NORTHCONNEX
AIR QUALITY MONITORING OPERATING PROCEDURE AND EQUIPMENT INDEPENDENT AUDIT

Transurban

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NorthConnex
Air Quality Monitoring Operating Procedures and Equipment
Independent Audit

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1 INTRODUCTION

Todoroski Air Sciences have conducted an independent audit of the operating procedures and equipment for the air quality monitoring (in-tunnel and external) for the NorthConnex Motorway (hereafter referred to as the Project).

This independent audit reviews the air quality monitoring for the Project during 31 October 2020 to 30 April 2021.

The auditor has previously conducted an independent review of the NorthConnex Project Air Quality Impact Assessment report for the NSW Department of Planning and Environment and is also conducting the 6-monthly NorthConnex audits for the in-tunnel monitoring data, ventilation outlet monitoring data and ambient air quality data.

2 SCOPE OF WORK

Condition E21 of Infrastructure Approval SSI-6136 requires an audit of the air quality for the Project. The relevant part of the condition reads as follows:

Air Quality — Auditing and Quality Assurance

E21 ...

> *The Proponent shall appoint an external auditor to conduct an audit of the air quality monitoring (in tunnel and external) at six-monthly intervals or at any longer interval if approved by the Secretary. Air quality audits shall commence six months from commencement of operation. The auditor shall ensure that the operating procedures and equipment to acquire air monitoring, meteorological data and emission monitoring data and monitoring reporting comply with NATA (or equivalent) requirements and sound laboratory practice. The Proponent must document the results of the audit and make available all audit data for inspection by the Secretary upon request. A copy of the audit report shall also be issued to the Proponent and AQCCC.*

The core purpose of the audit is to ensure that the operating procedures and the equipment used for monitoring complies with NATA (or equivalent) requirements and sound laboratory practice.

3 MONITORING REQUIREMENTS

This section outlines the monitoring requirements as specified in Infrastructure Approval SSI-6136 for the in-tunnel, ventilation outlet and ambient air quality monitoring.

3.1 In-tunnel monitoring

Under Condition E1 of Infrastructure Approval SSI-6136, the Project is required to monitor the following in-tunnel air quality pollutants and parameters set out in **Table 3-1** below, following the specified sampling method, units of measure, and sampling frequency.

Table 3-1: In-tunnel monitoring methodologies required under Condition E1

Pollutant/Parameter	Unit of measurement	Frequency	Method[1]
CO	ppm	Continuous	Special Method 1[1]
NO_2	ppm	Continuous	Special Method 1[1]
Visibility	m^{-1}	Continuous	Special Method 1[1]

Notes
1. Special Method 1 means a method approved by the Secretary in consultation with the EPA.

3.2 Ventilation outlet monitoring

Under Condition E10 of Infrastructure Approval SSI-6136, the Project is required to monitor the following ventilation outlet air quality pollutants and parameters set out in **Table 3-2** below, following the specified sampling method, units of measure, and sampling frequency.

Table 3-2: Ventilation outlet emission monitoring methodologies required under Condition E10

Pollutant/Parameter	Unit of measurement	Frequency	Method[1]
Solid particles	mg/m^3	Continuous	Special Method 1[4]
Solid particles	mg/m^3	Quarterly	TM-15
PM_{10}	mg/m^3	Quarterly	OM-5
$PM_{2.5}$	mg/m^3	Quarterly	OM-5
NO_2 or NO or both, as NO_2 equivalent	mg/m^3	Continuous	CEM-2
NO_2	mg/m^3	Continuous	CEM-2
CO	mg/m^3	Continuous	CEM-4
VOC[2]	mg/m^3	Continuous	CEM-8
Speciated VOC	mg/m^3	Annual	TM-34
PAH	$\mu g/m^3$	Annual	OM-6
Velocity	m/s	Continuous	CEM-6
Volumetric flow rate	m^3/s	Continuous	CEM-6
Moisture	%	Continuous	TM-22
Temperature	°C	Continuous	TM-2
Selection of sampling locations	N/A	N/A	TM-1

Notes
1. Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (EPA 2007) or an alternative method approved by the Secretary in consultation with the EPA.
2. Must include, but not be limited to: Benzene, Toluene, Xylenes, 1,3-Butadiene, Formaldehyde and Acetaldehyde.
3. Must include, but not limited to; 16 USEPA priority PAHs, namely; Naphthalene, Phenanthrene, Benz(a)anthracene, Benzo(a)pyrene, Acenapthylene, Anthracene, Chrysene, Indeno(1,2,3-cd)pyrene, Acenaphthene, Fluoranthene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Fluorene, Pyrene, Benzo(k)fluoranhtene, Benzo(g,h,i)perylene.
4. Special Method 1 means a method approved by the Secretary in consultation with the EPA.

3.3 Ambient air quality monitoring

Under Condition E7 of Infrastructure Approval SSI-6136, the Project is required to monitor the following ambient air quality pollutants and parameters set out in **Table 3-3** below, following the specified sampling method, units of measure, and sampling frequency.

Monitoring locations are required to be conducted at a minimum at;

- two ground level receptors near the northern ventilation outlet, at locations suitable for detecting any impact on air quality from the outlet;
- two ground level receptors near the southern ventilation outlet, at locations suitable for detecting any impact on air quality from the outlet;
- one location along Pennant Hills Road, at a location suitable for detecting any impact on air quality along Pennant Hills Road; and,
- one location away from any of the locations set out above suitable for providing background ambient air quality reference data for the project area.

Table 3-3: Ambient air quality monitoring methodologies required under Condition E7

Pollutant/Parameter	Unit of measurement	Averaging Period	Frequency	Method
NO	pphm	1-hour	Continuous	AM-12
NO_2	pphm	1-hour	Continuous	AM-12
NO_x	pphm	1-hour	Continuous	AM-12
PM_{10}	µg/m³	24-hour	Continuous	AS 3580.9.8-2008
$PM_{2.5}$	µg/m³	24-hour	Continuous	AS 3580.9.13-2013
CO	ppm	1-hour, 8-hour	Continuous	AM-2 & AM-6
Wind speed at 10m	m/s	1-hour	Continuous	AM-2 & AM-4
Wind direction at 10m	degrees	1-hour	Continuous	AM-2 & AM-4
Sigma theta	degrees	1-hour	Continuous	AM-2 & AM-4
Temperature at 2m	K	1-hour	Continuous	AM-4
Temperature at 10m	K	1-hour	Continuous	AM-4
Siting	-	-	-	AM-1 & AM-4

ppm = parts per hundred million

ppm = parts per million

µg/m³ = micrograms per cubic metre

4 MONITORING LOCATIONS

4.1 In-tunnel monitoring

The in-tunnel air quality sensor (AQS) and air speed sensor (ASS) locations are presented in **Appendix A**.

There are 26 AQS monitors which are used to record in-tunnel pollutant concentrations. The in-tunnel ASS monitors in conjunction with the variable ventilation outlet cross-section area data are used to calculate the flowrates and velocities for VSO1 and VSO4 respectively.

4.2 Ventilation outlet monitoring

Figure 4-1 presents the location of the ventilation outlet monitoring sites for the Project outlets located at Eaton Road, West Pennant Hills (VS01), and Woonona Avenue, Wahroonga (VS04).

