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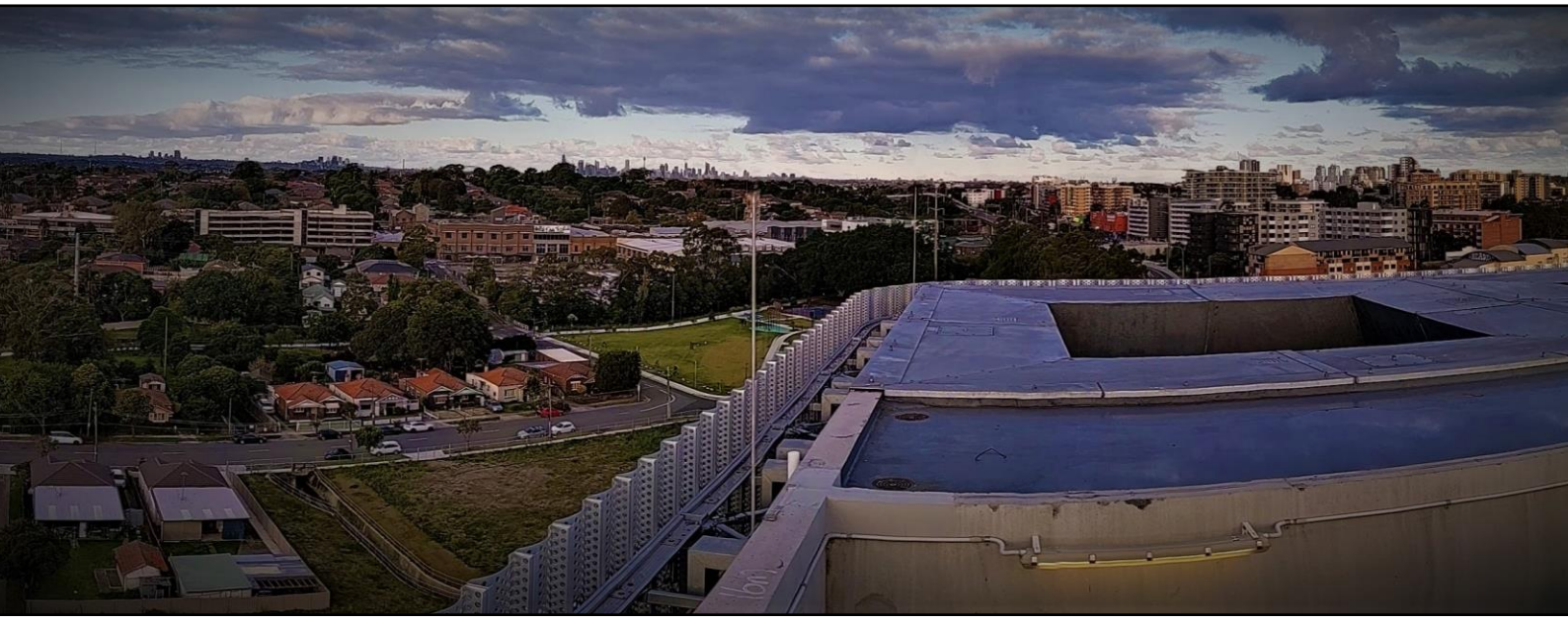

NEW M4 EAST: QUARTERLY COMPLIANCE EMISSIONS MONITORING

FULTON HOGAN EGIS O&M

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Table 1: History of Revisions

Revision	Date	Issued to	Changes
Draft_0	12/06/2020	Justin Hazelbrook	Draft report release for comment
R_0	16/06/2020	Justin Hazelbrook	Initial release, no changes from Draft_0.

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

Accreditation number: 19703

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EXECUTIVE SUMMARY

From 28 May and 1 June, Assured Environmental performed air emissions monitoring for Fulton Hogan Egis O&M in accordance with the New South Wales Environmental Protection Licence (Licence number – 21372). Monitoring was performed at two locations as listed below.

Table 2: Scope of works

EPA identification no.	Location description	Frequency	Scope
1	Western Vent Facility (URVF)	Quarterly	Particles (PM_{10} & $PM_{2.5}$)
2	Eastern Vent Facility (PRVF)	Quarterly	Particles (PM_{10} & $PM_{2.5}$)

In summary, there is no emission concentration limit for fine particulates, only the requirement to perform quarterly monitoring. A summary of the two tests is presented below, with further detail available in the body of this report.

