3 AIR QUALITY IMPACT ASSESSMENT

3.1 Introduction

An air quality impact assessment has been undertaken to define the nature and scale of potential environmental impacts associated with the Project specifically in terms of the effects in the vicinity of sensitive receivers. Both construction and operational phase impacts have been assessed and mitigation measures have been identified to determine whether any residual impacts can be reduced to acceptable levels.

3.2 Legislation, Standards, Guidelines and Criteria

Legislation, Standards, Guidelines and Criteria relevant to the consideration of air quality impacts under this study include the following:

- Hong Kong Air Pollution Control Ordinance;
- Air Pollution Control (Construction Dust) Regulation; and
- Environmental Impact Assessment Ordinance and Technical Memorandum on Environmental Impact Assessment Process.

Hong Kong Air Pollution Control Ordinance

The principal legislation for the management of air quality is the *Air Pollution Control Ordinance (APCO) (Cap 311).* The whole of the Hong Kong Special Administrative Region (HKSAR) is covered by the Hong Kong Air Quality Objectives (AQOs) which stipulate the statutory limits of some typical air pollutants and the maximum allowable numbers of exceedance over specific periods (refer to **Table 3.1**).

Table 3.1 Hong Kong Air Quality Objectives ($\mu g/m^{-3}$)[(i)]

Pollutant	1 Hour (ii)	8 Hours (iii)	24 Hours (iii)	3 Months (iv)	1 Year (iv)
Sulphur Dioxide	800		350		80
Total Suspended Particulates	500(vii)		260		80
Respirable Suspended Particulates (v)			180		55
Carbon Monoxide	30,000	10,000			
Nitrogen Dioxide	300		150		80
Photochemical Oxidants (as ozone) (vi)	240				
Lead				1.5	

Notes:
(i) Measured at 298K(25 ^{o}C) and 101.325 kPa (one atmosphere).
(ii) Not to be exceeded more than three times per year.
(iii) Not to be exceeded more than once per year.
(iv) Yearly and three monthly figures calculated as arithmetic means.
(v) Respirable suspended particulates means suspended particles in air with nominal aerodynamic diameter of 10 micrometres and smaller.
(vi) Photochemical oxidants are determined by measurement of ozone only.
Air Pollution Control (Construction Dust) Regulation
(vii) This is not an AQO but a criterion for construction dust impact assessment under Annex 4 of the Technical Memorandum on Environmental Impact Assessment Process.

Air Pollution Control (Construction Dust) Regulation

Air Pollution Control (Construction Dust) Regulation stipulates the construction dust control requirements for both notifiable (e.g. site formation) and regulatory (e.g. road opening) Works to be carried out by the Contractor. The requirements for various notifiable and regulatory works are given in Parts 1 and 2 of the Regulation respectively. Part 3 of the Regulation stipulates the general control requirements (e.g. site boundary and entrance) for construction dust. The control requirements for individual activities (e.g. stockpiling of dusty material) are given in Part 4 of the Regulation.

Environmental Impact Assessment Ordinance and Technical Memorandum on Environmental Impact Assessment Process

The criteria for evaluating air quality impacts are stated in Annexes 4 and 12 of the *Technical Memorandum on Environmental Impact Assessment Process* (TMEIA). The TMEIA also states that the hourly Total Suspended Particulate (TSP) level should not exceed 500μg/m^3 (measured at 25^{o}C and one atmosphere) for construction dust impact assessment.

3.3 Assessment Methodology

3.3.1 Construction

Dispersion Model

The extent of dust impacts arising from the construction of this Project have been predicted using the USEPA approved model Fugitive Dust Model (FDM) in conjunction with the construction programme. The *Compilation of Air Pollutant Emission Factors, 5th Edition, US Environmental Protection Agency, 1996, (AP-42)* was used to determine the various fugitive dust sources.

Meteorological Data Input

Sequential meteorological data for year 2003, were used as input to the model to obtain 1-hour and 24-hour average TSP concentration at the identified ASRs. Data obtained from Ching Pak House and King's Park stations used as input to the model includes, wind direction and speed together with atmospheric Pasquill stability class, and mixing heights together with air temperature.

