3 Air Quality Impact

3.1 Introduction

This section presents the assessment of potential air quality impacts associated with the construction and operation phases of the Project, which has been conducted in accordance with the criteria and guidelines as stated in section 1 of Annex 4 and Annex 12 of the Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM) as well as the requirements given in Clause 3.4.2 and Appendix B of the EIA Study Brief (ESB-276/2014).

3.2 Environmental Legislation, Standards and Guidelines

The assessment is carried out following the relevant criteria and standards as specified in the following legislation and guidelines for evaluating air quality impacts:

- Environmental Impact Assessment Ordinance (EIAO) (Cap. 499.S16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 4 and 12;
- Air Pollution Control Ordinance (APCO) (Cap. 311);
- Air Pollution Control (Construction Dust) Regulation; and
- Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation

3.2.1 Technical Memorandum on Environmental Impact Assessment Process

The criteria and guidelines for evaluating air quality impacts are laid out in Section 1 of Annex 4 and Annex 12 respectively of the EIAO-TM. Section 1 of Annex 4 stipulates the criteria for evaluating air quality impacts. This includes meeting the Air Quality Objectives (AQOs) and other standards established under the APCO, as well as meeting the hourly Total Suspended Particulate (TSP) concentration of 500 μg/m^3 and the 5-second average odour concentration of 5 odour units (ou/m^3). Annex 12 provides the guidelines for conducting air quality assessments under the EIA process, including determination of Air Sensitive Receivers (ASRs), assessment methodology as well as impact prediction and assessment.

3.2.2 Air Pollution Control Ordinance

3.2.2.1 Air Quality Objectives

The principal legislation for the management of air quality is the APCO. It specifies AQOs which stipulate the statutory limits of air pollutants and the maximum allowable numbers of exceedance over specific periods. The AQOs are listed in **Table 3.1**.

Table 3.1: Hong Kong Air Quality Objectives

Pollutant	Averaging Time	AQO concentration (μg/m³)	Allowable exceedances
Sulphur Dioxide (SO_2)	10 minute	500	3
	24 hour	125	3
Total Suspended Particulates (TSP)	1 hour[(1)]	500[(1)]	0

Pollutant	Averaging Time	AQO concentration (µg/m³)	Allowable exceedances
Respirable Suspended Particulates (RSP or PM10)	24 hour	100	9
	Annual	50	0
Fine Suspended Particulates (FSP or PM2.5)	24 hour	75	9
	Annual	35	0
Nitrogen Dioxide (NO_2)	1 hour	200	18
	Annual	40	0
Carbon Monoxide (CO)	1 hour	30,000	0
	8 hour	10,000	0
Ozone (O3)	8 hour	160	9
Lead	Annual	0.5	0
Odour	5-second (1)	5 odour units (ou)(1)	0

1. Criterion under EIAO-TM not an AQO

3.2.2.2 Air Pollution Control (Construction Dust) Regulation

The Air Pollution Control (Construction Dust) Regulation enacted under the APCO defines notifiable and regulatory works activities that are subject to construction dust control, as listed below:

Notifiable Works:
1. Site formation
2. Reclamation
3. Demolition of a building
4. Construction of the foundation of a building
5. Construction of the superstructure of a building
6. Road construction work

Regulatory Works:

1. Renovation carried out on the outer surface of the external wall or the upper surface of the roof of a building
2. Road opening or resurfacing work
3. Slope stabilisation work
4. Any work involving any of the following activities:
    a. Stockpiling of dusty materials
    b. Loading, unloading or transfer of dusty materials
    c. Transfer of dusty materials using a belt conveyor system
    d. Use of vehicles
    e. Pneumatic or power-driven drilling, cutting and polishing
    f. Debris handling
    g. Excavation or earth moving

h. Concrete production
i. Site clearance
j. Blasting

Notifiable works require that advance notice of activities shall be given to Environmental Protection Department (EPD). The Air Pollution Control (Construction Dust) Regulation also requires the works contractor to ensure that both notifiable works and regulatory works are conducted in accordance with the Schedule of the Regulation, which provides dust control and suppression measures. The Project includes, site formation, construction of the foundation of buildings, construction of the superstructure of buildings and road construction work; and is therefore notifiable. The Project also includes: stockpiling of dusty materials; loading, unloading or transfer of dusty materials; use of vehicles; excavation or earth moving, and; site clearance and is therefore regulatory.

3.2.2.3 Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation

The Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation has come into operation since 1 June 2015. This regulation regulates emission of dust from non-road vehicle and regulated machine to be used in construction sites. The regulated machines must comply with the emission standards of Stage IIIA of the European Union (EU) or the equivalent, while non-road vehicles must comply with the prevailing emission standards for newly registered road vehicles, which is Euro V. Upon confirmation of their compliance with emission requirement, EPD will issue them with an approval label. Existing non-road mobile machinery (NRMM) will be exempted from the emission compliance requirement. EPD will issue exemption labels to existing NRMM upon application by their owners. A grace period of six months between 1 June and 30 November 2015 will be allowed for the application of exemption.

According to the regulation, mobile machine and equipment (regulated machines) means any mobile machine or transportable industrial equipment that is powered by an internal combustion engines with a rated engine power output that is greater than 19 kW but not greater than 560 kW. The NRMM is intended to be used in a private road that is within an area wholly or mainly used for the carrying on of construction work/industry. The regulated machines include crawler cranes, excavators, etc., while NRMM means a private car, goods vehicles, etc. Therefore, this regulation is applicable to the regulated machines and NRMM to be deployed for construction activities of the Project.

3.3 Project Site

3.3.1 Site Description and Surrounding Environment

The Project is a 19-ha site located in Kong Nga Po. Land-uses in the vicinity are mostly rural, village houses and pig farms. The committed Organic Waste Treatment Facilities – Phase 2, will be located about 327m away from and on the south-western side of the Development.

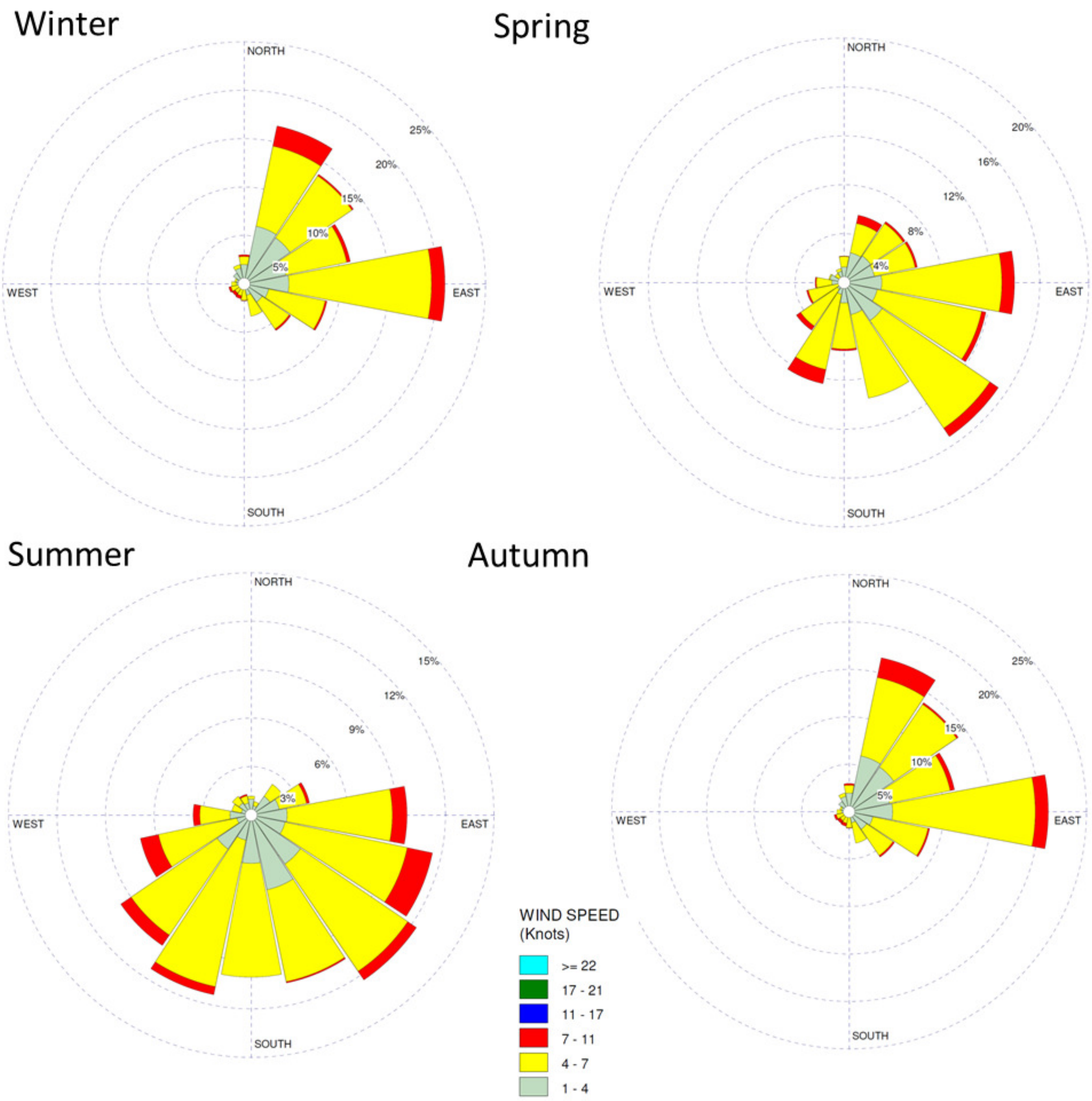
3.3.2 Meteorology

The PATH (Pollutants in the Atmosphere and their Transport over Hong Kong) model, a regional air quality prediction model developed by EPD, is used to predict the meteorology at Kong Nga Po. PATH is also used to predict background air quality as a result of various sources in Hong Kong and the surrounding regions including the Pearl River Delta Economic Zone (PRDEZ).

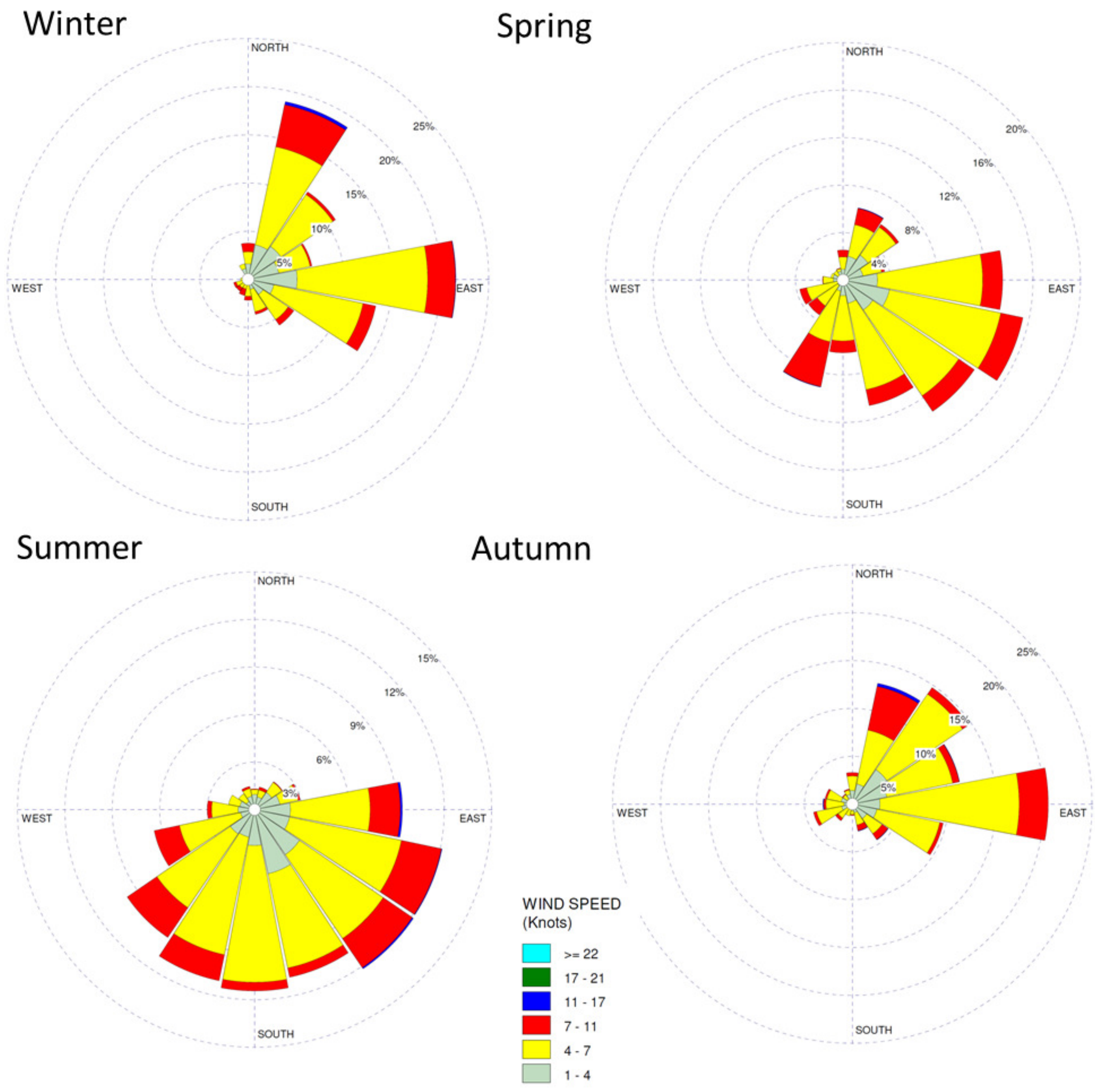
Graph 3.1 to **Graph 3.4** show seasonal windroses for the Project site from 2010 PATH data at the relevant grids (25,43), (25,44), (25,45), and (26, 44) which collectively cover the Study Area as described in **Section 3.4** below. Features of the wind profile that are significant for the Project are both the wind speed and direction. Low wind speeds are significant for dispersion of non-buoyant area sources, such as odours, as low wind speeds can allow for accumulation of odour which may be swept of site when the wind speed increases. However at high wind speeds, dust emissions can become significant.