Table 3: Test summary results for URVF

Parameter	Unit of measure	Test result	Licence limit
Site	-	URVF	-
Source	-	Vent Duct 1	-
Date	dd/mm/yyyy	1/06/2020	-
Time start	hh:mm	9:26	-
Time end	hh:mm	16:56	-
Exhaust air velocity	m/sec	10.81	-
Exhaust air temperature	°C	23	-
Exhaust air absolute pressure	mbar	996.7	-
Exhaust air moisture content	% v/v	1.0	-
Exhaust air density	kg/Nm^3	1.29	-
Exhaust air volume flow	Nm^3/sec-dry	197	-
Particulates - PM_{10}	mg/Nm^3	0.72	-
- emission rate	g/sec	0.14	-
Particulates - $PM_{2.5}$	mg/Nm^3	0.47	-
- emission rate	g/sec	0.09	-

Table 4: Test summary results for PRVF

Parameter	Unit of measure	Test result	Licence limit
Site	-	PRVF	-
Source	-	Vent A	-
Date	dd/mm/yyyy	28/05/2020	-
Time start	hh:mm	10:55	-
Time end	hh:mm	18:55	-
Exhaust air velocity	m/sec	7.40	-
Exhaust air temperature	°C	24	-
Exhaust air absolute pressure	mbar	1013.6	-
Exhaust air moisture content	% v/v	0.8	-
Exhaust air density	kg/Nm^3	1.29	-
Exhaust air volume flow	Nm^3/sec-dry	528	-
Particulates - PM_{10}	mg/Nm^3	0.52	-
- emission rate	g/sec	0.27	-
Particulates - $PM_{2.5}$	mg/Nm^3	0.23	-
- emission rate	g/sec	0.12	-

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GLOSSARY

Conversion of ppm to mg/Nm^3	Where R is the ideal gas constant; T, the temperature in kelvin (273.16 + T°C); and P, the pressure in mm Hg, the conversion is as follows: µg m^3 = (P/RT) x Molecular weight x (concentration in ppm) $= \frac{P \times \text{Molecular weight} \times (\text{concentration in ppm})}{62.4 \times (273.2 + T°C)}$ For the purposes of the air quality assessment all conversions were made at 0°C unless stated otherwise. Particulate matter is referenced to 0°C.
m^3/sec	Volume flow of exhaust gas in cubic meters per second. No normalisation has been performed, i.e. velocity in m/sec multiplied by the sample plane area in m^2.
Nm^3/sec	Volume flow of exhaust gas in cubic meters per second. Normalisation has been performed to dry, 273.16 °K and 101.325 kPa.
g/s	Grams of a pollutant emitted every second.
mg/Nm^3	Milligrams (10-3) per cubic metre. Conversions from mg/m^3 to parts per volume concentrations (i.e., ppm) are calculated at 0 °C.
µg/Nm^3	Micrograms (10-6) per cubic metre. Conversions from µg/m^3 to parts per volume concentrations (i.e., ppb) are calculated at 0 °C.
ppb	Parts per billion.
ppm	Parts per million.
PM_{10} & $PM_{2.5}$	Fine particulate matter with an equivalent aerodynamic diameter of less than 10 or 2.5 micrometres, respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
PM	Particulate matter, meaning total solid particles, regardless of size fraction, that can enter the isokinetic sampling system.
100th percentile	The value exceeded for 100 % of the time.

ABBREVIATIONS

US EPA	United State Environmental Protection Authority
AS	Australian Standard

1 INTRODUCTION

Assured Environmental (AE) was appointed by Fulton Hogan Egis O&M to conduct the Quarterly compliance monitoring as required by the Licence 21372, on the Western and Eastern Ventilation Facility release points.

The scope of work at both facilities is the same with the following measurements performed:

- Particulate matter (PM_{10}),
- Particulate matter ($PM_{2.5}$).

2 METHODOLOGY

One 'duct' (release point/vent) at each facility was tested. The fan settings were place in manual for the duration of the test to ensure a constant emission with no changes to the flow paths.

The methodology for this project was selected based on the requirements of the Licence and with reference to the '*Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*' document. The methodology is listed in Table 5 below along with AE's NATA accreditation in relation to the work.