Emission Factors

Prediction of dust emissions was based on emission factors from USEPA's *Compilation of Air Pollution Emission Factors, 5th Edition,* (AP-42). For a conservative simulation, general construction activities were considered to be the major dust emission sources from the construction work in this study.

The dust emission factors adopted in this assessment are given in **Table 3.2**. Detailed calculations of the emission factors are provided in **Appendix B**.

Based on the assumption of 26 working day per month and 10 operation hours per day, the dust emission factor of 2.90 x 10^{-4} $gs^{-1}m^{-2}$ was predicted.

Table 3.2 Emission Factors for Construction Activities

Activities	Emission Factors	Reference
General Construction Activities	2.69 Mg/hectare/month	Section 13.2.3, AP-42
Wind Erosion	2.695 x 10^{-6} $gs^{-1}m^{-2}$	Table 11.9-4, AP-42
Locations	**Respective Emission Factors[1]**	**Respective Site Area[2]**
Intake 1	0.13 g/s	448m^2
Intake 2	0.07 g/s	240m^2
Intake 3	0.36 g/s	356.3m x 3.5m = 1247m^2
Outfall 1	0.45 g/s	1548m^2

Notes: 1 Respective emission factor equals to the respective site area times the total emission factor, i.e. 2.9 x 10^{-4} g/s/m^2 for area source and 1.02 x 10^{-3} g/s/m for line source. Please refer to Appendix B for detailed calculation.
2 The modelled source area that is about 30% of the entire site.

In order to assess the worst case scenario, 30% of the entire site as close to the nearest receptor to be exposed active works area was used for the assessment. This is the same approach as adopted in other environmental studies such as Dualling of Clear Water Bay Road from Tai Po Tsai to Hang Hau.

1-hour TSP Levels

It was assumed that construction would take place over 10 hours per day. The corresponding meteorological data has thus been used as input to the FDM. The highest predicted TSP levels during construction of tunnel, intakes and outfal, together with the potential interfacing project (i.e. Construction and Improvement of Tuen Mun Road) and the background TSP were added together and compared with the recommended 1-hour limit of 500 μgm^{-3}.

24-hour TSP Levels

The 24-hour TSP level was estimated by taking the average of 10 hours with worst-case daytime 1-hour average concentration and 14 hours with worst-case night time 1-hour average concentration. The predicted 24-hour TSP levels during construction of tunnel, intakes and outfall together with the potential interfacing project (i.e. Construction and Improvement of Tuen Mun Road) and the background daily TSP level were added together and compared with the AQO of 260 μgm^{-3}.

3.3.2 Operation

The operation of the drainage tunnel has insignificant impacts in relation to air quality.

3.4 Baseline Conditions/ Sensitive Receivers

3.4.1 Baseline Conditions

Existing air quality of the Study Area is mainly affected by the traffic flow along major roads near the Project such as:

- Intake I-1 is within 60m of Cheung Pei Shan Road; and a number of smaller roads including Wo Yi Hop Road (20m), Shing Mun Road (adjoining) and Wo Yi Hop Lane (20m).
- Intake I-2 adjoins Lo Wai Road, within 100m of Hill Top Road and other smaller roads.
- Intake I-3 is located 350m from at Route Twisk.
- Outfall O-1 adjoins Castle Peak Road (Ting Kau), Tau Lai Road (160m) and Tuen Mun Road (100m) and other smaller roads.

The Air Services Group of the Environmental Protection Department (EPD) operates a network of 14 Air Quality Monitoring Stations in Hong Kong. The nearest EPD's monitoring stations are located at Kwai Chung and Tsuen Wan. The 5-year annual averages of air quality data monitored at EPD's Kwai Chung station (1999 – 2003) and Tsuen Wan station (1998 – 2002) are shown in **Table 3.3**. The 5-year average (1999 – 2003) TSP monitoring data recorded at Kwai Chung monitoring station will be used as background concentration in this assessment.