At Kong Nga Po, wind from south and south-east (SE) is significant in summer. Easterly winds are dominant in winter and autumn. During spring the winds are predominantly from South-East and East.

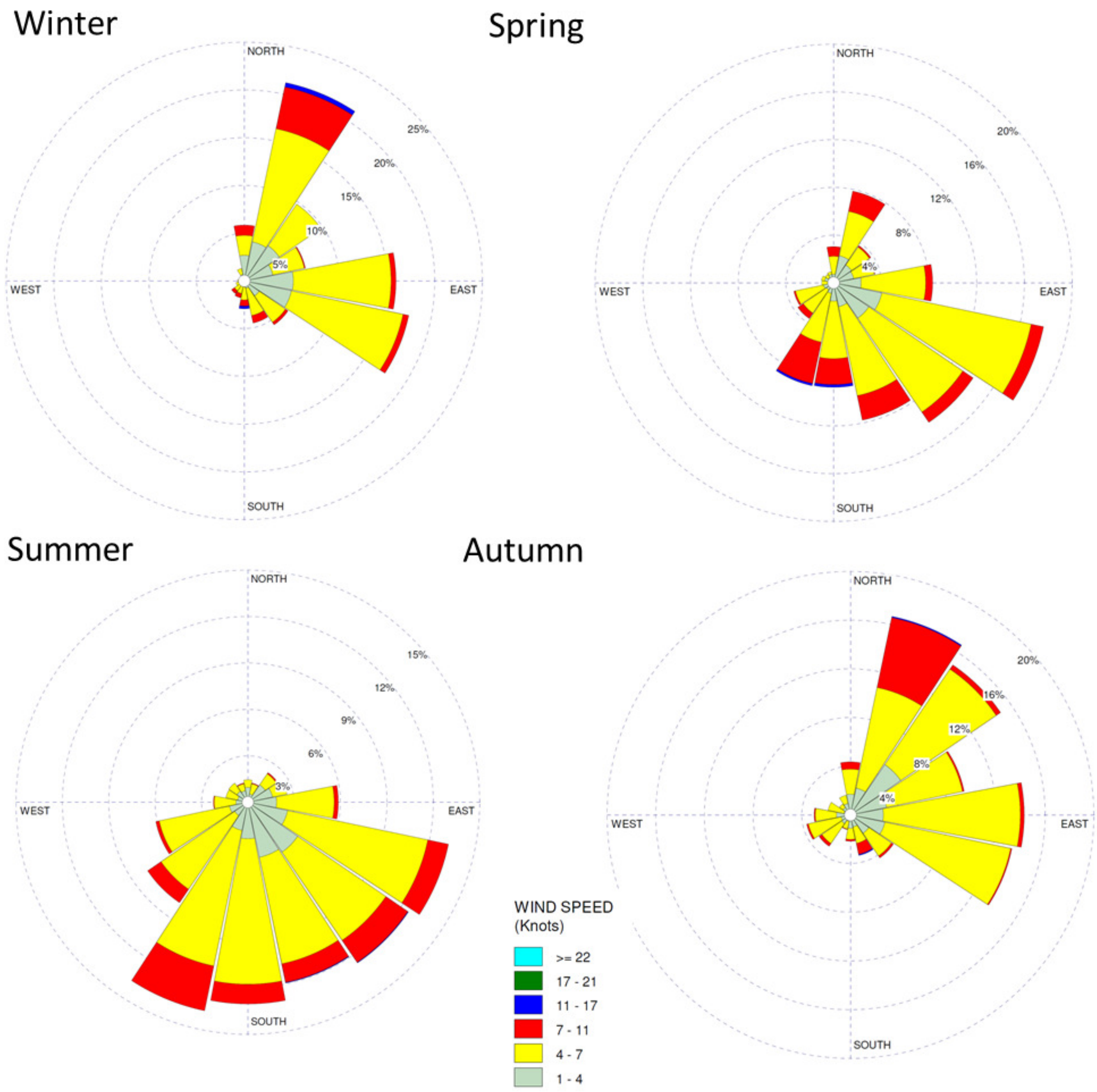
Graph 3.1: Seasonal Windroses for Kong Nga Po from 2010 PATH data at grid (25,43)



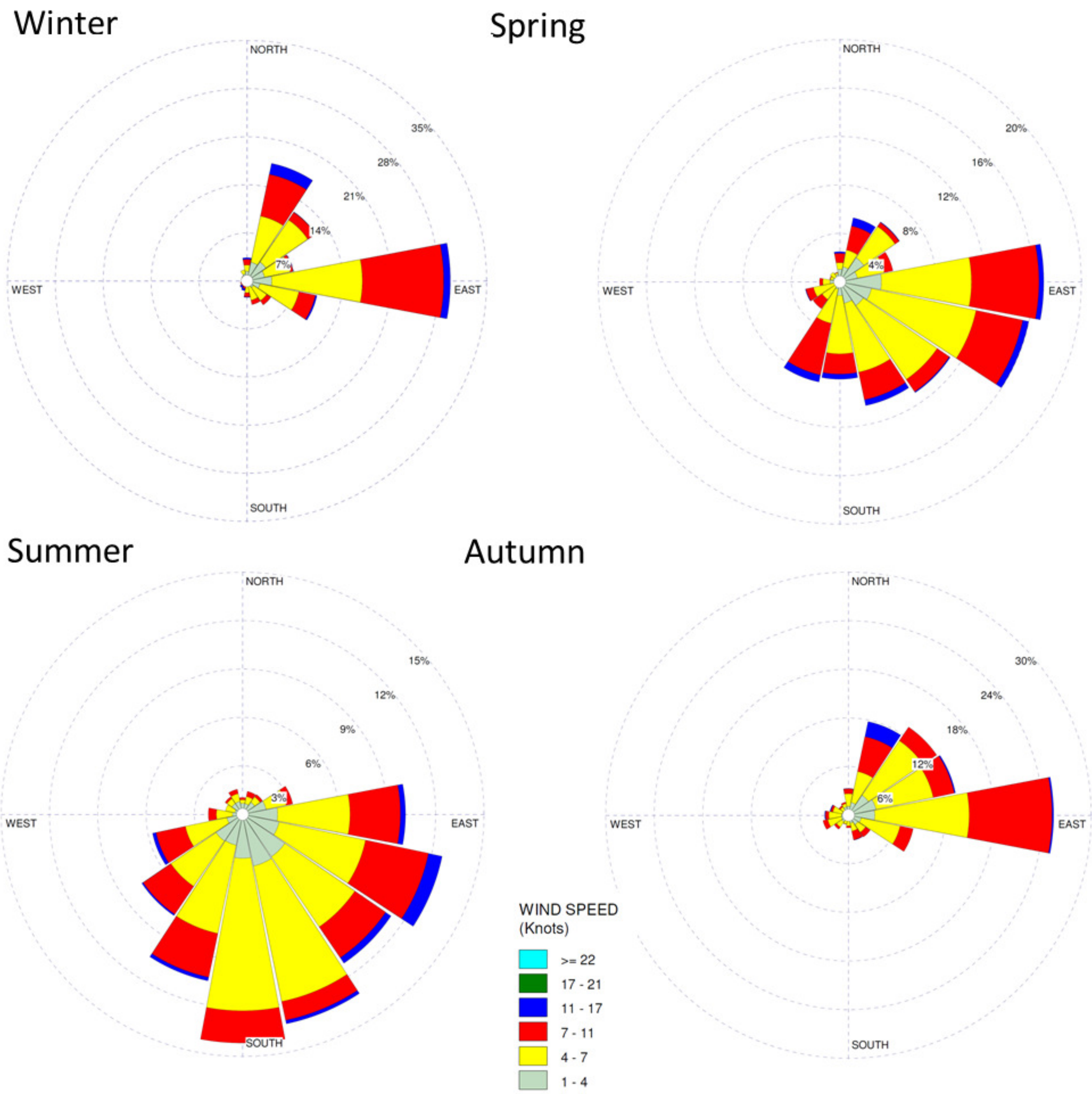
Graph 3.2: Seasonal Windroses for Kong Nga Po from 2010 PATH data at grid (25,44)



Graph 3.3: Seasonal Windroses for King Nga Po from 2010 PATH data at grid (25,45)



Graph 3.4: Seasonal Windroses for Kong Nga Po from 2010 PATH data at grid (26,44)



3.3.3 Background Air Quality

Since there is no EPD general air quality monitoring station located in project area, with reference to EPD's Air Quality Annual Report, the latest 5-year annual average (Year 2011 – 2015) at EPD's general air quality monitoring station in Tai Po are shown in **Table 3.2**.

Table 3.2: Air Quality Monitoring Data at Tai Po Station (Year 2011 – 2015)

Pollutant	Annual Average Concentration (µg/m^3)					5-year Annual Average Background Concentration (µg/m^3)
	2011	2012	2013	2014	2015	
Sulphur Dioxide (SO_2)	8	7	9	4	6	7
Nitrogen Dioxide (NO_2)	**45**	**51**	**53**	**45**	37	**46**
Total Suspended Particulates (TSP)	69	NM	NM	NM	NM	69
Respirable Suspended Particulates (RSP)	46	41	#	41	36	41
Fine Suspended Particulates (FSP)	#	28	#	27	23	26

Note:

1) Monitoring results that exceeded prevailing AQO criteria are shown in bold characters.
2) #: Annual Average is not published for noncompliance with the representative requirement of no less than 2/3 representative period in a quarter.
3) NM: No measurement is conducted at this station.

With reference to EPD's Past Air Quality Monitoring Data, the 1-hour NO_2 and 10-minute SO_2 concentrations; as well as the 24-hour average RSP, FSP and SO_2 concentration at EPD's general air quality monitoring station in Tai Po are shown in **Table 3.3** and **Table 3.4** respectively.

Table 3.3: Background concentrations for 1-hour average NO_2 and 10-minute average SO_2 (Year 2011 – 2015) at Tai Po Station

Pollutant	Averaging Period	Concentration (µg/m^3)				
		2011	2012	2013	2014	2015
Nitrogen Dioxide (NO_2)	19th Maximum 1-hour	146	145	159	145	136
Sulphur Dioxide (SO_2)	4th Maximum 10- minute	NM	NM	NM	70	56

Note: NM: Not measured.

Table 3.4: Background concentrations for 24-hour average RSP, FSP and SO_2 (Year 2011 – 2015) at Tai Po Station

Pollutant	Averaging period	10th Maximum 24-hour Concentration (µg/m^3)				
		2011	2012	2013	2014	2015
Respirable Suspended Particulates (RSP)	10th Maximum 24-hour	93	91	102	92	77
Fine Suspended Particulates (FSP)	10th Maximum 24-hour	58	69	80	63	57
Sulphur Dioxide (SO_2)	4th Maximum 24-hour	23	17	24	15	13

The future background air pollutant concentrations to be used for predicting the total air quality impact due to the Project emissions were extracted from the latest PATH model on EPD's website, as it was considered to be more representative for the assessment in vicinity of the Project site.

3.4 Study Area and Air Sensitive Receivers

According to Clause 3.4.2.2 of the EIA Study Brief, the Study Area for air quality impact assessment of this Assignment shall be defined by a distance of 500m from the boundary of the Project site. Therefore, the Study Area is defined as 500m outside of the Project Boundary. In addition, the Study Area "shall be extended to include major existing, planned and committed air pollutant emission sources that may have a bearing on the air quality impact of the Project". However, the Air Sensitive Receivers (ASRs) as identified within 500m from the Project Boundary and within the Project site are considered to be representative in terms of their distances, height and types of uses. As such, the Study Area for air quality impact assessment is defined as within 500m from the Project Boundary as shown in **Figure 3.1**. The existing and planned representative ASRs within the Study Area and within the Project site have been identified for assessment of potential air quality impacts during both construction and operation phases, as summarised in **Table 3.5**. The locations of ASRs and relevant PATH grids where the relevant ASRs are located are also shown in **Figure 3.1** to **Figure 3.3.**