Table 5: Test scope

Parameter	Unit	Reference test method	NSW EPA TM	NATA
Sample point selection	-	AS 4323.1	TM-1	Yes
Velocity	m/sec	USEPA Method 2	TM-2	Yes
Volume flow	m^3/sec	USEPA Method 2	TM-2	Yes
Temperature	°C	USEPA Method 2	TM-2	Yes
Gas molecular weight	g/g mole	USEPA Method 3	TM-23	Yes
Moisture content	% v/v	USEPA Method 4	TM-22	Yes
Solid particles – PM_{10}	mg/Nm^3	USEPA Method 201A	OM-5	Yes
Solid particles – $PM_{2.5}$	mg/Nm^3	USEPA Method 201A	OM-5	Yes

2.1 Subcontracted laboratories

To achieve a lower limit of detection, filters and sample rinses were analysed using a 5-point (0.01mg) balance. Sample weighing was performed by Envirolab Group (NATA ID. 2901 – Report ID. 244264).

2.2 Measurement uncertainty

There is an inherent uncertainty associated with any scientific measurement, including stack emissions monitoring. The measurement uncertainty can be controlled with adherence to the reference methodology which includes utilising appropriate calibration standards with corresponding acceptable uncertainty reports.

Many source sampling methods do not outline exact procedures for establishing direct measurement uncertainty. In the absence of a defined procedure, the uncertainty budgets presented are based on estimations using ISO-GUM method.

Each individual source and test may have a unique associated uncertainty, due largely to the stack sample location in relation to the positioning requirements of AS4323.1 and whether it meets the ideal or non-ideal descriptions.

Table 6: Uncertainty budget

Sample location	Parameter	Reference method	Uncertainty	Coverage factor	Confidence coefficient
			± %		%
URVF	Velocity	USEPA Method 2	10	2	95
	Temperature	USEPA Method 2	5.0	2	95
	Moisture content	USEPA Method 4	5.0	2	95
	PM_{10} & $PM_{2.5}$	USEPA Method 201A	20	2	95
PRVF	Velocity	USEPA Method 2	15	2	95
	Temperature	USEPA Method 2	5.0	2	95
	Moisture content	USEPA Method 4	5.0	2	95
	PM_{10} & $PM_{2.5}$	USEPA Method 201A	20	2	95

3 PROCESS DESCRIPTION

WestConnex M4 East (M4E) is a 14-km tolled section of M4 Western Motorway that runs between Parramatta and Haberfield in Sydney's inner west. The M4E tunnel sections are vented through two ventilation facilities known as Underwood Road Ventilation Facility (URVF) and Parramatta Road Ventilation Facility (PRVF).

3.1 Sampling Location

Access to the sampling locations is via stairs and ladders to the sample access points located near the top of the ventilation structures.

3.1.1 Western Ventilation Facility – URVF

The sample points at URVF contain nine 150mm diameter flanged sampling ports positioned along one face of the duct shown in Figure 1. Due to space constraints it is not possible to traverse the ventilation ducts using standard sampling probes. A guy wire system was devised where a series of 10mm diameter stainless steel wires were strung through the opposing sampling ports reaching across the entire width of each sampling traverse. Using a custom made sampling head attached to the guy wires we were able to slide the head into the duct and attach segments of piping to the sample head to push and pull it across the duct allowing compliant sampling. The custom sampling head housed the pitot tube, thermocouple, gas sample probe, filter housing and particle sizing device. The pitot lines, sample vacuum line, thermocouple lead & gas sampling line were contained inside the pipe which were attached to our sampling console and gas analyser system.

Figure 1: Inside URVF Vent 1

The sampling position was evaluated in accordance with AS 4323.1 to determine the total number sampling points, based on the cross-sectional area and effective distance from disturbances. It is noted that given the design of the structure and required exhaust duct size, meeting each requirement of the method is not possible. The assessment is summarised in the following tables and figures.

