



May 2016

BROADSPECTRUM PTY LTD

EastLink Ventilation Stack Emission Monitoring Report January - March 2016

Submitted to:
Broadspectrum Pty Ltd
EastLink Operations Centre,
2 Hillcrest Avenue,
Ringwood, 3134

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.



Accreditation No. 1910

Report Number. 097613024-047-R-Rev0

Distribution:

Electronic Copy - Broadspectrum

Electronic Copy - Golder Associates Pty. Ltd.



REPORT



Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery
Broadspectrum Pty Ltd, EastLink Operations Centre, 2 Hillcrest Avenue, Ringwood, 3134	Ms. Alex Monson	Revision 0	20/05/2016	Electronic



Table of Contents

1.0 INTRODUCTION	1
2.0 DISCHARGES TO AIR	2
3.0 VENTILATION STACK MONITORING PARAMETERS	3
4.0 METHODS	4
4.1 PM _{2.5}	4
4.2 PM ₁₀	4
4.3 Carbon Monoxide	4
4.4 Oxides of Nitrogen	4
4.5 Stack Velocity	5
5.0 MEASUREMENT UNCERTAINTY	5
6.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/10/2015 – 31/10/2015	6
6.1 Data Capture	6
6.2 Results	6
6.2.1 PM _{2.5}	6
6.2.2 PM ₁₀	7
6.2.3 Carbon Monoxide	8
6.2.4 Oxides of Nitrogen	9
6.2.4.1 Nitric Oxide	9
6.2.4.2 Nitrogen Dioxide	10
6.2.5 Stack Velocity	11
6.3 Data Validation and Exceptions	13
7.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/11/2015 – 30/11/2015	15
7.1 Data Capture	15
7.2 Results	15
7.2.1 PM _{2.5}	15
7.2.2 PM ₁₀	16
7.2.3 Carbon Monoxide	17
7.2.4 Oxides of Nitrogen	18
7.2.4.1 Nitric Oxide	18
7.2.4.2 Nitrogen Dioxide	19



EASTLINK VENTILATION STACK EMISSION MONITORING REPORT: JANUARY - MARCH 2016

7.2.5	Stack Velocity	20
7.3	Data Validation and Exceptions	21
8.0	VENTILATION STACK EMISSION MONITORING PERIOD: 01/12/2015 – 31/12/2015.....	22
8.1	Data Capture	22
8.2	Results.....	22
8.2.1	PM _{2.5}	22
8.2.2	PM ₁₀	23
8.2.3	Carbon Monoxide.....	24
8.2.4	Oxides of Nitrogen	25
8.2.4.1	Nitric Oxide	25
8.2.4.2	Nitrogen Dioxide	26
8.2.5	Stack Velocity	27
8.3	Data Validation and Exceptions	28
9.0	DISCUSSION.....	29
9.1	Comparison with Licence Limits	29
9.2	Data Capture Year to Date	29
9.3	Bubble Licence	30

TABLES

Table 1:	Discharges to Air	2
Table 2:	Measurement Uncertainty	5
Table 3:	Data Capture Statistics - 1 Hour Averages.....	6
Table 4:	PM _{2.5} Mass Rate Percentiles (1 Hour Average)	6
Table 5:	PM ₁₀ Mass Rate Percentiles (1 Hour Average)	7
Table 6:	Carbon Monoxide Mass Rate Percentiles (1 Hour Average).....	8
Table 7:	Nitric Oxide Mass Rate Percentiles (1 Hour Average).....	9
Table 8:	Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average).....	10
Table 9:	Data Exceptions - Eastern Ventilation Stack: October 2015	13
Table 10:	Data Exceptions - Western Ventilation Stack: October 2015	13
Table 11:	Data Capture Statistics - 1 Hour Averages.....	15
Table 12:	PM _{2.5} 2.5 Mass Rate Percentiles (1 Hour Average)	15
Table 13:	PM ₁₀ Mass Rate Percentiles (1 Hour Average)	16
Table 14:	Carbon Monoxide Mass Rate Percentiles (1 Hour Average).....	17
Table 15:	Nitric Oxide Mass Rate Percentiles (1 Hour Average).....	18
Table 16:	Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average).....	19



EASTLINK VENTILATION STACK EMISSION MONITORING REPORT: JANUARY - MARCH 2016

Table 17: Data Exceptions - Eastern Ventilation Stack: November 2015.....	21
Table 18: Data Exceptions - Western Ventilation Stack: November 2015.....	21
Table 19: Data Capture Statistics - 1 Hour Averages.....	22
Table 20: PM _{2.5} Mass Rate Percentiles (1 Hour Average)	22
Table 21: PM ₁₀ Mass Rate Percentiles (1 Hour Average)	23
Table 22: Carbon Monoxide Mass Rate Percentiles (1 Hour Average).....	24
Table 23: Nitric Oxide Mass Rate Percentiles (1 Hour Average).....	25
Table 24: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average).....	26
Table 25: Data Exceptions - Eastern Ventilation Stack: December 2015.....	28
Table 26: Data Exceptions - Western Ventilation Stack: December 2015.....	28
Table 27: Maximum (1 Hour Average) Mass Rate (01/10/2015 - 31/12/2015)	29
Table 28: Data Capture Year to Date (%)	29
Table 29: Ventilation Stack Emissions 1/07/2015 – 31/12/2015 (tonnes/year).....	30

FIGURES

Figure 1: Ventilation Stack Locations	2
Figure 2: PM _{2.5} Mass Rate (1 Hour Average).....	7
Figure 3: PM ₁₀ Mass Rate (1 Hour Average)	8
Figure 4: Carbon Monoxide Mass Rate (1 Hour Average)	9
Figure 5: Nitric Oxide Mass Rate (1 Hour Average)	10
Figure 6: Nitrogen Dioxide Mass Rate (1 Hour Average)	11
Figure 7: Stack Velocity (1 Hour Average)	12
Figure 8: PM _{2.5} Mass Rate (1 Hour Average).....	16
Figure 9: PM ₁₀ Mass Rate (1 Hour Average)	17
Figure 10: Carbon Monoxide Mass Rate (1 Hour Average)	18
Figure 11: Nitric Oxide Mass Rate (1 Hour Average)	19
Figure 12: Nitrogen Dioxide Mass Rate (1 Hour Average)	20
Figure 13: Stack Velocity (1 Hour Average)	21
Figure 14: PM _{2.5} Mass Rate (1 Hour Average).....	23
Figure 15: PM ₁₀ Mass Rate (1 Hour Average)	24
Figure 16: Carbon Monoxide Mass Rate (1 Hour Average)	25
Figure 17: Nitric Oxide Mass Rate (1 Hour Average)	26
Figure 18: Nitrogen Dioxide Mass Rate (1 Hour Average)	27
Figure 19: Stack Velocity (1 Hour Average)	27
Figure 20: Ventilation Stack Emissions as Percentage of Licence Limit (1/07/2015 – 31/12/2015)	30



APPENDICES

APPENDIX A

Important Information Relating to this Report



1.0 INTRODUCTION

EastLink is a 39 kilometre motorway running between Donvale in Melbourne's north-east to Frankston in Melbourne's south-east with two tunnels under the Mullum Mullum Valley. Broadspectrum Pty Ltd, who are responsible for operation and maintenance of the road, commissioned Golder Associates Pty. Ltd. to provide continuous emission monitoring services for the EastLink motorway project. The services provided include:

- Operations and maintenance services for the EastLink ventilation stack continuous emission monitoring systems (CEMS)
- NATA endorsed emission monitoring reports.

Monitoring commenced on the 29th June, 2008 with the opening of the EastLink motorway. Results for the sampling period 1st January, 2016 to 31st March, 2016 inclusive are contained in the following report.

The work was conducted under the following Broadspectrum Pty Ltd Work Order numbers:

Month	Western Stack	Eastern Stack
January	692651	691128
February	699303	698810
March	703951	703952

Your attention is drawn to the document - "Important Information Relating to this Report" (LEG04, RL2), which is included in Appendix A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing. We would be pleased to answer any questions the reader may have regarding this document.



2.0 DISCHARGES TO AIR

EastLink has discharges to air servicing two road tunnels. Discharge Point No. 1 (DP1) services the inbound (Melba) tunnel and Discharge Point No. 2 (DP2) services the outbound (Mullum Mullum) tunnel.

The locations of the discharges to air are described in Table 1 and presented in Figure 1.

Table 1: Discharges to Air

Discharge Point No.	Station Name	Location
1	Western ventilation stack	Western end of inbound tunnel (Melba) - Donvale
2	Eastern ventilation stack	Eastern end of outbound tunnel (Mullum Mullum) – Ringwood

Monitoring equipment is housed in temperature controlled cabinets located at the base of each of the ventilation stacks. Particulate matter and gaseous sample inlets are installed inside the plenum chamber of each of the ventilation stacks.

Figure 1: Ventilation Stack Locations





3.0 VENTILATION STACK MONITORING PARAMETERS

The following parameters are monitored continuously, with averages logged at 5 minute intervals:

- Particulate matter with an equivalent aerodynamic diameter less than 2.5 microns (PM_{2.5})
- Particulate matter with an equivalent aerodynamic diameter less than 10 microns (PM₁₀)
- Total oxides of nitrogen (NO_x)
- Nitric oxide (NO)
- Nitrogen dioxide (NO₂)
- Carbon monoxide (CO)
- Stack velocity
- Stack temperature
- Ambient pressure.



4.0 METHODS

4.1 PM_{2.5}

PM_{2.5} concentrations in the tunnel ventilation stacks are determined using 1400 Series Tapered Element Oscillating Microbalance (TEOM) analysers. Sample inlets are located inside the plenum chamber of each ventilation stack.

Exhaust gas is drawn through a PM_{2.5} size selective inlet (PM₁₀ WINS head fitted with a PM_{2.5} sharp cut cyclone (SCC)) at 1 m³/h. The flow is then isokinetically split into two streams; 1 l/min stream which passes through the filter on the mass transducer and a 15.7 l/min bypass stream.

The sample stream is heated to 50°C to maintain a low and therefore relatively constant humidity.