Table 3.5: Representative ASRs Identified for Air Quality Impact Assessment

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during:	
							Construction Phase	Operation Phase
A1a	Village House, San Uk Ling	Residential	Existing	351.8	1.5	(25,45)	Yes	Yes
A1b					4			
A1c					8			
A1d					12			
A2a	Village House No. 308, Sha Ling	Residential	Existing	431.5	1.5	(25,44)	Yes	Yes
A2b					4			
A2c					8			
A2d					12			
A3a	San Uk Ling Holding Centre	Office	Existing	200.9	1.5	(25,44)	Yes	Yes
A3b					4			
A3c					8			
A3d					12			
A4a	Rifle range	Office	Existing	54.6	1.5	(25,44)	Yes	Yes
A5a	Village House, Sha Ling	Residential	Existing	321.5	1.5		Yes	Yes
A5b					4			
A5c					8			
A5d					12			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during: Construction Phase	Operation Phase
A6a	Village House, Sha Ling	Residential	Existing	170.5	1.5	(25,44)	Yes	Yes
A6b					4			
A6c					8			
A6d					12			
A7a	Village House, Sha Ling	Residential	Existing	337.8	1.5	(25,44)	Yes	Yes
A7b					4			
A7c					8			
A7d					12			
A8a	Village House, Kong Nga Po	Residential	Existing	52.0	1.5	(25,44)	Yes	Yes
A8b					4			
A8c					8			
A8d					12			
A9a	Village House, Kong Nga Po	Residential	Existing	39.2	1.5	(25,44)	Yes	Yes
A9b					4			
A9c					8			
A9d					12			
A10a	Village House, Kong Nga Po	Residential	Existing	159.2	1.5	(25,44)	Yes	Yes
A10b					4			
A10c					8			
A10d					12			
A11a	Village House, Kong Nga Po	Residential	Existing	54.0	1.5	(26,44)	Yes	Yes
A11b					4			
A11c					8			
A11d					12			
A12a	Cheung Po Tau Firing Range	Office	Existing	456.4	1.5	(25,44)	Yes	Yes
A13a	Assumed warehouse 1, Proposed Man Kam To Development Corridor	Office	Proposed	353.9	1.5	(25,44)	Yes	Yes
A13b					4			
A13c					8			
A13d					12			
A13e					16			
A13f					20			
A14a	Assumed warehouse 2, Proposed Man Kam To	Office	Proposed	419.4	1.5	(25,44)	Yes	Yes
A14b					4			
A14c					8			
A14d					12			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during: Construction Phase	Operation Phase
A14e	Development Corridor				16			
A14f					20			
B1a	Temple	Temple	Existing	561.9	1.5	(25,44)	Yes	Yes
B2a	Assumed warehouse 3, Proposed Man Kam To Development Corridor	Office	Proposed	613.4	1.5	(25,44)	Yes	Yes
B2b					4			
B2c					8			
B2d					12			
B2e					16			
B2f					20			
B3a	Village House No. 257, Sha Ling	Residential	Existing	590.1	1.5	(25,44)	Yes	Yes
B3b					4			
B3c					8			
B3d					12			
D1a	Village House No. 62, Sha Ling	Residential	Existing	851.5	1.5	(25,44)	Yes	Yes
D1b					4			
D1c					8			
D1d					12			
D2a	Village House No. 248, Kong Nga Po	Residential	Existing	589.4	1.5	(25,44)	Yes	Yes
D2b					4			
D2c					8			
D2d					12			
D3a	Police Dog Unit and Force Search Unit Training School	Office	Existing	622.5	1.5	(25,44)	Yes	Yes
D3b					4			
D3c					8			
D3d					12			
D4a	Hong Kong Police Force Border District Headquarters	Office	Existing	863.2	1.5	(25,44)	Yes	Yes
D4b					4			
D4c					8			
D4d					12			
D5a	Village House, Hung Kiu San Tsuen	Residential	Existing	991.0	1.5	(25,43)	Yes	Yes
D5b					4			
D5c					8			
D5d					12			
N1a	Village House, Sha Ling	Residential	Existing	854.5	1.5	(25,44)	Yes	Yes
N1b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during: Construction Phase	Operation Phase
N2a	Village House, Sha Ling	Residential	Existing	814.6	1.5	(25,44)	Yes	Yes
N2b					4			
N2c					8			
N4a	Village House, Sha Ling	Residential	Existing	491.4	1.5	(25,44)	Yes	Yes
N4b					4			
N5a	Village House No. 272, Sha Ling	Residential	Existing	406.6	1.5	(25,44)	Yes	Yes
N5b					4			
N6a	Village House, Sha Ling	Residential	Existing	377.5	1.5	(25,44)	Yes	Yes
N6b					4			
N13a	Village House, Sha Ling	Residential	Existing	282.0	1.5	(25,44)	Yes	Yes
N13b					4			
N13c					8			
N14a	Village House near Man Kam To Road	Residential	Existing	289.1	1.5	(25,44)	Yes	Yes
N14b					4			
P1a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P1b					4			
P1c					8			
P1d					12			
P1e					16			
P1f					20			
P2a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P2b					4			
P2c					8			
P2d					12			
P2e					16			
P2f					20			
P3a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P3b					4			
P3c					8			
P3d					12			
P3e					16			
P3f					20			
P4a	Proposed Police	Training Facilities	Planned within the	N.A	1.5	(25,44)	No	Yes
P4b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Subject to Impact Assessment during:		
						Relevant PATH grids	Construction Phase	Operation Phase
P4c	Training Facility		Project site		8			
P4d					12			
P4e					16			
P4f					20			
P5a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P5b					4			
P5c					8			
P5d					12			
P5e					16			
P5f					20			
P6a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P6b					4			
P6c					8			
P6d					12			
P6e					16			
P6f					20			
P7a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P7b					4			
P7c					8			
P7d					12			
P7e					16			
P7f					20			
P8a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P8b					4			
P8c					8			
P8d					12			
P8e					16			
P8f					20			
P9a	Proposed Police Training Facility	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P9b					4			
P9c					8			
P9d					12			
P9e					16			
P9f					20			
P10a	Weapons Training	Training Facilities	Planned within the	N.A	1.5	(25,44)	No	Yes
P10b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during: Construction Phase	Operation Phase
P10c	Facilities		Project site		8			
P10d					12			
P11a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P11b					4			
P11c					8			
P11d					12			
P12a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P12b					4			
P12c					8			
P12d					12			
P13a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P13b					4			
P13c					8			
P13d					12			
P14a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P14b					4			
P14c					8			
P14d					12			
P15a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P15b					4			
P15c					8			
P15d					12			
P16a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P16b					4			
P16c					8			
P16d					12			
P17a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(25,44)	No	Yes
P17b					4			
P17c					8			
P17d					12			
P18a	Weapons Training Facilities	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P18b					4			
P18c					8			
P18d					12			
P19a	Multi-Storey Training	Training Facilities	Planned within the	N.A	1.5	(26,44)	No	Yes
P19b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during: Construction Phase	Operation Phase
P19c	Complex		Project site		8			
P19d					12			
P19e					16			
P19f					20			
P20a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P20b					4			
P20c					8			
P20d					12			
P20e					16			
P20f					20			
P21a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P21b					4			
P21c					8			
P21d					12			
P21e					16			
P21f					20			
P22a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P22b					4			
P22c					8			
P22d					12			
P22e					16			
P22f					20			
P23a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P23b					4			
P23c					8			
P23d					12			
P23e					16			
P23f					20			
P24a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P24b					4			
P24c					8			
P24d					12			
P24e					16			
P24f					20			
P25a	Multi-Storey Training	Training Facilities	Planned within the	N.A	1.5	(26,44)	No	Yes
P25b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during:	
							Construction Phase	Operation Phase
P25c	Complex		Project site		8			
P25d					12			
P25e					16			
P25f					20			
P26a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P26b					4			
P26c					8			
P26d					12			
P26e					16			
P26f					20			
P27a	Multi-Storey Training Complex	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P27b					4			
P27c					8			
P27d					12			
P27e					16			
P27f					20			
P28a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P28b					4			
P28c					8			
P29a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P29b					4			
P29c					8			
P30a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P30b					4			
P30c					8			
P31a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P31b					4			
P31c					8			
P32a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P32b					4			
P32c					8			
P33a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P33b					4			
P33c					8			
P34a	Skid Pan with a	Training Facilities	Planned within the	N.A	1.5	(26,44)	No	Yes
P34b					4			

ASR No.	Description	Type of Use	Existing / Planned	Horizontal Distance from Project Site to Boundary (m)	Assessment height above ground (m)	Relevant PATH grids	Subject to Impact Assessment during:	
							Construction Phase	Operation Phase
P34c	Control Tower		Project site		8			
P35a	Skid Pan with a Control Tower	Training Facilities	Planned within the Project site	N.A	1.5	(26,44)	No	Yes
P35b					4			
P35c					8			

3.5 Identification of Pollution Sources and Key Pollutants

3.5.1 Construction Phase

In accordance with the EIA Study Brief, Appendix B, Clause 3 (ii), quantitative assessment shall be carried out to evaluate fugitive dust impact if it is anticipated that the Project will give rise to construction dust impacts likely to exceed recommended limits in the EIAO-TM at the ASRs despite the incorporation of the dust control measures proposed. In accordance with EPD's *Guidelines on Choice of Models and Model Parameters* (Section 3.6), suitable dust size categories relevant to the dust sources concerned with reasonable breakdown in TSP, RSP and FSP compositions should be used in evaluating the impacts of dust emitting activities. Therefore, it is considered that the air pollutants of concerns during the construction phase of the Project are TSP, RSP and FSP from dust emitting activities. Quantitative construction dust modelling has been undertaken as a prudent approach to the assessment.

3.5.1.1 Air Pollutant Sources

The key activities that would potentially result in dust emissions during construction phase of the Project have been identified as follows:
- Site formation;
- Foundation works;
- Excavation activities;
- Movement of mobile plant and vehicles on haul roads; and
- Storage of potentially dusty construction materials.

3.5.1.2 Identification of Key Air Pollutants of Concern

The air pollutants of concerns during the construction phase of the project are TSP, RSP and FSP from dust emitting activities.

3.5.2 Operation Phase

3.5.2.1 Air Pollutant Sources

During the operation phase, cumulative air quality impacts on the ASRs due to the following emissions are anticipated:

- Vehicular emissions from the existing open roads and the proposed improvements of open roads within the 500m Study Area;
- Chimney emissions from Organic Waste Treatment Facilities, Phase 2 (OWTF2) which is, based on site visit and letter from EPD (**Appendix 3.20**), the only chimney emission source identified within 500m Study Area of the Project;
- Dust and lead dust from the proposed firing ranges; and
- Emission from helicopter from the proposed helipad.

<u>Operation Phase – Helicopter Emissions</u>

The proposed helipad is located to the north of the Project Site and with at least 120m horizontal distance from the nearby ASRs (i.e. Proposed ASR P33). The operation of the proposed helipad is for emergency use (i.e. air ambulance, search & rescue, supporting law enforcement agencies and fire fighting) without time restriction and non-emergency use (i.e. training) restricted to 7am to 7pm only. As confirmed by GFS and HKPF, the durations of all localized helicopter manoeuvring events over the helipad are 1 minute for approach, 1 minute for take-off, 8 seconds (for hovering as orientation adjustment) / 2 minutes (for hovering as training), and 4 minutes for idling (see **Section 4.7.1**). Those localized helicopter manoeuvring events will only occupy short durations over the averaging times of pollutants in AQOs. As shown in **Table 3.1**, the minimum averaging time of air pollutants is 10 minutes (i.e. SO_2). As such, the localized event will only occupy up to 4 minutes over the minimum 10 minutes averaging time of air pollutants (or Max. 40% on-time for air pollutants). In addition, the proposed helipad will be used for conducting two types of scheduled training, namely Type A (with 2 helicopters in operation per occasion) and Type B (with 1 helicopter in operation per occasion). For Type A, it will be conducted in weekly basis with expected duration less than 1 hour per occasion. For Type B, it will be conducted in 16 occasions in average per year with expected duration less than 2.5 hours per occasion. In other words, the total duration of potential exhaust emission associated with the scheduled trainings would be less than 52 hours per year (i.e. 0.6% of the total hours in a year) for Type A and less than 40 hours per year (i.e. 0.5% of the total hours in a year) for Type B. Moreover, even though it is impossible to determine the frequency of emergency use, the durations of manoeuvring associated with the emergency operation should be relatively smaller than those due to the scheduled trainings. Thus, the potential helicopter emission due to emergency / non-emergency operation would only be temporary with sporadic occurrence.

As confirmed by GFS, kerosene-type aviation fuel Jet A-1 (with fuel sulphur content of max. 0.3%) will be adopted by the GFS helicopters in the proposed KNP helipad. Also, as inferred from **Table 3.3** and **Table 3.4**, the 4^{th} maximum 10-minute and 4^{th} maximum 24-hour SO_2 levels at EPD's general air quality monitoring station in Tai Po in the past 5 years are only up to 14% and 20% of the corresponding AQO respectively. It shows the ambient SO_2 levels are well below the relevant AQOs with large margin.

In conclusion, the proposed helipad located at open spaces (with at least 120m horizontal distance from the nearby ASRs) is of low usage frequency for emergency / non-emergency use. In addition, the localized helicopter manoeuvring events will only occupy short durations over the averaging times of pollutants in AQOs (or Max. 40% on-time for air pollutants), and the turbulence created by helicopters rotors should readily dissipate the exhaust gases from the helicopter. As a result, accumulation of exhaust emissions from helicopters associated with the proposed helipad is not expected and the air quality impact of the helicopter operation is anticipated to be insignificant on the immediate environs.

3.5.2.2 Identification of Key Air Pollutants of Concern

As presented in **Section 3.2.2**, under the APCO, AQOs are stipulated for seven criteria air pollutants namely, nitrogen dioxide (NO_2), sulphur dioxide (SO_2), respirable suspended particulate (RSP), fine suspended particulate (FSP), carbon monoxide (CO), ozone and lead. As identified in **Section 3.5.2.1**, during operation phase, the identified ASRs would be subject to potential air quality impact due to vehicular and chimney emissions. Each of the seven criteria pollutants has been reviewed for its relevance to such major air pollution sources as follows.

Nitrogen Dioxide (NO_2)

According to the "*2014 Hong Kong Emission Inventory Report*" published by EPD in May 2016, , public electricity generation, navigation and road transport are the top three major sources of nitrogen oxides (NOx) generated in Hong Kong, constituting respectively about 33%, 33% and 19% of the total NOx emission in 2014 respectively. NOx would be transformed to NO_2 in the presence of O_3 under sunlight. As summarized in **Table** 3.2, the latest 5-year average of the annual NO_2 concentration at Tai Po Station exceeded the corresponding AQO by about 15%. Therefore, NO_2 has been identified as a key air pollutant of the emissions from both road traffic and chimney emissions, and has been assessed against the relevant AQOs for this Project.

Respirable Suspended Particulates (RSP)

According to the "*2014 Hong Kong Emission Inventory Report*", navigation, public electricity generation and non-combustion sectors are the top three sources of RSP emissions in Hong Kong, accounting for about 36%, 17% and 15% respectively of the total RSP emissions in 2014, and there was a decline in emissions from the road transport and biomass burning sectors. However, as summarized in **Table 3.2**, the latest 5-year average of the annual RSP concentration at Tai Po Station is about 82% of the corresponding AQO. Therefore, RSP has been identified as a key air pollutant of the emissions from both road traffic and chimney emissions, and has been assessed against the relevant AQOs for this Project.

Fine Suspended Particulates (FSP)

According to the "*2014 Hong Kong Emission Inventory Report*" published by EPD, as FSP is a fraction of RSP, they share similar emission sources and emission trends. Navigation, road transport, and other combustion sectors were the top three sources of FSP emissions, accounting for 42%, 17% and 16% of total FSP emissions in 2014, respectively. As the Project is expected to produce dust during the construction phase and an increase in traffic during operation phase, FSP has been identified as a key pollutant of concern for assessment during operation phase.