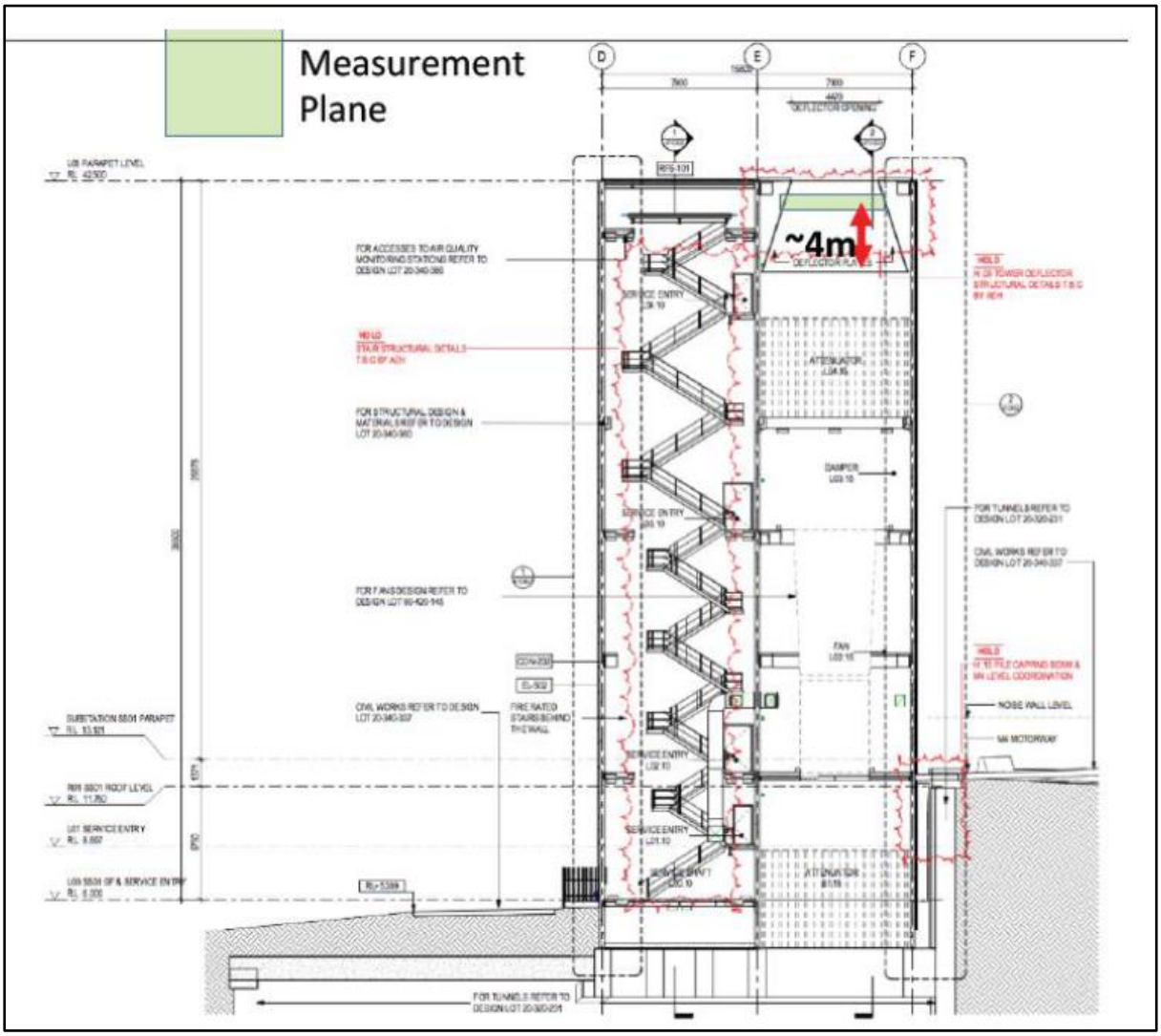

Figure 2: URVF Ventilation Duct 1 sampling plane – side view

Table 7: Source description – URVF

Sample location	URVF 1
Easting[a]	LAT -33.862491
Northing	LONG 151.082976
Stack Exit point from ground (m)	36
Stack Shape	RECTANGULAR
Equivalent Stack Diameter (m)	6.05
Stack Dimensions (m)	6.0 x 6.10
Stack Cross Section Area (m^2)	36.60
Distance to upstream disturbance (m)	4.0
Diameters (D)	0.7
Distance to downstream disturbance (m)	1.5
Diameters (D)	0.2
Total traverse point factors	1.38
Port size (mm)	150
Port Thread Type	Flange
Number of traverses	9
Number of points per traverse	9
Total number of traverse points (for velocity measurements)	81
Total number of traverse points (as per USEPA Method 201A sampling)	12
Condition check requirements (Section 4 – AS4323.1)	
(a) The gas flow is basically in the same direction	Yes
(b) The gas velocity at all points greater than 3 m/sec	Yes
(c) Gas flow profile is steady with <15° cyclonic flow component	Yes
(d) Temperature difference between points <10% of mean	Yes
(e) The highest to lowest pitot pressure and velocity < 9:1 and 1.6:1 respectively	Yes
(f) Gas temperature above dew point	Yes