Measurements are made in real-time (2 s intervals) with the 5 minute averages logged. 1 hour averages are then calculated from the logged data.

The PM_{2.5} monitoring method is based on the requirements of Australian Standard AS 3580.9.13, *"Methods for Sampling and Analysis of Ambient Air: Determination of Suspended Particulate Matter – PM_{2.5} Continuous Direct Mass Method Using a Tapered Element Oscillating Microbalance Monitor"*.

4.2 PM₁₀

PM₁₀ concentrations in the tunnel ventilation stacks are determined using 1400 Series Tapered Element Oscillating Microbalance (TEOM) analysers. Sample inlets are located inside the plenum chamber of each ventilation stack.

Exhaust gas is drawn through a PM₁₀ size selective inlet (PM₁₀ WINS head) at 1 m³/h. The flow is then isokinetically split into two streams; 1 l/min stream which passes through the filter on the mass transducer and a 15.7 l/min bypass stream.

The sample stream is heated to 50°C to maintain a low and therefore relatively constant humidity.

Measurements are made in real-time (2 s intervals) with the 5 minute averages logged. 1 hour averages are then calculated from the logged data.

The PM₁₀ monitoring method is based on the requirements of Australian Standard AS 3580.9.8, *"Methods for Sampling and Analysis of Ambient Air: Determination of Suspended Particulate Matter – PM₁₀ Continuous Direct Mass Method Using a Tapered Element Oscillating Microbalance Analyser"*.

4.3 Carbon Monoxide

Carbon monoxide concentrations in the tunnel ventilation stacks are determined by infra-red gas filter correlation analysers.

Automatic calibrations are carried out daily against a NATA certified reference gas mixture. Manual calibrations are conducted at one month intervals.

The carbon monoxide monitoring method is based on the requirements of Australian Standard AS 3580.7.1, *"Determination of Carbon Monoxide – Direct Reading Instrumental Method"*.

4.4 Oxides of Nitrogen

Oxides of nitrogen concentrations in the tunnel ventilation stacks are determined by chemiluminescence gas analysers.

Automatic calibrations are carried out daily against a NATA certified reference gas mixture. Manual calibrations are conducted at one month intervals.

The oxides of nitrogen (NO, NO₂ and NO_x) monitoring method is based on the requirements of Australian Standard AS 3580.5.1, *"Determination of Oxides of Nitrogen – Chemiluminescence Method"*.



4.5 Stack Velocity

Stack gas velocity was determined using an optical flow sensor that complies with USEPA Code of Federal Regulations (CFR 40) Part 75, “Continuous Emission Monitoring” requirements.

5.0 MEASUREMENT UNCERTAINTY

Table 2: Measurement Uncertainty

Parameter	Method	Estimated Uncertainty
PM ₁₀	TEOM	± 5%
PM _{2.5}	TEOM	± 5%
NO, NO ₂ , NO _x	Chemiluminescence	± 10%
CO	Infra-red gas filter correlation	± 10%
Stack velocity	Optical flow sensor	± 0.1 m/s or 5% of reading, whichever is greater
Ambient temperature	Thermocouple (TEOM)	± 2°C
Ambient pressure	TEOM pressure transducer	± 1.5%



6.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/01/2016 – 31/01/2016

6.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st January to 31st January, 2016 are shown in Table 3. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 6.3 provides further information on the reasons for invalid data periods.

Table 3: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	743	744	99.9%
	Western	740	744	99.5%
PM ₁₀	Eastern	743	744	99.9%
	Western	742	744	99.7%
NO, NO ₂	Eastern	710	744	95.4%
	Western	711	744	95.6%
CO	Eastern	643	744	86.4%
	Western	709	744	96.3%

6.2 Results

6.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 4. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 2.

Table 4: PM_{2.5} Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.32	0.28	0.26	0.21	0.19	0.11	0.043
Western	0.41	0.30	0.26	0.19	0.16	0.10	0.051

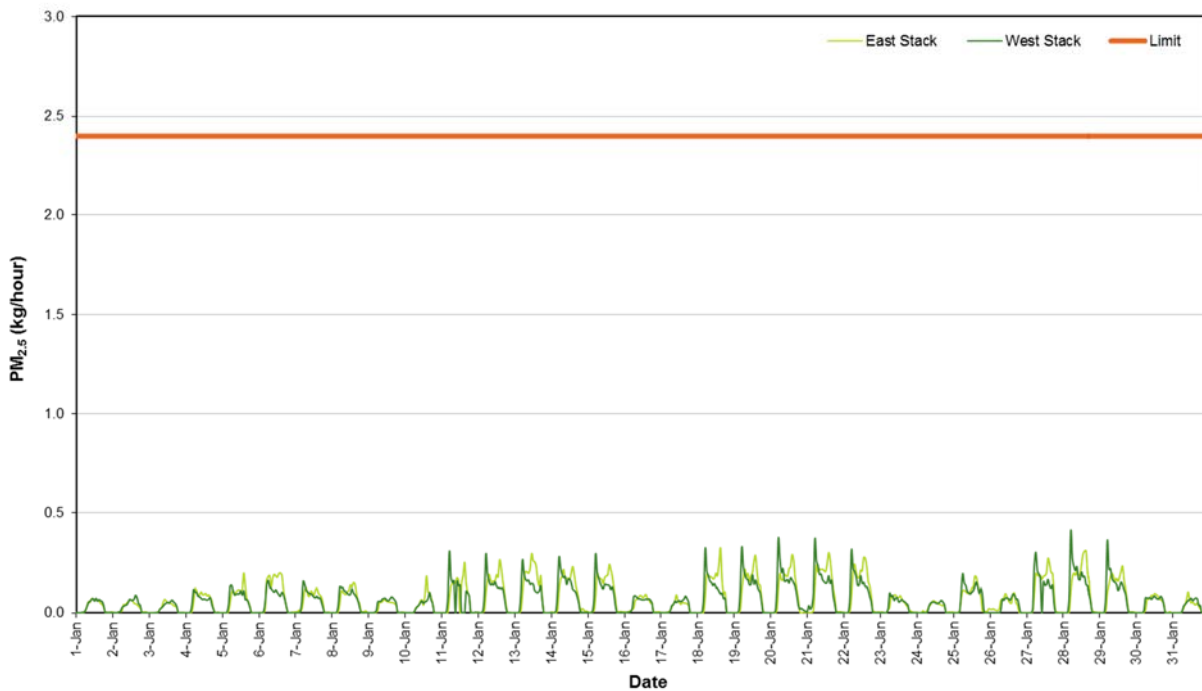


Figure 2: PM_{2.5} Mass Rate (1 Hour Average)

6.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 5. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 3.

Table 5: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.57	0.45	0.41	0.36	0.31	0.18	0.072
Western	1.6	0.68	0.54	0.33	0.26	0.18	0.090

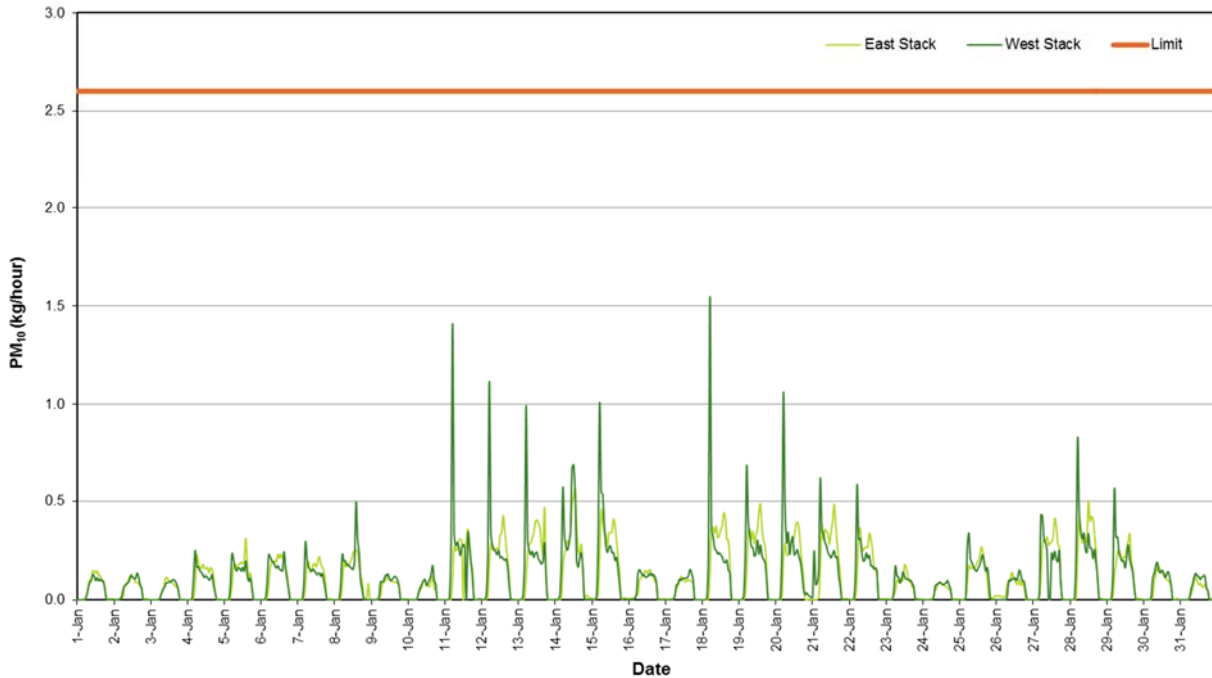


Figure 3: PM10 Mass Rate (1 Hour Average)

6.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 6. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 4.