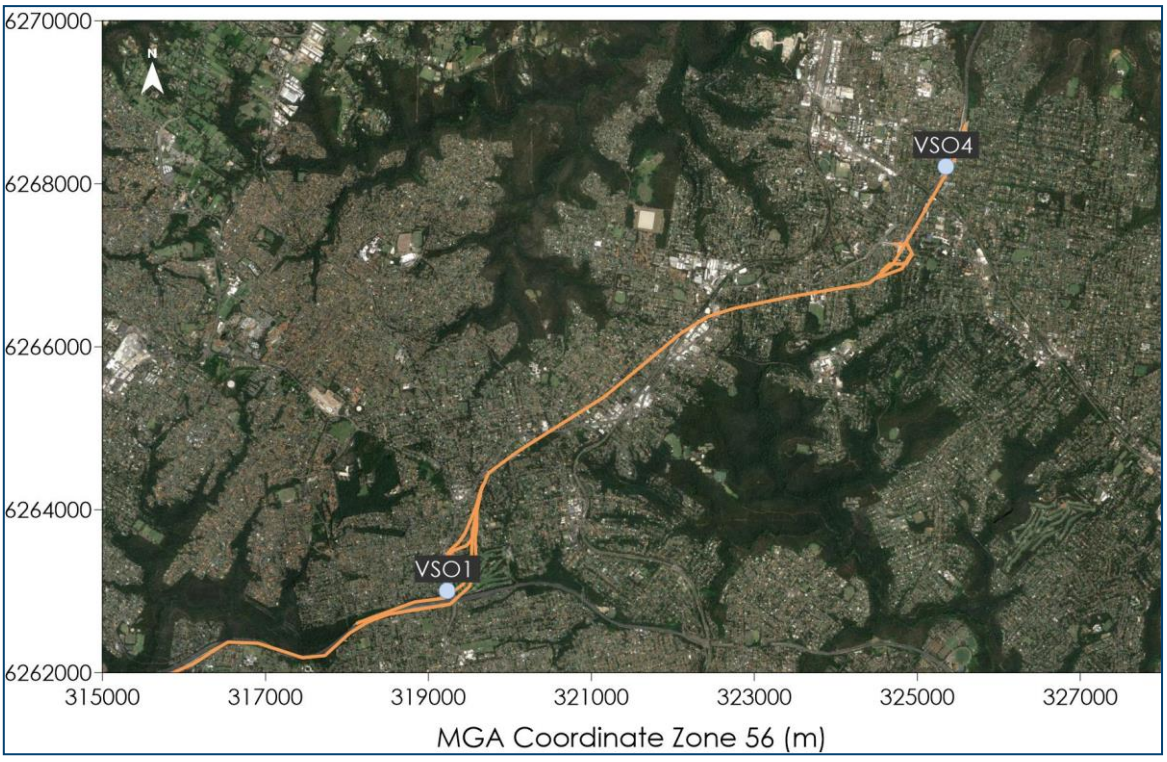

Figure 4-1: Ventilation outlet monitoring site locations

4.3 Ambient air quality monitoring

Figure 4-2 presents the location of the ambient air quality monitoring sites for the Project.

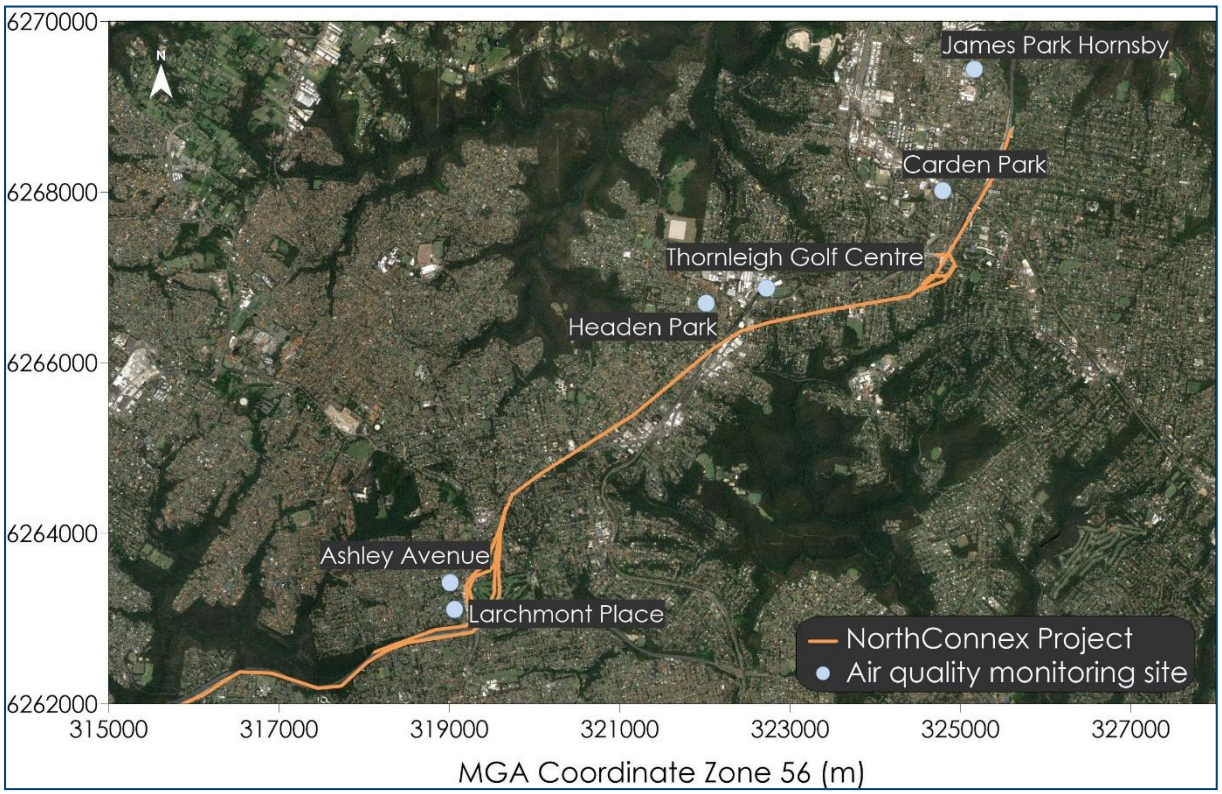

Figure 4-2: Ambient air quality monitoring site locations

Table 4-1 identifies the corresponding ambient air quality monitoring locations per the Condition E7 location requirements. It is noted that the auditor assisted in the selection of the monitoring locations, as outlined in (**Todoroski Air Sciences, 2018**). The monitoring locations meet the requirements per Condition E7.

Table 4-1: Ambient air quality monitoring locations

Location requirement	Monitor/s
Outlet Monitoring North x 2	Carden park and James Park Hornsby
Outlet Monitoring South x 2	Ashley Avenue and Larchmont Place
Along road monitoring x 1	Thornleigh Golf Centre
Background monitoring x 1	Headen Park

5 MONITORING METHODS

5.1 In-tunnel monitoring

Continuous in-tunnel monitoring, data collection and reporting was conducted by Norditech Pty Ltd, a NATA accredited organisation. Monthly validation reports are prepared by Norditech (**Norditech, 2020b & Norditech, 2021b, d, f, h, j**).

Table 5-1 presents the instrument and measurement technology used for the in-tunnel monitoring. Per Condition E1 of Infrastructure Approval SSI-6136, Special Method 1 is the required in-tunnel monitoring method for the NorthConnex Project. This monitoring is achieved by using 26 in-tunnel combined sensors (AQS) which measure CO, NO_2 and visibility, (13 in the northbound tunnel and 13 in the southbound tunnel).

Table 5-2 summarises the in-tunnel measurement performance.

Table 5-1: Instrument and measurement technology – in-tunnel monitoring

Pollutant/ Parameter	Instrument	Measurement Technology	Method
CO	Tunnel Sensors VICONOX 3	Nondispersive Infrared (NDIR) Spectroscopy	Special Method 1[1]
NO_2	Tunnel Sensors VICONOX 3	Differential Optical Absorption Spectroscopy (DOAS) Method	Special Method 1[1]
Visibility	Tunnel Sensors VICONOX 3	Light Transmission Obscuration Method	Special Method 1[1]

Table 5-2: Measurement performance – in-tunnel monitoring

Pollutant/Parameter	Resolution	Range*	Accuracy
CO	0.1ppm	0-500ppm	±5% of reading
NO_2	0.01ppm	0-10ppm	±5% of reading
Visibility	0.0001m^{-1}	0-0.1m^{-1}	±0.0005 at 10m path length

*As advised by Norditech

5.2 Ventilation outlet monitoring

5.2.1 Continuous outlet monitoring

Continuous ventilation outlet monitoring, data collection and reporting was conducted by Norditech Pty Ltd, a NATA accredited organisation. Monthly validation reports are prepared by Norditech (**Norditech, 2020a & Norditech, 2021a, c, e, g, i**).