Sulphur Dioxide (SO_2)

According to the "*2014 Hong Kong Emission Inventory Report*", public electricity generation and navigation were the top two sources of SO_2 emission in Hong Kong in 2014, accounting for 53% and 44% of total SO_2 emissions respectively. As inferred from **Table 3.3** and **Table 3.4**, the 4^{th} maximum 10-minute and 4^{th} maximum 24-hour SO_2 levels at EPD's general air quality monitoring station in Tai Po in the past 5 years are only up to 14% and 20% of the corresponding AQO respectively. Given that the ambient SO_2 levels are well below the relevant AQO, SO_2 is not considered as a key air pollutant for air quality impact assessment for this Project.

Ozone

According to the "*Air Quality in Hong Kong 2014*" published by EPD, ozone is a major constituent of photochemical smog. It is not a pollutant directly emitted from man-made sources but formed by photochemical reactions of primary pollutants such as NOx and volatile organic compounds (VOCs) under sunlight. As it takes several hours for these photochemical reactions to take place, ozone recorded in one place could be attributed to VOC and NOx emissions from places afar. Hence, ozone is a regional air pollution problem. In other words, unlike such air pollutants as NOx and RSP, ozone is not a pollutant directly attributable to emissions from nearby road traffic. As a result, ozone is not identified as a key air pollutant for air quality impact assessment for this Project, though it is one of the criteria pollutants under the AQO.

Carbon Monoxide (CO)

According to the "*2014 Hong Kong Emission Inventory Report*", road transport is the major CO emitter in Hong Kong, contributing to about 60% of the total CO emission in 2014. However, based on the *"Air Quality in Hong Kong 2015 Statistical Report"* published by EPD, the highest 1-hour CO level and the highest 8-hour CO concentration in Mong Kok roadside station are respectively 3,410μg/m^3 and 2,303μg/m^3, which are only 11% and 23% of the corresponding AQO respectively. Given that the ambient CO levels are well below the relevant AQO with large margins as opposed to the other pollutants such as RSP and NO_2, it is considered appropriate to select RSP and NO_2, but not CO, as the key pollutants for air quality impact assessment against the AQO for this Project.

Lead

Since leaded petrol was banned in Hong Kong on 1 April 1999, it is no longer considered as a primary source in Hong Kong. According to the "*Air Quality in Hong Kong 2014*" published by EPD, the ambient lead concentrations continued to linger at very low levels during 2014 as in previous years, and the overall annual averages, ranging from 4-29 ng/m^3 (at Central/Western, Kwai Chung and Mong Kok) to 35 ng/m^3 (at Yuen Long), were well below the AQO limit of 500 ng/m^3. Therefore, it is not considered as a key air pollutant for the operation phase air quality impact assessment.

3.5.3 Odour Emissions

During operation phase, it is anticipated that the ASRs would be subject to potential odour impacts due to the following proposed and existing odour emission sources within the 500m Study Area are:

- the proposed firing ranges of the Project;
- the proposed OWTF2;
- the existing San Uk Ling Firing Range and Cheung Po Tau Firing Range; and
- the three existing pig farms.

3.5.4 Concurrent Projects

The Project is anticipated to commence in 2018 and complete by 2022. According to **Section 2.9**, cumulative impacts are expected due to concurrent projects in the vicinity. **Table 3.6** summarizes the concurrent projects that may contribute to cumulative impact during construction and operation phase.

Table 3.6: Summary of concurrent projects during construction and operation phase

Project	Construction Period	Operation Period	Possible Cumulative Impact	Included in cumulative impact assessment	
				Construction Phase	Operation Phase
Proposed Organic Waste Treatment Facilities Phase 2 (OWTF2)	Late 2017	2019/2020 (tentatively)	Dust emissions from construction, and chimney emissions from operation of the OWTF2 project.	Yes	Yes
Columbarium Crematorium and Related Facilities at Sandy Ridge	Handover the formed land in 2019, complete construction in 2022	2023	Dust emissions from construction phase	Yes	No

3.6 Air Quality Modelling Methodology

3.6.1 Introduction

In accordance with the EPD's *Guidelines on Choice of Models and Model Parameters*, the following models have been employed to assess the air quality impacts due to the Project:

- PATH has been used to predict the current background air pollution due to sources outside the Project boundary. Sources include, but are not limited to: the Pearl River Deltas Economic Zone (PRDEZ); the Hong Kong International Airport; power plants in HKSAR; roads beyond the Project, and marine emissions. Background data predicted by PATH for year 2020 represents the worst case year relevant to the assessment of the Project.

- FDM has been used to predict the air pollutant concentrations due to fugitive and open dust source impacts during the construction phase.
- EMFAC-HK v2.6 model has been used to determine the fleet average emission factors, for all the planned and existing roads within the 500m Study Area. The model has included the effect of Inspection and Maintenance (I/M) program and is applicable for calendar years between 2013 and 2040.
- CALINE4 has been used to predict the air pollutant concentrations due to vehicular emissions from all open road links within the 500m Study Area, which are as shown in **Figure 3.10**.
- ISCST3 has been used to predict the air pollutant concentrations due to chimney emissions from the nearby OWTF2. The location of the chimney sources are as shown in **Figure 3.11**.

3.6.2 Model Limitations

It should be noted that all Gaussian based dispersion models, including FDM, CALINE4 and ISCST3, have limited ability to predict dispersion in the following situations.

Causality effects

Gaussian plume models assume pollutant material is transported in a straight line instantly (like a beam of light) to receptors that may be several hours or more in transport time away from the source. The model takes no account for the fact that the wind may only be blowing at 1 m/s and will have only travelled 3.6 km in the first hour. This means that Gaussian models cannot account for causality effects, where the plume may meander across the terrain as the wind speed or direction changes. This effect is not considered to be significant for the Project site as the site is small.

Low wind speeds

Gaussian-plume models 'break down' during low wind speed or calm conditions due to the inverse speed dependence of the steady state plume equation. These models usually set a minimum wind speed of 0.5 or 1.0 m/s and ignore or overwrite data below this limit.

Straight-line trajectories

Gaussian models will typically overestimate terrain impingement effects during stable conditions because they do not account for turning or rising wind caused by the terrain itself. This effect is not considered to be important for Kong Nga Po as the site is relatively flat.

Spatially uniform meteorological conditions

Gaussian models assume that the atmosphere is uniform across the entire modelling domain, and that transport and dispersion conditions exist unchanged long enough for the material to reach the receptor even if this is several kilometres away. In the atmosphere, truly uniform conditions rarely occur.

Although the site is small, variation in the meteorological conditions is expected due to the local terrain. However, as a full year is modelled, most conditions are expected to be modelled and therefore the results are considered reasonable.

No memory of previous hour's emissions

In calculating each hour's ground-level concentrations, Gaussian models have no memory of the contaminants released during the previous hours. This limitation is especially important for the proper simulation of morning inversion break-up, fumigation and diurnal recycling of pollutants.

3.6.3 Construction Phase

3.6.3.1 Model Description – FDM

To assess the air quality through air quality modelling, use of the model FDM was required. In accordance with the EPD's *Guidelines on Choice of Models and Model Parameters*, FDM is proposed to predict the air pollutant concentrations due to open dust source impacts for dust effects. The FDM is a computerised air quality model specifically designed for computing the concentration and deposition impacts from fugitive dust sources. The model is generally based on the Gaussian Plume formulation for computing concentrations, but the model has been specifically adapted to incorporate an improved gradient transfer deposition algorithm. FDM is one of the air quality models listed as commonly used for EIA studies by EPD in *Guidelines on Choice of Models and Model Parameters*.

3.6.3.2 Assumption and Inputs - FDM

Dust Emission Factors

Prediction of dust emissions is based on emissions factors from the *Compilation of Air Pollution Emission Factors (AP-42), 5th Edition* published by the US Environmental Protection Agency (USEPA). The emission factor for a typical heavy construction activity is 2.69 megagrams (Mg)/hectare/month according to Section 13.2.3.3 of AP-42. Based on Table 11.9-4 of AP-42, the emission factor for wind erosion of 0.85 megagrams (Mg)/hectare/year is adopted. The key dust emission factors adopted in the Fugitive Dust Model (FDM) are summarised in **Table 3.7**.

Suitable dust size categories relevant to the dust sources concerned with reasonable breakdown in TSP, RSP and FSP compositions should be used in evaluating the impacts of dust-emitting activities. With reference to the USEPA document *Estimating Particulate Matter Emissions from Construction Operations*, 1999, a typical ratio of 0.3:1 is used for RSP:TSP. Therefore, the RSP emission rates for heavy construction activities and wind erosion are estimated as 30% of the corresponding TSP emission rates. Based on the USEPA's *Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10*, April 2005, FSP emission from heavy construction activities and wind erosion can be estimated as 3% of the corresponding TSP emissions. Details of these emission factors are given in **Table 3.7**.

TSP, RSP and FSP emissions rates for loading and unloading of dusty materials for stockpiles are estimated by the relevant formulae based on Section 13.2.4.3 of the USEPA AP-42, as detailed in **Table 3.7**.

For mitigated scenarios, the active construction areas would have ground watering applied approximately once every 1.25 hours or eight times per day. This gives rise to an estimated dust suppression efficiency of 91.7% (refer to **Appendix 3.1** for detailed calculations). The unmitigated scenario does not employ any watering for dust suppression.

Table 3.7: Key Dust Emission Factors Adopted in the Assessment

Activities	Emission Factors	Reference
Heavy construction activities including all above ground and open construction works, excavation, slope cutting and earth works	TSP Emission Factor = 2.69 Mg/hectare/month	Section 13.2.3.3 AP-42, 5th Edition
	RSP Emission Factor = 2.69 x 30% Mg/hectare/month	USEPA document Estimating *Particulate Matter Emissions from Construction Operations, 1999*
	FSP Emission Factor = 2.69 x 3% Mg/hectare/month	Thompson G. Pace, USEPA. *Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10, April 2005*
Wind erosion from heavy construction, open area and stockpile	TSP Emission Factor = 0.85 Mg/hectare/year	Table 11.9-4 AP-42, 5th Edition
	RSP Emission Factor = 0.85 x 30% Mg/hectare/month	USEPA document Estimating *Particulate Matter Emissions from Construction Operations, 1999*
	FSP Emission Factor = 0.85 x 3% Mg/hectare/month	Thompson G. Pace, USEPA. *Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10, April 2005*
Loading or unloading of dusty materials for stockpiles, and concrete batching plant (if any)	TSP or RSP or FSP Emission Factor = k*0.0016*[(U/2.2)1.3/(M/2)1.4] kg/Mg k is particle size multiplier[a] U is Average wind speed M is Moisture content	Section 13.2.4.3 AP-42, 5th Edition

Note: (a) The particle size multipliers for TSP, RSP and FSP are made reference to Section 13.2.4.3 of the USEPA Compilation of Air Pollution Emission Factors (AP-42), 5th Edition (Jan 2011 edition).

The particulate size distributions of the dust emissions from all the aforementioned construction activities and facilities are estimated based on the relevant references as given **Table 3.7**. Details of the estimated particle size distributions are given in **Appendix 3.2**.

Working Hours and Days

The number of working hours per day and number of working days per month for which construction of the Project will be carried out are respectively 10 hours per day (8am to 6pm) and 6 days per week (Monday to Saturday), i.e. no construction of the Project is expected on Sundays.

Roughness Factor

According to the EPD guideline on *Choice of Models and Model Parameters*, the selection of rural or urban dispersion coefficients in a specific application should follow a land use classification procedure. If the land use types including industrial, commercial and residential uses account for 50% or more of an area within a 3 km radius from the source, the site is classified as urban; otherwise it is classified as rural. The surface roughness height is closely related to the land use characteristics of a Study Area and associated with the roughness element height. As a first approximation, the surface roughness can be estimated as 3 % to 10 % of the average height of physical structures. Typical values used for urban and new development areas are 370 cm and 100 cm, respectively. The Project site is located at area with industrial, commercial and residential land uses less than 50%, therefore a roughness coefficient of 100 cm is used in FDM modelling.

Background TSP, RSP and FSP

PATH model can be used to predict background air quality as a result of various sources in Hong Kong and the surrounding regions, including the Pearl River Delta Economic Zone (PRDEZ). Grids (25,43), (25,44), (25,45), and (26, 44) have been adopted as background levels for prediction of cumulative fugitive dust impact at the identified ASRs (see **Table 3.5**).

As the PATH model does not generate TSP results, the PATH RSP results are taken to represent the background contributions to TSP at the sensitive receivers. This is considered to be a reasonable assumption as particulate matter of sizes larger than RSP from far-field sources would be largely settled before reaching the sensitive receivers. Therefore, the background hourly TSP levels can be reasonably estimated as the same as RSP concentrations for the purpose of estimating the cumulative 1-hour TSP levels due to the activities of the Project.

PATH model was used to predict far-field contributions to the background RSP levels on an hour-by-hour basis within the 500m Study Area during the construction phase of the Project. The hourly RSP levels as predicted by PATH is multiplied by a factor of 0.75 to conservatively estimate the corresponding FSP levels according to EPD's *Guidelines on the Estimation of PM2.5 for Air Quality Assessment in Hong Kong*.

Modelling Methodology

Heavy construction associated with site formation, excavation or earth moving and site clearance and wind erosion at the Project are the main sources of dust emissions during the Project.

For hourly TSP, daily RSP and daily FSP, a tiered modelling approach is adopted. A hypothetical Tier 1 screening assumes 100% of the work areas as active areas that are emitting particulate matter. This Tier 1 scenario (i.e. assuming 100% active area for the Kong Nga Po and the concurrent project) is hypothetical and used for screening purposes to identify which ASRs may be subject to concentrations above the relevant standards.