Table 6: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	16	15	14	11	10	7.2	4.6
Western	15	14	12	10	9.0	7.4	5.4

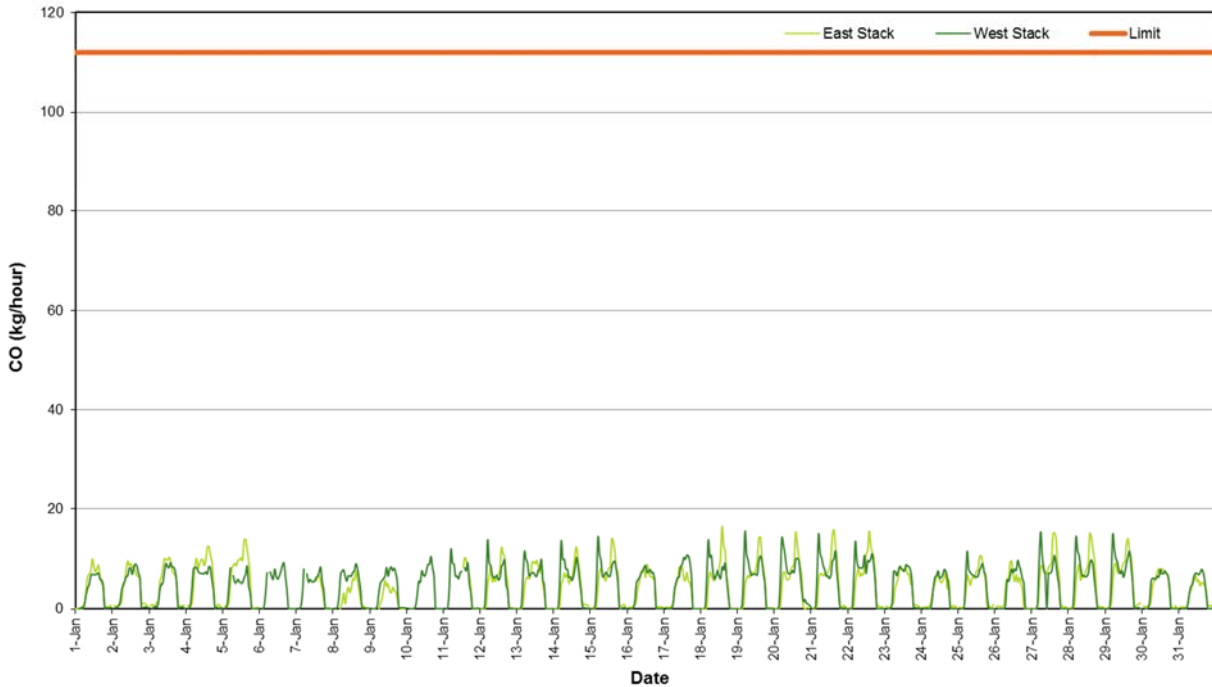


Figure 4: Carbon Monoxide Mass Rate (1 Hour Average)

6.2.4 Oxides of Nitrogen

6.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 7. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 5.

Table 7: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	4.6	3.8	3.4	3.0	2.6	1.8	0.85
Western	4.6	4.1	3.2	2.6	2.3	1.7	1.0

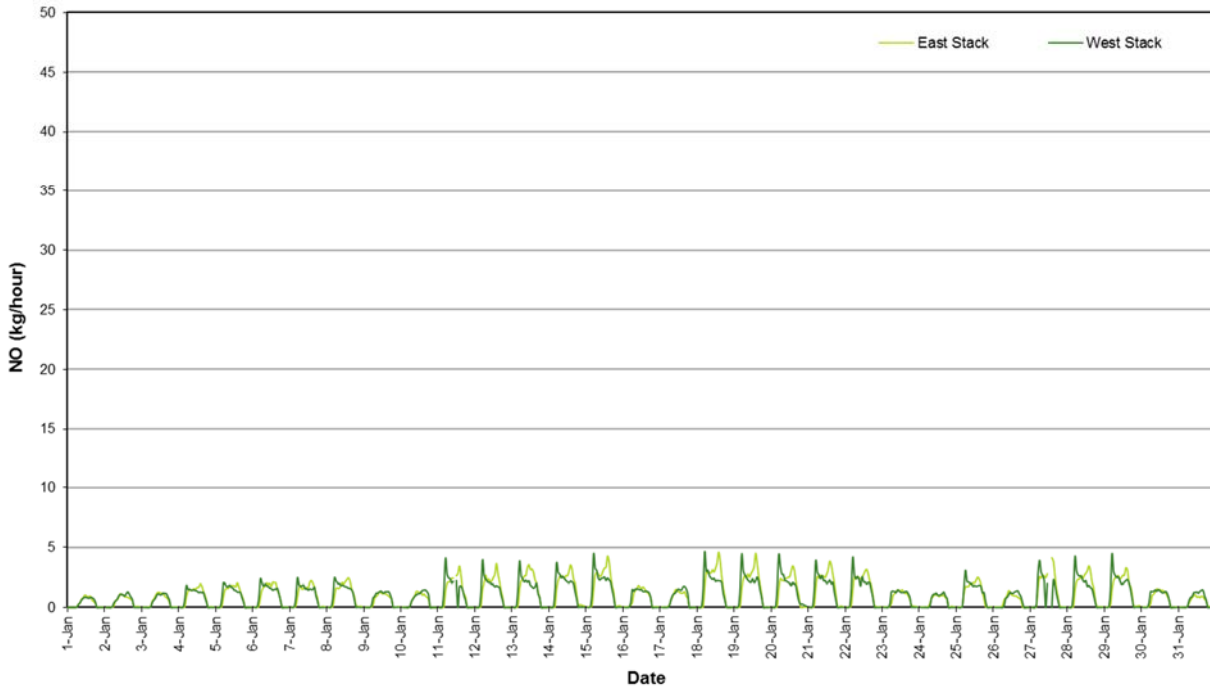


Figure 5: Nitric Oxide Mass Rate (1 Hour Average)

6.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 8. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 6.

Table 8: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	1.3	0.96	0.90	0.70	0.54	0.40	0.19
Western	1.0	0.85	0.77	0.62	0.54	0.40	0.23

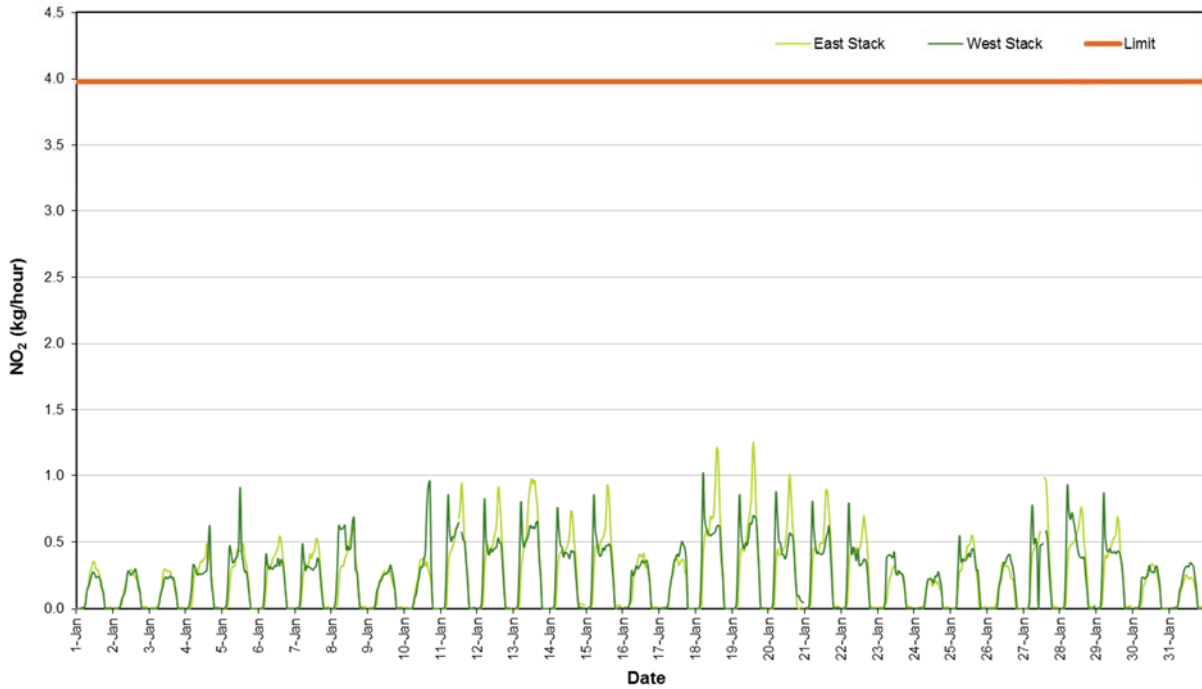


Figure 6: Nitrogen Dioxide Mass Rate (1 Hour Average)

6.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 7.



EASTLINK VENTILATION STACK EMISSION MONITORING REPORT: JANUARY - MARCH 2016

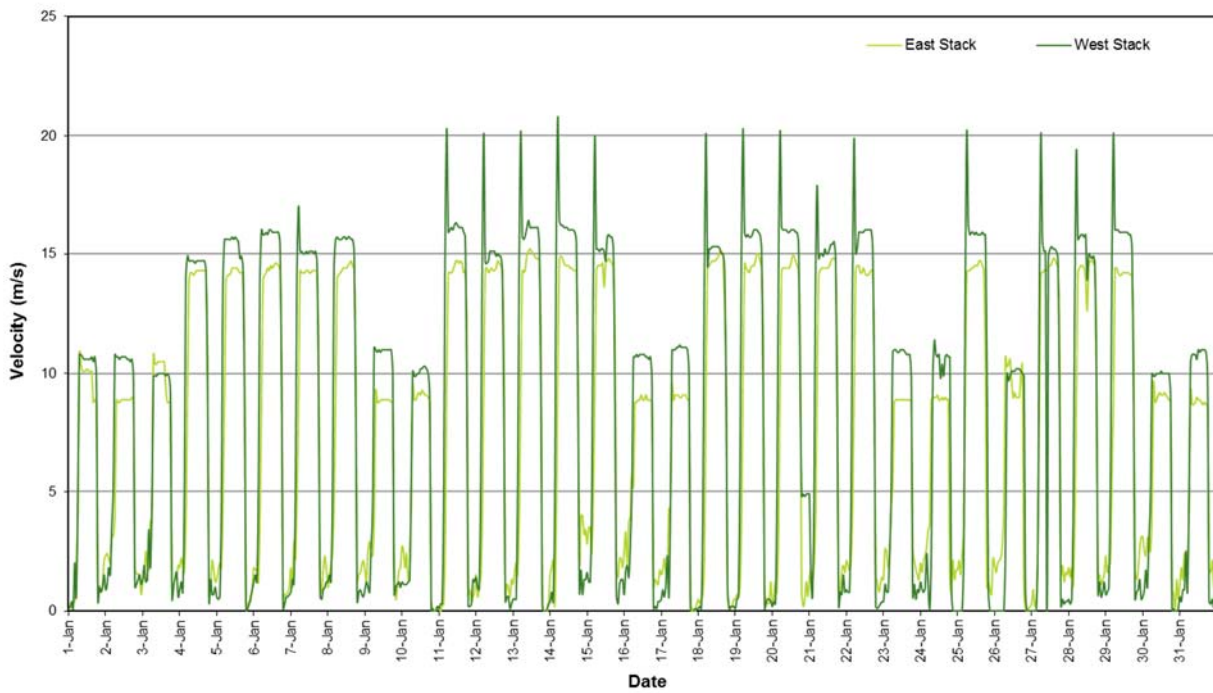


Figure 7: Stack Velocity (1 Hour Average)