Table 5-3 presents the instrument technology used for the continuous ventilation outlet monitoring. The sampling methods are in line with the requirements of Condition E10 of Infrastructure Approval SSI-6136.

Table 5-4 summarises the instrument measurement performance for the ventilation outlet continuous monitoring.

Table 5-3: Instrument technology – continuous ventilation outlet monitoring

Pollutant/Parameter	Instrument Technology	Method number
Total Solid Particles (TSP)	Palas Fidas	Special Method 1
Oxides of Nitrogen (NO_x)	Ecotech Serinus S40	CEM-2
Nitrogen Dioxide (NO_2)	Ecotech Serinus S40	CEM-2
Carbon Monoxide (CO)	Ecotech Serinus S30	CEM-4
Volatile Organic Compounds (VOC)	Ecotech VOC1000	CEM-8
Moisture	Vaisala HMT337	TM-22
Temperature	Vaisala HMT337	TM-2

Table 5-4: Instrument measurement performance – continuous ventilation outlet monitoring

Pollutant/Parameter	Resolution	Range*	Uncertainty
Solid Particles	0.1 µg/m^3	0 – 10,000 mg/m^3	Not specified
NO_x	0.4 ppb	0 - 20 ppm	±2.9% relative + 2.1% FS K=2
NO_2	0.4 ppb	0 – 2 ppm	±2.9% relative + 2.1% FS K=2
CO	0.1 ppm	0 – 200 ppm	±2.5% relative + 3.6% FS K=2
VOC	0.001 ppm	0 – 200 ppm	±3.0% relative + 2.8% FS K=2
Moisture	1% RH	0 – 100% RH	±3.62% relative
Temperature	0.1 °C	-70 - +180 °C	±0.54°C

*As advised by Norditech

5.2.2 Velocity and airflow

Neither of the installed facility CEMS at VSO1 or VSO4 measure the velocity or volumetric flow rate. It should be noted that due to the outlet design there is no ideal sampling point for velocity and airflow within the ventilation outlets.

As such, the indirect measurement methodology using a sensor in the duct is appropriate. The ASS203 and ASS113 sensors which are located upstream of the stack and fans for VSO1 and VSO4 respectively, but downstream of the tunnel were selected as suitably positioned to directly measure the air flow and hence calculate the outlet velocity using the outlet cross-sectional-areas.

However, intermittent, erratic readings at the ASS203 data have been identified in the NorthConnex Southern Tunnel Airflow Review (**Todoroski Air Sciences, 2021**). Despite investigations, it has not been possible to determine the cause of the anomalous readings. As such sensors in the main tunnel "S7-S8" have been used as a surrogate for the ASS203 sensor. S7 and S8 are located either side of the horizontal off-take tunnel in which ASS203 is located and thus the difference in the air flows at Location S7 and Location S8 can be used to represent the airflow that would occur at ASS203. The airflows at "S7-S8" should be compared for consistency with the ASS203 readings when excluding any erratic readings.

The flow rate and velocity monitoring methods use the correct type of equipment, are located in appropriate positions and appear to be operated correctly, and are thus in line with the requirements of Condition E10 of Infrastructure Approval SSI-6136.

5.2.2.1 Data records

It is noted that ventilation outlet flowrate and velocity is continuously calculated and used for the management and operation of the tunnel however, due to a technical issue this data was not logged during the review period. It has been advised that this issue was rectified on the 18 August 2021. For the purpose of this review, Transurban provided ventilation outlet flow rates and velocities calculated using the raw/ primary data that is logged.

Table 5-5 presents the instrument technology used for the continuous ASS monitoring.

Table 5-5: Instrument technology – ASS velocity and airflow monitoring

Pollutant/Parameter	Instrument Technology
Velocity	Tunnel Sensors Crossflow – Ultrasonic Sensor
Volumetric Flow Rate	Tunnel Sensors Crossflow – Ultrasonic Sensor

5.2.3 Quarterly monitoring

Quarterly ventilation outlet monitoring, data collection and reporting was conducted by Assured Environmental, (**Assured Environmental, 2021a** and **2021b**). Assured Environmental is a NATA accredited organisation.

Table 5-6 presents the sampling methods used for the quarterly ventilation outlet particulate monitoring. The sampling methods are in line with the requirements of Condition E10 of Infrastructure Approval SSI-6136.

Table 5-7 presents the "uncertainty budget" per the Q1 report (**Assured Environmental, 2021a**).

Table 5-6: Quarterly ventilation outlet sampling methods

Pollutant	Sampling method	Method number
Solid particles	AS 4323.2	TM-15
PM_{10}	US EPA M201A	OM-5
$PM_{2.5}$	US EPA M201A	OM-5

Table 5-7: Sampling methods – quarterly monitoring

Parameter	Sampling method	Uncertainty	Coverage factor	Confidence coefficient %
Solid particles	AS 4323.2	±10%	2	95
PM_{10} and $PM_{2.5}$	US EPA M201A	±20%	2	95

It is important to note that the particulate matter sampling methods specified in the consent conditions are the only available EPA approved methods, per the *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW, 2007,* (**EPA, 2007**) but they are not ideally suitable for measuring particulate concentrations below a few mg/m^3 for the purpose of calculating emission rates or pollution concentrations. The key limitation of the methods is that they do not provide a feasible way to sample a large enough quantity of air to collect sufficient particulate matter for making an accurate measurement of particulate concentration levels near to the compliance limit, thus there is an inherent, large error margin in the results.

It is noted that alternative methods are permitted to be used, (with the permission of the Secretary). This would be because there was no suitable alternative sampling method available when the Approval Conditions were developed, but there was work underway in developing alternatives. It is therefore relevant to evaluate whether any alternative methods have now become available, and if they could be used to provide more precise results.

The audit therefore recommends that any potentially more reliable method for particulate sampling at VSO1 and VSO4 be evaluated, and if suitable be proposed to the Secretary for approval.

5.3 Ambient air quality monitoring

Ambient air quality monitoring, data collection and reporting was conducted by Ecotech Pty Ltd (Ecotech), a NATA accredited organisation. Monthly ambient air quality and weather monitoring validation reports are prepared by Ecotech (**ACOEM Ecotech, 2020 & ACOEM Ecotech, 2021a-e**).

Table 5-8 outlines the various pollutants and parameters recorded at each of the air quality monitoring sites for the Project.

It is noted that the method of sampling $PM_{2.5}$, AS 3580.9.12-2013 (refer to **Table 5-8**), is equivalent to that listed in Table 8 per Condition E7 and on 8 September 2017 was approved for use by the Department of Planning and Environment (**ACOEM Ecotech, 2020 & ACOEM Ecotech, 2021a-e**). Note that all parameters in the table are monitored at each of the Monitoring Station locations.

The approved method for the Guide to Siting of Sampling Units AM-1 (AS 2922-1987) was superseded by AS/NZS 3580.1.1-2016 and the current method has been adopted. This is appropriate and is in keeping with good practice (however it is noted that there is minimal difference between the old and new standard, essentially the figures are now printed with better clarity/ resolution).

The method of sampling for CO monitoring in the monthly validation monitoring reports lists method AM-6 and does not include AM-2. This is correct as Method AM-2 refers to the guide for measurement of horizontal wind and is not related to CO measurements.

The methods of sampling for wind speed, wind direction and sigma theta list AM-2 in monthly validation monitoring reports and does not refer to AM-4, which is used for temperature measurement.

The monitoring methods meet the requirements per Condition E7 and have been assured through a NATA accredited process.

