8.17. Air Quality Monitoring Station - St Leonards Park

AUTHOR: Peter Massey, Environmental Services Manager

ENDORSED BY: Rob Emerson, Director Open Space and Environmental Services

ATTACHMENTS:
1. Air Quality Final Report [**8.17.1** - 28 pages]

PURPOSE:

Provide details on the outcomes of the monitoring of the background air quality that occurred from March 2020 to March 2021 at St Leonards Park.

EXECUTIVE SUMMARY:

The report outlines the ambient air quality concentrations of measured parameters through the installation of an Air Quality Monitoring Station (AQMS) at St Leonards Park. The AQMS was installed on a twelve month temporary basis and the ambient air quality results were all below the NSW EPA goals for particulate matter and oxides of nitrogen. The report also details the relevant conditions of approval for the operation of the Western Harbour Tunnel facility in relation to ambient air quality.

FINANCIAL IMPLICATIONS:

There are no financial implications associated with this report

RECOMMENDATION:

1. THAT Council receive and note the Baseline Ambient Air Quality Monitoring Program report.

LINK TO COMMUNITY STRATEGIC PLAN

The relationship with the Community Strategic Plan is as follows:

1. Our Living Environment
1.3 Quality urban greenspaces

2. Our Built Infrastructure
2.1 Infrastructure and assets meet community needs

BACKGROUND

Council at its meeting dated 26th August 2019 resolved to employ the services of an air quality consultant to undertake an air quality monitoring program for a period of twelve months in the vicinity of the proposed Western Harbour Tunnel Beaches link ventilation stacks.

The above Council resolution was considered necessary as the State Government refused to undertake baseline air quality monitoring in the vicinity of the ventilation stacks.

After numerous sites were considered, it was decided, for several technical reasons, that a specific location in St Leonards Park be selected. The Air Quality Monitoring Station (AQMS) was operational from 20 March 2020 to 21 March 2021.

CONSULTATION REQUIREMENTS

Community engagement is not required.

DETAIL

Specifically, the AQMS was installed in the southeastern corner of St Leonards Park, 60 metres west of Warringah Freeway and 35 metres north of Ridge Street North Sydney.

The monitoring program included the continuous monitoring of the following air pollutants:

- Fine Particulates
    - PM_{10}
    - $PM_{2.5}$
- NO_x (NO and NO_2)

Also meteorological monitoring of:

- Wind speed and wind direction;
- Relative humidity;
- Solar radiation;
- Temperature and ;
- Barometric pressure.

Fine particulates (PM_{10} and $PM_{2.5}$) were measured as they refer to a category of airborne particles that are capable of penetrating the lungs. The potential adverse health impacts included increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary diseases and heart disease and reduced lung capacity in asthmatic children.

Oxides of nitrogen (NO) were measured as they include a mixture of nitrogen oxides formed during combustion. NO_2 can have significant health impacts in the short term such as damage to the respiratory tract and increased susceptibility to respiratory infections and asthma. Long term affects included lung disease.

The defining ambient air quality criteria for NSW as specified by the NSW Environment Protection Authority (EPA) are as follows;

Table 1

Pollutant	Averaging Period	Concentration	
PM_{10}	24 hours Annual	50 µg/m^3 25 µg/m^3	- -
$PM_{2.5}$	24 hours Annual	25 µg/m^3 8 µg/m^3	- -
NO_2	1 hour Annual	246µg/m^3 62 µg/m^3	120 ppb 30 ppb

The siting of the AQMS, the pollutant and meteorological monitoring were conducted in accordance with Australian Standard/NZ Standard AS/NZ 3580 (2007) "Methods for sampling and analysis of ambient air".

The results of the monitoring were then presented to Council via a monthly report and on a "real time" basis via a link through Council's website.

Results

Representation of the 24-hour PM_{10} concentrations are presented in Table 2. No exceedances of the relevant criteria as outlined in Table 1 were recorded with the highest 24-hour PM_{10} concentration recorded being 49.6µg/m^3 on 24th April 2020. The annual average PM_{10} concentration was 19.1µg/m^3.

Table 2 PM_{10} Results St Leonards Park 24-hour period and Annual Average

Data Summary	PM_{10} 24-hour average (µg/m^3)	PM_{10} annual average (µg/m^3)
Minimum	1	19.1
Maximum	49.6	
Air Quality Criteria	50	25

Representation of the 24-hour $PM_{2.5}$ concentrations are presented in Table 3. No exceedances of the 24-hour criteria were recorded with the maximum concentration recorded as 19.9 µg/m^3 on 3rd October 2020. The annual average $PM_{2.5}$ concentration was 5.4 µg/m^3 .

Table 3 $PM_{2.5}$ Results St Leonards Park 24-hour period and Annual Average

Data Summary	$PM_{2.5}$ 24-hour average (µg/m^3)	$PM_{2.5}$ annual average (µg/m^3)
Minimum	0.2	5.4
Maximum	19.9	
Air Quality Criteria	25	8

Table 4 shows the minimum and maximum 1-hour NO_2 concentrations recorded at St Leonards Park. It can be seen that no exceedances of the 1-hour criteria was recorded with the maximum 1-hour concentration being 63.2ppb on 22 April 2020. The annual average NO_2 concentration was 12.3 ppb.

Table 4 NO_2 Results St Leonards Park 1-hour Average and Annual Average

Data Summary	NO_2 1-hour average (ppb)	NO_2 annual average (ppb)
Minimum	<0.1	12.3
Maximum	63.2	
Air Quality Criteria	120	30

Discussion

The ambient air quality concentrations of oxides of NO, PM_{10} and $PM_{2.5}$ that were found during the twelve-month monitoring period were all below the air quality criteria as defined by the Environment Protection Authority as outlined in Table 1.

The conclusion reached by the air quality consultant responsible for the monitoring noted

"that the entire region surrounding the monitoring station was impacted for large periods of the monitoring program by reduced traffic volumes due to Covid 19 restrictions and the reported maximums and annual averages may be conservatively low compared to baseline conditions under normal traffic conditions."

To address the Covid 19 concentration anomalies, the final data summary report dated September 2021 (attached), the consultant has attempted to draw comparisons between the historic ambient air quality data recorded at the nearest permanent AQMS located at Rozelle and the St Leonards Park setting. The consultant argues due to the proximity, similar surrounding land uses and dense road networks that both AQMS were expected to experience similar trends. When the comparisons are made, there are differences in results between PM_{10} and $PM_{2.5}$ and differences between the 24-hour and annual averages between Rozelle and St Leonards Park. Concentrations of oxides of nitrogen, both on an 1-hour and annual average indicate higher concentrations at St Leonards Park. The results for the two locations differ depending upon the parameter measured.

The other factor potentially influencing the results were neighbouring construction works that were occurring while the monitoring station was collecting data. In reality, there was minor soil stabilisation works and returfing occurring for four weeks from early April to early May 2020. It is not considered a major factor in the influencing of the air quality data collected.

Concurrently, during the period that the AQMS was operational at St Leonards Park, infrastructure approval was granted on 21st January 2021 to the Western Harbour Tunnel and Warringah Freeway upgrade together with several approval conditions, a number of which directly relate to air quality.

The aforementioned conditions of consent relevant to air quality, both during the construction and operational phase of the Western Harbour Tunnel are contained within Part C (Construction Environment Management Plan) and Part E (Air Quality and Odour). Specifically, the conditions E1-E37 directly relate to such issues as air quality monitoring and reporting, acceptable emission standards, design and operation of the ventilation system and non-compliance protocols.

The above conditions also oblige the operator of the motorway facility to establish two ground level ambient air quality receptors located near the Cammeray ventilation outlet at least one year prior to commencement of the use of the facility and two years after the facility is utilised. There are no obligations for the operator to monitor ambient air quality beyond the above timeframes.

ST LEONARDS PARK

Baseline Ambient Air Quality Monitoring Program
Final Data Summary
20 March 2020 to 21 March 2021

Prepared for:

North Sydney Council
200 Miller Street
North Sydney NSW 2060

SLR Ref: 610.18926-R18
Version No: -v1.1
September 2021

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Tenancy 202 Submarine School, Sub Base Platypus, 120 High Street
North Sydney NSW 2060 Australia

T: +61 2 9427 8100
E: sydney@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with North Sydney Council (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18926-R18-v1.1	30 September 2021	Danroy Dsouza	Graeme Starke	Ali Naghizadeh
610.18926-R18-v1.0	26 May 2021	Danroy Dsouza	Graeme Starke	Ali Naghizadeh

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TABLES

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1 Introduction

SLR Consulting Pty Ltd (SLR) was commissioned by the North Sydney Council to install and operate an Air Quality Monitoring Station (AQMS) at St. Leonards Park, North Sydney (the Project Site) in order to undertake a baseline air quality monitoring program. SLR commenced the monitoring program on 20/03/2020 and performed routine maintenance on the AQMS. The following parameters were measured by the AQMS:

- Continuous Monitoring for Fine Particulates:
  - PM_{10}
  - $PM_{2.5}$
- Continuous Monitoring for NO_X (NO and NO_2)
- Meteorological Monitoring

This report is a summary of all air quality and meteorological monitoring conducted over one year between 20 March 2020 to 21 March 2021.