6.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 9 and 10 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 9: Data Exceptions - Eastern Ventilation Stack: January 2016

Start	End	Parameter	Reason
6/01/2016 01:00	7/01/2016 12:30	CO	Invalid data - Span drift
7/01/2016 06:40	7/01/2016 06:45	NO, NO ₂ , NO _x	Maintenance / calibration
10/01/2016 01:00	11/01/2016 12:45	NO, NO ₂ , NO _x	Invalid data - Span drift
11/01/2016 11:15	11/01/2016 11:40	NO, NO ₂ , NO _x	Maintenance / calibration
11/01/2016 12:00	11/01/2016 12:00	PM _{2.5}	Maintenance / calibration
11/01/2016 12:10	11/01/2016 13:00	PM ₁₀	Maintenance / calibration
11/01/2016 19:50	11/01/2016 19:55	PM _{2.5}	Invalid data ¹
18/01/2016 07:50	18/01/2016 08:10	NO, NO ₂ , NO _x	Maintenance / calibration
22/01/2016 21:30	22/01/2016 21:35	PM ₁₀	Invalid data ¹
27/01/2016 11:50	27/01/2016 11:55	PM _{2.5}	Maintenance / calibration
27/01/2016 12:30	27/01/2016 13:35	NO, NO ₂ , NO _x	Maintenance / calibration
28/01/2016 07:50	28/01/2016 08:10	CO	Maintenance / calibration

Notes: ¹ – In the opinion of the reviewer

Table 10: Data Exceptions - Western Ventilation Stack: January 2016

Start	End	Parameter	Reason
5/01/2016 06:15	5/01/2016 07:05	CO	Maintenance / calibration
6/01/2016 06:00	6/01/2016 06:25	CO	Maintenance / calibration
7/01/2016 06:00	7/01/2016 06:25	CO	Maintenance / calibration
11/01/2016 08:55	11/01/2016 09:15	PM _{2.5}	Invalid data ¹
11/01/2016 13:00	11/01/2016 13:30	NO, NO ₂ , NO _x	Maintenance / calibration
11/01/2016 13:40	11/01/2016 15:55	PM _{2.5}	Maintenance / calibration
11/01/2016 13:45	11/01/2016 14:50	PM ₁₀	Maintenance / calibration
27/01/2016 10:35	27/01/2016 11:10	Velocity	Invalid data ¹
27/01/2016 11:40	27/01/2016 11:55	PM ₁₀	Maintenance / calibration
27/01/2016 11:50	27/01/2016 11:55	PM _{2.5}	Maintenance / calibration
27/01/2016 14:00	27/01/2016 14:55	NO, NO ₂ , NO _x	Maintenance / calibration

Notes: ¹ – In the opinion of the reviewer



A number of periods occurred where PM_{2.5} concentrations were greater than the corresponding PM₁₀ concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- East Ventilation stack 10/01/2016 13:45 – 15:30
- West Ventilation stack 01/01/2016 00:00 – 06:30



7.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/02/2016 – 29/02/2016

7.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st February to 29th February, 2016 are shown in Table 11. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 7.3 provides further information on the reasons for invalid data periods.

Table 11: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	694	696	99.7%
	Western	693	696	99.6%
PM ₁₀	Eastern	696	696	99.9%
	Western	695	696	99.9%
NO, NO ₂	Eastern	662	696	95.1%
	Western	665	696	95.5%
CO	Eastern	664	696	95.4%
	Western	663	696	95.3%

7.2 Results

7.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 12. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 8.

Table 12: PM_{2.5} 2.5 Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.34	0.32	0.29	0.25	0.22	0.17	0.059
Western	0.85	0.40	0.37	0.25	0.21	0.15	0.067

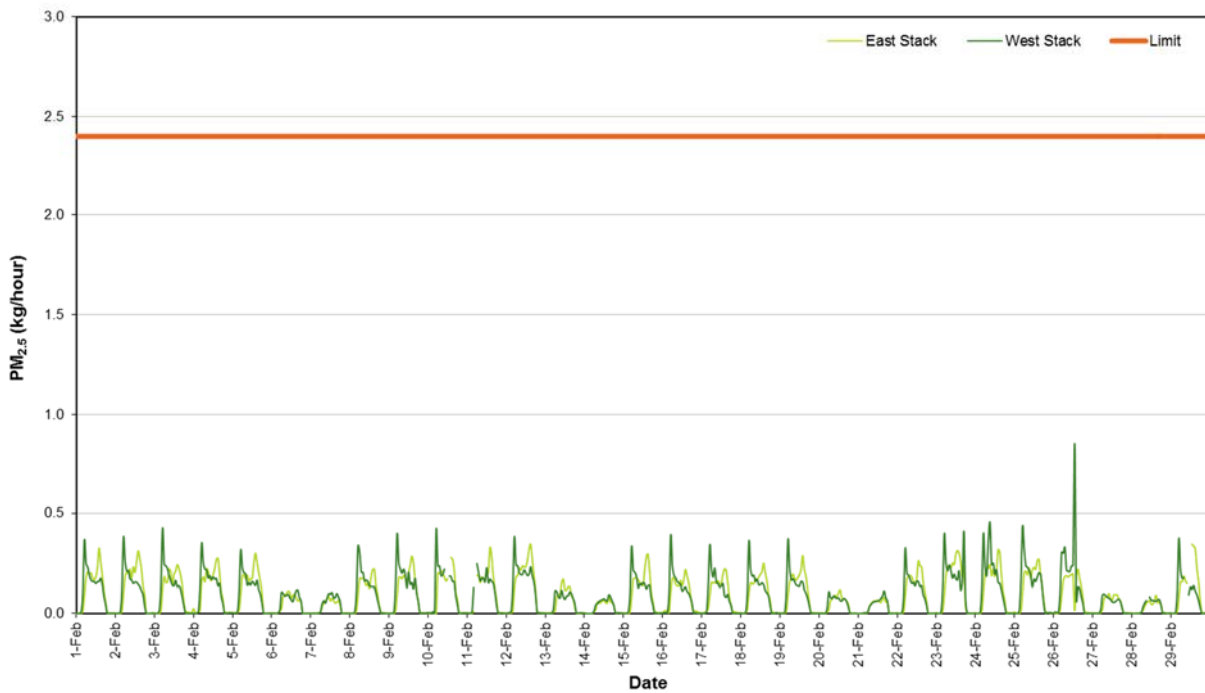


Figure 8: PM_{2.5} Mass Rate (1 Hour Average)

7.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 13. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 9.

Table 13: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.79	0.49	0.47	0.41	0.36	0.28	0.11
Western	1.4	0.76	0.67	0.36	0.31	0.24	0.13

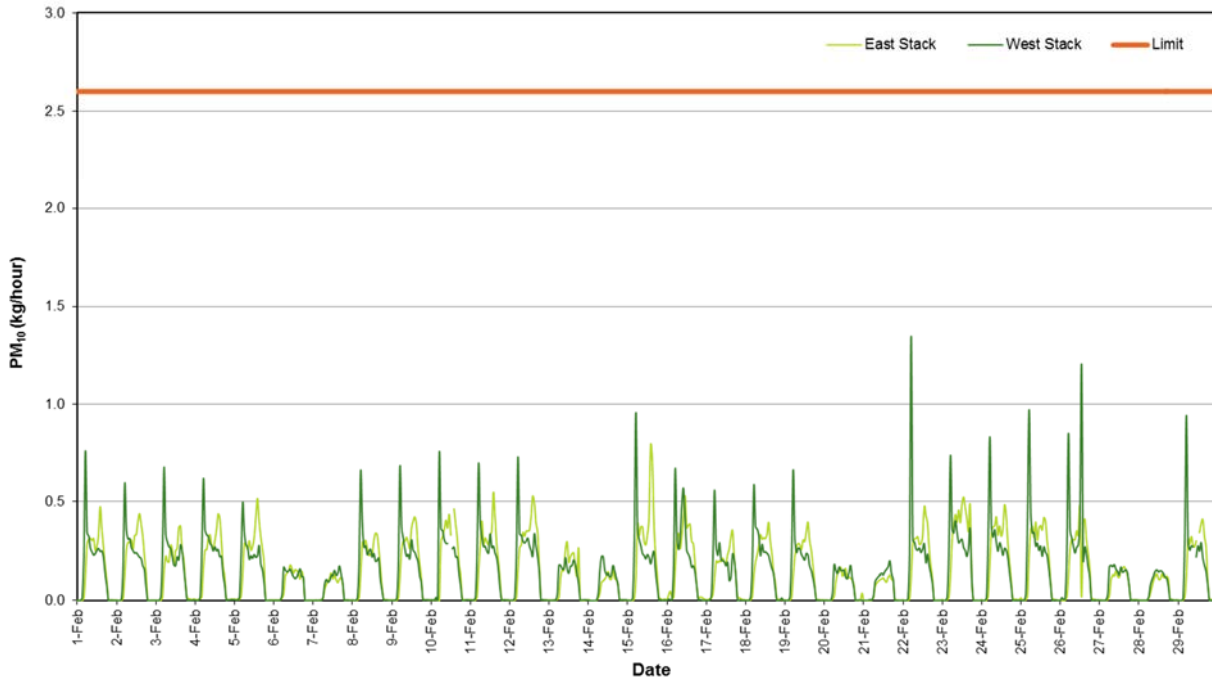


Figure 9: PM₁₀ Mass Rate (1 Hour Average)

7.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 14. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 10.