Table 5-8: Ambient monitoring sites measured parameters

Monitoring Station	Pollutant/Parameters	Unit of measurement	Elevation	Method
Ashley Avenue	$PM_{2.5}$ (BAM)	µg/m³	2	AS3580.9.12-2013
Carden Park	PM_{10} (TEOM)	µg/m³	2	AS3580.9.8-2008
Headen Park	NO, NO_2, NO_x	ppm	2	AM-12 (AS/NZS 3580.5.1 –1993)
James Park Hornsby	CO	ppm	2	AM-6 (AS 3580.7.1-1992)
Larchmont Place	Temperature	K	2 & 10	AM-4 (USEPA (2000) EPA 454/R-99-005)
Thornleigh Golf Centre	Wind speed	m/s	10	AM-2 (AS 2923-1987)
	Wind direction	degrees	10	AM-2 (AS 2923-1987)
	Sigma	degrees	10	AM-2 (AS 2923-1987)
	Siting	-	-	AS/NZS 3580.1.1-2016

Table 5-9 presents units and uncertainties for the monitoring equipment as outlined in the monthly validation monitoring reports (**ACOEM Ecotech, 2020 & ACOEM Ecotech, 2021a-e**).

Table 5-9: Ambient monitoring units and uncertainties

Monitoring Station	Recorded Pollutant/ Parameters	Instrument and Measurement Technique	Resolution	Uncertainty[a]	K factor	Measurement Range[b]
Ashley Avenue Carden Park Headen Park James Park Hornsby Larchmont Place Thornleigh Golf Centre	$PM_{2.5}$	Met One BAM 1020 – Beta ray attenuation	1µg/m³	24hr: ±(5.5 % of reading + 4.0 µg/m³) (in range 0 - 100 µg/m³) hr: ±(8 % of reading + 8.0 µg/m³)	2	0-1000µg/m³ LDL_{24hr} = 1.0µg/m³ LDL_{hr} = 4.8µg/m³
	PM_{10}	Thermo – 1405 TEOM (Tapered Element Oscillating Microbalance)	0.1µg/m³	±5.0µg/m³ or 3.6% of reading[c]	2	0µg/m³ - 1g/m³
	NO, NO_x	Ecotech Serinus 40 – gas phase chemiluminescence	0.001ppm	±(6% of reading + 0.011 ppm)	2	0-0.5 ppm LDL=0.004 ppm
	NO_2		0.001ppm	±(6% of reading + 0.011 ppm)	2	0-0.5 ppm LDL=0.004 ppm
	CO	Ecotech Serinus 30 – NDIR gas filter correlation infrared photometry	0.1ppm	±(7% of reading + 0.8ppm))	2	0-50 ppm LDL=0.04 ppm
	Temperature	Met One 062MP	0.1K	±0.6K	2	263.15-323.15K
	WS	Gill Windsonic Op3	0.1m/s	±0.4m/s or 2 % of reading[c]	2	0-30m/s
	WD	Gill Windsonic Op3	1 deg	±4 deg	2	0-360 deg[d]
	Sigma	Calculation	-	-	-	-
	Siting	-	-	-	-	-

[a]Uncertainties are calculated based on the full measurement range unless stated otherwise

[b]The max measurement range for gas analysers is defined as the full scale (FS=Span/0.8)

[c]Whichever is greater

[d]Starting threshold = 0 m/s

6 MONITOR CALIBRATION

This section outlines the monitoring calibration schedules and calibrations undertaken during 31 October 2020 to 30 April 2021 review period.

Note, for specific information on the ventilation outlet and in-tunnel QA/QC (including maintenance schedule, calibration schedule, data recording and corrective action program) refer to the Condition E22 report (**Todoroski Air Sciences, 2020b**).

Any specific issues with sensors are identified in the relevant monthly monitoring reports.

6.1 In-tunnel

In accordance with NorthConnex Operation and Maintenance manuals, the AQS monitors are to be calibrated at annual intervals. **Table 6-2** summarises the schedule of calibration conducted during the review period. The February 2021 monthly report indicates that a calibration of all AQS monitors was undertaken in February 2021, however refers to this calibration as a 3-monthly calibration type, which may be referring to the 3-monthly zero and span checks rather than the annual calibrations.

It was advised that prior to the review period, the AQS sensors were calibrated in June/July as part of the commissioning process.

Table 6-1: AQS calibration schedule

AQS monitor	November	December	January	February	March	April
AQS101				✓		
AQS102				✓		
AQS103				✓		
AQS104				✓		
AQS105				✓		
AQS106				✓		
AQS107				✓		
AQS108				✓		
AQS109				✓		
AQS110				✓		
AQS701				✓		
AQS702				✓		
AQS703				✓		
AQS201				✓		
AQS202				✓		
AQS203				✓		
AQS204				✓		
AQS205				✓		
AQS206				✓		
AQS207				✓		
AQS208				✓		
AQS209				✓		
AQS210				✓		
AQS801				✓		
AQS802				✓		
AQS803				✓		

6.2 Ventilation outlet

The CEMS combined monitors (NO_x, CO, VOC) undergo a daily calibration check and are to be manually calibrated at monthly intervals. Multi-point audits are conducted at 6-monthly intervals and proficiency audits are to be conducted annually.

The CEMS particulate monitors are to be manually calibrated at 3 monthly intervals as described in the Operation and Maintenance manuals prepared for the project. Particle sensor sensitivity checks are conducted on a monthly basis. The CEMS particulate monitors will also undergo gravimetric correlation testing at yearly intervals as described in the Operation and Maintenance manuals prepared for the project.

The calibration frequency for temperature and moisture is per 6-monthly single point calibration checks and annual multipoint calibrations.

The in-tunnel ASS sensors which are used to calculate ventilation outlet velocity and flowrate are to be calibrated at annual intervals as described in the Operation and Maintenance manuals prepared for the project.

Table 6-2 summarises the schedule of manual calibration conducted during the review period. Calibration for pollutant sensors generally followed their calibration schedule with the exception of TSP in April 2021 for both VSO1 and VSO4 which do not appear to have undergone their monthly checks.

It is understood that the CEMS temperature and moisture calibration within the review period occurred in November 2020.

Norditech has advised that all November maintenance and calibrations were conducted by the instrumentation supplier.

With regards to ventilation outlet velocity and airflow, note that the annual calibration for the ASS sensors was not due, and thus hence not conducted during this 6-month review period.

Table 6-2: Ventilation outlet calibration schedule

Monitor	Parameter	Calibration cycle	November	December	January	February	March	April
VSO1	CO	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓
	$NO/NO_2/NO_x$	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓
	VOC	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓
	TSP	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	-
	Temperature	6-monthly and annual	✓*					
	Moisture	6-monthly and annual	✓*					
VSO4	CO	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓
	$NO/NO_2/NO_x$	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓

Monitor	Parameter	Calibration cycle	November	December	January	February	March	April
	VOC	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	✓
	TSP	Monthly, 6-monthly and annual	✓*	✓	✓	✓	✓	-
	Temperature	6-monthly and annual	✓*					
	Moisture	6-monthly and annual	✓*					

*it is understood that the November maintenance and calibrations were conducted by the instrumentation supplier, however the details of this calibration have not been provided for this review

6.3 Ambient air quality

Table 6-3 summarises the schedule of calibration conducted during the review period. Calibration for all instruments generally followed their calibration schedule. All monitors except Ashely Avenue are overdue for a PM_{10} sensor calibration. It is noted that no CO, NO, NO_2 or NO_x calibration was completed at the Carden Park, Headen Park and James Park Hornsby monitors during the month of January, however calibrations were subsequently performed at the monitors on 8/02/2021, 2/02/2021 and 2/02/2021 respectively. The calibrations were completed soon after the month, and this is unlikely to cause any issues with data quality.