Table 3.3 Air Quality at Kwai Chung and Tsuen Wan Monitoring Stations (5-year annual averages)

Pollutant	Kwai Chung	Tsuen Wan
Nitrogen Dioxide	66	63
Total Suspended Particulates	79	72
Respirable Suspended Particulates	52	52

Source: Adapted from EPD's Air Quality Annual Reports for 1998 to 2003.
Notes:
Values presented are 5-year annual averages from 1999 to 2003 for Kwai Chung Station and from 1998 to 2002 for Tsuen Wan Station, since data from Tsuen Wan Station were insufficient in 2003.
All units are in micrograms per cubic metre.

3.4.2 Sensitive Receivers

Representative Air Sensitive Receivers (ASRs) within 500m of the Project limit have been identified according to the criteria set out in the TMEIA and through site inspections and a review of land use plans. ASRs and their horizontal distance to the nearest emission source have been identified and are summarized in **Table 3.4**. Locations of the ASRs are the same as the NSRs and are shown in **Figure 4.1** (Intake I-1), **Figure 4.2** (Intake I-2), **Figure 4.3** (Intake I-3) and **Figure 4.4** (Outfall O-1).

Table 3.4 Representative Air Sensitive Receivers (ASRs)

ID No.	ASR No.	Locat.	Description	Usage[1]	Distance to the nearest Emission Source (m)
1	ASR1*	**I1**	Sik Sik Yuen Ho Fung College	I	60
2	ASR2*		Kwai Shue House	R	90
3			Chuk Shue House	R	120
4			Sheng Kung Hui Li Ping Secondary School	I	130
5			Lei Muk Shui Estate (Block 6)	R	140
6			Lei Muk Shui Estate Chung Shue House	R	140
7			Leu Muk Shui Estate (Block 5)	R	190
8			Ho Shun Primary School	I	210
9			Chu Oi Primary School	I	260
10	ASR3*	**I2**	Hong Hoi Chee Hong Temple	I	10
11	ASR4*		Yuen Yuen Care and Attention Home for the Aged	I	30
12	ASR5*		Western Monastery	I	50
13			Yuen Yuen Home for the Aged	I	70
14			Yuen Yuen Institute (Sam Dip Tam Temple)	R	100
15	ASR6*	**I3**	Squatters	R	50
16	ASR7*		Route Twisk Villa (Block 7-8)	R	160
17	ASR8*	**O1**	Beach Tower (Long Beach Gardens)	R	70
18	ASR9*		Greenview Terrace (Block 1)	R	60
19			Marina Tower (Long Beach Gardens)	R	130
20			Fung Chik Sen Villa	R	95
21			Grandview Villa (Block 10)	R	120
22			Blossom Terrace (Block 10)	R	130

Note: 1 I = Institutional; R = Residential;
* Air Sensitive Receivers are representative and will be used in prediction calculations.

3.5 Impact Assessment

3.5.1 Construction

Identification of Potential Impacts

Dust, in relation to the construction of drainage tunnel, will be generated by spoil handling from the tunnel driven by the TBM, drill and blast technique, excavation, material handling and vehicle movements on unpaved work sites. Four possible worksites i.e. at Intakes 1, 2, 3 and Outfall 1 have been identified for the tunnelling works. It should be noted that the construction method proposed is to use precast segments for lining the tunnel, and no concrete batching will be required on site. This presumption has been made due to a lack of space and on environmental grounds. However, should the Contractor wish to establish a batching plant on-site (and given the space constraints this is unlikely) he would be required to obtain a licence from EPD and would need to demonstrate that the batching plant can comply with the APCO and EIAO requirements.

Vehicles and plant powered by diesel that emit SO_2 and NO_2 can cause some air quality impact but the amount of such emission would be limited and will be unlikely to breach the AQO.