[a] Coordinates from Google Earth®

3.1.1 Eastern Ventilation Facility – PRVF

The sample points at PRVF contain eleven 150mm diameter flanged sampling ports positioned along one face of the duct. Due to space constraints it is not possible to traverse the ventilation ducts using standard sampling probes. A guy wire system was devised where a series of 10mm diameter stainless steel wires were strung through the opposing sampling ports reaching across the entire width of each sampling traverse. Using a custom made sampling head attached to the guy wires we were able to slide the head into the duct and attach segments of piping to the sample head to push and pull it across the duct allowing compliant sampling. The custom sampling head housed the pitot tube, thermocouple, gas sample probe, filter housing and particle sizing device. The pitot lines, sample vacuum line, thermocouple lead & gas sampling line were contained inside the pipe which were attached to our sampling console and gas analyser system.

Figure 3: Inside PRVF Vent A

The sampling position was evaluated in accordance with AS 4323.1 to determine the total number sampling points, based on the cross-sectional area and effective distance from disturbances. It is noted that given the design of the structure and required exhaust duct size, meeting every requirement of the method is not possible. The assessment is summarised in the following tables and figures.

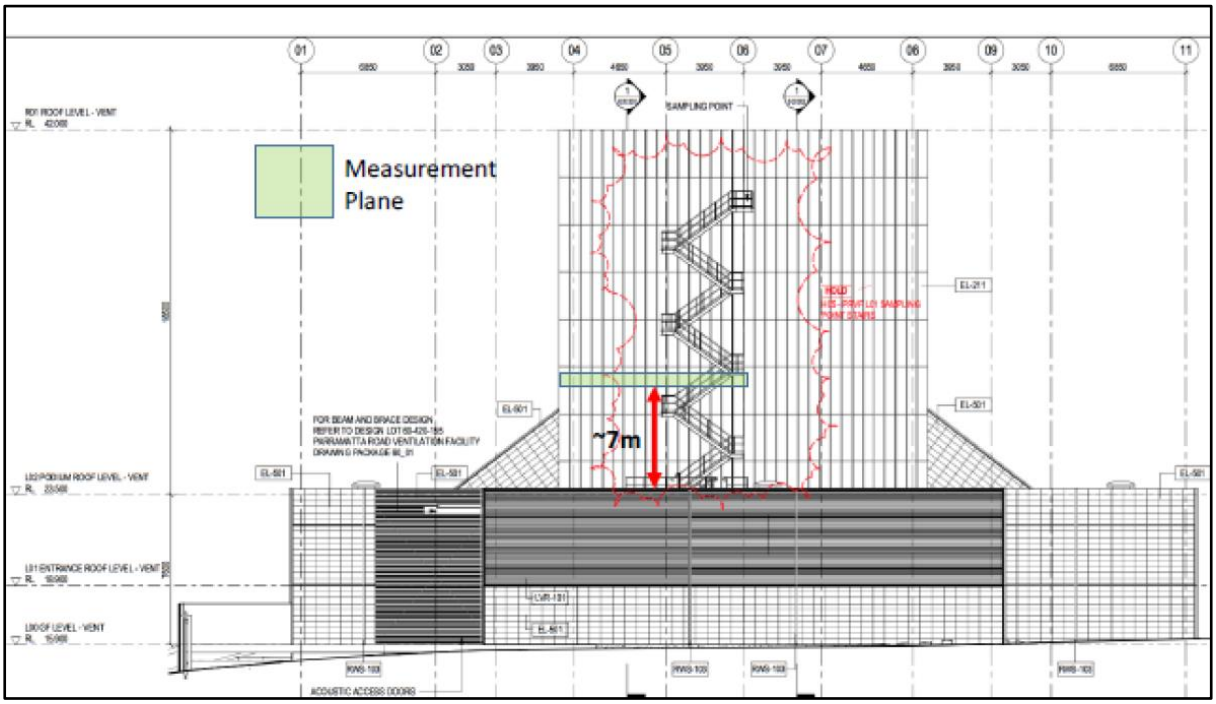

Figure 4: PRVF Ventilation Duct sampling plane – side view

Table 8: Source description – PRVF

Sample location	PRVF #A
Easting[b]	LAT -33.8775225
Northing	LONG 151.1302426
Stack Exit point from ground (m)	36
Stack Shape	RECTANGULAR
Equivalent Stack Diameter (m)	8.84
Stack Cross Section Area (m^2)	78.2
Stack dimensions (m)	8.85 x 8.83
Distance to upstream disturbance (m)	10.0
Diameters (D)	1.1
Distance to downstream disturbance (m)	10.0
Diameters (D)	1.1
Total traverse point factors	1.26
Port size (mm)	150
Port Thread Type	Flange
Number of traverses	11
Number of points per traverse	10
Total number of traverse points (for velocity measurements)	110
Total number of traverse points (as per USEPA Method 201A sampling)	12
Condition check requirements (Section 4 – AS4323.1)	
(a) The gas flow is basically in the same direction	Yes
(b) The gas velocity at all points greater than 3 m/sec	Yes
(c) Gas flow profile is steady with <15° cyclonic flow component	Yes[c]
(d) Temperature difference between points <10% of mean	Yes
(e) The highest to lowest pitot pressure and velocity < 9:1 and 1.6:1 respectively	No[d]
(f) Gas temperature above dew point	Yes

[b] Coordinates from Google Earth®

[c] A number of individual traverse points were found to have a cyclonic angle of up to 40°, however the average across all traverse points is below 15°.

[d] Given the size of the size of the duct and number of traverse points, it is difficult to meet this condition. The difference between highest and lowest pitot differential pressure was 10.8:1 and 3.2:1 for velocity.

