C	26.8 °C	26.3 °C	25.1 °C	22.4 °C	17.6 °C	12.6 °C	9.3 °C	6.7 °C
6 pm	23.0 °C	22.5 °C	22.2 °C	21.7 °C	20.5 °C	18.2 °C	14.7 °C	11.8 °C	9.5 °C	6.9 °C
Northern ventilation outlet (January)										
Midnight	19.5 °C	19.0 °C	19.2 °C	19.0 °C	18.2 °C	16.2 °C	13.4 °C	11.2 °C	9.1 °C	6.9 °C
6 am	20.8 °C	20.6 °C	20.3 °C	19.7 °C	18.0 °C	15.6 °C	12.9 °C	11.0 °C	9.0 °C	6.8 °C
10 am	26.5 °C	26.3 °C	26.0 °C	25.4 °C	24.3 °C	21.6 °C	15.3 °C	10.8 °C	8.9 °C	6.6 °C
2 pm	26.9 °C	26.7 °C	26.4 °C	25.8 °C	24.7 °C	22.0 °C	17.1 °C	11.8 °C	9.5 °C	6.7 °C
6 pm	22.8 °C	22.2 °C	22.0 °C	21.4 °C	20.3 °C	18.0 °C	14.5 °C	12.0 °C	9.5 °C	6.9 °C

(blank page)