For the purpose of the Tier 1 screening, dust mitigation measures, including frequent water spraying, are taken into account when estimating the dust emission rates from the construction activities. The Tier 1 hourly TSP, daily RSP and daily FSP levels at all the ASRs are then predicted for both scenarios of with and without the dust mitigation measures in place. Locations of the Tier 1 dust sources are given in **Figure 3.4** to **3.6**. **Appendix 3.3** presents the TSP, RSP and FSP emission rates of the Tier 1 dust sources estimated based on details of the construction programme and the relevant emission factors as given in **Table 3.7**.

Since no ASRs were identified with hourly TSP, daily RSP or daily FSP non-compliance under Tier 1 screening, no subsequent Tier 2 assessment was conducted.

For the assessment of annual RSP and FSP concentrations, the active work area over the entire year would be less than that for a typical working hour or a typical working day. The percentage active area averaged over the entire construction year is estimated for each work area. The annual RSP and FSP assessment is based on the maximum of the estimated percentage active areas for all zones, which is applied to all the areas. The annual RSP and FSP levels are predicted at all the ASRs for both scenarios of with and without the dust mitigation measures in place. Details of the estimated percentage active areas for annual RSP and FSP assessment are given in **Appendix 3.4**.

All the model input files for Tier 1 of TSP, RSP and FSP are given in **Appendix 3.6**. **Appendix 3.8** presents the RSP and FSP emission rates of the annual dust sources estimated based on details of the construction programme and the relevant emission factors as given in **Table 3.7**. **Appendix 3.9** shows all the model input files for annual assessment of RSP and FSP.

3.6.4 Operation Phase – Vehicular and Chimney Emissions

3.6.4.1 Introduction

To assess the operational phase air quality, a variety of models are required. In accordance with the EPD's *Guidelines on Choice of Models and Model Parameters*, the following air dispersion models have been employed to predict the cumulative levels of various air pollutants at the identified ASRs:

- EMFAC-HK V2.6 (I and M) model has been used to determine the fleet average emission factors, for all the existing roads and proposed improvement of open roads within the 500m Study Area. The model has included the effect of Inspection and Maintenance (I/M) program and is applicable for calendar years between 2013 and 2040.
- CALINE4 has been used to predict the air pollutant concentrations due to vehicular emissions from all existing and proposed improvement of open road links within the 500m Study Area, which are as shown in **Figure 3.10**.

- ISCST3 has been used to predict the air pollutant concentrations due to stack sources from the nearby OWTF2. The locations of all such pollution sources are as shown in **Figure 3.11**.
- PATH has been used to predict the current background air pollution due to sources outside the Project boundary. Sources include, but are not limited to: the Pearl River Deltas Economic Zone (PRDEZ); the Hong Kong International Airport; power plants in HKSAR; roads, and; marine emissions. Background data predicted by PATH for year 2020 represents the worst case year relevant to the assessment of the Project.

The cumulative hourly maximum NO_2, RSP and FSP concentrations are predicted by the above models by using the corresponding MM5 hourly meteorological data in 2010 as extracted from the PATH model released by EPD in December 2012.

3.6.4.2 EMFAC-HK V.2.6

Model Description

EMFAC-HKV2.6 is an emissions inventory model that calculates emissions inventories for motor vehicles operating on roads in Hong Kong. The model is used for estimating vehicular tailpipe emissions including NOx, RSP and FSP. The model can take into account both vehicle technologies and driving conditions. The model follows that of the California Air Resources Boards' EMFAC model but with modifications to cater for local factors, including the substantial reduction of the smoky vehicle problem in recent years.

Assumptions and Inputs

For all the planned and existing roads within the 500m Study Area, the EMFAC-HK V2.6 (I and M) model has been used to determine the fleet average emission factors. The model includes the effect of the Inspection and Maintenance (I/M) program and is applicable for calendar years between 2013 and 2040.

The Burden mode, used for calculating area-specific emission factors, was selected in the model. Under this mode, the total emissions of pollutants such as PM10 and PM2.5 have been computed for each type of vehicle class based on temperature, speed corrected emission factors and vehicle activity. Hourly output has been selected.

The assumptions and input parameters on modelling of vehicle emission factors are presented in the following sections. The traffic data to be used for the assessment included hourly traffic flows of 16 vehicle classes at various road links, and the speed fractions of various vehicle classes in four model years. According to the Project programme (see **Appendix 2.1**), the planned commencement of operation of the Project will be 2023. The model years were: the 1st operation year of the Project; intermediate years at five-year intervals until 15 years after the commencement of operation the Project. The model years of the EMFAC-HK are: 2023 (the year when operation of the Project is planned to commence); intermediate years 2028 and 2033, and 2038 (15 years after commencement of operation of the Project).

Traffic data is provided by the Traffic Consultant, and are presented in the following sections. The traffic forecast data has been submitted to the Transport Department (TD) for review. TD has no objection in principle to the traffic data. The correspondence from TD is provided in **Appendix 3.10**. The 24-hour traffic patterns are given in **Appendix 3.11**.

Vehicle Emission Standards

The emission standards according to the latest implementation schedule (as of January 2014) have been adopted in EMFAC-HK V2.6 model for vehicles registered in Hong Kong. In this model, the latest European Union (EU) emission standard, Euro VI, for all vehicle classes can be applied, with the exception of motorcycles which do not have applicable new EU emission standards.

Road Grouping

The road links for assessment have been grouped into two types. Emission factors for the following two road types have been calculated:

Road Type 1 – Local Road (Design speed limit: 50kph) without cold start, and;

Road Type 2 - Local Road (Design speed limit: 50kph) with cold start.

There is interrupted flow in Local Roads of both two road types. The road type classification of individual road links in the Study Area is as shown in **Appendix 3.13** and **Figure 3.10**.

Vehicle Classes

Vehicles operating on open roads have been categorised into 16 vehicle classes according to the Guideline on Modelling Vehicle Emission – Appendix I for EMFAC-HK V2.6, and is presented in **Table 3.8**.

Table 3.8: Vehicle Classification in the EMFAC-HK Model

Index	Description	Notation in EMFAC-HK Model	Fuel Type	Gross Vehicle Weight
1	Private Cars (PC)	PC	ALL	ALL
3	Taxi	Taxi	ALL	ALL
4	Light Goods Vehicles (<=2.5t)	LGV3	ALL	<=2.5ton
5	Light Goods Vehicles (2.5-3.5t)	LGV4	ALL	>2.5-3.5ton
6	Light Goods Vehicles (3.5-5.5t)	LGV6	ALL	>3.5-5.5ton
7	Medium & Heavy Goods Vehicles (5.5-15t)	HGV7	ALL	>5.5ton-15ton
8	Medium & Heavy Goods Vehicles (>15t)	HGV8	ALL	>15ton
11	Public Light Buses	PLB	ALL	ALL
12	Private Light Buses (<=3.5t)	PV4	ALL	<=3.5ton
13	Private Light Buses (>3.5t)	PV5	ALL	>3.5ton
14	Non-franchised Buses (<6.4t)	NFB6	ALL	<=6.4ton

Index	Description	Notation in EMFAC-HK Model	Fuel Type	Gross Vehicle Weight
15	Non-franchised Buses (6.4-15t)	NFB7	ALL	>6.4ton – 15ton
16	Non-franchised Buses (>15t)	NFB8	ALL	>15ton
17	Single Deck Franchised Buses	FBSD	ALL	ALL
18	Double Deck Franchised Buses	FBDD	ALL	ALL
19	Motor Cycles	MC	ALL	ALL

Exhaust/ Evaporation Technology Fraction

Vehicle classes are grouped by different exhaust technology indexes and technology fractions. Each technology group represents a distinct emission control technology. The EMFAC-HK V2.6 model has a set of default exhaust technology fractions which best represents the scheduled implementation of new vehicle emission standards as of January 2014. As there is no update to the planned emission control measures since the release of the guideline in January 2014, the default exhaust technology fractions are considered to be applicable in this assessment.

Vehicle Population

According to the *Guidelines on Modelling Vehicle Emissions*, the vehicle population forecast function in EMFAC-HK v2.6 used 2010 as the base year. Natural replacement of vehicles and a set of annual growth rates and survival rates for different vehicles were assumed for 2011 to 2040. In particular, vehicles including private cars, motorcycles, and goods vehicles are assumed to grow by a varying percentage (from 0%-2.5% annually) during the period whereas the number of franchised buses, public light buses and taxis are assumed to have no growth.

The default populations from the November 2012 population information were adopted for the model years in this assessment. The vehicle age distributions, in the base year 2010, are presented in **Appendix 3.12** for reference.

The use of electric vehicles (EVs), which do not have tailpipe emissions, has been promoted by the government in recent years. By the end of December 2014, there were 1,551 EVs in use in Hong Kong. The introduction of EVs will have an impact on the future vehicle fleet composition, although the effect is still unknown. Impacts will vary with policy in the future and the successful application of EVs as an alternative to the traditional vehicles. As a conservative approach, this assessment will not take into account the presence of EVs and any programme on the promotion of EVs.

Accrual Rate

Default values were adopted with reference to in the EMFAC-HK Guideline.

Diurnal Variation of Daily Vehicle-kilometre-travelled

For each vehicle class, the Vehicle Kilometre Travelled (VKT) of individual hours is calculated by multiplying the hourly number of vehicles with the length of the corresponding road links (in kilometres). Diurnal (24-hour) traffic pattern has been provided by the Traffic Consultant. The lengths of individual road links of the connecting road are given in **Appendix 3.13**. The 24-hour VKT values for all vehicle classes in each of the model years 2023, 2028, 2033 and 2038, are provided in **Appendix 3.14**.

Daily Trips

The daily trips were used to estimate cold start emissions of petrol and LPG vehicles only and is prescribed by the model. Therefore, trips for vehicles other than petrol or LPG type vehicles would be assumed to be zero. Different road types have different number of trips, as follows:

Local Road Types (Road Type 2)

For Local Roads, the number of trips in the assessment area, $Trip_{\text{within assessment area}}$, has been estimated as:

$Trip_{\text{within study area}} = (Trip_{\text{within HK}} / VKT_{\text{within HK}}) \times VKT_{\text{within study area}}$

$Trip_{\text{within HK}}$ is the default data of EMFAC-HK model. $VKT_{\text{within HK}}$ is the VKT of local roads in Hong Kong, which is estimated based on the default VKT data of EMFAC-HK model and the relevant data as published in the latest *Annual Traffic Census 2014* by TD. Details of the trip estimation are as shown in **Appendix 3.15**. According to the Mobile Source Group of EPD, the default VKT and trips in the model are based on EPD's estimated data for Hong Kong. $VKT_{\text{within assessment area}}$ is calculated as mentioned above. The trips in each year are provided in **Appendix 3.14**.

While the number of trips is dependent on vehicle population, if no project-specific vehicle population data can be identified for the assessment area, according to the Traffic Consultants. However, project-specific VKT has been estimated based on the traffic forecast in the assessment area. Moreover, It can be argued that VKT is related to vehicle population in such a way that a higher vehicle population would generally result in a higher VKT. As a result, it has been proposed to estimate the number of trips in the assessment area on the basis of the project-specific VKT and the assumption that the number of trips per VKT in the Study Area would be similar to the number of trips per VKT in Hong Kong. This proposed approach would be based on the best available data and therefore considered a reasonable assumption. This approach for estimating the number of trips together with the results of estimation was submitted to TD for review. TD has no objection in principle to the method and the correspondence from TD is provided in **Appendix 3.10**.

Hourly Temperature and Relative Humidity Profile

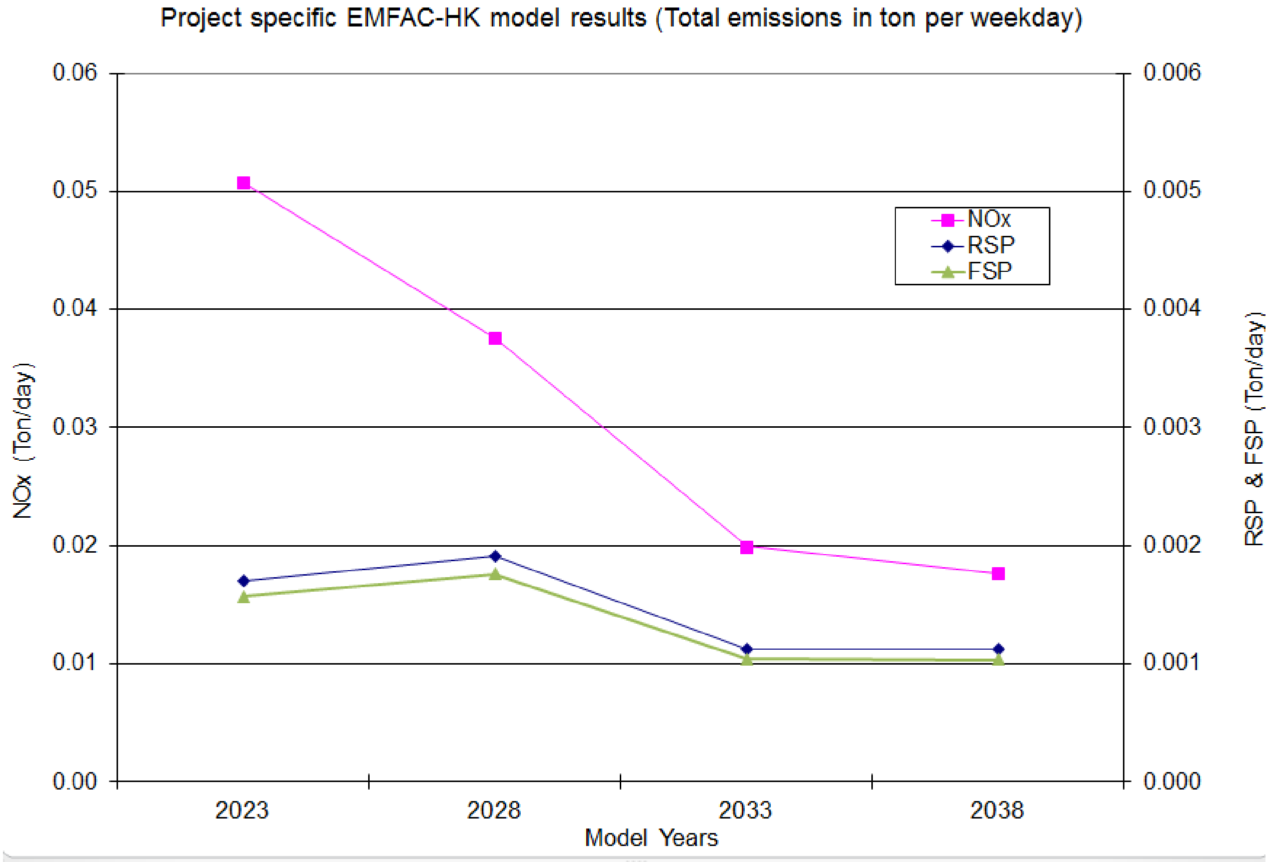
Annual and monthly hourly average ambient temperature and relative humidity as extracted from the 2014 meteorological data obtained from Hong Kong Observatory (HKO) at King's Park meteorology station (with at least 90% valid data) were adopted. The 24-hour variations of the annual averages of temperature and relative humidity are presented in **Appendix 3.16**.