4 QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

Assured Environmental operates within a quality system based upon the requirements of ISO17025. Our quality system defines specific procedures and methodologies to ensure any project undertaken by Assured Environmental is conducted with the highest level of quality given the specific confines of each project. The overall objective of our QA/QC procedures is to representatively sample and accurately analyse components in the gas streams and therefore report valid measurements of emission concentrations.

To ensure representativeness of field work, our quality procedures target:

1. Correct sampling locations
2. Sample time
3. Frequency of samples and
4. Method selection & adherence

To ensure representativeness of lab work, our quality procedures target:

1. Sample preservation
2. Chain of custody (COC)
3. Sample preparation and
4. Analytical techniques

Assured Environmental maintains strict quality assurance throughout all its sampling programs, covering on-site 'field work' and the analytical phase of our projects. Our QA program covers the calibration of all sampling and analytical apparatus where applicable and the use of spikes, replicate sample and reference standards. The test methodologies used for this project are outlined in the methods section of this document. Field test data has been recorded and calculated using direct entry into Microsoft Excel spreadsheets following the procedures of the appropriate test methods. Determination of emission concentrations has been performed using the same Microsoft Excel spreadsheets which are partially supplied as an attachment to this report. More detailed information can be supplied upon request.

QA/QC checks for this project will use validation techniques and criteria appropriate to the type of data and the purpose of the measurement to approve the test report. Records of all data will be maintained. Complete chain of custody (COC) procedures have been followed to document the entire custodial history of each sample. The COC forms also served as a laboratory sheet detailing sample ID and analysis requirements.

Table 9: Sampling data QA/QC checklist

Sampling Data QA/QC Checklist	Comment
Use of appropriate test methods	Yes
'Normal' operation of the process being tested	Yes – as instructed by client
Use of properly operating and calibrated test equipment	Yes
Use of high purity reagents	Yes
Performance of leak checks post sample (at least)	Yes

Table 10: Laboratory data QA/QC checklist

Laboratory Data QA/QC Checklist	Comment
Use of appropriate analytical methods	Yes
Use of properly operating and calibrated analytical equipment	Yes
Precision and accuracy comparable to that achieved in similar projects	Yes
Accurate reporting	Yes

5 RESULTS

The results of the measurements are presented below along with other pertinent data associated with the tests.