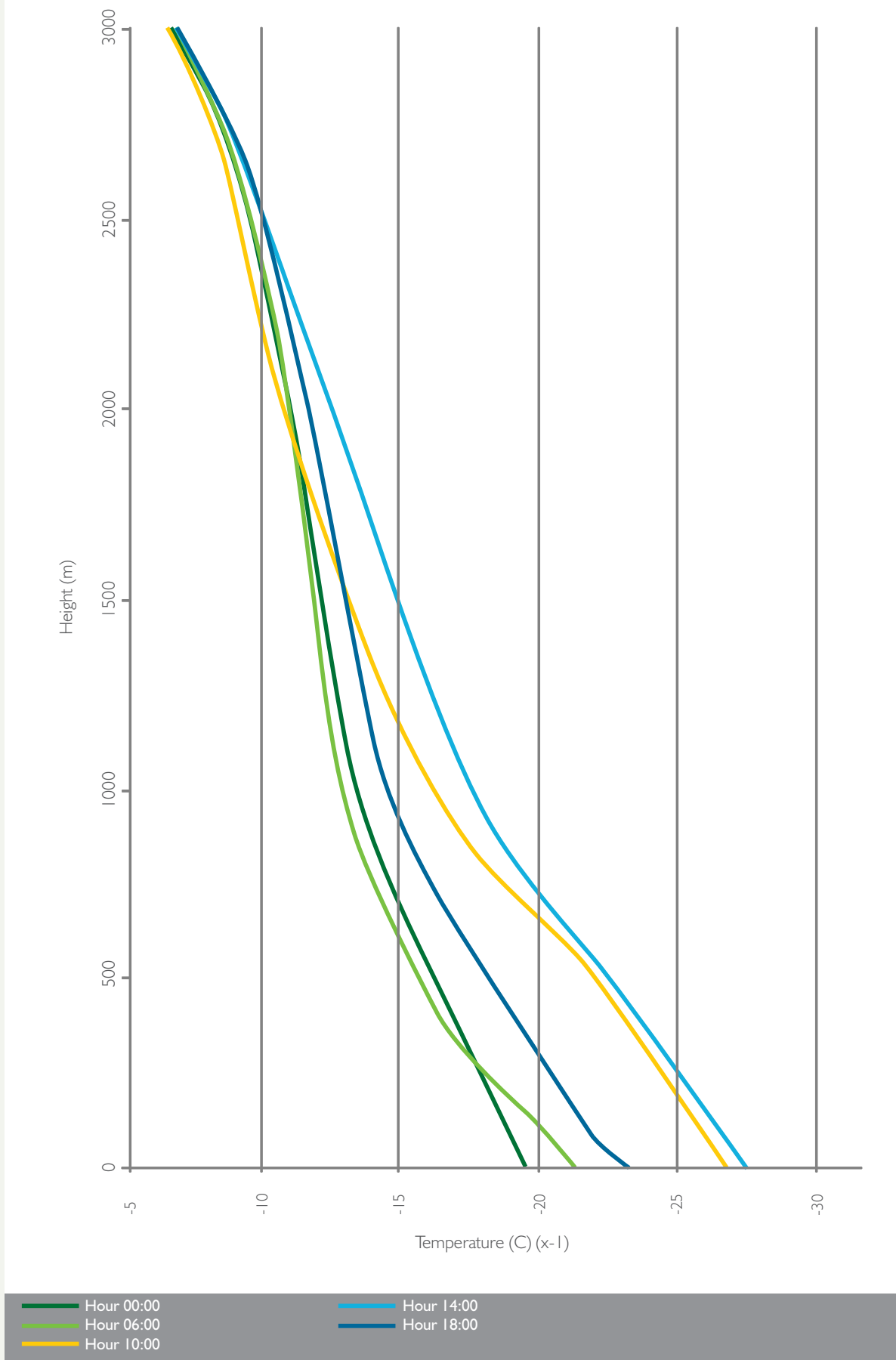


Figure 7-8 Temperature profiles at the southern ventilation outlet in summer

(blank page)

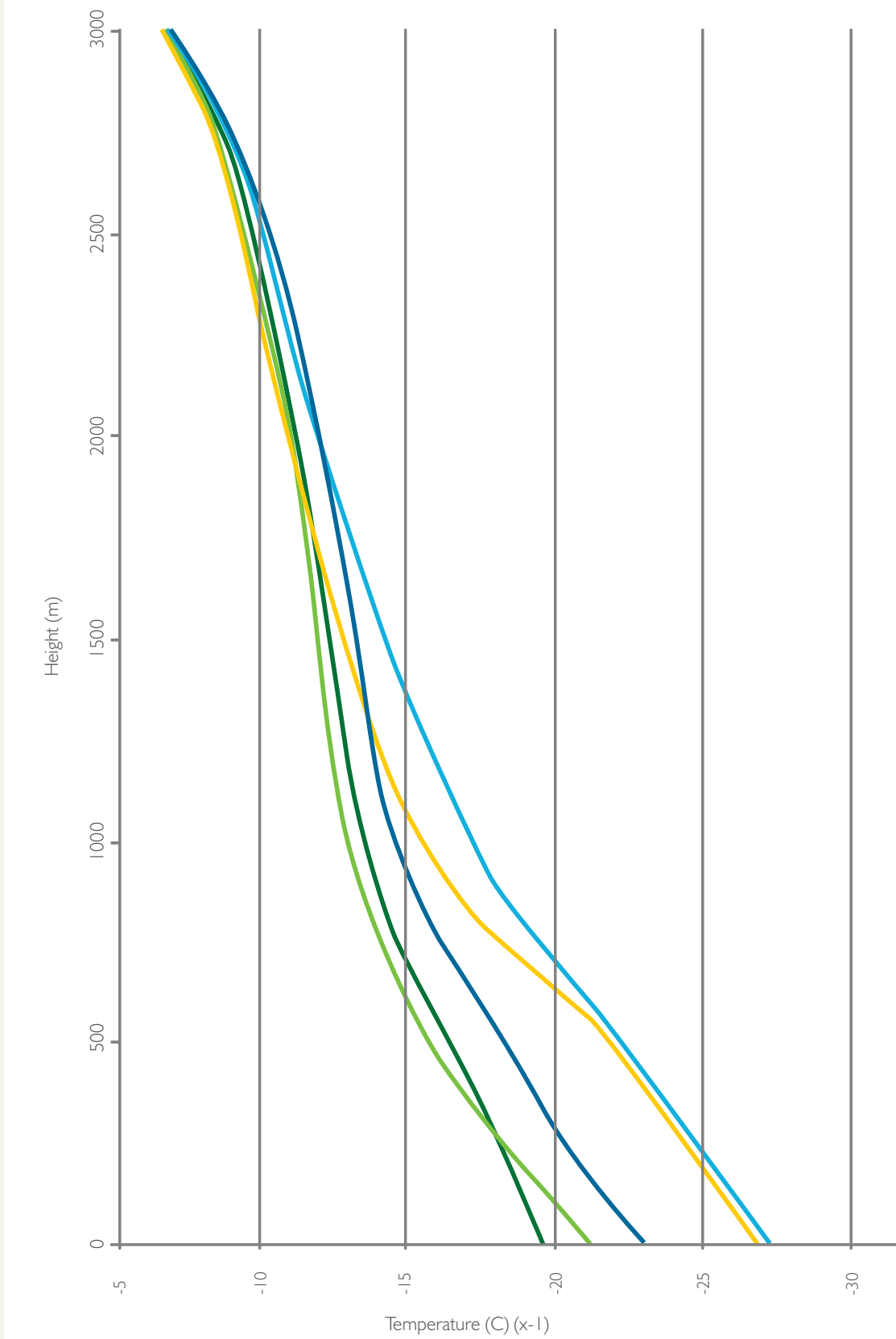


Figure 7-9 Temperature profiles at the northern ventilation outlet in summer

(blank page)