Table 14: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	19	17	16	15	12	9.4	6.9
Western	18	16	15	12	10	8.0	5.9

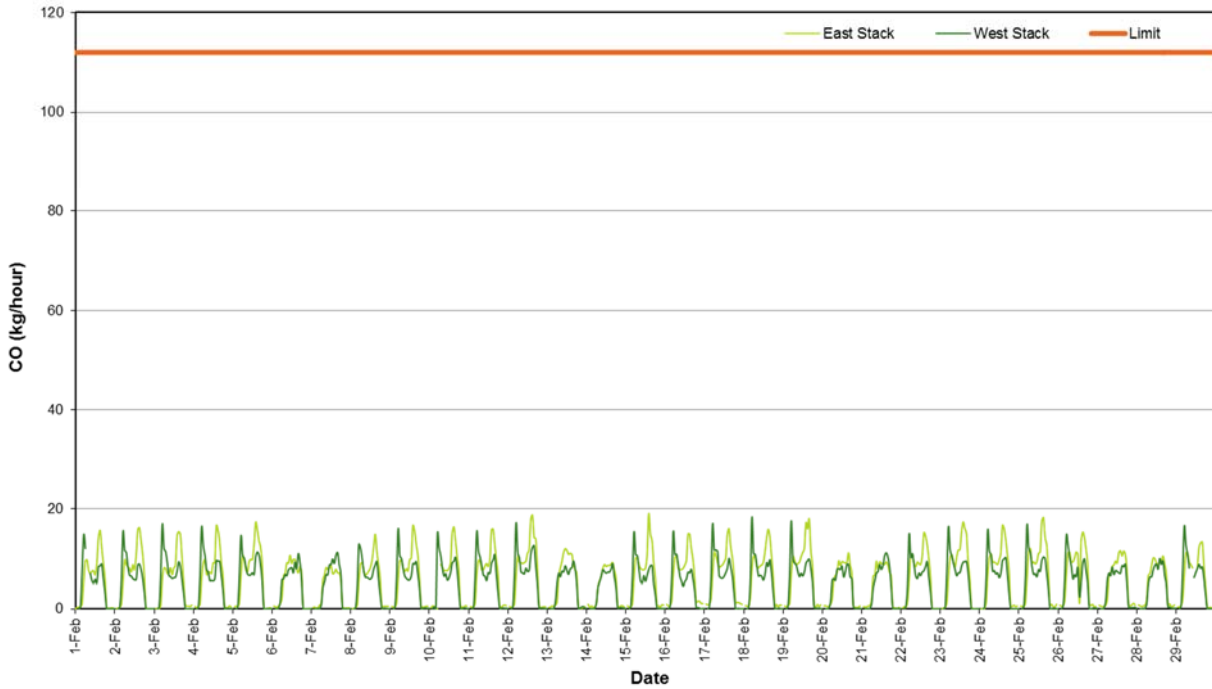


Figure 10: Carbon Monoxide Mass Rate (1 Hour Average)

7.2.4 Oxides of Nitrogen

7.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 15. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 11.

Table 15: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	5.0	4.2	4.1	3.6	3.1	2.6	1.3
Western	5.2	4.8	4.6	3.1	2.7	2.2	1.3

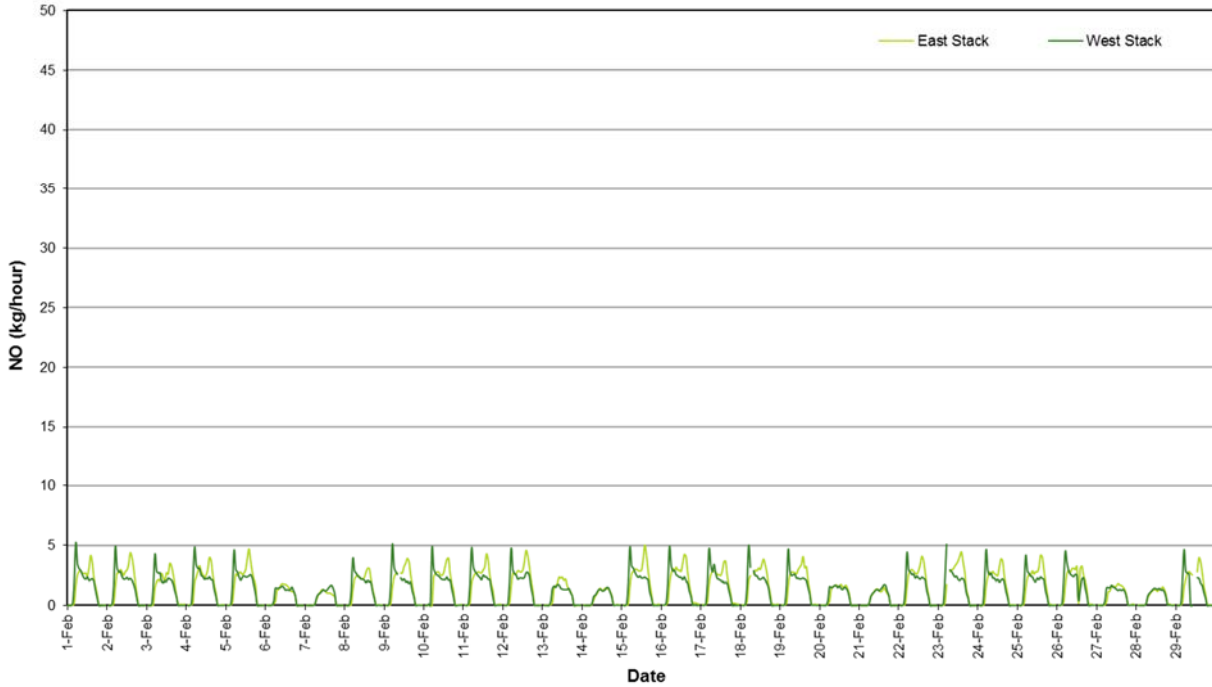


Figure 11: Nitric Oxide Mass Rate (1 Hour Average)

7.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 16. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 12.

Table 16: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	1.2	1.1	0.92	0.83	0.66	0.47	0.28
Western	1.0	0.93	0.89	0.62	0.54	0.46	0.29

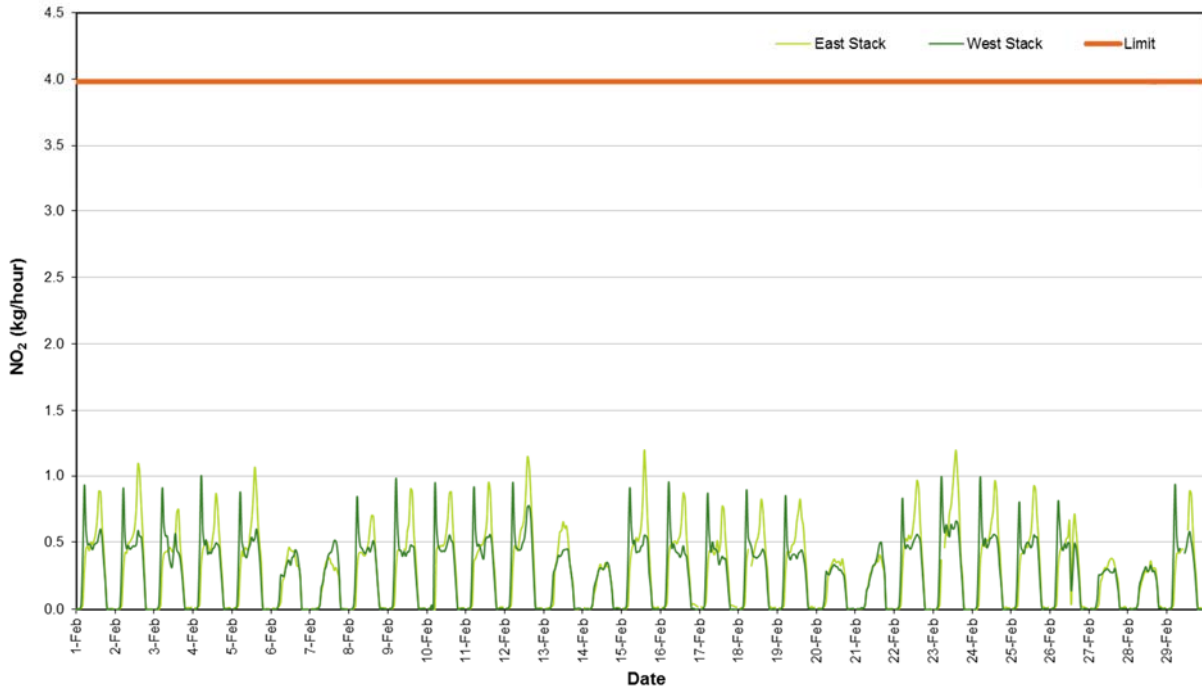


Figure 12: Nitrogen Dioxide Mass Rate (1 Hour Average)

7.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 13.