Table 6-3: Ambient monitoring calibration schedule

Site	Recorded Pollutant/Parameters	Calibration Cycle	Nov	Dec	Jan	Feb	March	April
Ashley Avenue	$PM_{2.5}$	3 Monthly		✓		✓		
	PM_{10}	3 Monthly		✓			✓	
	NO, NO_2, NO_x	Monthly	✓	✓	✓	✓	✓	✓
	CO	Monthly	✓	✓	✓	✓	✓	✓
	Temperature	Yearly		✓				
	WS	2 yearly		✓				
	WD	2 yearly		✓				
	Sigma	2 yearly		✓				
Carden Park	$PM_{2.5}$	3 Monthly		✓		✓		
	PM_{10}	3 Monthly		✓			Overdue	
	NO, NO_2, NO_x	Monthly	✓	✓	Overdue	✓	✓	✓
	CO	Monthly	✓	✓	Overdue	✓	✓	✓
	Temperature	Yearly	✓					
	WS	2 yearly						
	WD	2 yearly						
	Sigma	2 yearly						
Headen Park	$PM_{2.5}$	3 Monthly		✓		✓		
	PM_{10}	3 Monthly		✓			Overdue	
	NO, NO_2, NO_x	Monthly	✓	✓	Overdue	✓	✓	✓
	CO	Monthly	✓	✓	Overdue	✓	✓	✓
	Temperature	Yearly		✓				

Site	Recorded Pollutant/Parameters	Calibration Cycle	Nov	Dec	Jan	Feb	March	April
	WS	2 yearly		✓				
	WD	2 yearly		✓				
	Sigma	2 yearly		✓				
James Park Hornsby	$PM_{2.5}$	3 Monthly		✓		✓		
	PM_{10}	3 Monthly		✓			Overdue	
	NO, NO_2, NO_x	Monthly	✓	✓	Overdue	✓	✓	✓
	CO	Monthly	✓	✓	Overdue	✓	✓	✓
	Temperature	Yearly	✓					
	WS	2 yearly						
	WD	2 yearly						
	Sigma	2 yearly						
Larchmont Place	$PM_{2.5}$	3 Monthly		✓		✓	✓	
	PM_{10}	3 Monthly		✓			Overdue	
	NO, NO_2, NO_x	Monthly	✓	✓	✓	✓	✓	✓
	CO	Monthly	✓	✓	✓	✓	✓	✓
	Temperature	Yearly		✓				
	WS	2 yearly						
	WD	2 yearly						
	Sigma	2 yearly						
Thornleigh Golf Centre	$PM_{2.5}$	3 Monthly		✓		✓		
	PM_{10}	3 Monthly		✓			Overdue	
	NO, NO_2, NO_x	Monthly	✓	✓	✓	✓	✓	✓
	CO	Monthly	✓	✓	✓	✓	✓	✓
	Temperature	Yearly		✓				
	WS	2 yearly						
	WD	2 yearly						
	Sigma	2 yearly						

7 DISCUSSION AND RECOMMENDATIONS

Todoroski Air Sciences have conducted an independent audit of the operating procedures and equipment for the NorthConnex Project air quality monitoring (in-tunnel and external) between 31 October 2020 and 30 April 2021.

The in-tunnel, ventilation outlet and ambient air quality monitoring validated data spreadsheets and monthly reports and the ventilation outlet quarterly reports are produced by NATA accredited organisations.

Pollutant and parameter monitoring for the NorthConnex Project was found to be in general accordance with the requirements set out under the Planning Approval Conditions E1, E7 and E10.

It is recommended evaluate whether alternative new methods to those specified for the quarterly ventilation outlet particulate testing have become available, and that could be used to provide more precise results, than the nominated methods (which were all that was available at the time of the Conditions being drafted). If such new methods are identified, and it is found they can improve the monitoring, it is recommended the methods be proposed to the Secretary for approval.

The ventilation outlet velocity and flow rate data were not logged during the review period however this issue has been rectified moving forward.

The required minimum calibration schedule was generally followed during the review period. Some monitors performed calibrations a little past the due calibration period, but this is unlikely to affect data quality in this case.

The current data checks and calibration processes appear to operate well to ensure data that quality is generally good.

8 REFERENCES

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"DM Roads - NorthConnex Tunnel In-tunnel Air Quality Monitoring Validated Data Report 1 February 2021 to 28 February 2021", prepared by Norditech, March 2021

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"DM Roads - NorthConnex Tunnel In-tunnel Air Quality Monitoring Validated Data Report 1 March 2021 to 31 March 2021", prepared by Norditech, April 2021

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Appendix A

In-Tunnel Monitoring Locations

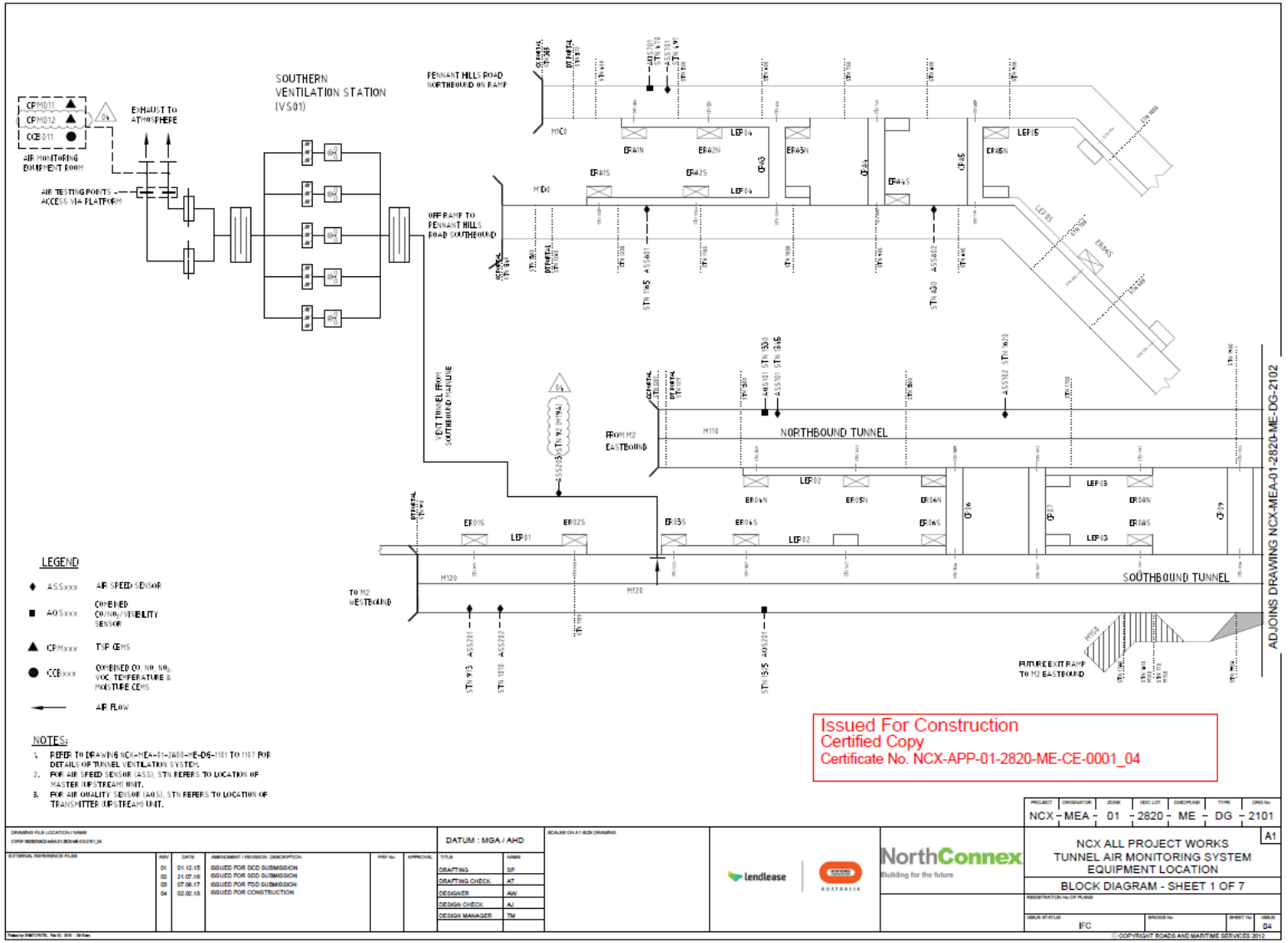

Figure A-1: In-tunnel air monitoring locations – Sheet 1 (AQS101, AQS201, AQS701)