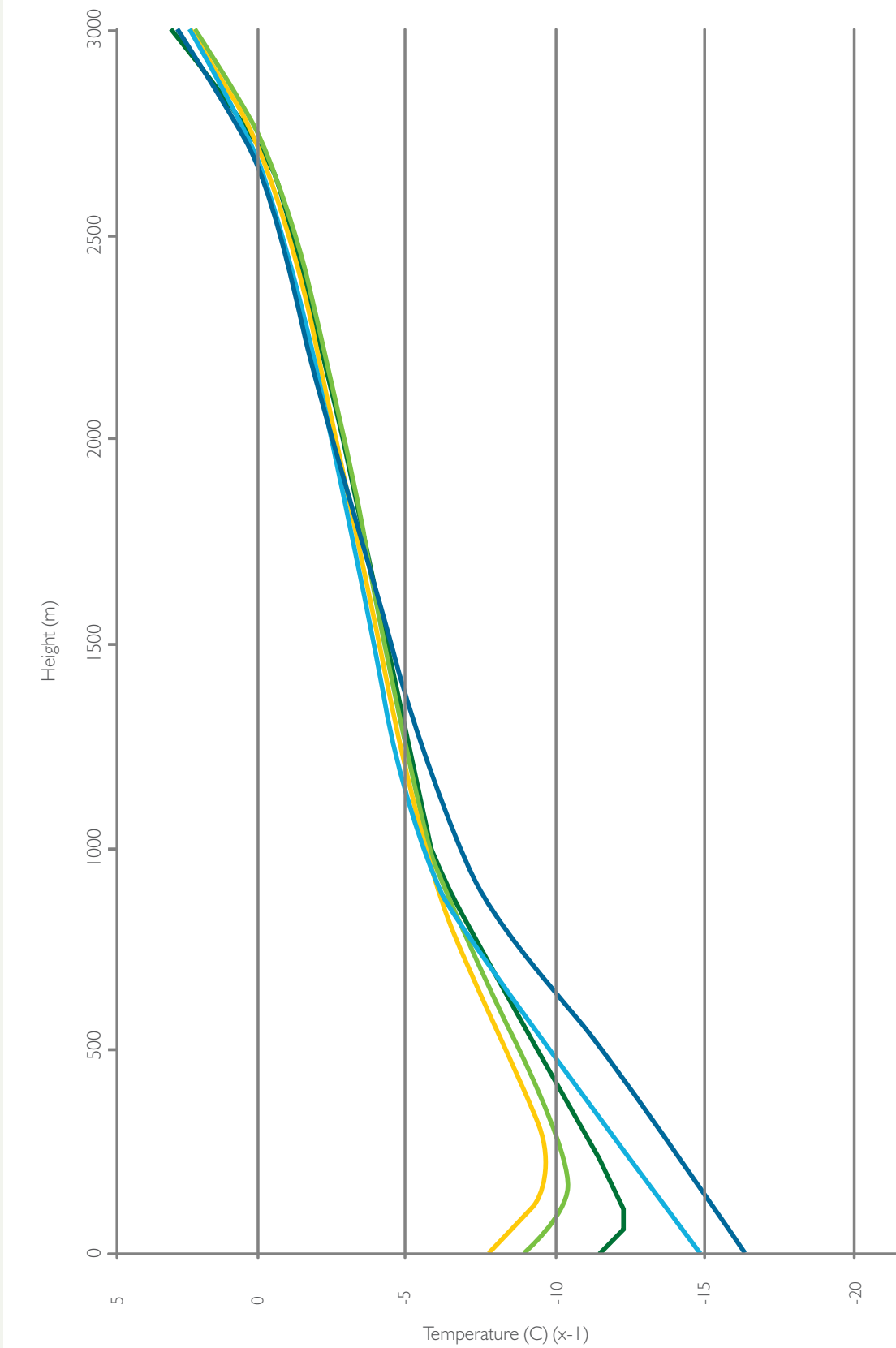


Figure 7-10 Temperature profiles at the southern ventilation outlet in winter

(blank page)