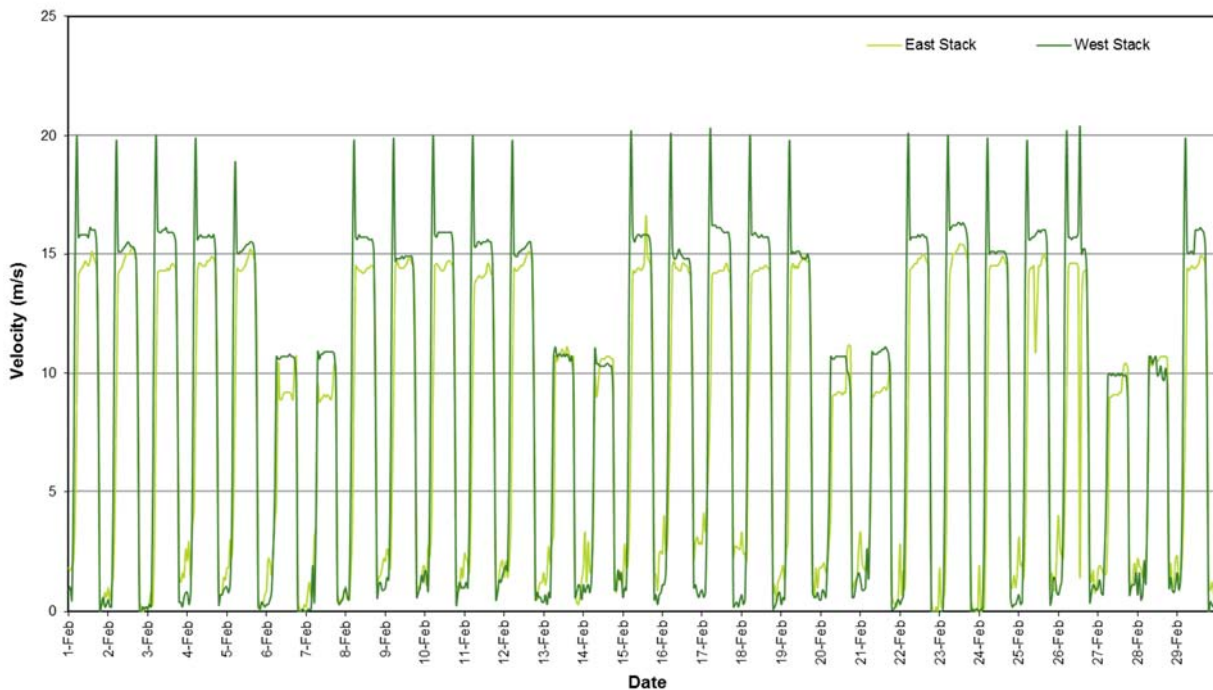




Figure 13: Stack Velocity (1 Hour Average)

7.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 17 and 18 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 17: Data Exceptions - Eastern Ventilation Stack: February 2016

Start	End	Parameter	Reason
9/02/2016 09:10	9/02/2016 09:30	NO, NO ₂ , NO _x	Maintenance/ calibration
10/02/2016 06:30	10/02/2016 07:00	CO	Maintenance/ calibration
18/02/2016 07:05	18/02/2016 07:55	NO, NO ₂ , NO _x	Maintenance/ calibration
23/02/2016 06:35	23/02/2016 07:00	NO, NO ₂ , NO _x	Maintenance/ calibration
29/02/2016 11:15	29/02/2016 12:15	NO, NO ₂ , NO _x	Maintenance/ calibration
29/02/2016 11:15	29/02/2016 12:15	CO	Maintenance/ calibration
29/02/2016 11:40	29/02/2016 12:20	PM _{2.5}	Maintenance/ calibration
29/02/2016 11:50	29/02/2016 13:05	PM ₁₀	Maintenance/ calibration

Table 18: Data Exceptions - Western Ventilation Stack: February 2016

Start	End	Parameter	Reason
1/02/2016 07:35	1/02/2016 08:50	CO	Maintenance/ calibration
28/02/2016 10:00	28/02/2016 10:15	PM _{2.5}	Invalid data 1
29/02/2016 09:15	29/02/2016 10:15	CO	Maintenance/ calibration
29/02/2016 09:15	29/02/2016 10:30	NO, NO ₂ , NO _x	Maintenance/ calibration
29/02/2016 09:40	29/02/2016 10:30	PM _{2.5}	Maintenance/ calibration
29/02/2016 09:50	29/02/2016 10:50	PM ₁₀	Maintenance/ calibration

A number of periods occurred where PM_{2.5} concentrations were greater than the corresponding PM₁₀ concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- East Ventilation stack 04/02/2016 19:05 – 19:25
- East Ventilation stack 04/02/2016 21:50 – 22:05
- West Ventilation stack 23/02/2016 17:15 – 21:50
- West Ventilation stack 24/02/2016 08:20 – 10:30



8.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/03/2016 – 31/03/2016

8.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st March to 31st March, 2016 are shown in Table 19. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 8.3 provides further information on the reasons for invalid data periods.

Table 19: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	712	744	95.7%
	Western	741	744	99.6%
PM ₁₀	Eastern	743	744	99.9%
	Western	743	744	99.9%
NO, NO ₂	Eastern	681	744	91.5%
	Western	661	744	88.8%
CO	Eastern	712	744	96.7%
	Western	711	744	95.8%

8.2 Results

8.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 20. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 14.

Table 20: PM_{2.5} Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.45	0.35	0.32	0.29	0.25	0.18	0.052
Western	0.48	0.38	0.32	0.23	0.20	0.14	0.053

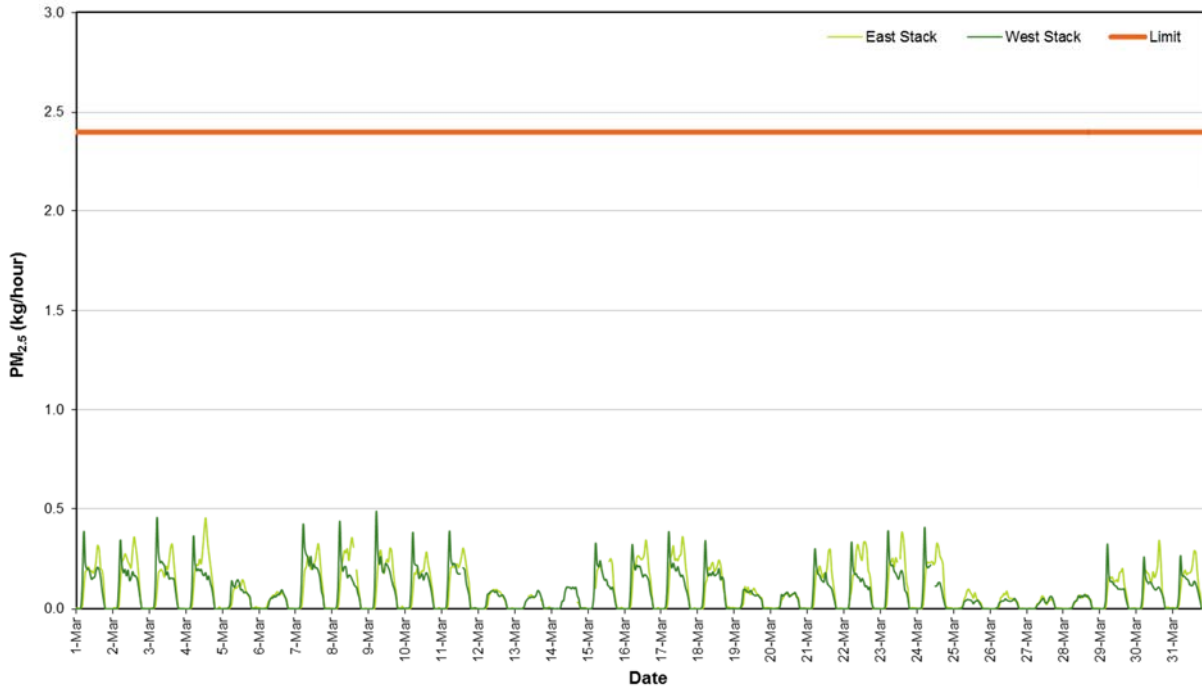


Figure 14: PM_{2.5} Mass Rate (1 Hour Average)

8.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 21. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 15.

Table 21: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	2.3	0.96	0.52	0.47	0.40	0.29	0.083
Western	0.95	0.73	0.58	0.36	0.32	0.23	0.10

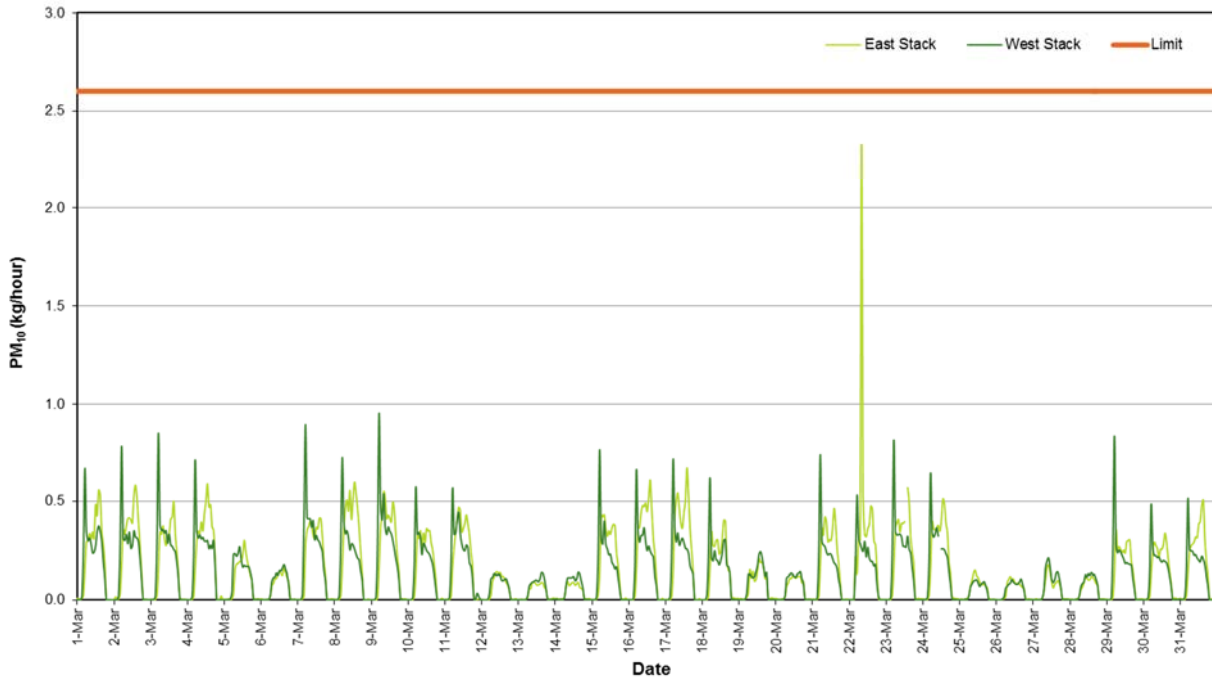


Figure 15: PM₁₀ Mass Rate (1 Hour Average)

8.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 22. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 16.