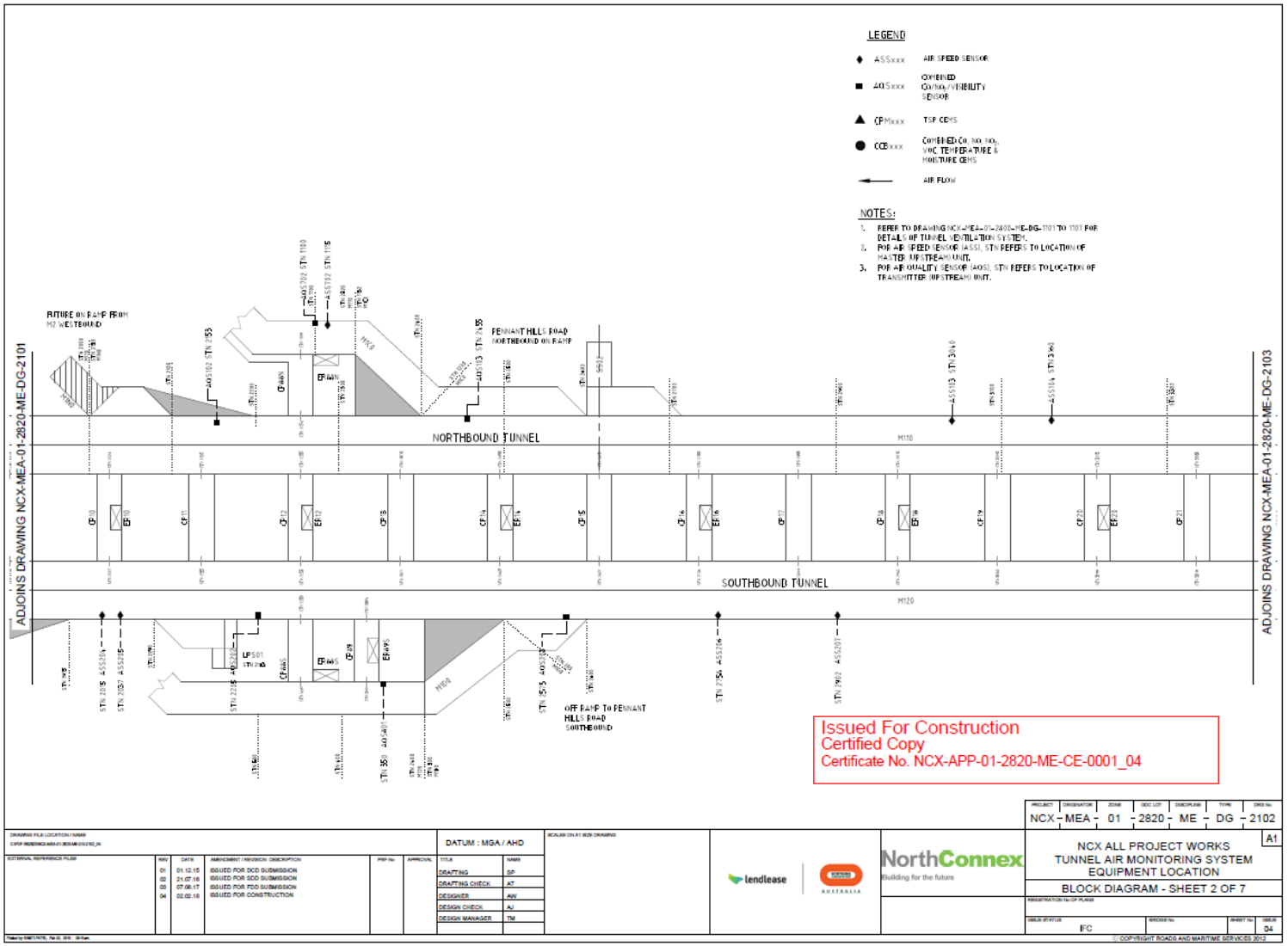

Figure A-2: In-tunnel air monitoring locations – Sheet 2 (AQS102, AQS103, AQS202, AQS203, AQS702, AQS801)

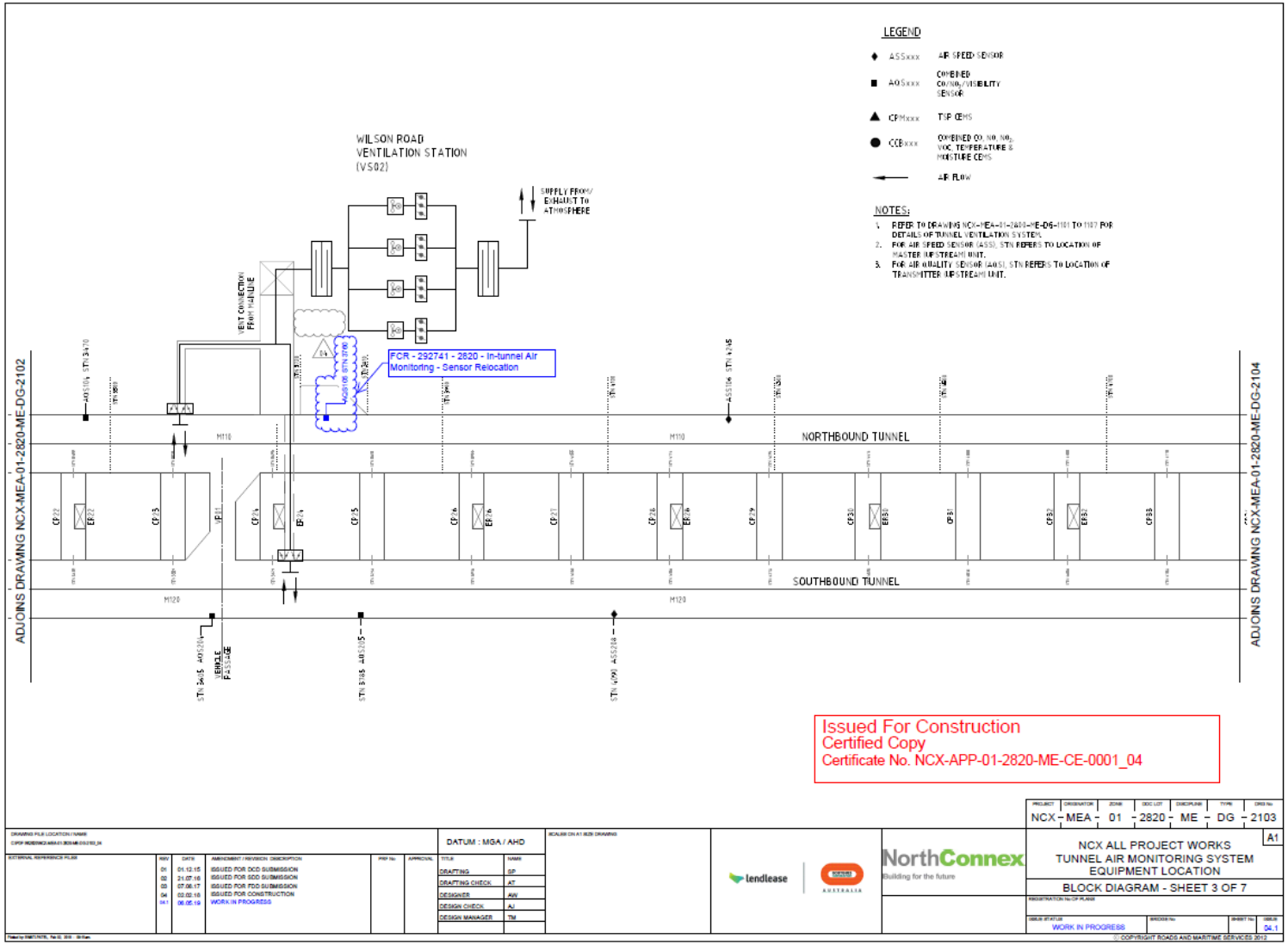

Figure A-3: In-tunnel air monitoring locations – Sheet 3 (AQS104, AQS105, AQS204, AQS205)