Speed Fractions

The 24-hour speed fractions for different road types and individual vehicle classes are provided by the Traffic Consultant, and are calculated based on the 24-hour traffic flow in each model year and the volume/capacity ratio of different road types. For each vehicle class, the VKT of each road type was grouped into sub-groups with speed bins of 8 km/h (0 – 8 km/h, 8 – 16 km/h, 16 – 24 km/h, etc.). The speed fraction of each sub-group was derived by the summation of the total VKT of road links within the sub-group and divided by the total VKT of all road links. The estimated speed fractions provided by the Traffic Consultant are given in **Appendix 3.17**.

Predicted Emission Factors by EMFAC-HKV2.6

To determine the emissions within 15 years after the commencement of operation of the Project, emission rates were modelled for year 2023, 2028, 2033 and 2038. Upon modelling by EMFAC-HKV2.6, the emissions of each vehicle class at different hours are then be divided by its corresponding VKT to obtain 24-hr emission factors in grams/vehicle-km (g/veh-km). The calculations of emission factors for each model year are shown in **Appendix 3.18**. By comparing the total emissions in different model years as shown in **Graph 3.5**, year 2023 represents the worst case scenario where the total NOx emission is the highest among all model years. This is because despite the increased traffic volume with every passing year, the total emissions are expected to decrease as a result of the retirement of older and more polluting vehicles in the fleet, which would be replaced with newer vehicles with lower emissions. Such a trend is not as clearly observed for RSP and FSP where years 2028 appear to have higher total emissions. However, due to the fact that the NO_x emissions are significantly higher than those of particulate matter and the annual average background NO_2 levels as recorded at the Tai Po Monitoring Station over the past five years from 2011 to 2015 (as shown in **Table 3.2**) were greater than its corresponding AQO, making NO_x the pollutant of greatest concern; it is proposed to use the emission factors of this worst case year 2023 for the prediction of air quality impacts due to vehicular emissions in order to arrive at conservative impact assessment results.



3.6.4.3 CALINE4

Model Description

CALINE4 is a line source air quality model developed by the California Department of Transportation and is one of the models prescribed by the EPD *Guidelines on Choice of Models and Model Parameters*. It is based on Gaussian diffusion equations and employs a mixing zone concept to characterise pollutant dispersion over the roadway.

The purpose of the model is to assess air quality impacts near transportation facilities. Given the source strength, meteorology and site geometry, CALINE4 can predict pollutant concentrations for receptors located within 500m of a given roadway. As with all Gaussian models, CALINE4 has the same limitations as described in **Section 3.1.1**.

Assumptions and Inputs

The predicted traffic flows will take into account the development of the concurrent projects referred to in **Section 3.5.4**. **Appendix 3.11** presents details of the 24-hour traffic forecast for different vehicles and individual road links within the 500m Study Area (see **Figures 3.10**) as provided by the Traffic Consultants.

The hourly NO_2, RSP and FSP concentrations due to vehicular emissions have been predicted by CALINE4 by using the corresponding MM5 hourly meteorological data in 2010 as extracted from the PATH model at the relevant grids (25,43), (25,44), (25,45), and (26, 44) for the identified ASRs (see **Table 3.5**). The data is considered to be the most up to date data available. PATH data has been observed to have a lower mixing height for some hours, when compared to the measured mixing height. The minimum mixing height recorded by HKO in year 2010 is 121.3m, whereas the PATH minimum mixing height is 40m. The HKO minimum mixing height of 121.3m is used to replace any PATH mixing height below this value. This approach is considered appropriate as it will minimise over-estimation due to lower mixing heights and also will minimise under-estimation due to high stacks being excluded in the mixing volume. The PATH data with the above modification is considered to be representative of the site wind data at the Project.

According to EPD's guideline on *Choice of Models and Model Parameters*, the selection of rural or urban dispersion coefficients in a specific application should follow a land use classification procedure. If the land use types including industrial, commercial and residential uses account for 50% or more of an area within a 3km radius from the source, the site is classified as urban; otherwise it is classified as rural. The surface roughness height is closely related to the land use characteristics of a Study Area and associated with the roughness element height. Typical values used for urban and new development areas are 370cm and 100cm, respectively. The Project site is located at area with industrial, commercial and residential land uses less than 50%, therefore a roughness coefficient of 100cm is used in Caline4 modelling.

Based on the worst case emission factors and the 24-hour traffic flow in the worst case year 2023 (see last paragraph of **Section 3.6.4.2**), the composite fleet emission factors have been calculated for the road links, as detailed in **Appendix 3.19**.

3.6.4.4 ISCST3

Model Description

In accordance with EPD's *Guidelines on Choice of Models and Model Parameters*, the Industrial Source Complex – Short Term version 3 (ISCST3) model was used to quantitatively assess the air quality impact due to the chimney emissions from the OWTF2 (modelled as point sources) (see **Section 3.6.4.1**).

ISCST3 is a steady state Gaussian plume model which is one of the models prescribed by EPD's *Guidelines on Choice of Models and Model Parameters* and can be used to assess pollutant concentrations from sources associated with an industrial source complex. ISCST3 is considered an appropriate model to use for this situation as meteorological conditions will not vary greatly over the site, as the site is relatively flat and small. ISCST3 and all Gaussian based dispersion models have limited ability to predict dispersion in the situations as described previously in **Section 3.1.1**.

Assumptions and Inputs

According to the information provided by EPD (**Appendix 3.20**), there is no existing/planned chimney emission (e.g., chimney for the Specified Process or chimney application under the Air Pollution Control Ordinance) except OWTF2 within the 500m Study Area of the Project. Therefore, chimney emissions point sources from only OWTF2 are included in the ISCST3 modelling.

For chimney emission from OWTF2, assumption, emission factor and model inputs of these sources were extracted from the approved OWTF2 EIA Report (AEIAR – 180/2013) (refer to **Appendix 3.21** for the ISCST3 model input parameters).

Based on the latest information provided from the engineer of OWTF2, assumption in the approved OWTF2 are still valid. According to the approved OWTF2 EIA Report, the stack sources of the OWTF2 for ISCST3 modelling (shown in **Figure 3.11**) include:

- Stack exhaust for combined heat and power (CHP) (Point Source);
- Exhaust from odour treatment unit (Point Source);
- Flare exhausts (Point Source).

Modelled emissions of the OWTF2 CHP, odour treatment unit and flare exhaust are in **Table 3.9** to **Table 3.11** below.

Table 3.9: Operational Emissions of the OWTF2 CHP

Equipment	Parameter	Units	Valued used for OWTF2 assessment	Notes
Energy Generation				
	Flowrate	Nm^3/hr	2,500	Flowrate is a maximum
	Temperature	°C	460	
	RSP	mg/Nm^3	15	
	NOx	mg/Nm^3	500 (1)	OWTF2 – no gas cleaning OWTF 2 - with catalytic treatment OWTF 2 - with thermal

Source: Extracted from the approved OWTF2 EIA

Note: (1) Worst-case of two post gas-treatment technologies

Table 3.10: Operational Emissions of the OWTF2 odour treatment units

Equipment	Parameter	Units	Valued used for OWTF2 assessment	Notes
Odour treatment unit				
	Flowrate	Nm^3/hr	195,000	Flowrate is maximum
	Temperature	°C	35	Maximum temperature from odour treatment unit. Lower value used as this give worse thermal dispersion

Equipment	Parameter	Units	Valued used for OWTF2 assessment	Notes
	RSP	mg/Nm^3	6	

Source: Extracted from the approved OWTF2 EIA

Table 3.11: Operational Emission of the OWTF2 flare

Equipment	Parameter	Units	Valued used for OWTF2 assessment	Notes
Flare				
	Flowrate	Nm^3/hr	1,500	Flowrate is a maximum
	Temperature	°C	900	
	RSP	mg/Nm^3	5	
	NOx	mg/Nm^3	200	

Source: Extracted from the approved OWTF2 EIA

The hourly NO_2 and RSP concentrations were predicted by ISCST3 by using the corresponding MM5 hourly meteorological data in 2010 as extracted from the PATH model at grids (25,43), (25,44), (25,45), and (26,44) for the identified ASRs (see **Table 3.5**). As no FSP emissions from the chimney are provided in the approved OWTF2 EIA Report, the FSP concentrations from OWTF2 are assumed to be 100% of the RSP concentration. It is conservative approach to estimate the FSP concentrations from the chimney to be the same as the RSP concentrations for the purpose of estimating the cumulative daily and annual FSP levels. The assumption of mixing height of PATH and surface roughness are the same assumption as those described in **Section 3.6.4.3**.

3.6.4.5 PATH

Model Description

The PATH model is a numerical air quality modelling system developed specifically for use in Hong Kong. The model comprises of three modules: an emission model; a prognostic meteorological model and an Eulerian transport and chemistry model. These modules are interfaced together and set up on a series of nested domains to account for influences outside of Hong Kong.

Assumption and Inputs

An updated version of PATH was released by the EPD for general use in December 2012. As there is no significant inventory update since the release of the latest PATH and the submission of this EIA report, use of the 2012 PATH model in its current state is considered appropriate.

For EIA applications, PATH simulates wind field, pollutant emissions, transportation and chemical transformation and outputs pollutant concentrations over Hong Kong and the Pearl River Delta (PRD) region at a fine grid size of 1.5 km.

During the 12th Hong Kong-Guangdong Joint Working Group Meeting on Sustainable Development and Environmental Protection (Nov 2012), the Hong Kong and Guangdong Governments jointly endorsed a Major Air Pollutant Emission Reduction Plan for the Pearl River Delta Region up to year 2020. A comprehensive emission inventory for Hong Kong and PRD was compiled for year 2010 based on current best estimates and projected to years 2015 and 2020 in accordance with the emission reduction measures proposed in the plan. The emission inventory for year 2010 was used in PATH and produced reasonable agreement with air quality measurements. The projected emission inventories for years 2015 and 2020 were also used in PATH to predict air qualities for future years. The emission inventories include the total emissions from six key groups, namely, public electricity generation, road transport (emissions estimated based on VKT forecast provided by TD and EMFAC-HK model version 2.1), navigation, civil aviation (emissions estimated based on forecasted air traffic movements), other fuel combustion (covering emissions from such major facilities as HK & China Gas, Green Island Cement and Integrated Waste Management Facilities) and non-combustion. The Hong Kong emission inventories of the key air pollutants of concerns for the Project are summarised in **Table 3.12**.

Table 3.12: Summary of Years 2015 and 2020 Hong Kong Emission Inventory for the PATH Model

Pollutant	Total Emission in 2015 (ton/year)	Total Emission in 2020 (ton/year)
SO_2	26,625	23,075
NOx	97,740	86,880
RSP	5,706	5,389

Source: Annex B of 12th Hong Kong-Guangdong Joint Working Group Meeting on Sustainable Development and Environmental Protection (Nov 2012)

PATH model was used to quantify the background air quality during both construction and operational phases of the Project. Emission sources including roads, marine, airports, power plants and industries within the Pearl River Delta Economic Zone and Hong Kong were considered in the PATH model. Details of the PATH Model and related emission inventory can be found in EPD's web site.

The hourly NO_2 and RSP concentrations as extracted from the PATH for year 2020 are adopted as the background air pollutant concentrations in the estimation of cumulative impact for the Project during the Project period.

The vehicular emissions and chimney emissions at local scale (i.e. within the 500m Study Area) have been modelled by near-field dispersion model, CALINE4 and ISCST3 respectively. Adding the PATH background concentrations to the near-field modelling results would lead to certain amount of double counting, and hence conservative cumulative modelling results.

Other Assumption

NO_x to NO_2 Conversion

The Ozone Limiting Method (OLM) as described in EPD's *Guidelines on Choice of Models and Model Parameters* has been adopted to estimate the conversion of NOx to NO_2 based on the future hourly background ozone concentrations for year 2020, which were extracted from the relevant grids (25,43), (25,44), (25,45) and (26,44) of the most up-to-date PATH model. Grid (25,43), (25,44), (25,45), and (26, 44) of the PATH model are used because the identified ASRs are located within these grids (see **Table 3.5**).The NO_x/NO_2 conversion are therefore estimated as follows:

Vehicular emission sources:

$[NO_2]_{vehicle}$ = 0.075 x $[NO_x]_{CALINE4}$ + minimum of {0.925 x $[NO_x]_{CALINE4}$ or (46/48) x (1.017 x $O_3]_{PATH}$)}

Industrial emission sources

$[NO_2]_{Industrial}$ = 0.1 x $[NO_x]_{ISCST3}$ + minimum of {0.9 x $[NO_x]_{ISCST3}$ or (46/48) x (1.017 x $[O_3]_{PATH}$)}

where

$[NO_2]_{vehicle}$ is the estimated hourly vehicular NO_2 concentration (predicted by CALINE4);

$[NO_x]_{CALINE4}$ is the hourly NOx concentration as predicted by CALINE4 for vehicular emissions at the receptor;

$[NO_2]_{industrial}$ is the estimated hourly industrial NO_2 concentration (predicted by ISCST3);

$[NO_x]_{ISCST3}$ is the hourly NOx concentration as predicted by ISCST3 for chimney emissions at the receptor; and

$[O_3]_{PATH}$ is the hourly ozone concentrations as extracted from the aforementioned grids of the PATH model for year 2020, multiplied by a factor of 1.017 to convert the concentration to the reference temperature of the existing air quality objectives of 293K.