Table 22: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	18	17	16	14	11	8.2	5.3
Western	20	16	15	11	10	8.3	5.9

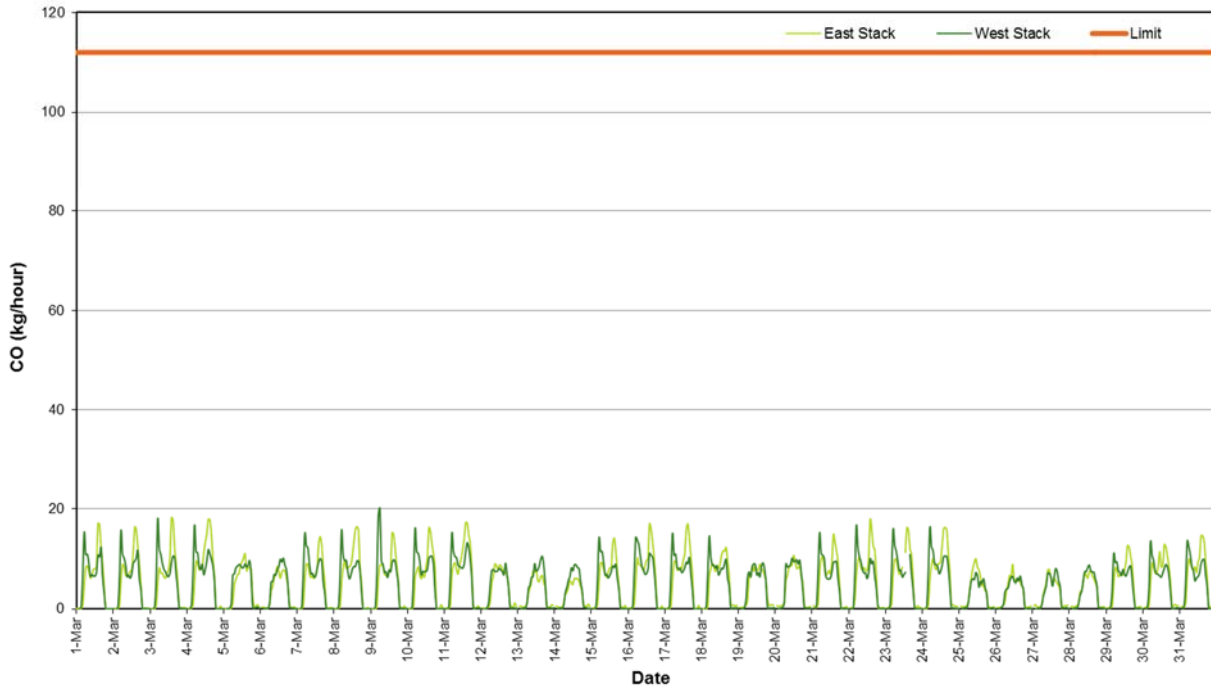


Figure 16: Carbon Monoxide Mass Rate (1 Hour Average)

8.2.4 Oxides of Nitrogen

8.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 23. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 17.

Table 23: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	5.5	4.6	4.5	3.7	3.2	2.5	0.97
Western	5.4	4.8	4.3	3.1	2.8	2.2	1.1

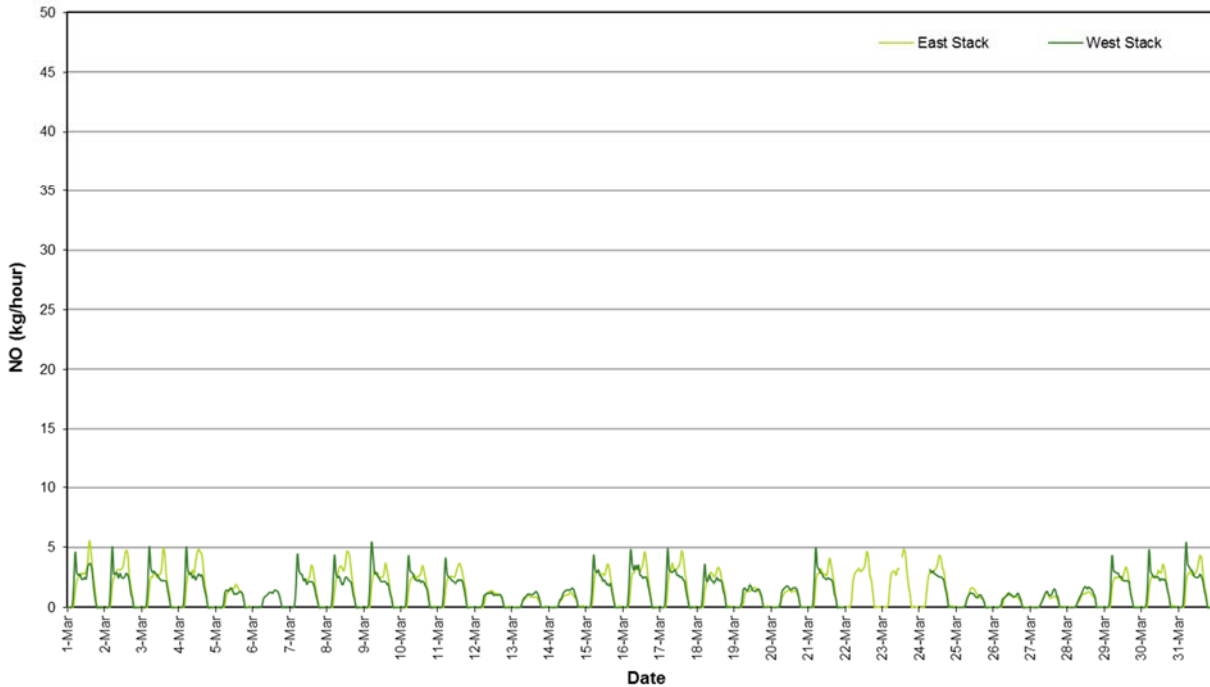


Figure 17: Nitric Oxide Mass Rate (1 Hour Average)

8.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 24. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 18.

Table 24: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	1.4	1.2	1.1	0.87	0.68	0.49	0.22
Western	1.4	1.0	0.9	0.66	0.58	0.47	0.25

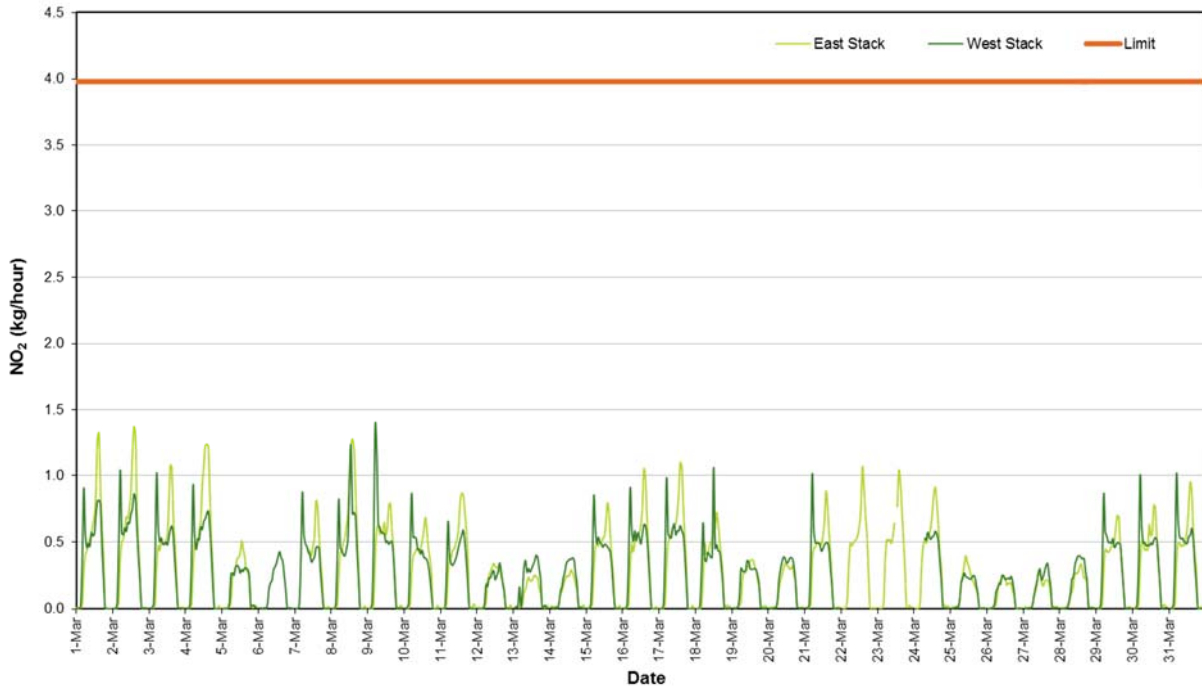


Figure 18: Nitrogen Dioxide Mass Rate (1 Hour Average)

8.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 19.