2 Factors Influencing Monitoring Data

2.1 Neighbouring construction works

SLR observed ongoing construction works including earthworks, stockpiling and heavy machinery operation in close proximity (approximately 10 meters (m)) to the AQMS located at St Leonards Park after commissioning the AQMS and while performing routine maintenance. It is noted that these operations are likely to impact PM_{10}, $PM_{2.5}$ and NO_X (NO and NO_2) monitoring results presented in this report and may not be indicative of baseline air pollution levels in the neighbouring area.

2.2 COVID- 19 restrictions

Owing to the recent COVID-19 pandemic and the subsequent ongoing restrictions imposed by the NSW Government, a reduction in traffic volumes is expected along all neighbouring roads. This in turn is likely to cause lower PM_{10}, $PM_{2.5}$ and NO_X (NO and NO_2) concentrations in ambient air.

In order to identify the extent of this impact SLR analysed publicly available historic ambient air quality data recorded at the nearest NSW Office of Environment and Heritage (OEH) AQMS located at Rozelle, approximately 5.5 kilometres (km) southwest of the Project Site. Additionally, land use around the Rozelle AQMS comprises mainly of public recreation, residential and commercial buildings and relatively dense road network which is similar to that around the Project Site. Thus, due to proximity and similar land uses both stations are expected to experience similar trends in ambient air quality.

Figure 1 shows monthly average PM_{10} concentrations recorded at the Rozelle AQMS from 1 January 2016 to 31 March 2021. It also highlights average monthly PM_{10} concentrations recorded between March 2020 to March 2021 (shown as green and yellow bars) which coincides with the current monitoring program at St Leonards Park (20 March 2020 to 21 March 2021) and compares the average concentration for each month with the average long term (2016 to 2019) monthly trends (represented as a blue line).

Based on the data presented in **Figure 1**, it can be observed that monthly average PM_{10} concentrations recorded between March 2020 and March 2021 (shown as green and yellow bars) are lower for all months when compared to the long term monthly trends in PM_{10} concentrations (shown as a blue line) with the exception of June 2020. December 2020 represents the most significant variation from the long-term trend of up to 32%.

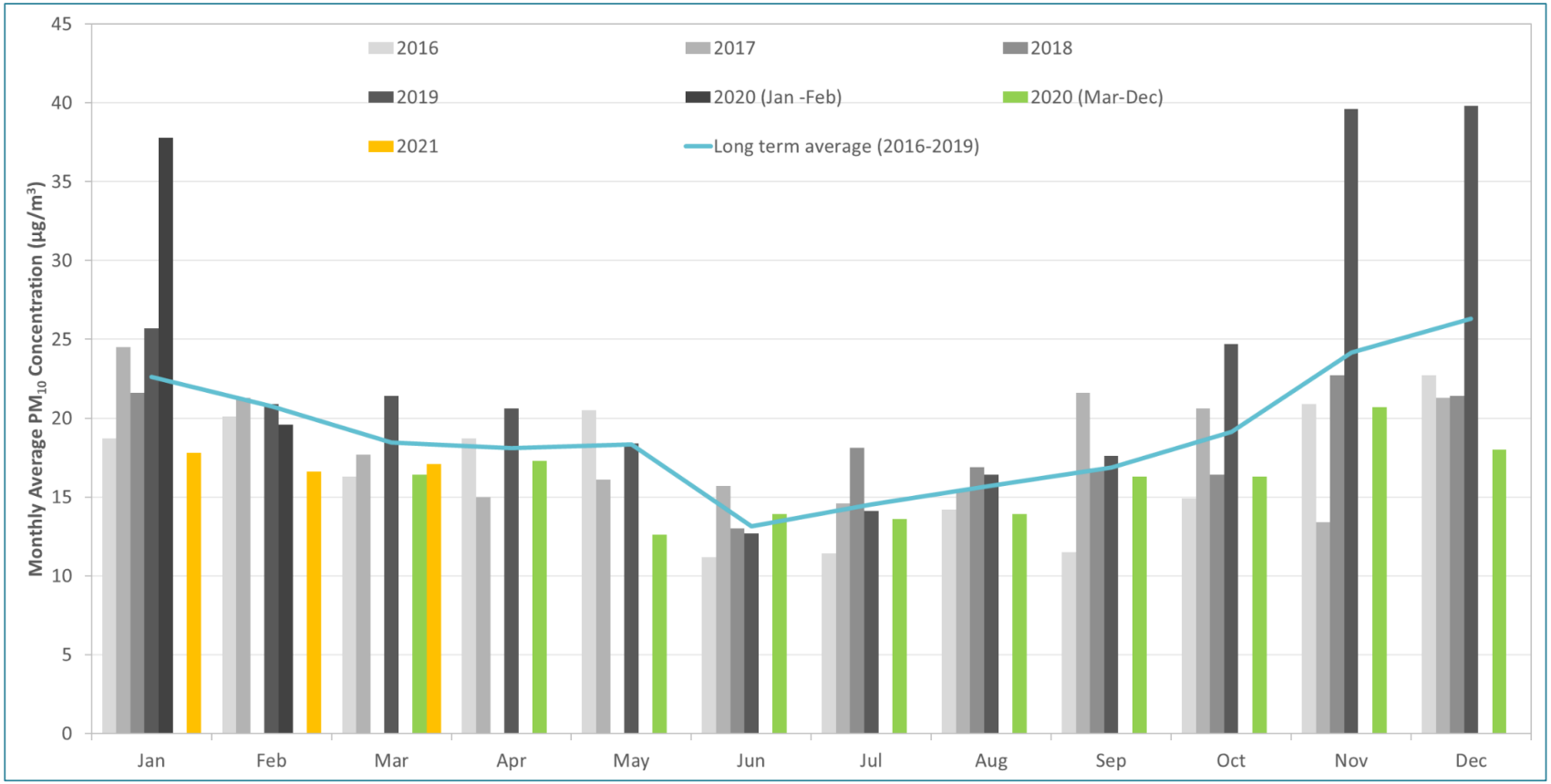
Similarly, **Figure 2** and **Figure 3** compare long term (2016-2019) trends in monthly $PM_{2.5}$ and NO_2 concentrations recorded at Rozelle AQMS, respectively with the monthly average data for the period coinciding with the current monitoring program (March 2020 to March 2021). It can be observed that monthly average $PM_{2.5}$ and NO_2 concentrations recorded between March 2020 and March 2021 are lower than the long term mean monthly trends for the respective pollutants for all months with the exception of June 2020 for $PM_{2.5}$ and March and April 2020 for NO_2. In both cases the month of December represents the highest rate of variation from the long-term trend with 50% variation in monthly average $PM_{2.5}$ concentrations and 48% variation in monthly average NO_2 concentrations from the respective long-term mean concentrations.

It is noted that the average monthly PM_{10}, $PM_{2.5}$ and NO_2 concentrations for the months of November and December 2019 are likely to be significantly influenced by severe bushfires in the region. Nevertheless, a trend showing lower than usual monthly average concentration of ambient air pollutants is evident for the period of March 2020 to March 2021. This may be attributed to lower vehicle emissions due to the subsequent COVID-19 restrictions.

Thus, ambient air quality monitoring conducted by SLR at the neighbouring St Leonards Park AQMS between 20 March 2020 to 21 March 2021 is unlikely to be representative of baseline ambient air pollution levels in the region.