Prediction of Impacts

Construction dust impacts were modelled using the Fugitive Dust Model (FDM) with worst case assumptions as input data and at ground level. The construction programme for Tsuen Wan Drainage tunnel is given as **Appendix A**. It has been identified that the Construction and Improvement of Tuen Mun Road potentially overlaps with this project and in order to predict the dust level in worse case scenario, the cumulative effect of construction activities at outfall location of Tsuen Wan Drainage tunnel and at Yau Kan Tau section of Tuen Mun Road have been assumed to be undertaken concurrently. An area dust emission source of 20m x 22m (i.e. about 30% of the nearest construction site of "the Construction and Improvement of Tuen Mun Road" to the Project) to the northeast of Outfall 1 and to the south of Tuen Mun Road is assumed in the model to account for the cumulative impact from Tuen Mun Road project. The same emission factor presented in **Table 3.2** (general construction activities and wind erosion) is also assigned for this emission source. Predicted net and cumulative hourly and daily TSP levels at 1.5m above local ground level at the identified ASRs are shown in **Table 3.5** below. The background annual average TSP levels of 79 μgm^{-3} measured at Kwai Chung monitoring station has been added to the predicted hourly and daily results to provide the cumulative impact.

Table 3.5 Predicted Cumulative Hourly and Daily TSP Levels (μgm^{-3}) at 1.5m above local ground level – Unmitigated

ASR No.	Location	Description	Predicted Cumulative Dusts Impacts	
			Maximum Hourly Average TSP Level	Maximum Daily Average TSP Level
ASR1	**Intake 1**	Sik Sik Yuen Ho Fung College	**678**	**332**
ASR2		Kwai Shue House	481	249
ASR3	**Intake 2**	Hong Hoi Chee Hong Temple	**974**	**457**
ASR4		Yuen Yuen Care and Attention Home for the Aged	476	247
ASR5		Western Monastery	342	190
ASR6	**Intake 3**	Squatters	377	205
ASR7		Route Twisk Villa	218	138
ASR8	**Outfall 1**	Beach Tower (Long Beach Gardens)	**1416**	**643**
ASR9		Greenview Terrace (Block 1)	**1203**	**553**

Notes:
Background TSP levels included in the results of hourly and daily average TSP
Bold figure exceeds dust criteria

Evaluation of Impacts

As indicated in **Table 3.5**, due to the close proximity to the area sources, the majority of the predicted 1-hour and 24-hour TSP levels at the ASRs would exceed the recommended hourly TSP guideline level of 500μgm^{-3} and daily TSP AQO criteria of 260μgm^{-3} during construction of tunnel, intakes and outfall together with the potential interfacing project respectively. Therefore, dust mitigation measures are required in order to reduce the TSP concentrations at all the identified sensitive receivers to the acceptable levels.

By considering the predicted results at the representative ASRs, a 75% dust suppression measures, which can be achieved by watering four times daily, has been recommended. The

mitigated cumulative 1-hour average and 24-hour average TSP concentrations at the representative ASRs at 1.5m above ground have been estimated and presented in **Table 3.6**.

Table 3.6 Predicted Cumulative Hourly and Daily TSP Levels (μgm^{-3}) at 1.5m above local ground level – Mitigated

ASR No.	Location	Description	Predicted Cumulative Dusts Impacts	
			Maximum Hourly Average TSP Level	Maximum Daily Average TSP Level
ASR1	**Intake 1**	Sik Sik Yuen Ho Fung College	229	142
ASR2		Kwai Shue House	179	121
ASR3	**Intake 2**	Hong Hoi Chee Hong Temple	303	173
ASR4		Yuen Yuen Care and Attention Home for the Aged	178	121
ASR5		Western Monastery	145	107
ASR6	**Intake 3**	Squatters	153	110
ASR7		Route Twisk Villa	114	94
ASR8	**Outfall 1**	Beach Tower (Long Beach Gardens)	413	220
ASR9		Greenview Terrace (Block 1)	360	198

Notes:
Background TSP levels included in the results of hourly and daily average TSP
Bold figure exceeds dust criteria

Under the recommended mitigation measures, all the identified ASRs are below the relevant TSP criteria.