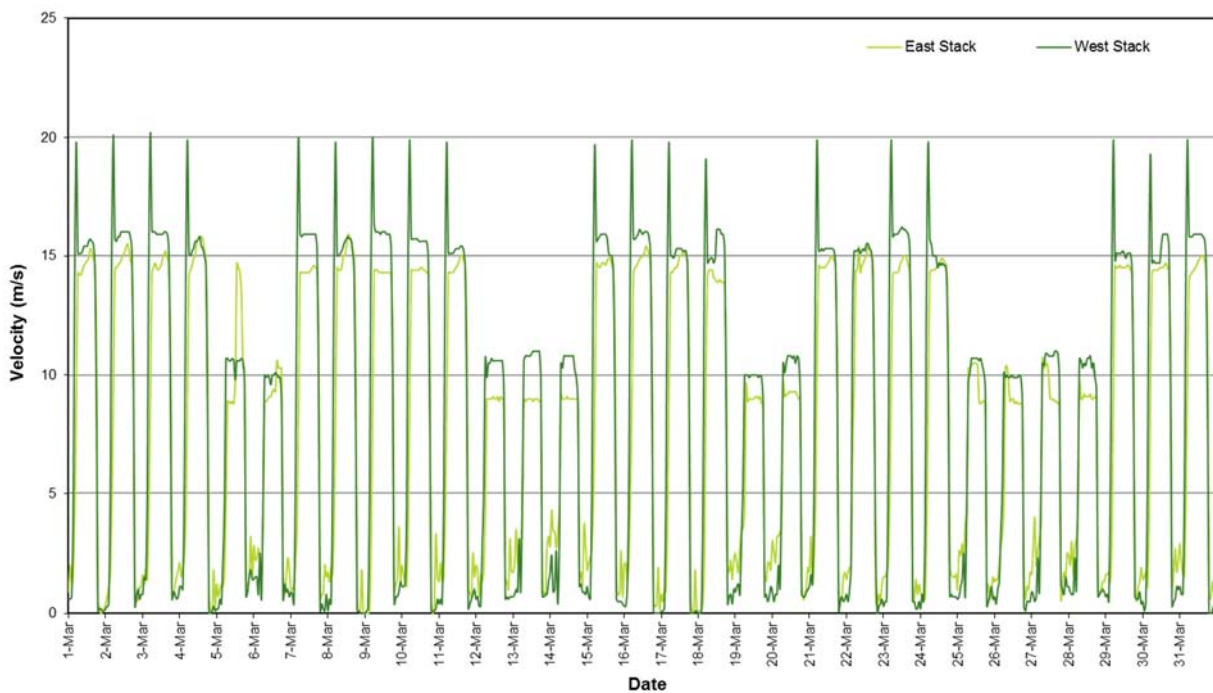


Figure 19: Stack Velocity (1 Hour Average)



8.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 25 and 26 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 25: Data Exceptions - Eastern Ventilation Stack: March 2016

Start	End	Parameter	Reason
6/03/2016 00:40	7/03/2016 08:20	NO, NO ₂ , NO _x	Instrument out of service
8/03/2016 15:00	8/03/2016 16:05	PM _{2.5}	Invalid data ¹
13/03/2016 02:20	13/03/2016 03:35	PM _{2.5}	Invalid data ¹
13/03/2016 07:10	13/03/2016 08:45	PM _{2.5}	Invalid data ¹
13/03/2016 14:40	13/03/2016 16:30	PM _{2.5}	Invalid data ¹
13/03/2016 23:50	14/03/2016 16:40	PM _{2.5}	Invalid data ¹
15/03/2016 02:10	15/03/2016 05:10	PM _{2.5}	Invalid data ¹
15/03/2016 10:25	15/03/2016 10:45	PM _{2.5}	Invalid data ¹
15/03/2016 12:30	15/03/2016 13:15	PM _{2.5}	Maintenance / calibration
15/03/2016 12:55	15/03/2016 13:05	PM ₁₀	Maintenance / calibration
23/03/2016 12:15	23/03/2016 13:05	NO, NO ₂ , NO _x	Maintenance / calibration
23/03/2016 12:15	23/03/2016 13:00	CO	Maintenance / calibration
23/03/2016 12:40	23/03/2016 13:10	PM _{2.5}	Maintenance / calibration
23/03/2016 12:50	23/03/2016 13:20	PM ₁₀	Maintenance / calibration

Note: ¹ – In the opinion of the reviewer.

Table 26: Data Exceptions - Western Ventilation Stack: March 2016

Start	End	Parameter	Reason
11/03/2016 13:00	11/03/2016 13:15	PM _{2.5}	Invalid data ¹
22/03/2016 00:40	24/03/2016 06:15	NO, NO ₂ , NO _x	Invalid data ¹
23/03/2016 14:40	23/03/2016 15:45	CO	Maintenance / calibration
24/03/2016 10:40	24/03/2016 11:35	PM _{2.5}	Maintenance / calibration
24/03/2016 10:55	24/03/2016 11:55	PM ₁₀	Maintenance / calibration

A number of periods occurred where PM_{2.5} concentrations were greater than the corresponding PM₁₀ concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- East Ventilation stack 01/03/2016 22:15 – 23:25
- East Ventilation stack 04/03/2016 19:40 – 20:25
- West Ventilation stack 18/03/2016 13:35 – 14:10
- West Ventilation stack 18/03/2016 22:35 – 22:50



9.0 DISCUSSION

9.1 Comparison with Licence Limits

EastLink emissions to air from the road tunnel ventilation stacks DP1 and DP2 are subject to the licence requirements contained in Environment Protection Authority (Victoria) Environmental Licence No. 2043 (The Licence).

The maximum measured 1 hour average mass rate for each parameter is compared with the applicable licence limit in Table 27.

Table 27: Maximum (1 Hour Average) Mass Rate (01/01/2016 - 31/03/2016)

Discharge Point No.	Discharge Description	Compound	Mass Rate (kg/h)	Licence Limit (kg/h)
1	Western ventilation stack	PM _{2.5}	0.85	2.4
		PM ₁₀	1.6	2.6
		NO ₂	1.4	3.98
		CO	20	112
2	Eastern ventilation stack	PM _{2.5}	0.45	2.4
		PM ₁₀	2.3	2.6
		NO ₂	1.4	3.98
		CO	19	112

There were no exceedences of the licence limits for DP1 and DP2 during the reporting period.

The procedure for reporting of particulate matter results from the TEOMs and assessment of licence compliance is outlined in the EastLink Particulate Matter Protocol (PMP) dated 17/6/2013 (Golder Reference 107613157-020-R-Rev0). The PMP requires validated uncorrected TEOM one hour clock average data to be reported and compared to the following TEOM mass rate compliance limits for both DP1 and DP2:

- PM_{2.5} (DP1, DP2): 2.0 kg/h
- PM₁₀ (DP1, DP2): 2.0 kg/h

There was no exceedences of the PM₁₀ or PM_{2.5} TEOM mass rate compliance levels for DP1 during the reporting period.

There was no exceedence of the PM_{2.5} TEOM mass rate compliance levels for DP2 during the reporting period. There was one exceedence of the PM₁₀ TEOM mass rate compliance level for DP2 on 22 /03/2016 08:00-09:00 hours.

9.2 Data Capture Year to Date

Data capture statistics for 2016 year to date (01/01/2016 – 31/03/2016) are presented in Table 28.

Table 28: Data Capture Year to Date (%)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀	Velocity
Eastern	95.7	94.2	98.6	99.9	100
Western	94.7	96.9	99.8	99.8	100



9.3 Bubble Licence

The Licence contains a Bubble Limit which specifies the annual discharge limits of each parameter for each ventilation stack. Annual emission rates are calculated from 1st July to 30th June each year to coincide with the Annual Performance Statement (APS) reporting period. Ventilation stack emission rates year to date (1/07/2015 to 31/03/2016) are shown in Table 29.

Table 29: Ventilation Stack Emissions 1/07/2015 – 1/03/2016 (tonnes/year)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀
Eastern	1.8	37	0.52	0.96
Western	1.7	31	0.46	0.90
Total	3.5	68	0.98	1.9
Licence limit	35	980	21	23

Figure 20 presents the ventilation stack emissions of each parameter as a percentage of the Licence limit compared with the percentage of APS reporting period elapsed.

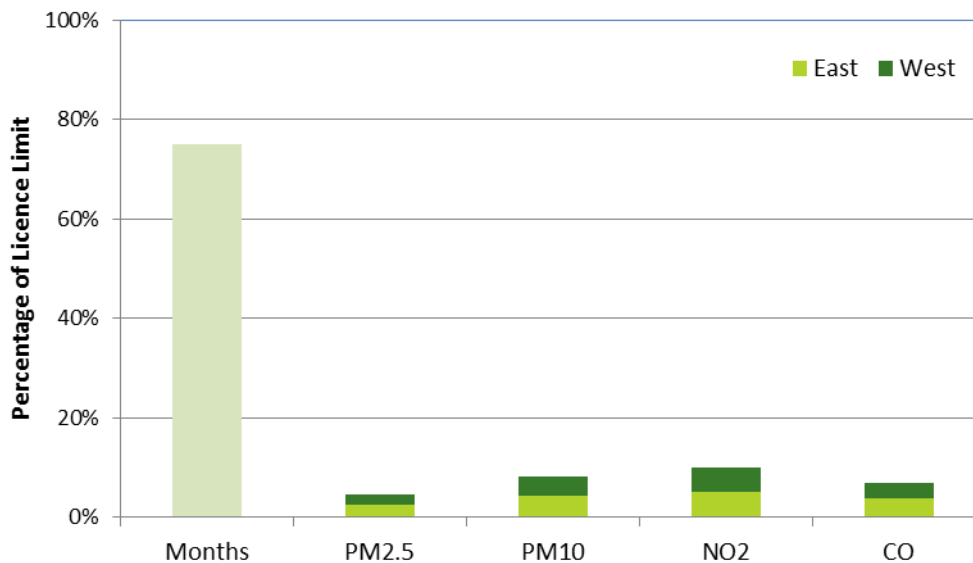


Figure 20: Ventilation Stack Emissions as Percentage of Licence Limit (1/07/2015 – 31/03/2016)

The corresponding bubble limits for uncorrected PM_{2.5} and PM₁₀ TEOM data are:

- PM_{2.5} (DP1 and DP2): 17.5 tonnes/year
- PM₁₀ (DP1 and DP2): 17.5 tonnes/year



Report Signature Page

GOLDER ASSOCIATES PTY LTD

Handwritten signature of Anthony Myszka in blue ink.

Anthony Myszka
Environmental Technician

Handwritten signature of Mark Tulau in blue ink.

Mark Tulau
Senior Air Quality Specialist

AM/MDT/am

A.B.N. 64 006 107 857

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

j:\env\2009\097613024 - eastlink stack\correspondence\correspondence out\097613024-047-r-rev0.docx



APPENDIX A

Important Information Relating to this Report



IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
Building 7, Botanicca Corporate Park
570 – 588 Swan Street
Richmond, Victoria 3121
Australia
T: +61 3 8862 3500