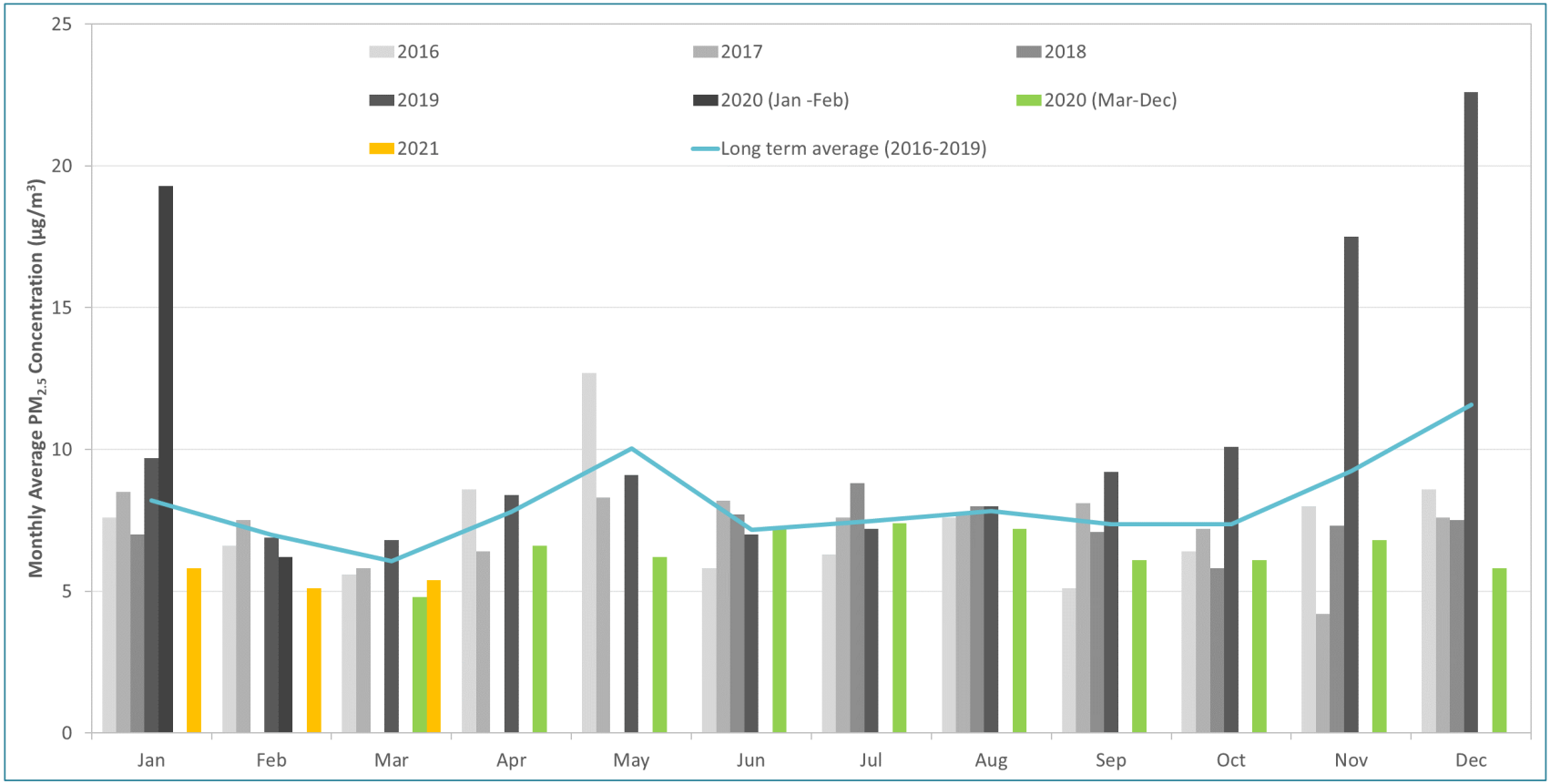
The implication of these impacts is that validating operational monitoring against the predicted impacts, from the environmental impact statement, will be difficult.

Figure 1 Monthly Average PM_{10} Concentrations Recorded at Rozelle AQMS – 1 January 2016 to 31 March 2021



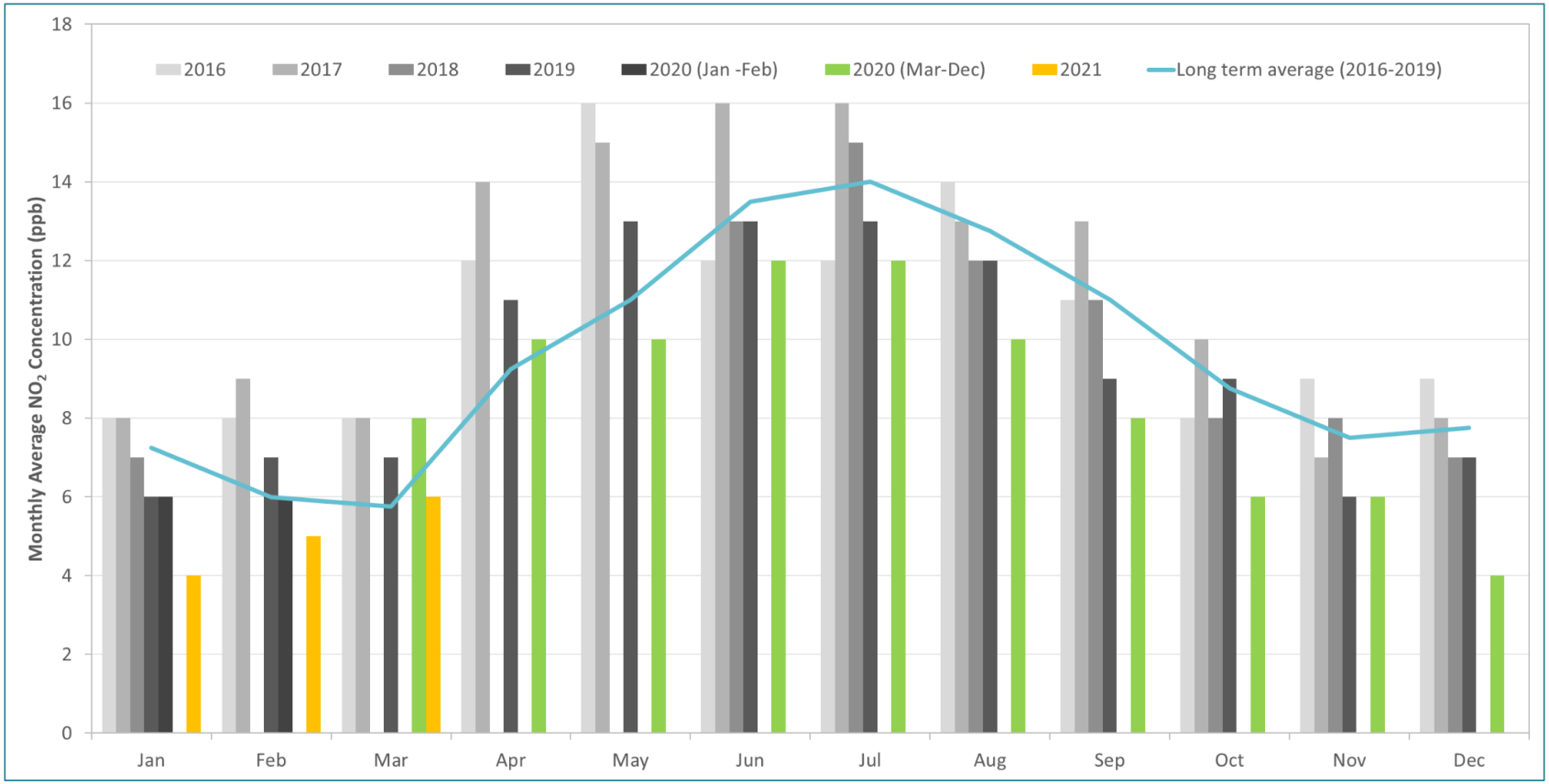
Note – data coinciding with the St Leonards Park AQMS monitoring period (March 2020 to March 2021) are shown as green and yellow bars respectively

Figure 2 Monthly Average $PM_{2.5}$ Concentrations Recorded at Rozelle AQMS – 1 January 2016 to 31 March 2021



Note – data coinciding with the St Leonards Park AQMS monitoring period (March 2020 to March 2021) are shown as green and yellow bars respectively

Figure 3 Monthly Average NO_2 Concentrations Recorded at Rozelle AQMS – 1 January 2016 to 31 March 2021



Note – data coinciding with the St Leonards AQMS monitoring period (March 2020 to March 2021) are shown as green and yellow bars respectively

3 Project Site Location

As shown in **Figure 4** the AQMS is located in southeast part of St Leonards Park, North Sydney. The monitoring station is located approximately 3 kilometres (km) from Sydney CBD. The AQMS is surrounded by the park in all directions and is approximately 60 m west of Warringah Freeway and 35 m north of Ridge Street.

Figure 4 Project Location

4 Pollutants Monitored

The current scope of this monitoring program includes the continuous monitoring of the following air pollutants:

4.1 Fine Particulates (PM_{10} and $PM_{2.5}$)

Airborne contaminants that can be inhaled directly into the lungs can be classified on the basis of their physical properties as gases, vapours or particulate matter. In common usage, the terms “dust” and “particulates” are often used interchangeably.

The term Total Suspended Particulate (TSP) refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm. Particulate matter with an aerodynamic diameter of 10 microns or less is referred to as PM_{10} while particulate matter with an aerodynamic diameter of 2.5 micros or less is referred to as $PM_{2.5}$.

The PM_{10} size fraction is sufficiently small to penetrate the large airways of the lungs, while $PM_{2.5}$ particulates are generally small enough to be drawn in and deposited into the deepest portions of the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children. The main anthropogenic sources of particulate matter in the air include construction activities, motor vehicles and other fuel combustion processes.