For chimney emissions from OWTF2 outside the Project site but within the 500m Study Area, the NO_x to NO_2 conversion for industrial emission have been used, i.e. with an initial 10% of NO_2 in NO_x. To estimate the total hourly concentrations, the hourly pollutant concentrations as predicted by CALINE4 (vehicular) and ISCST3 (Chimney) are added together with the future hourly background pollutant concentrations as extracted from the relevant grids of the PATH model. Therefore, the total hourly concentrations of NO_2 are calculated as follows:

$[NO_2]_{total}$ = $[NO_2]_{vehicular}$ + $[NO_2]_{industrial}$ + (1.017 x $[NO_2]_{PATH}$)

where

$[NO_2]_{total}$ is the total hourly NO_2 concentration;

$[NO_2]_{vehicle}$	is the hourly vehicular NO_2 concentration which is first predicted by CALINE4 NO_x and then converted to NO_2 by using OLM, and;
$[NO_2]_{ISCST3}$	is the hourly NO_2 concentration which is first predicted by ISCST3 as NO_x and then converted to NO_2 by using OLM, and;
$[NO_2]_{PATH}$	is the hourly NO_2 concentrations as extracted from the aforementioned grids of the PATH model, multiplied by a factor of 1.017 to convert the concentration to the reference temperature of the existing air quality objectives of 293K.

Similarly, the total hourly RSP concentrations have been calculated by adding together the hourly RSP results predicted by CALINE4, ISCST3 and PATH. For the hourly FSP concentration, it has been calculated by adding hourly FSP results predicted by CALINE4 and PATH. PATH model are used to predict far-field contributions to the background RSP levels on an hour-by-hour basis within the 500m Study Area during the operation phase of the Project. The hourly RSP levels as predicted by PATH are multiplied by a factor of 0.75 to conservatively estimate the corresponding FSP levels according to EPD's *Guidelines on the Estimation of PM2.5 for Air Quality Assessment in Hong Kong*.

With the total hourly NO_2, RSP and FSP estimated, the daily results are obtained by taking the arithmetic mean of the 24 hour results. Similarly, the annual NO_2, RSP and FSP concentrations are calculated as the arithmetic mean of the whole year of hourly results.

3.6.5 Operation Phase – Helicopter Emissions

A qualitative assessment has been carried out to assess the potential air quality impacts due to exhaust emission from helicopter from the proposed helipad.

3.6.6 Operation Phase – Dust and Lead Dust Emissions from Firing Ranges

A qualitative assessment has been carried out to assess the potential air quality impacts due to operation of the proposed firing ranges.

3.7 Odour Impact Assessment Methodology

3.7.1 Review of Historical Odour Complaints

Records of odour complaints received by EPD within the 500m Study Area in past five years have been reviewed for odour impact assessment of the Project.

3.7.2 Odour Patrol and Measurement

In order to assess the current background odour impacts within and in the vicinity of the Project site, odour patrol and collection of air samples for odour testing at locations within the Project site as well as the nearby existing ASRs, the existing pig farms and firing range were carried out on two separate hot days when the ambient temperatures are at least 30°C.

The methodology of odour patrol and collecting air samples for odour testing are summarised as the following steps. Details of the methodology are as shown in **Appendix 3.23.**

1. Collection of air samples at the representative locations (S1- S9) of Kong Nga Po in agreement with the Authority (see **Table 3.13** and **Figure 3.12**). Samples were carried out on typical hot and sunny days for analysis of odour concentration which were determined by a laboratory accredited under the Hong Kong Laboratory Accreditation Scheme (HOKLAS).
2. During odour sampling at each sampling locations, on-site odour evaluation of odour quality, odour intensity and hedonic tone and on-site measurement of ambient temperature, relative humidity, wind direction and wind speed have been conducted.
3. GPS locations of sampling and measurement points have been recorded.
4. Any relevant site observation with photo-taking during odour sampling and measurement works has been recorded.
5. Laboratory testing of the collected odour samples to measure odour concentration using dynamic olfactometry according to the European Standard Method BS EN13725:2003.
6. Repeat the above Steps (1) to (5) on another sampling day with at least 3 days apart.
7. Upon completion of the odour analysis, a detailed testing report has been provided with the sampling and testing results including odour sampling and testing methodology, field observation results, laboratory results and conclusion of the sampling and testing works.

Table 3.13: Locations of air sample collection for odour testing

Odour air sampling points ID.	Description
S1	Within the Project site
S2	Within the Project site
S3	Within the Project site
S4	Near the village house, Kong Nga Po
S5-1	Existing San Uk Ling Firing Range
S5-2	Existing San Uk Ling Firing Range
S6	Near the village house, Kong Nga Po
S7	Near existing Pig Farm LK179
S8	Near existing Pig Farm LK148
S9	Near existing Pig Farm LK884

Odour measurements were carried out on two separate days at the sampling locations as summarized in **Table 3.14**. It can be seen from **Figure 3.12** that the sampling location S8 is different on the two sampling days in order to match the downwind location of the pig farm LK148 on each of the two days. On both odour patrol and sampling days, the weather was sunny and the air temperatures were in the range of 30°C to 37°C. Odour samples at the existing San Uk Ling Firing Range, i.e., S5-1 and S5-2, were collected on 19 Aug 2015 only because no firing training was conducted on 26 Aug 2015.

Table 3.14: Odour patrol and sampling dates and locations

Date and Time of Odour Patrol and Sampling	Sampling Locations
19 Aug 2015, between 11:15 and 16:19	S1 to S9, i.e. including the San Uk Ling Firing Range
26 Aug 2015, between 13:41 and 16:10	S1 to S4 and S6 to S9, i.e. excluding the San Uk Ling Firing Range

3.7.3 Review of Potential Odour Impacts

The potential odour impacts due to the three existing pig farms and existing firing ranges have been assessed based on the results of odour patrol and measurement.

The potential air quality impacts due to operation of the proposed firing ranges to be reprovisioned by the Project have been assessed by making reference to the relevant odour measurement results and the project profile prepared for the approved direct application for Environmental Permit for "Proposed Shooting Range at Pillar Point Valley Landfill" (Application No.: DIR-164/2008).

The potential odour impacts due to the OWTF2 has been reviewed by making reference to the approved EIA report of OWTF2 (EIA Register No.: AEIAR-180/2013).

3.8 Evaluation and Assessment of Air Quality Impacts

3.8.1 Construction Phase

3.8.1.1 General

According to the tentative construction programme (**Appendix 2.1**), construction of the Project is anticipated to commence in 2018 and complete by 2022. For the purpose of air quality modelling, construction works at the whole Project site are assumed to take place at the same time as a conservative approach.

3.8.1.2 Tier 1 Screening Results

The Tier 1 hourly TSP and daily RSP screening results for both unmitigated and mitigated scenarios and daily FSP screening results for the unmitigated scenario, including the background contributions are summarized in **Table 3.15**, with details as tabulated in **Appendix 3.24**. The Tier 1 pollutant contours for unmitigated and mitigated scenarios are presented in **Figures 3.14** to **3.18**. It can be seen from the Table that the Tier 1 mitigated results of TSP and RSP as well as the Tier 1 unmitigated results of FSP at all ASRs are in compliance with the relevant criteria. Hence, no Tier 2 modelling is required.

Table 3.15: Summary of Predicted Cumulative Maximum Hourly Average TSP Concentration and 10th Highest Daily Average RSP and FSP Concentrations (Tier 1 Unmitigated and Mitigated)

Air Pollutant	Averaging Time	Criteria (µg/m³)	Allowable Exceedances in a Year	Scenario	Range of Concentrations (µg/m³)	Remark
TSP	1 hour	500	0	Unmitigated	435 - 3087	Maximum values
				Mitigated	159 - 341	
RSP	24 hours	100	9	Unmitigated	94 - 213	10th maximum values
				Mitigated	84 - 94	
FSP	24 hours	75	9	Unmitigated	63 - 73	10th maximum values

3.8.1.3 Annual Results

The Annual RSP and FSP results for both unmitigated and mitigated scenarios including the background contributions are summarized in **Table 3.16** and tabulated in detail in **Appendix 3.26**. The annual pollutant contours for unmitigated and mitigated scenarios are presented in **Figures 3.24** to **3.27**. It can be seen from the Table that all the ASRs would comply with the AQOs for annual average RSP and FSP under the mitigated scenario.

Table 3.16: Summary of Predicted Cumulative Annual Average RSP and FSP Concentrations (Unmitigated and Mitigated)

Air Pollutant	Criteria (µg/m³)	Allowable Exceedances in a Year	Scenario	Range of Concentrations (µg/m³)
RSP	50	0	Unmitigated	44 - 60
			Mitigated	43 - 46
FSP	35	0	Unmitigated	32 - 35
			Mitigated	32 - 33

3.8.2 Operation Phase – Vehicular and Chimney Emissions

The predicted air quality modelling results have included the background pollutant levels as extracted from the PATH model for year 2020 based on the latest released model and the cumulative impacts of the following emissions:

- Existing and proposed improvement open roads within the 500m Study Area; and
- Chimney emissions from OWTF2

The cumulative air pollutant modelling results are summarized in **Table 3.17.** Full results can be found in **Appendix 3.28**. The contours for cumulative NO_2, RSP and FSP at 1.5m above ground are shown in **Figures 3.29** to **3.40**. It can be seen from the Table that the predicted cumulative results of NO_2, RSP and FSP at all ASRs are well below the relevant AQOs.

Table 3.17: Summary of Predicted Cumulative Modelling Results during Operation Phase

Air Pollutant	Averaging Time	AQO (μg/m^3)	Allowable Exceedance in a year	Range of Concentrations (μg/m^3)	Remarks
NO_2	1 hour	200	18	115 - 133	19th maximum values
	1 year	40	0	18 - 25	Annual average
RSP	24 hours	100	9	84 - 88	10th maximum values
	1 year	50	0	42 - 44	Annual average
FSP	24 hours	75	9	63 - 66	10th maximum values
	1 year	35	0	32 - 33	Annual average

3.8.3 Operation Phase – Helicopter Emissions

As mentioned in **Section 3.5.2.1**, the proposed helipad located at open spaces (with at least 120m horizontal distance from the nearby ASRs) is of low usage frequency for emergency / non-emergency use. In addition, the localized helicopter manoeuvring events will only occupy short durations over the averaging times of pollutants in AQOs (or Max. 40% on-time for air pollutants), and the turbulence created by helicopters rotors should readily dissipate the exhaust gases from the helicopter. As a result, accumulation of exhaust emissions from helicopters associated with the proposed helipad is not expected and the air quality impact of the helicopter operation is anticipated to be insignificant on the immediate environs.

3.8.4 Operation Phase – Dust and Lead Dust Emissions from Firing Ranges

A qualitative assessment is carried out to assess the potential air quality impacts due to operation of the proposed firing ranges by making reference to the approved direct application for Environmental Permit for "Proposed Shooting Range at Pillar Point Valley Landfill" (DIR-164/2008).

Bullet containment systems such as backstops of soft materials (e.g. timber baffles) and sand traps behind bullet targets are proposed to be installed to collect bullets from gunshots, which would reduce lead dust and dust in general. Such systems will reduce ricochet and bullet fragmentation, thus minimising air quality impacts. Monitoring and adjusting of soil pH or runoff control measures may be required to ensure no lead migration occurs. Alternatively, the use of lead-free primers mixture for firearms or air pistols would eradicate lead dust emissions completely.

The proposed firing ranges will be designed such that all gun shots point away from the identified ASRs. In addition, a solid fence wall (at least 2.4m to 3.5m high) with a backstop of soft material (of a density of at least 20kg/m^2) will also be erected around the boundary of the firing ranges to further contain potential air quality impacts during operation phase of the proposed firing ranges.

With implementation of the above practical mitigation measures, impacts of dust, lead dust are anticipated to be localised within the proposed firing ranges. Accumulation of air pollutants at the proposed firing ranges leading to exceedance of the relevant air quality criteria is therefore not anticipated. Hence, adverse air quality impacts from the proposed firing ranges are not anticipated.

3.8.5 Operation Phase – Odour Emissions

3.8.5.1 Historical Odour Complaints

Based on the information provided by EPD, the odour complaints related to the existing pig farms and firing ranges as received by EPD in the last 5.5 years (between January 2010 and July 2015) are summarised in **Table 3.18**. It can be seen from the Table that only two odour complaints related to one of the existing pig farms were received in 2011 and since then no odour complaints had been received. Review of the past odour complaints revealed that:

- Only a small number (2) of odour complaints against an existing pig farm were raised in some 4 years ago and the odour episode was detected only at the vicinity of the boundary of the concerned pig farm; and
- No odour complaints were raised against the existing firing range in the past 5.5 years.

Table 3.18: Summary of historical odour complaints related to the existing pig farms and firing ranges

Year	No. of Odour Complaints Received by EPD	Location of Detected Odour
2010	0	Not applicable
2011	2	Opposite to Lamp Post AD9660 at Kong Nga Po Road, which is close to the boundary of Pig Farm LK884
2012	0	Not applicable
2013	0	Not applicable
2014	0	Not applicable
2015 (up to July 2015)	0	Not applicable

Source: Information provided by EPD

3.8.5.2 Odour Patrol and Testing Results

The odour testing results obtained on the two typical hot and sunny days (with air temperatures of at least 30^{o}C) at the various sampling locations (see **Table 3.13** and **Figure 3.12**) are summarized in **Table 3.19**. Details of the odour patrol and testing results are given in **Appendix 3.23**. The odour testing results together with the wind directions recorded during the time of sampling are also presented in **Figure 3.41**. As shown in the Figure, the odour testing results at all sampling locations can generally represent the worst-case odour levels on typical hot and sunny days under downwind conditions.