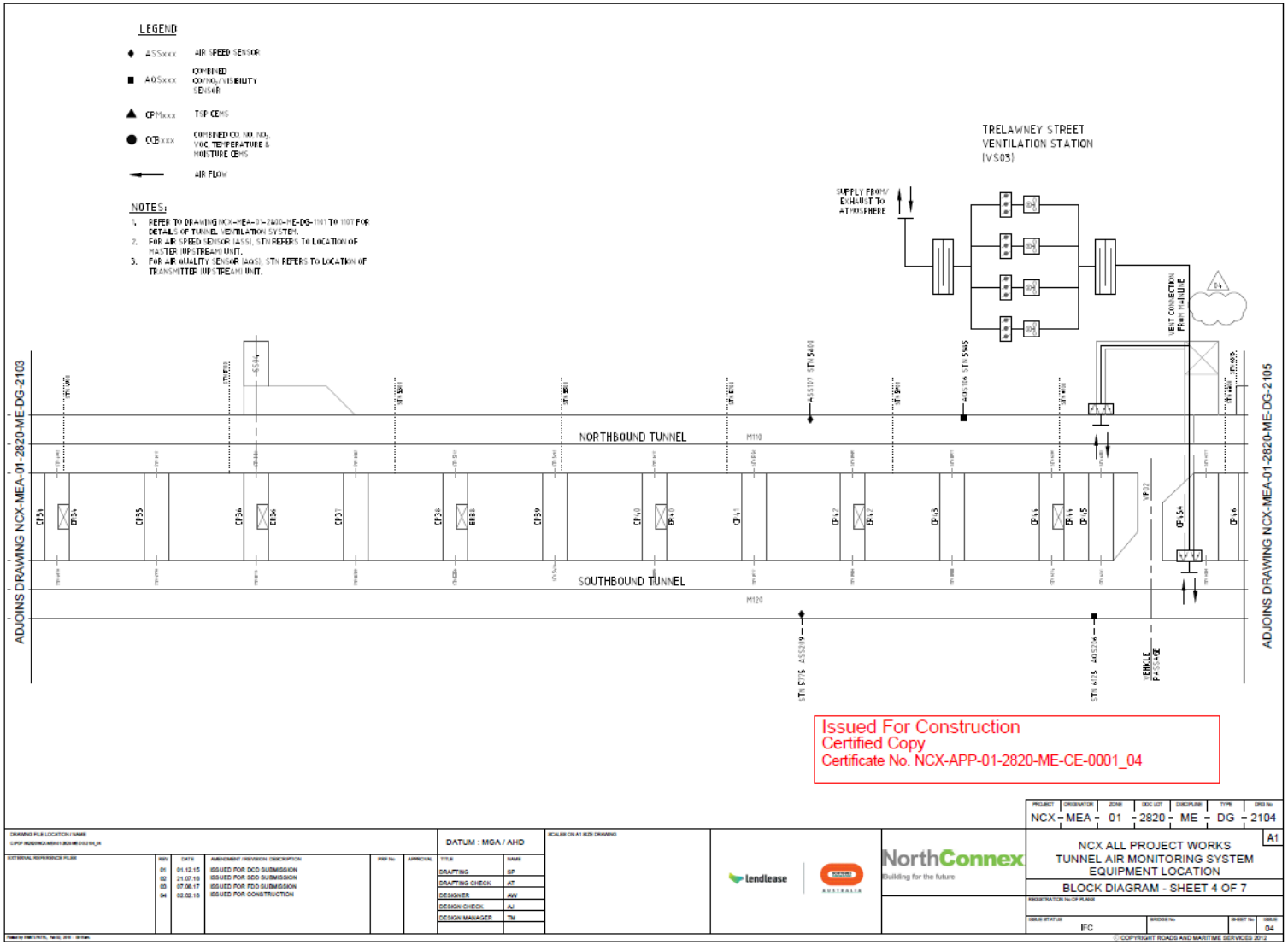

Figure A-4: In-tunnel air monitoring locations – Sheet 4 (AQS106, AQS206)

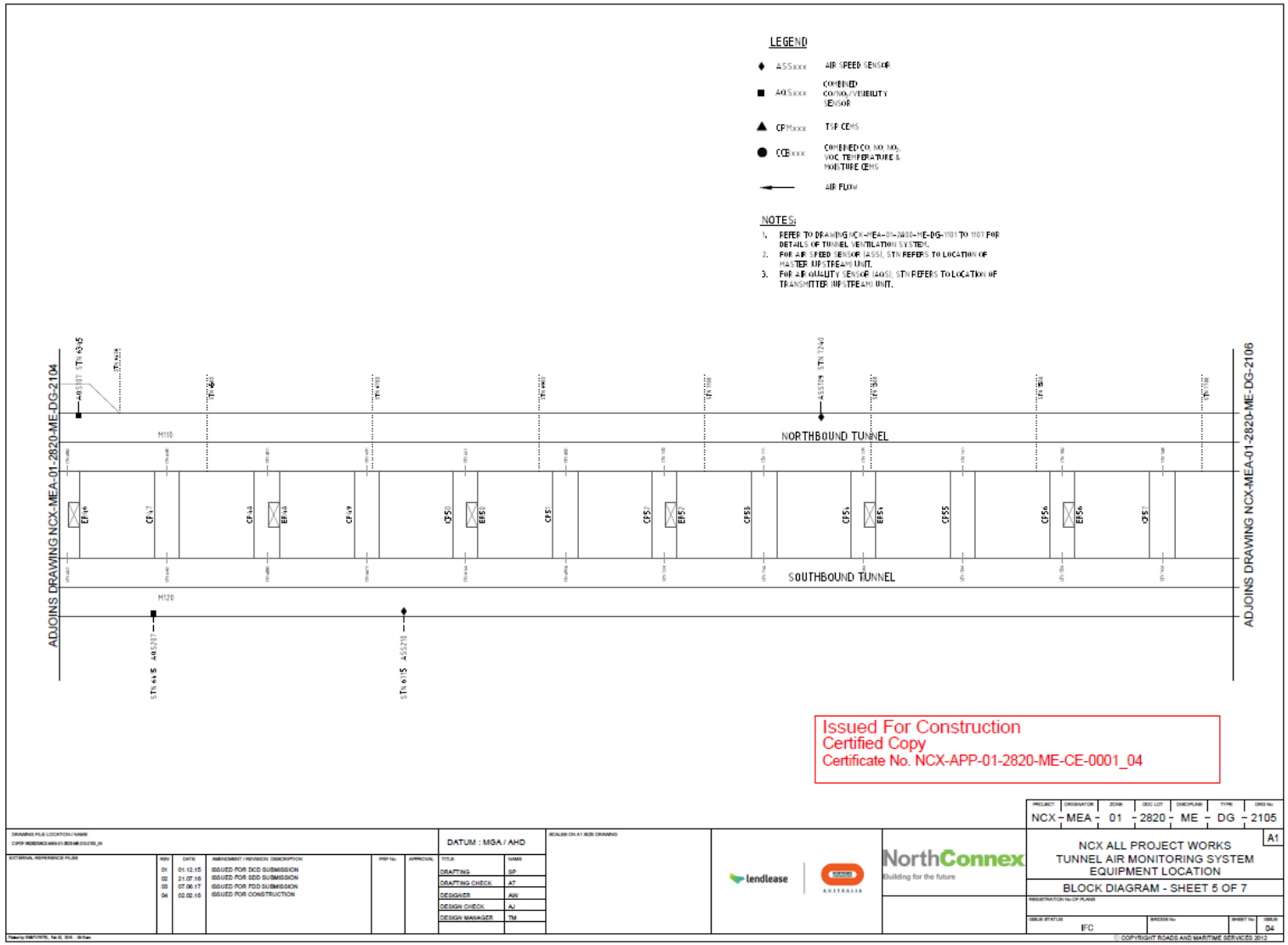

Figure A-5: In-tunnel air monitoring locations – Sheet 5 (AQS107, AQS207)