4.2 Oxides of Nitrogen (NO_X- NO and NO_2)

Oxides of nitrogen (NO_X) is a general term used to describe any mixture of nitrogen oxides formed during combustion. In atmospheric chemistry NO_X generally refers to the total concentration of nitric oxide (NO) and nitrogen dioxide (NO_2).

NO is a colourless and odourless gas that does not significantly affect human health. However, in the presence of oxygen, NO can be oxidised to form NO_2 which can have significant health effects including damage to the respiratory tract and increased susceptibility to respiratory infections and asthma. Long term exposure to NO_2 can lead to lung disease.

NO, emitted from combustion sources such as vehicle exhausts, will be converted to NO_2 in the atmosphere after leaving a car exhaust.

5 Air Quality Criteria

Air quality guidelines specified by the NSW Environmental Protection Agency (EPA) for the pollutants monitored by the St Leonards Park AQMS are published in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2017) [hereafter 'Approved Methods']. The ground level air quality impact assessment criteria listed in Section 7 of the Approved Methods have been established by NSW EPA to achieve appropriate environmental outcomes and to minimise associated risks to human health as published in the Approved Methods. They have been derived from a range of sources and are the defining ambient air quality criteria for NSW and are considered to be appropriate for use in this assessment.

A summary of the relevant criteria for particulate matter and NO_2 is provided in **Table 1**.

Table 1 NSW EPA Goals for Particulate Matter and NO_2

Pollutant	Averaging Period	Concentration	
PM_{10}	24 Hours Annual	50 µg/m^3 25 µg/m^3	-
$PM_{2.5}$	24 Hours Annual	25 µg/m^3 8 µg/m^3	-
NO_2	1 hour Annual	246 µg/m^3 62 µg/m^3	120 ppb 30 ppb

Source: NSW EPA, 2017

6 Air Quality Monitoring Methodology

The monitoring location was selected as best as practicable in accordance with Australian Standard/New Zealand Standard, AS/NZS 3580.1.1:2007 Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment. A summary of monitoring methodologies undertaken at the AQMS located at St. Leonards Park is provided in **Table 2.**

Table 2 Summary of monitoring Methodology

Parameter	Test Method
Site Selection	AS/NZS 3580.1.1:2016
PM_{10} (TEOM)	AS/NZS 3580.9.8:2008
$PM_{2.5}$ (TEOM)	AS/NZS 3580.9.13:2013
$PM_{2.5}$ (BAM1022)	AS/NZS 3580.9.12:2013
NO_2	AS/NZS AS3580.5.1:2011
Meteorology	AS/NZS 3580.14:2014

6.1 Particulate Monitoring (PM_{10} and $PM_{2.5}$)

Ambient PM_{10} monitoring was undertaken in accordance with Australian Standard AS/NZS 3580.9.8:2008 Methods for sampling and analysis of ambient air Determination of suspended particulate matter - PM_{10} continuous direct mass method using a tapered element oscillating microbalance (TEOM) analyser using Thermo Scientific TEOM Series 1405 from 20 March 2020 to 21 March 2021.

Ambient $PM_{2.5}$ monitoring was undertaken in accordance with AS/NZS 3580.9.13:2013 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 using Thermo Scientific TEOM Series 1405 from 20 March 2020 to 31 October and in accordance with AS/NZS 3580.9.12:2013 Methods for sampling and analysis if ambient air Determination of suspended particulate matter- $PM_{2.5}$ beta attenuation monitors using a Met One Instruments, Inc. BAM 1022, real-time portable beta attenuation mass monitor from 1 November 2020 to 21 March 2021.

The main principle of measurement for the TEOMs consists of ambient air being drawn through a size selective inlet at a constant flow rate of 16.7 litres per minute (L/min) which is then separated using an isokinetic splitter into a main flow (3 L/min) and an auxiliary/by-pass flow (13.7 L/min). The main flow enters the sensor unit and then passes through an exchangeable sample filter placed at the tip of an oscillating hollow tapered element. As sample air is drawn through the filter, suspended particle matter accumulates on the filter. Increased mass on the filter reduces the frequency at which the hollow tapered element oscillates. A precision electronic counter measures the oscillating frequency with a two-second sampling period.

On the other hand, the BAM1022 working principle involves the loss of energy or absorption of high-energy electrons emanating from radioactive decay (beta rays) on interaction with matter. This process is known as beta attenuation. When matter is placed between a radioactive source and a sensor, a reduction in the number of beta particles is detected. This measured magnitude of reduction in beta particles is a function of the mass of the absorbing matter. The number of beta particle passing through matter, such as particulate matter deposited on filter media after sampling through a size selected inlet, decreases nearly exponentially with the mass of deposited particulate.

SLR also performed data validation of hourly concentrations based on guidance in relevant standards, manufacturer's instructions and techniques adopted by the Queensland Department of Environment and Science (DES, 2019).

6.2 NO_X (NO and NO_2) Monitoring

Continuous monitoring of ambient NO_2 concentrations was conducted in accordance with AS 3580.5.1:2011 using Thermo Scientific 42*i* analyser from 20 March 2020 to 31 May 2020 and using Thomson 200E gas analyser from 01 June 2020 to 21 March 2021. The working principle of the gas analysers involves a sample of the ambient air being presented to the instrument, in which the response of the detector based on chemiluminescent technology is recorded as a concentration.

SLR also performed data validation on hourly concentrations based on guidance in relevant standards, and manufacturer's instructions.

6.3 Meteorological Monitoring

Meteorological monitoring was conducted 20 March 2020 to 21 March 2021 in accordance with AS/NZS 3580.14:2014 Methods for sampling and analysis of ambient air - Meteorological monitoring for ambient air quality monitoring applications. All sensors were provided with current factory calibration certificates prior to deployment.

The following parameters are presented in the current reporting period:

- Wind speed and wind direction sensor
- Relative humidity
- Solar radiation
- Temperature
- Barometric pressure
- Rainfall

7 Air Quality Monitoring Results

7.1 Particulate Monitoring (PM_{10} and $PM_{2.5}$)

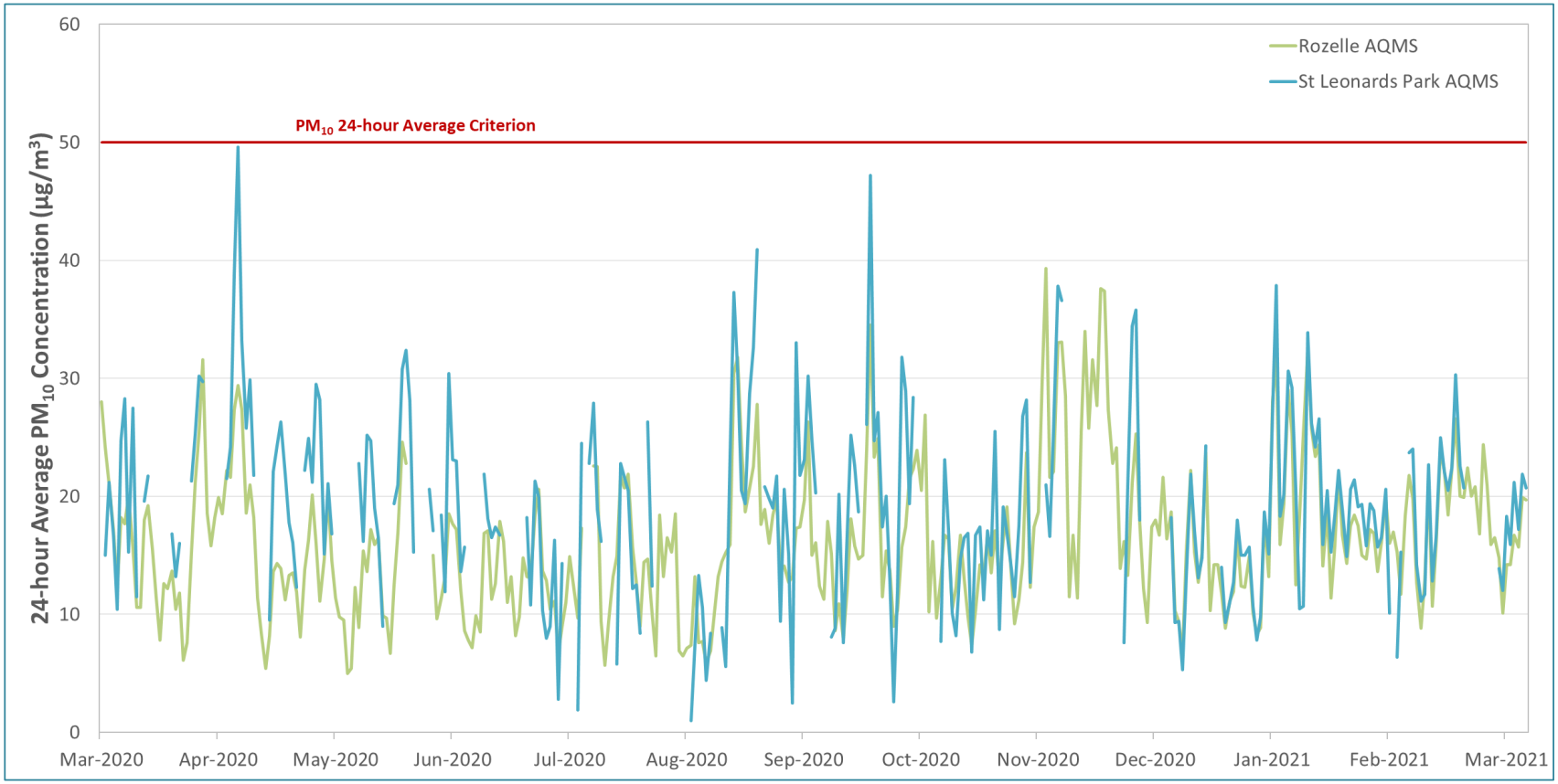
Graphical representation of the 24-hour PM_{10} concentrations measured by the St Leonards Park AQMS are presented in **Figure 5** for the monitoring period 20 March 2020 to 21 March 2021, along with a comparison to data recorded at the nearest NSW OEH AQMS located at Rozelle. The 24-hour PM_{10} concentrations at both locations are assessed against the relevant 24-hour air quality standard (50 µg/m^3). **Table 3** shows the minimum and maximum 24-hour PM_{10} concentrations recorded at the St Leonards Park AQMS and Rozelle AQMS during the monitoring period. **Table 4** shows the annual average PM_{10} concentrations recorded at the St Leonards Park AQMS and Rozelle AQMS during the monitoring period