Table 3.19: Summary of odour testing results

Sampling Location	Description	Existing Topography	Shortest Horizontal Distance from Existing Pig Farms	Odour Testing Results on Two Typical Hot Days (OU/m³)	
				Day 1 (19 Aug 2015)	Day 2 (26 Aug 2015)
S1	Representing future ASRs at the Driving and Traffic Training Facilities within project site	approx. 80mPD	372m	<2 (below detection limit)	<2 (below detection limit)
S2	Representing future ASRs at the Reprovisioned Firing Ranges within project site	approx. 71mPD	212m	<2 (below detection limit)	<2 (below detection limit)
S3	Representing future ASRs at the Proposed Police Training Facility and Weapons Training Facilities within project site	approx. 50mPD	56m	<2 (below detection limit)	<2 (below detection limit)
S4	Representing existing ASR A9 Village House, Kong Nga Po outside project site	approx. 31mPD	272m	<2 (below detection limit)	<2 (below detection limit)
S5-1	Location close to the firing training location within the existing firing ranges	approx. 32mPD	Not applicable	<2 (below detection limit)	No sample collected due to no firing training
S5-2	Location close to the firing training location within the existing firing ranges	approx. 32mPD	Not applicable	<2 (below detection limit)	No sample collected due to no firing training
S6	Representing existing ASR A11 Village House, Kong Nga Po outside project site	approx. 33mPD	308m	<2 (below detection limit)	<2 (below detection limit)
S7	Representing location in close proximity to the boundary of existing pig farm LK179	approx. 37mPD	8m	23	16
S8	Representing location in close proximity to the boundary of existing pig farm LK148	approx. 27mPD	12m	18	18
S9	Representing location in close proximity to the boundary of existing pig farm LK884	approx. 25mPD	8m	29	<2 (below detection limit)

3.8.5.3 Potential Odour Impacts

Odour from the Existing Pig Farms

According to the odour testing results as summarized in **Table 3.19**, the measured odour levels at the three sampling locations S7, S8 and S9 that are adjacent to the three existing pig farms are ranging from 16 to 29 ou/m^3 on both typical hot days (except the result at S9 on Day 2). However, at the sampling locations S1, S2 and S3 representing the various future ASRs within the Project site as well as the sampling locations S4 and S6 representing the existing ASRs outside the Project site, the measured odour concentrations on both typical hot days under generally downwind conditions are all below the detection limit, i.e., below 2 ou/m^3. It should be noted that among these five sampling locations representing future/ existing ASRs, S3 is nearest to the existing pig farms – only approximately 56m from the pig farm boundary.

The above results demonstrate that while certain levels of odour could be detected right next to the boundaries of the three existing pig farms on typical hot days, the odour levels at future ASRs within the Project site would become non-detectable or well below the odour criterion of 5 ou/m^3 even under downwind conditions. Such odour testing results are consistent with the findings from review of the historical odour complaints against the existing pig farms, i.e., in the 2 odour complaints raised against an existing pig farm some 4 years ago, the odour episode was detected near the boundary of the concerned pig farm (see **Section 3.8.5.1**). This can be attributable to the hilly terrain between the sampling locations within the Project site (currently located at higher topography, about 50 to 80mPD) and the existing pig farms (located at lower topography, about 25 to 37mPD), which acts as a natural barrier to screen off odour impact from the pig farms as illustrated in **Figures 3.42** and **3.43**. As also illustrated in same **Figures**, the terrain between the proposed Project development and the existing pig farms will have a similar barrier or screening effect for the future ASRs within the Project site. As a result, it is anticipated that the potential odour impacts on future ASRs within the Project site due to the three existing pig farms would be insignificant.

<u>Odour from the Existing Firing Range</u>

According to the odour testing result as summarized in **Table 3.19**, the odour testing results at the two sampling locations S5-1 and S5-2 that are close to firing training activities of the existing San Uk Ling Firing Range on a typical hot day are all below the detection limit, i.e., below 2 ou/m^3, which is well below the odour criterion of 5 ou/m^3. Such odour testing results are consistent with the findings from review of the historical odour complaints against the existing firing range, i.e., no odour complaints were raised against the existing firing range in the past 5.5 years (see **Section 3.8.5.1**). These testing results show that there is insignificant odour emission from firing training of the existing San Uk Ling Firing Range, hence its potential odour impact on the future ASRs within the Project site is anticipated to be negligible.

<u>Odour from the Proposed Firing Ranges</u>

Based on the available information provided from Hong Kong Police Force, the type of firearms, firing pattern and training hours of the proposed firing ranges to be reprovisioned by the Project will be similar to those of the existing San Uk Ling Firing Range. Therefore, the odour emission from the proposed firing ranges would be similar to that from the existing San Uk Ling Firing Range, which is anticipated to be insignificant in view of the aforementioned odour testing results.

With reference to the project profile prepared for the approved direct application for Environmental Permit for “Proposed Shooting Range at Pillar Point Valley Landfill” (Application No.: DIR-164/2008), a number of precautionary measures, as detailed in **Section 3.9.2.2**, are suggested to minimize and further contain the potential air pollutant and odour emissions from the proposed firing ranges of the Project. With implementation of such precautionary measures, the potential air quality impacts including odour impacts would be localised within the proposed firing ranges. Hence, negligible odour impacts on the surrounding ASRs are anticipated from the proposed firing ranges.

Odour from the Proposed OWTF2

Based on review of the predicted odour contour as given in Figure 3.33 of the approved EIA report of OWTF2 (EIA Register No.: AEIAR-180/2013), the predicted odour levels in the Project area due to emissions from the proposed OWTF2 would be around 0.001 ou/m^3, which are well below the odour criterion of 5 ou/m^3. Therefore, insignificant odour impacts on the Project site from the proposed OWTF2 are anticipated.

Cumulative Odour Impacts

Based on the aforementioned assessment findings, it is anticipated that the potential cumulative odour impacts at all the existing/ future ASRs due to the three existing pig farms, the existing San Uk Ling Firing Range, the proposed OWTF2 and the proposed firing ranges of the Project would be insignificant.

3.9 Mitigation of Adverse Environmental Impact

3.9.1 Construction Phase

To ensure compliance with the FSP, RSP and TSP criteria during the construction phase, good practices for dust control should be implemented to reduce dust impacts. The dust control measures are as follows:

- Use of regular water spraying (once every 1.25 hours or 8 times per day) to reduce dust emissions from heavy construction activities (including ground excavation, earth moving, etc.) at all active works area, exposed site surfaces and unpaved roads, particularly during dry weather.
- Covering 80% of stockpiling area by impervious sheets and spraying all dusty material with water immediately prior to any loading transfer operations to keep the dusty materials wet during material handling at the stockpile areas.

In addition to implementing the recommended dust control measures mentioned above, it is recommended that the relevant dust control practices as stipulated in the Air Pollution Control (Construction Dust) Regulation should also be adopted to further reduce the construction dust impacts of the Project. These practices include:

Good Site Management

- Good site management is important to help reduce potential air quality impact down to an acceptable level. As a general guide, the Contractor should maintain high standards of housekeeping to prevent emissions of fugitive dust. Loading, unloading, handling and storage of raw materials, wastes or by-products should be carried out in a manner so as to minimise the release of visible dust emission. Any piles of materials accumulated on or around the work areas should be cleaned up regularly. Cleaning, repair and maintenance of all plant facilities within the work areas should be carried out in a manner minimising generation of fugitive dust emissions. The material should be handled properly to prevent fugitive dust emission before cleaning.

Disturbed Parts of the Roads

- Main temporary access points should be paved with concrete, bituminous hardcore materials or metal plates and be kept clear of dusty materials; or
- Unpaved parts of the road should be sprayed with water or a dust suppression chemical so as to keep the entire road surface wet.

Exposed Earth

- Exposed earth should be properly treated by compaction, hydroseeding, vegetation planting or seating with latex, vinyl, bitumen within six months after the last construction activity on the site or part of the site where the exposed earth lies.

Loading, Unloading or Transfer of Dusty Materials

- All dusty materials should be sprayed with water immediately prior to any loading or transfer operation so as to keep the dusty material wet.

Debris Handling

- Any debris should be covered entirely by impervious sheeting or stored in a debris collection area sheltered on the top and the three sides.
- Before debris is dumped into a chute, water should be sprayed onto the debris so that it remains wet when it is dumped.

Transport of Dusty Materials

- Vehicles used for transporting dusty materials/ spoils should be covered with tarpaulin or similar material. The cover should extend over the edges of the sides and tailboards.

Wheel washing

- Vehicle wheel washing facilities should be provided at each construction site exit. Immediately before leaving the construction site, every vehicle should be washed to remove any dusty materials from its body and wheels.

Use of vehicles

- The speed of the trucks within the Project area should be controlled to about 10 km/hour in order to reduce adverse dust impacts and secure the safe movement around the Project area.
- Immediately before leaving the construction site, every vehicle should be washed to remove any dusty materials from its body and wheels.

- Where a vehicle leaving the construction site is carrying a load of dusty materials, the load should be covered entirely by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle.

Site hoarding

- Where a site boundary adjoins a road, street, service lane or other area accessible to the public, hoarding of not less than 2.4 m high from ground level should be provided along the entire length of that portion of the site boundary except for a site entrance or exit.

3.9.2 Operation Phase

3.9.2.1 Vehicular and Chimney Emissions

It has been assessed that the predicted cumulative air quality impacts on all identified ASRs due to emissions from the vehicular traffic and chimneys within the 500m Study Area would comply with the corresponding AQOs for NO_2, RSP and FSP. Therefore, no further mitigation measures for such emissions during the operation phase are required.

3.9.2.2 Proposed Firing Ranges

With reference to the project profile prepared for the approved direct application for Environmental Permit for "Proposed Shooting Range at Pillar Point Valley Landfill" (Application No.: DIR-164/2008), the following suggested precautionary measures should be implemented as far as practicable to minimize and further contain the potential air quality impacts from the proposed firing ranges of the Project:

- Bullet containment systems such as backstops of soft materials (e.g. timber baffles) and sand traps behind bullet targets are proposed to be installed to collect bullets from gunshots, which would reduce lead dust and dust in general. Such systems will reduce ricochet and bullet fragmentation, thus minimising air quality impacts.
- A solid fence wall (at least 2.4m to 3.5 m high) with a backstop of soft material (of a density of at least 20kg/m^2) is proposed to be erected around the boundary of the proposed firing ranges to further contain potential air pollutant and odour emissions during firing training.
- Use of lead-free primers mixture for firearms or air pistol would eradicate lead dust emissions completely.

3.10 Evaluation of Residual Impact

3.10.1 Construction Phase

With proper implementation of the recommended mitigation measures during the construction, all ASRs are predicted to comply with the TSP criterion as well as the relevant AQO for RSP and FSP under the mitigated scenario. Hence no residual air quality impacts are anticipated for the Project during the construction phase.

3.10.2 Operation Phase

During the operation phase, it has been assessed that the predicted cumulative NO_2, RSP and FSP concentrations at all ASRs due to vehicular and chimney emissions would comply with the relevant AQOs. No significant operational phase air quality impact from the proposed helipad is expected. Accumulation of air pollutants at the proposed firing ranges leading to exceedance of the relevant air quality criteria is not anticipated. The potential cumulative odour impacts at all ASRs due to the three existing pig farms, the existing San Uk Ling Firing Range, the proposed OWTF2 and the proposed firing ranges of the Project are anticipated to be insignificant. Hence, no residual air quality impacts are anticipated for the Project during the operation phase.

3.11 Environmental Monitoring and Audit

3.11.1 Construction Phase

Regular dust monitoring is considered necessary during the carrying out of the Project and regular site audits are also required to ensure the dust control measures are properly implemented. Details of the EM&A programme will be presented in the separate EM&A Manual.

3.11.2 Operation Phase – Vehicular and Chimney Emissions

No ASRs are predicted to exceed the relevant criteria under the AQOs. No monitoring for vehicular and chimney emission during operation phase is required.

3.11.3 Operation Phase – Helicopter Emissions

No monitoring for helicopter emission during operation phase is required.

3.11.4 Operation Phase – Dust and Lead Dust Emissions from Firing Ranges

No monitoring for dust and lead dust emission from the proposed firing ranges during operation phase is required.

3.11.5 Operation Phase – Odour Emissions

The potential cumulative odour impacts at all ASRs due to the three existing pig farms, the existing San Uk Ling Firing Range, the proposed OWTF2 and the proposed firing ranges of the Project are anticipated to be insignificant. No monitoring during operation phase is required.

3.12 Conclusion

3.12.1 Construction Phase

Potential air quality impacts from the construction works of the Project would mainly be related to construction dust from site formation, foundation works, excavation, and improvement works of existing Kong Nga Po Road. With proper implementation of the recommended mitigation measures, it has been assessed that all ASRs are predicted to comply with the TSP criterion as well as the relevant AQO for RSP and FSP. Hence, there is no adverse air quality impacts anticipated due to the Project during the construction phase.

3.12.2 Operation Phase

During the operation phase, based on the vehicular and chimney emission modelling results, it is concluded that all the identified ASRs would be in compliance with the AQOs for hourly NO_2, annual NO_2, daily RSP, annual RSP, daily FSP and annual FSP. No significant operational phase air quality impact from the proposed helipad is expected. With implementation of the practical mitigation measures, impacts of dust, lead dust are anticipated to be localised within the firing ranges. Accumulation of air pollutants at the proposed firing ranges leading to exceedance of the relevant air quality criteria is therefore not anticipated. The findings from the odour patrol and test results obtained on two typical hot and sunny days show that the potential cumulative odour impacts at all ASRs due to the three existing pig farms, the existing San Uk Ling Firing Range, the proposed OWTF2 and the proposed firing ranges of the Project would be insignificant. Hence, no adverse air quality impacts are anticipated during the operation phase.