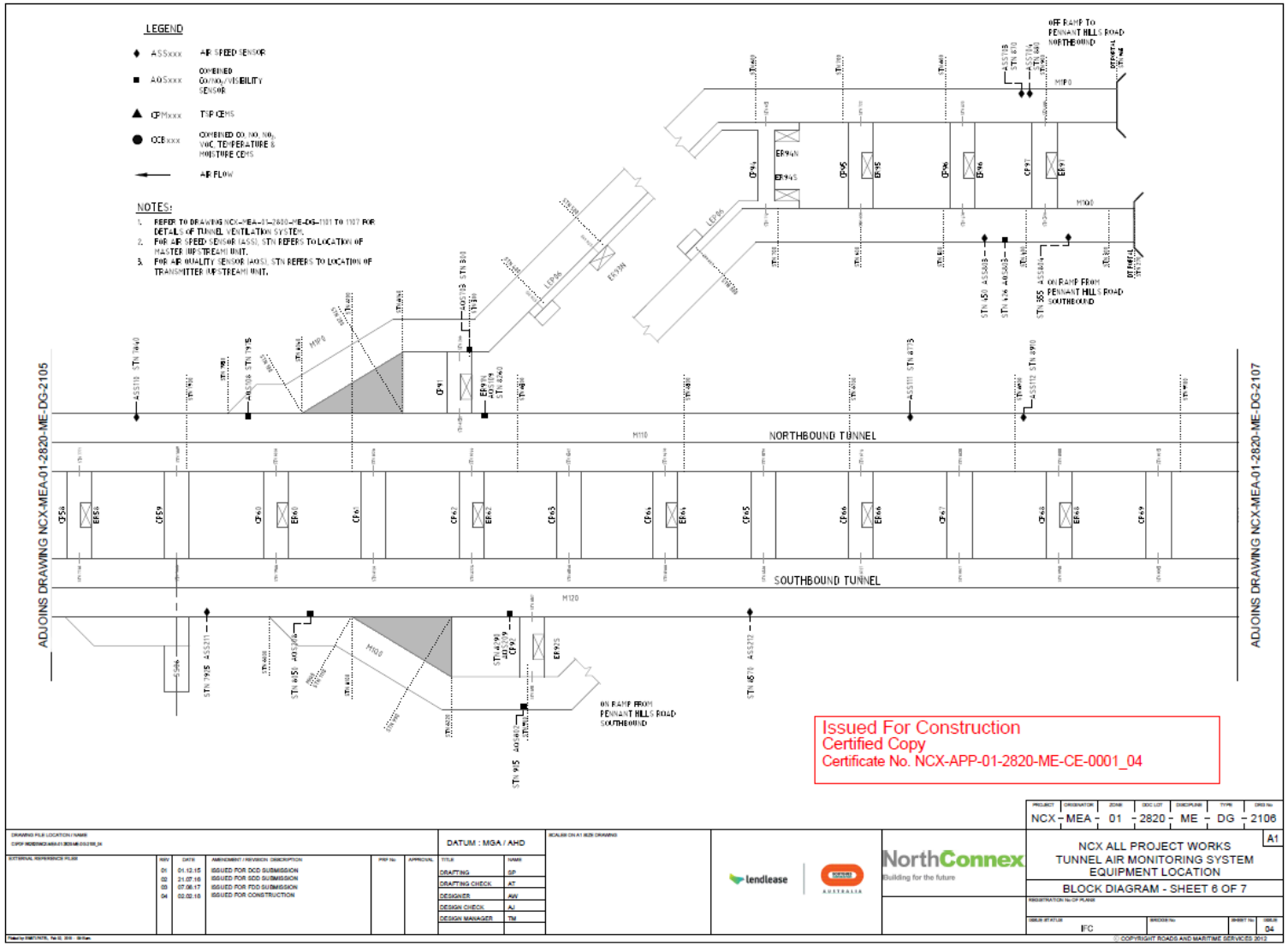

Figure A-6: In-tunnel air monitoring locations – Sheet 6 (AQS108, AQS109, AQS208, AQS209, AQS703, AQS802, AQS803)

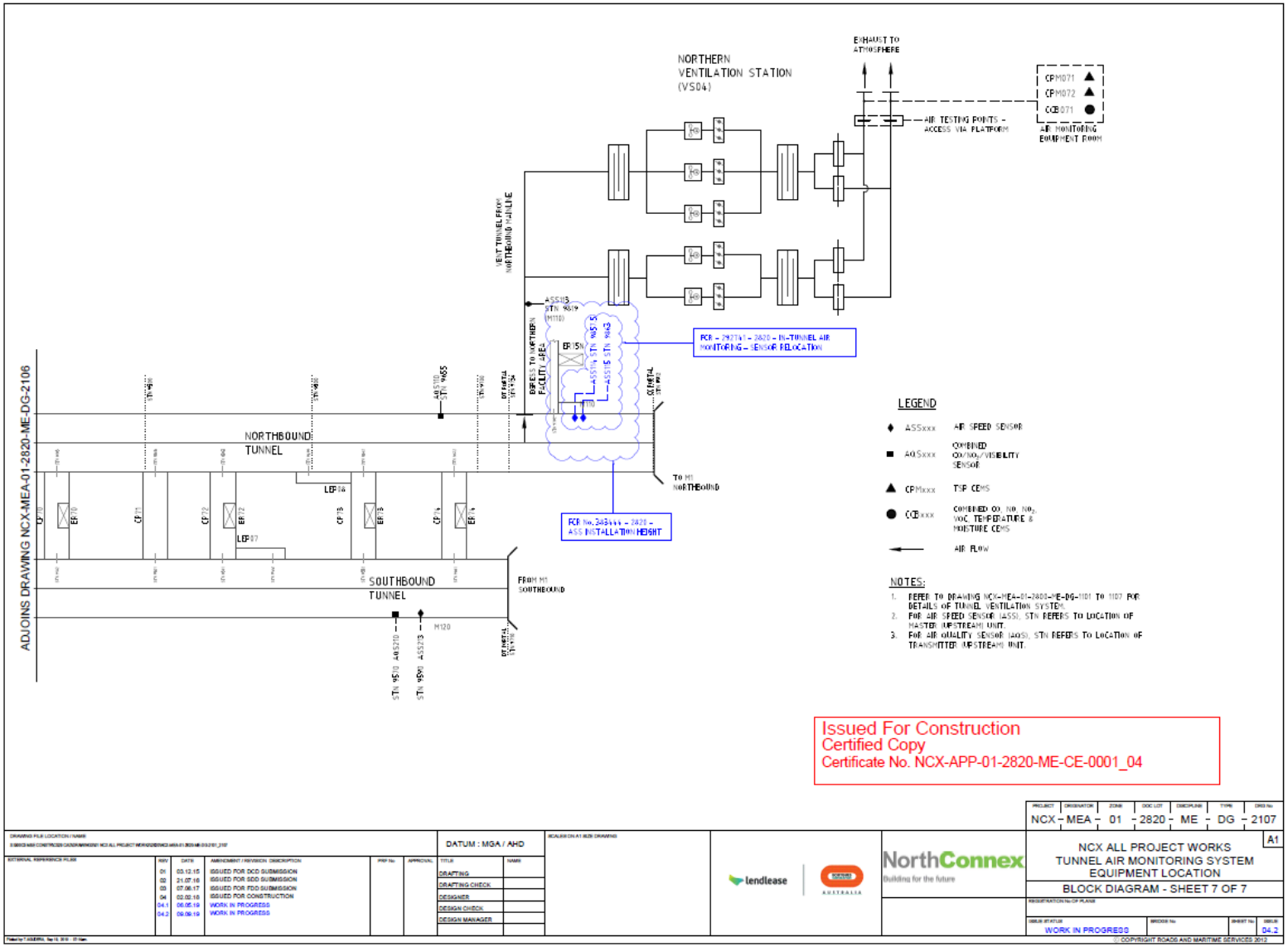

Figure A-7: In-tunnel air monitoring locations – Sheet 7 (AQS110, AQS210)