It can observed from **Figure 5** that no exceedances of the relevant criteria were recorded with the maximum 24-hour PM_{10} concentration recorded by St Leonards Park AQMS being 49.6 µg/m^3 on 24 April 2020. It is also observed that PM_{10} concentrations recorded at the St Leonards Park AQMS are generally higher than those recorded at Rozelle AQMS. This may be attributed to local sources of PM_{10} emissions including neighbouring construction works as noted in **Section 2.1**. Nevertheless, both monitoring stations display a similar trend in 24-hour concentrations. The annual average PM_{10} concentration recorded by the St Leonards Park AQMS was 19.1 µg/m^3 as shown in **Table 4**

Validated 24-hour PM_{10} data for the complete monitoring period have been provided in the following reports:

- *"St Leonards Park Ambient Air Quality Monitoring, 20 March to 30 June 2020"* (SLR Consulting Pty Ltd, September 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 July to 30 September 2020"* (SLR Consulting Pty Ltd, October 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 October to 31 December 2020"* (SLR Consulting Pty Ltd, January 2021)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 January to 21 March 2021"* (SLR Consulting Pty Ltd, May 2021)

Figure 5 24-hour average PM_{10} Concentration at St Leonards Park AQMS and Rozelle AQMS- 20 March 2020 to 21 March 2021



Graphical representation of the 24-hour $PM_{2.5}$ concentrations measured by the St Leonards Park AQMS are presented in **Figure 6** for the monitoring period 20 March 2020 to 21 March 2021 along with a comparison to data recorded at the nearest NSW OEH AQMS located at Rozelle. The 24-hour $PM_{2.5}$ concentrations at both locations are assessed against the relevant 24-hour air quality standard (25 µg/m^3). **Table 3** shows the minimum and maximum 24-hour $PM_{2.5}$ concentrations recorded at the St Leonards Park AQMS and Rozelle AQMS during the monitoring period. **Table 4** shows the annual average $PM_{2.5}$ concentrations recorded at the St Leonards Park AQMS and Rozelle AQMS during the monitoring period.

It can observed from **Figure 6** that no exceedances of the 24-hour criterion were recorded with the maximum 24-hour $PM_{2.5}$ concentration recorded by the St Leonards Park AQMS being 19.9 µg/m^3 on 3 October 2020. It is also observed that $PM_{2.5}$ concentrations recorded at the Rozelle AQMS are generally higher than those recorded at St Leonards Park AQMS. Nevertheless, both monitoring stations display a similar trend in 24-hour concentrations. The annual average $PM_{2.5}$ concentration recorded by the St Leonards Park AQMS was 5.4 µg/m^3 as shown in **Table 4**

Validated 24-hour $PM_{2.5}$ data for the complete monitoring period have been provided in the following reports:

- *"St Leonards Park Ambient Air Quality Monitoring, 20 March to 30 June 2020"* (SLR Consulting Pty Ltd, September 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 July to 30 September 2020"* (SLR Consulting Pty Ltd, October 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 October to 31 December 2020"* (SLR Consulting Pty Ltd, January 2021)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 January to 21 March 2021"* (SLR Consulting Pty Ltd, May 2021)

Table 3 24-Hour Average PM_{10} and $PM_{2.5}$ Data Summary at St Leonards Park and Rozelle- 20 March 2020 to 21 March 2020

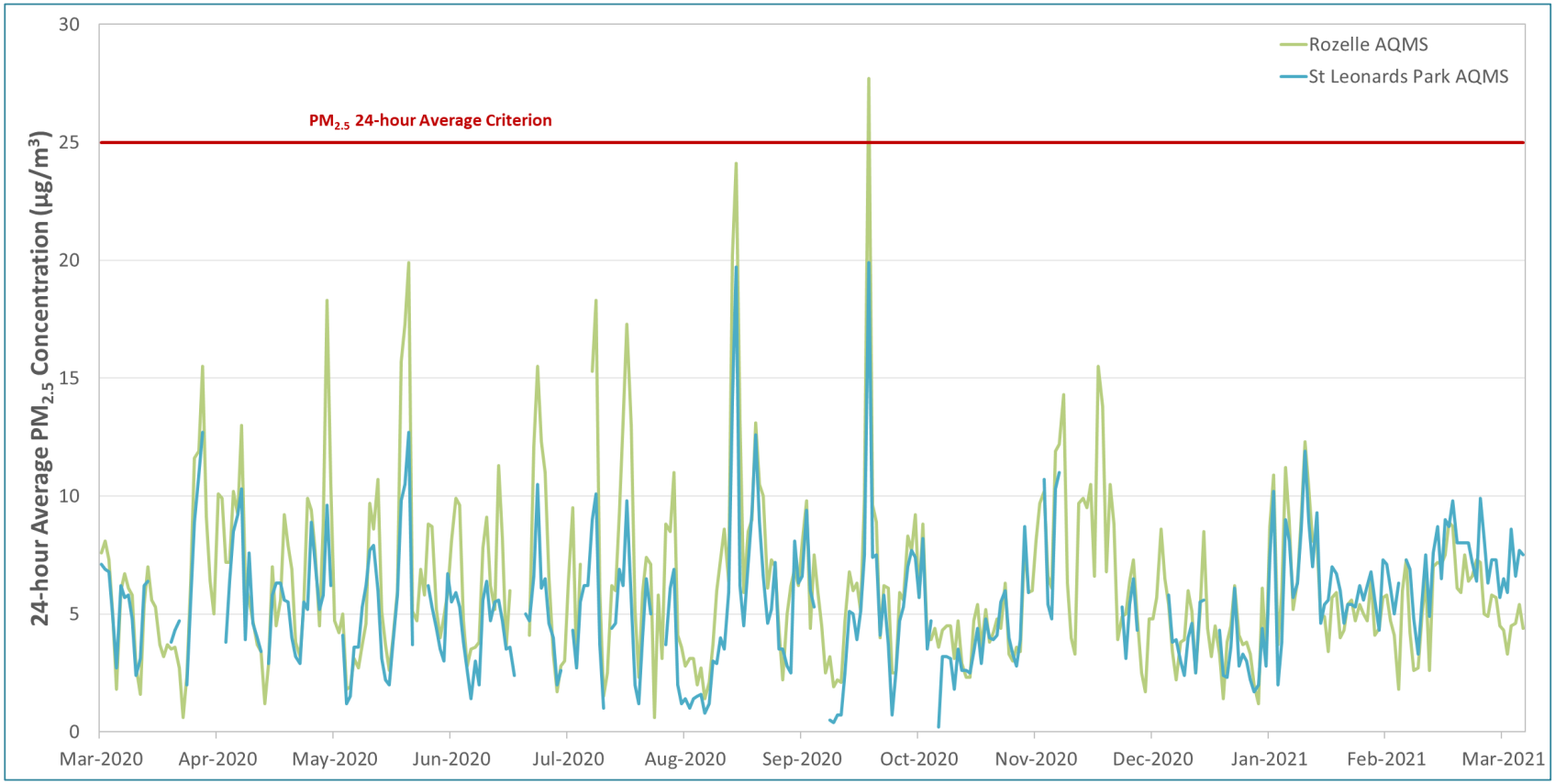
	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)	
	St Leonards Park AQMS	Rozelle AQMS	St Leonards Park AQMS	Rozelle AQMS
Minimum	1	5	0.2	0.6
Maximum	49.6	39.3	19.9	27.7
24-hour average criteria	**50**		**25**	