Table 11: URVF results

Source Data		URVF
Client		FHEOM
Site		URVF
Sample Point		Vent Duct 1
Reference Method		USEPA M201A
Test Parameters		PM10 & 2.5
Historical Data & Hardware Information - Manual Sample		
Run Start Date	dd-mm-yy	Monday, 1 June 2020
Project ID		12217
Run ID		-2
Run Start Time	hh:mm	9:26
Run Stop Time	hh:mm	16:56
Console Serial Number		SN256 APEX console
Meter Calibration Factor		0.97
Orifice Coefficient	(DH@)	45.30
Pitot Tube Coefficient		0.84
Actual Nozzle Diameter	mm	7.66
Stack Test Data		
Actual Sampling Time	minutes	450
Average Meter Temperature	°C	25
Average Stack Temperature	°C	23
Barometric Pressure	mb	996
Stack Static Pressure	mm H_2O	9.0
Absolute Stack Pressure	mb	996.7
Sample Volumes		
Actual Meter Volume	m^3	7.064
Standard Meter Volume	Nm^3	6.373
Moisture Content Data		
Calculated Stack Moisture	%	1.0
Stack Gas Density Analysis Data		
Dry Gas Density	kg/Nm^3	1.29
Dry Gas Molecular Weight	g/g-mole	28.84
Wet Stack Gas Molecular Weight	g/g-mole	28.81
Volumetric Flow Rate Data (at Sample Plane)		
Average Stack Gas Velocity	m/sec	6.0
Efflux factor		1.81
Average Efflux Stack Gas Velocity	m/sec	10.8
Actual Stack Flow Rate	m^3/sec	219
Wet Standard Stack Flow Rate	$Nm^3/sec\text{-}wet$	199
Dry Standard Stack Flow Rate	$Nm^3/sec\text{-}dry$	197
Percent of Isokinetic Rate	%	95
USEPA Method 201A		
D50	µm	10.1
D50 Criteria check	µm	D50 OK
Total Mass of PM_{10}	g	0.0046
Stack PM_{10} Concentration	mg/Nm^3	0.72
PM_{10} Emission Rate	g/sec	0.14
Total Mass of $PM_{2.5}$	g	0.0030
Stack $PM_{2.5}$ Concentration	mg/Nm^3	0.469
$PM_{2.5}$ Emission Rate	g/sec	0.092

Table 12: PRVF results

Source Data		PRVF
Client		Fulton Hogan Egis
Site		PRVF
Sample Point		Vent A
Reference Method		USEPA M201A
Test Parameters		PM10 & 2.5
Historical Data & Hardware Information - Manual Sample		
Run Start Date	dd-mm-yy	Thursday, 28 May 2020
Project ID		12217
Run ID		-1
Run Start Time	hh:mm	10:55
Run Stop Time	hh:mm	18:55
Console Serial Number		SN256 APEX console
Meter Calibration Factor		0.97
Orifice Coefficient	(DH@)	45.30
Pitot Tube Coefficient		0.84
Actual Nozzle Diameter	mm	6.01
Stack Test Data		
Actual Sampling Time	minutes	480
Average Meter Temperature	°C	20
Average Stack Temperature	°C	24
Barometric Pressure	mb	1014
Stack Static Pressure	mm H_2O	-3.8
Absolute Stack Pressure	mb	1013.6
Sample Volumes		
Actual Meter Volume	m^3	5.292
Standard Meter Volume	Nm^3	4.939
Moisture Content Data		
Calculated Stack Moisture	%	0.8
Stack Gas Density Analysis Data		
Dry Gas Density	kg/Nm^3	1.29
Dry Gas Molecular Weight	g/g-mole	28.84
Wet Stack Gas Molecular Weight	g/g-mole	28.75
Volumetric Flow Rate Data (at Sample Plane)		
Average Stack Gas Velocity	m/sec	7.4
Efflux factor		1.00
Average Efflux Stack Gas Velocity	m/sec	7.4
Actual Stack Flow Rate	m^3/sec	578
Wet Standard Stack Flow Rate	Nm^3/sec-wet	532
Dry Standard Stack Flow Rate	Nm^3/sec-dry	528
Percent of Isokinetic Rate	%	100
USEPA Method 201A		
D50	µm	10.1
D50 Criteria check	µm	D50 OK
Total Mass of PM_{10}	g	0.0026
Stack PM_{10} Concentration	mg/Nm^3	0.52
PM_{10} Emission Rate	g/sec	0.27
Total Mass of $PM_{2.5}$	g	0.0012
Stack $PM_{2.5}$ Concentration	mg/Nm^3	0.235
$PM_{2.5}$ Emission Rate	g/sec	0.124