Table 4 Annual Average PM_{10} and $PM_{2.5}$ Concentrations at St Leonards Park and Rozelle- 20 March 2020 to 21 March 2021

	PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)	
	St Leonards Park AQMS	Rozelle AQMS	St Leonards Park AQMS	Rozelle AQMS
Annual average	19.1*	16.3	5.4	6.3
Annual average criteria	**25**		**8**	

*Note – PM_{10} annual average is based on less than 75% data capture

Figure 6 24-hour average $PM_{2.5}$ Concentration at St Leonards Park AQMS and Rozelle AQMS- 20 March 2020 to 21 March 2021



7.2 NO_X (NO and NO_2) Monitoring

Table 5 shows the minimum and maximum 1-hour NO_2 concentrations recorded at St Leonards Park AQMS and at the nearest NSW OEH AQMS located at Rozelle for the monitoring period 20 March 2020 to 21 March 2021. **Table 6** shows annual average NO_2 concentration recorded at St Leonards Park AQMS and Rozelle AQMS. Graphical representation of the 1-hour NO_2 concentrations measured by the St Leonards Park AQMS is presented in **Figure 7** along with a comparison to data recorded at Rozelle. The 1-hour NO_2 concentrations at both locations are assessed against the relevant 1-hour air quality standard (120 ppb).

It can observed from **Figure 7** that no exceedances of the 1-hour criterion were recorded with the maximum 1-hour NO_2 concentration recorded by the St Leonards Park AQMS to be 63.2 ppb on 22 April 2020 at 5:00PM. It is also observed that both monitoring stations display a similar trend in 1-hour concentrations for most of the monitoring period. The annual average NO_2 concentration recorded by the St Leonards Park AQMS was 12.3 ppb as shown in **Table 6.**

Validated 1-hour NO_2 data for the complete monitoring period have been provided in the following reports:

- *"St Leonards Park Ambient Air Quality Monitoring, 20 March to 30 June 2020"* (SLR Consulting Pty Ltd, September 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 July to 30 September 2020"* (SLR Consulting Pty Ltd, October 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 October to 31 December 2020"* (SLR Consulting Pty Ltd, January 2021)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 January to 21 March 2021"* (SLR Consulting Pty Ltd, May 2021)

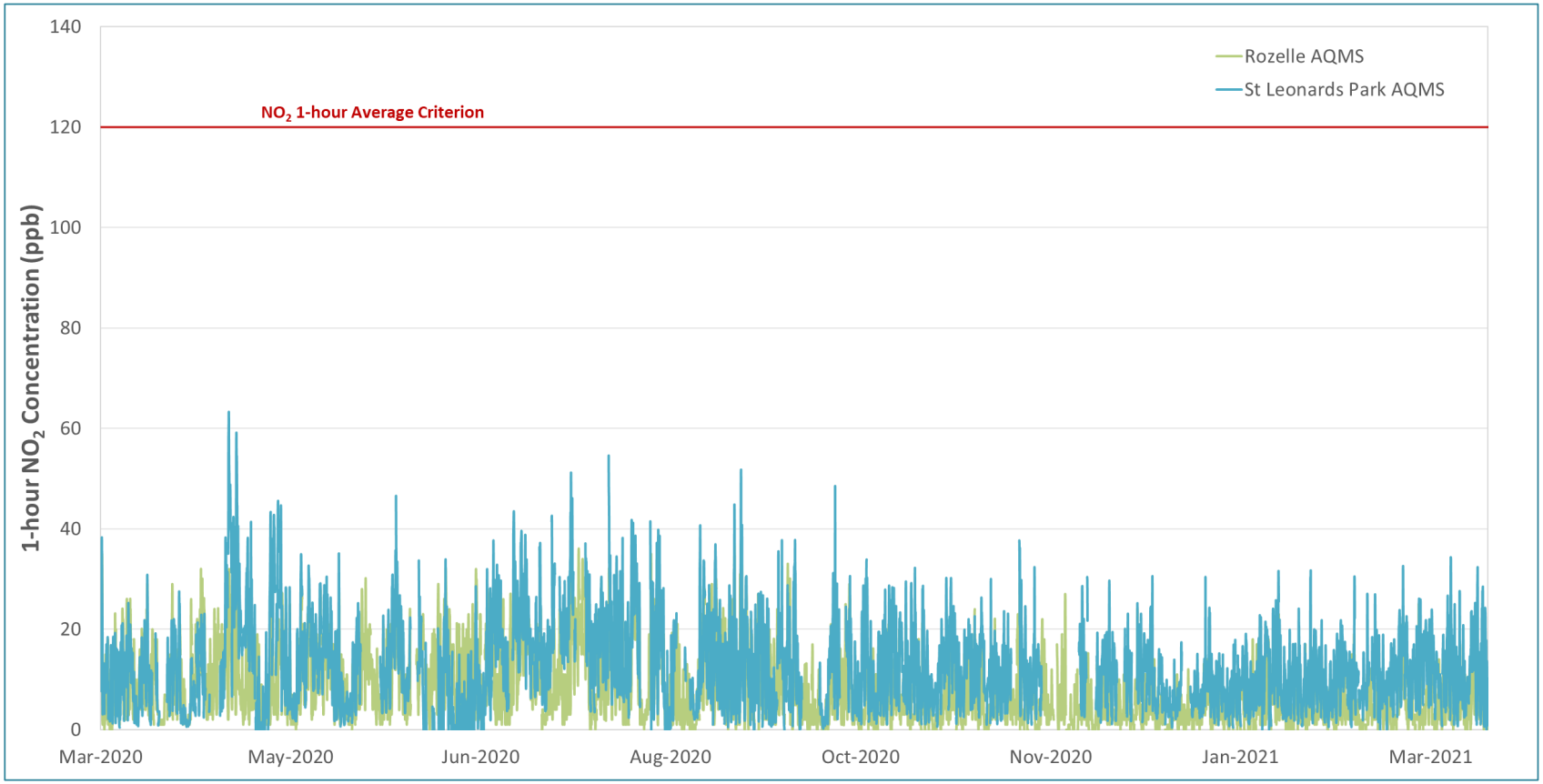
Table 5 1-Hour Average NO_2 Data Summary at St Leonards Park and Rozelle – 20 March 2020 to 20 March 2021

	NO_2 (ppb)	
	St Leonards Park AQMS	**Rozelle AQMS**
Minimum	<0.1	<0.1
Maximum	63.2	37
1-hour criterion	**120**	

Table 6 Annual Average NO_2 Concentrations at St Leonards Park and Rozelle - 20 March 2020 to 20 March 2021

	NO_2 (ppb)	
	St Leonards Park AQMS	**Rozelle AQMS**
Annual average	12.3	7.8
Annual average criterion	**30**	

Figure 7 1-hour average NO_2 Concentration at St Leonards Park AQMS and Rozelle AQMS- 20 March 2020 to 21 March 2021

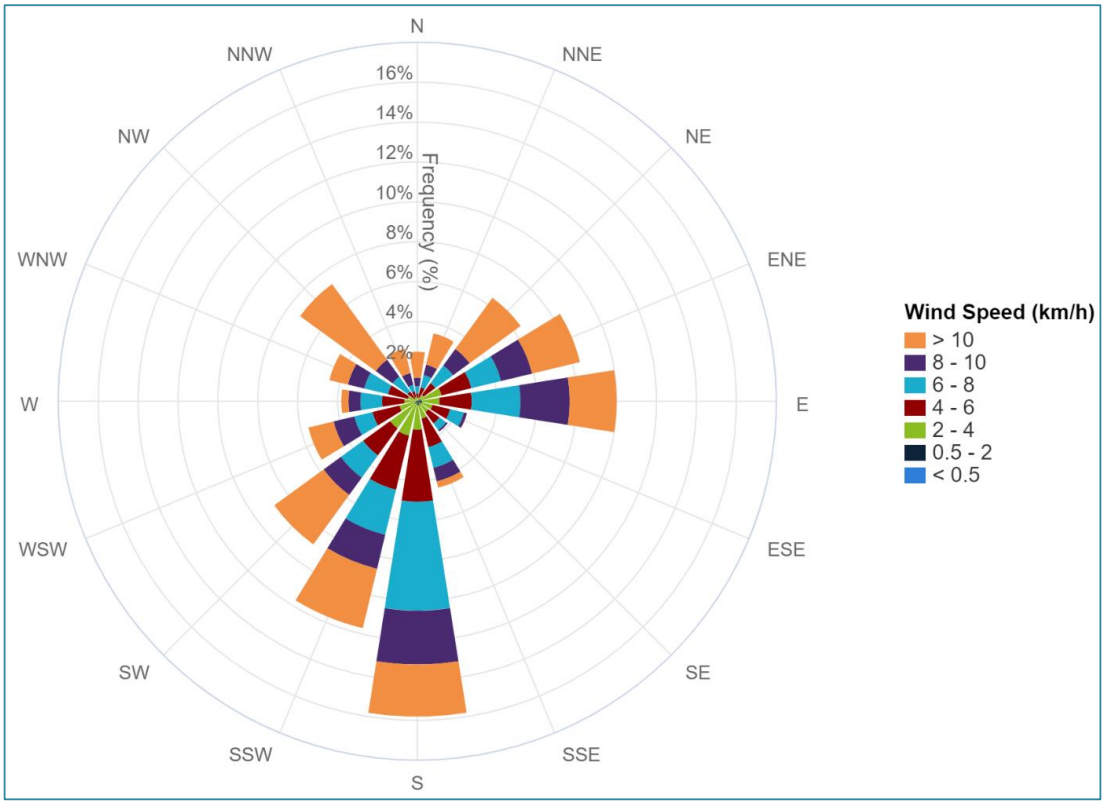


7.3 Meteorological Monitoring

7.3.1 Wind Speed and Wind Direction

Hourly wind speed and wind direction recorded by the meteorological monitoring station at St Leonard Park AQMS are presented as a wind rose in **Figure 8.** **Table 7** shows the minimum, maximum and average wind speeds recorded during the monitoring period. The wind rose provides information regarding the potential for pollutants to be carried to the AQMS.

Figure 8 Windrose based on 1-hour average wind conditions- 20 March 2020 to 21 March 2021



7.3.2 Temperature

Hourly varying temperature recorded by the meteorological monitoring station at St Leonard Park AQMS are presented in **Figure 9.** **Table 7** shows the minimum, maximum and average temperature recorded during the monitoring period. Ambient temperature can influence mixing of ambient air within the planetary boundary layer and hence pollutant dispersion.

7.3.3 Barometric Pressure

Hourly varying barometric pressure recorded by the meteorological monitoring station at St Leonard Park AQMS are presented in **Figure 10. Table 7** shows the minimum, maximum and average barometric pressure recorded during the monitoring period.

7.3.4 Solar Radiation

Hourly varying solar radiation recorded by the meteorological monitoring station at St Leonard Park AQMS are presented in **Figure 12. Table 7** shows the minimum, maximum and average solar radiation recorded during the monitoring period. Higher solar radiation can influence atmospheric temperature and hence pollutant dispersion.

7.3.5 Relative Humidity

Hourly varying relative humidity recorded by the meteorological monitoring station at St Leonard Park AQMS are presented in **Figure 11. Table 7** shows the minimum, maximum and average relative humidity recorded during the monitoring period. Relative humidity is a measure of the amount of moisture in the air and as water is lighter than other gases in the atmosphere more water dense air parcels will tend to rise in the atmosphere increasing atmospheric turbulence and hence pollutant dispersal.

Table 7 Meteorological Data summary based on 1-hour data- 20 March 2020 to 21 March 2021

	Wind Speed (km/h)	Relative Humidity (%)	Temperature (^{o}C)	Solar Radiation (Watts/m^2)	Barometric Pressure (hPa)
Minimum	0.9	51.0	15.4	0	1001.2
Maximum	16.7	93.7	34.3	740.3	1016.9
Average	7.1	76.8	20.6	138.5	1010.3

Figure 9 Temperature based on 1-hour average conditions- 20 March 2020 to 21 March 2021

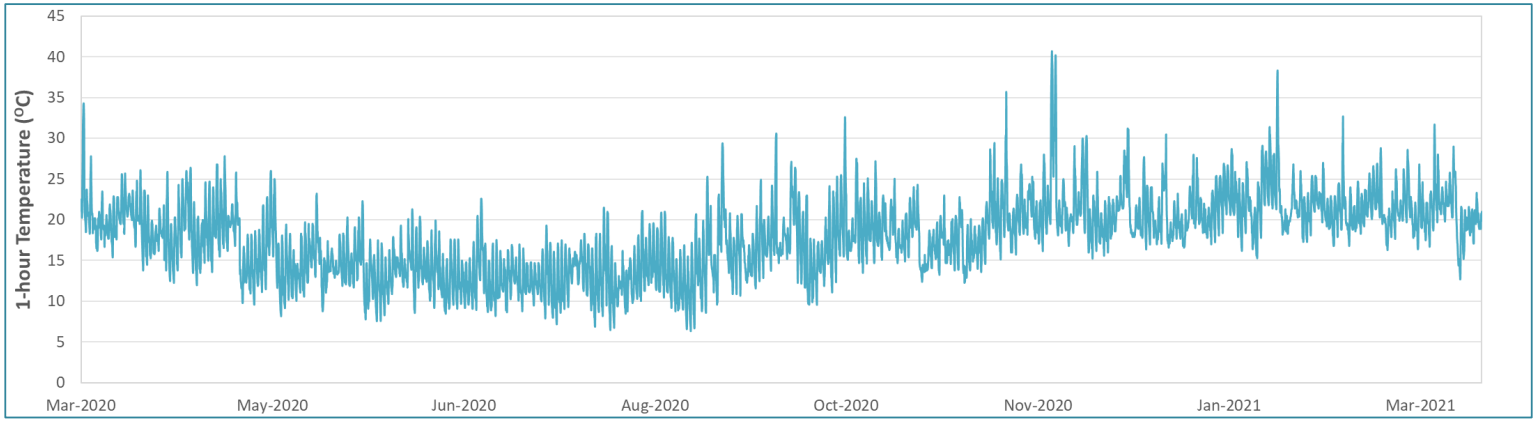


Figure 10 Barometric Pressure based on 1-hour average conditions-20 March 2020 to 21 March 2021

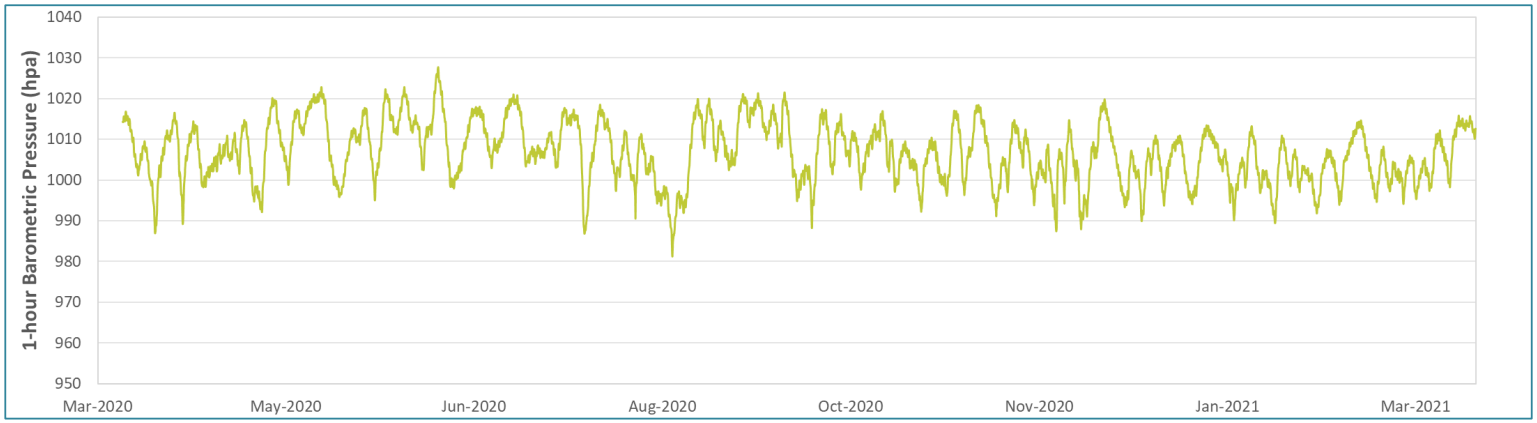


Figure 11 Relative Humidity based on 1-hour average conditions- 20 March 2020 to 21 March 2021

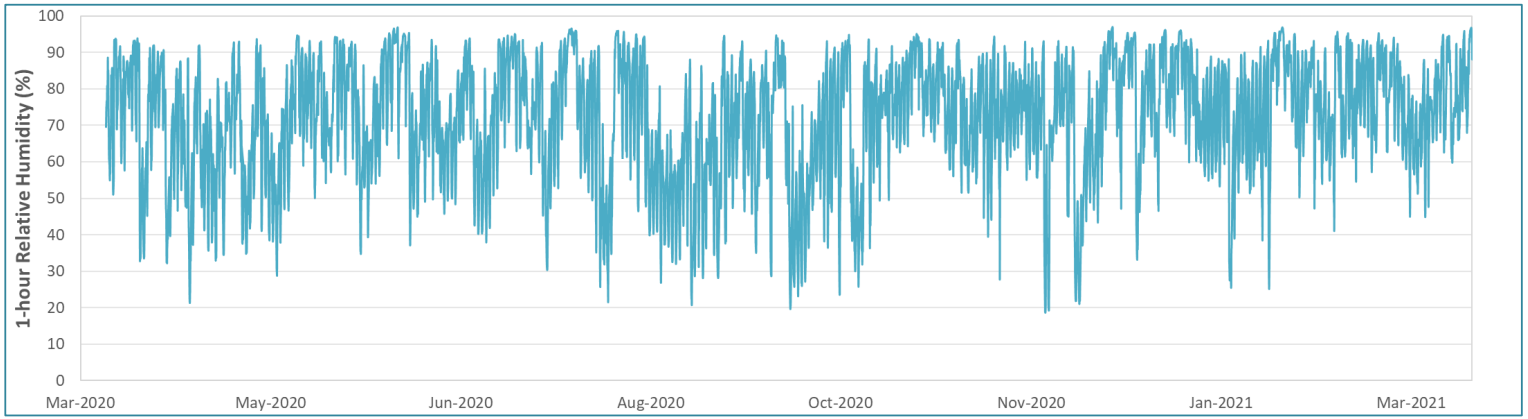
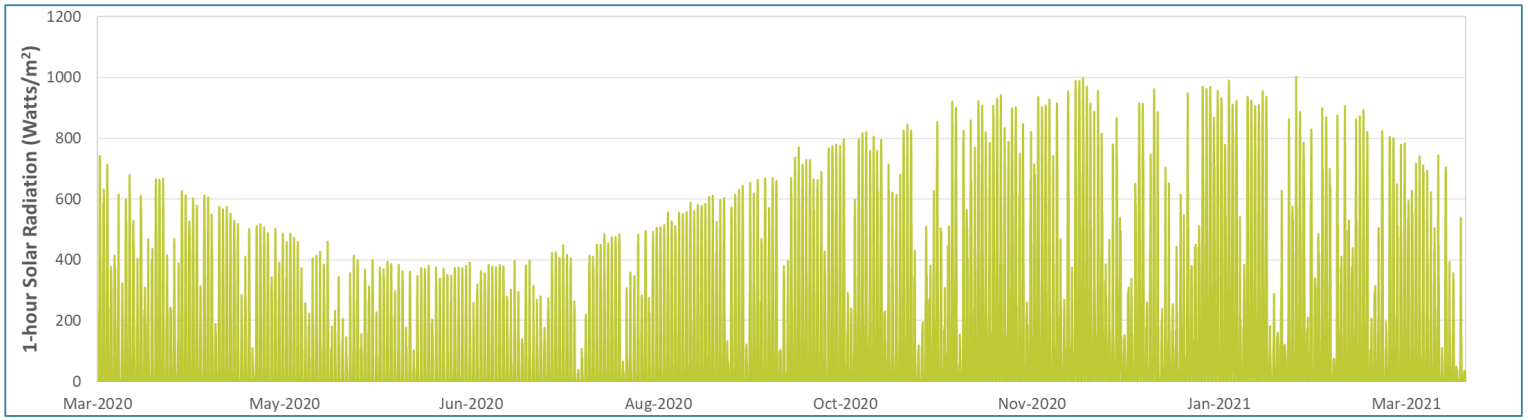


Figure 12 Solar Radiation based on 1-hour average conditions- 20 March 2020 to 21 March 2021



7.3.6 Rainfall

Precipitation has the potential to impact particulate matter concentrations by scrubbing particles from the air as the precipitation falls to the ground. Rainfall data for the monitoring period 20 March 2020 to 21 March 2021 was not recorded at the St Leonards Park AQMS and has been adopted from the Bureau of Meteorology (BoM) station located at Sydney Observatory Hill which is approximately 3.2 km from the St Leonard Park AQMS. Data collected at this BoM station is deemed to be representative of rainfall conditions at the St. Leonards Park AQMS. Sydney Observatory Hill Rainfall data for the current monitoring period is summarised in **Table 8**.

Table 8 Summary of Rainfall data at Sydney Observatory Hill –20 March 2020 to 21 March 2021

Month - Year	No of rain days	Total monthly rainfall (mm)	Maximum daily rainfall (mm)
March-2020#	7	41.4	19.4
April-2020	9	29.6	7.2
May -2020	14	138.2	53.4
June-2020	15	80.2	19.8
July-2020	14	209.2	84.6
August-2020	8	79.4	36.2
September-2020	8	23	7.8
October-2020	14	108.4	43.2
November-2020	11	69	23
December-2020	19	119	26.2
January-2021	14	97.8	29.6
February-2021	17	120.6	30.2
March-2021*	13	198.8	54.4

Note- Rainfall data adopted from Sydney Observatory Hill Mentoring Station

#Data reported from 20 March 2020

*Data reported until 21 March 2021

Validated 1-hour meteorological data for the complete monitoring period have been provided in the following reports:

- *"St Leonards Park Ambient Air Quality Monitoring, 20 March to 30 June 2020"* (SLR Consulting Pty Ltd, September 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 July to 30 September 2020"* (SLR Consulting Pty Ltd, October 2020)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 October to 31 December 2020"* (SLR Consulting Pty Ltd, January 2021)
- *"St Leonards Park Ambient Air Quality Monitoring, 1 January to 21 March 2021"* (SLR Consulting Pty Ltd, May 2021)

8 Conclusion

SLR was commissioned by the North Sydney Council to install and operate an AQMS at St. Leonards Park, North Sydney to undertake a baseline air quality monitoring program. SLR commenced the monitoring program on 20/03/2020 and performed routine maintenance on the AQMS. The following parameters were measured by the AQMS:

- Continuous Monitoring for Fine Particulates:
  - PM_{10}
  - $PM_{2.5}$
- Continuous Monitoring for NO_X (NO and NO_2)
- Meteorological Monitoring

The current report is a summary of air quality and meteorological monitoring conducted between 20 March 2020 to 21 March 2021. SLR noted that the following factors are likely to impact the data recorded by the AQMS making it unrepresentative of baseline air pollution levels at the Project Site:

- Neighbouring construction works
- COVID-19 restrictions

The monitoring location was selected as best as practicable in accordance with AS/NZS 3580.1.1:2007. SLR performed ambient PM_{10} monitoring in accordance with AS/NZS 3580.9.8:2008 using Thermo Scientific TEOM Series 1405 while ambient $PM_{2.5}$ monitoring was undertaken in accordance with AS/NZS 3580.9.13:2013 using Thermo Scientific TEOM Series 1405 from 20 March 2020 to 31 October 2020 and AS/NZS 3580.9.12:2013 using a Met One Instruments, Inc. BAM 1022 from 1 November 2020 to 21 March 2021. Additionally, monitoring of ambient NO_2 concentrations was conducted in accordance with AS 3580.5.1:2011 using Thermo Scientific 42*i* from 20 March 2020 to 31 May 2020 and using Thomson 200E gas analyser from 01 June 2020 to 21 March 2021. Meteorological monitoring was conducted in accordance with AS/NZS 3580.14:2014.

Air quality monitoring results for the current monitoring period indicate the following:

- The maximum 24-hour average PM_{10} concentration was 49.6 µg/m^3 recorded on 24 April 2020 which is below the specified 24-hour average air quality criteria of 50 µg/m^3 while annual average PM_{10} concentration was recorded to be 19.1 µg/m^3 which is below the annual average criterion of 25 µg/m^3.
- The maximum 24-hour average $PM_{2.5}$ concentration was 19.9 µg/m^3 recorded on 3 October 2020 which is below with the specified 24-hour average air quality criteria of 25 µg/m^3. The annual average $PM_{2.5}$ concentration was recorded to be 5.4 µg/m^3 which is also below the annual average criterion of 8 µg/m^3.
- The maximum 1-hour average NO_2 concentration during the current monitoring period was 63.2 ppb recorded on 22 April 2020 at 5:00PM which is below the specified 1-hour average air quality criteria of 120 ppb. The annual average NO_2 concentration was recorded to be 12.3 ppb which is below the annual average criterion of 30 ppb.

It is noted that the entire region surrounding the monitoring station was impacted for large periods of the monitoring program by reduced traffic volumes, due to COVID19 restrictions, and the above reported maximums and annual average may be conservatively low compared to baseline conditions under normal traffic conditions.

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

www.slrconsulting.com