A sample output file of the FDM model run, which includes all the input information and model parameters for this assessment, is provided in **Appendix C** for reference.

In accordance with the requirements of the Study Brief, both mitigated and unmitigated daily and hourly TSP levels contour plots (Refer to **Figures 3.1** to **3.16**) have been prepared to illustrate the mitigated and unmitigated construction dust levels within the boundary of 500m from the Study area.

3.5.2 Operation

Identification of Potential Impacts

Impacts arising from the operation of this Project primarily relate to gaseous emissions from vehicles and plants which may impact ASRs, the potential impacts identified are during tunnel maintenance activities such as desilting and concrete repair works. This will be an infrequent activity (two times per year) involving only a very small number of vehicles and plant (eg. lorry, loader and excavator).

Prediction of Impacts

The air quality impacts generated at the intake and outfall structure in terms of operation project are likely to be minimal.

Evaluation of Impacts

Impacts from maintenance activities are insignificant as the amount of gaseous emissions from vehicles would be negligible.

3.6 Mitigation of Impacts

3.6.1 During Construction

Specific

As mentioned in Section 3.5, exceedances of 1-hour and 24-hour average TSP guideline levels have been predicted at most of the ASRs. Hence, mitigation measures are considered necessary in order to suppress the potential dust impact.

The dust suppression measures set out in the *Air Pollution Control (Construction Dust) Regulation*, in fact, are more extensive. Therefore, it is expected that with watering the construction site every four times daily together with strict implementation of dust suppression measures as stipulated in the *Air Pollution Control (Construction Dust) Regulation*, the dust level is expected to be reduced by over 75%.

General

To further ensure compliance with the guideline and AQO limit at the ASRs at all time, it is recommended to implement of the *Air Pollution Control (Construction Dust) Regulation* and include good site practice in the contract clauses to minimize cumulative dust impact. In addition, a comprehensive dust monitoring and audit programme is recommended to ensure proper implementation of the identified mitigation measures. Details of the monitoring and audit requirements are provided in a separate EM&A Manual.

- effective dust screens, sheeting or netting should be provided to enclose the scaffolding from the ground floor level of the building or if a canopy is provided at the first floor level, from the first floor level, up to the highest level of the scaffolding where a scaffolding is erected around the perimeter of a building under construction;
- dump truck for material transport should be totally enclosed by impervious sheeting;
- any excavated dusty materials or stockpile of dusty materials should be covered entirely by impervious sheeting or sprayed with water so as to maintain the entire surface wet, and recovered or backfilled or reinstated within 24 hours of the excavation or unloading;
- stockpile of dusty materials should not extend beyond the pedestrian barriers, fencing or traffic cones;
- dusty materials remaining after a stockpile is removed should be wetted with water and cleared from the surface of roads;
- the area where vehicle washing takes place and the section of the road between the washing facilities and the exit point should be paved with concrete, bituminous materials or hardcores;
- where a site boundary adjoins a road, streets or other area accessible to the public, hoarding of not less than 2.4m high from ground level should be provided along the entire length except for a site entrance or exit;

- every main haul road should be scaled with concrete and kept clear of dusty materials or sprayed with water so as to maintain the entire road surface wet;
- the portion of road leading only to a construction site that is within 30m of a designated vehicle entrance or exit should be kept clear of dusty materials;
- stockpile of dusty materials should be either covered entirely by impervious sheeting, placed in an area sheltered on the top and the 3 sides; or sprayed with water so as to maintain the entire surface wet;
- all dusty materials should be sprayed with water prior to any loading, unloading or transfer operation so as to maintain the dusty material wet;
- vehicle speed should be limited to 10 kph except on completed access roads;
- every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites;
- the load of dusty materials carried by vehicle leaving a construction site should be covered entirely by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle; and
- the working area of excavation should be sprayed with water immediately before, during and immediately after the operations so as to maintain the entire surface wet.

3.6.2 During Operation

As the impacts from maintenance activities during operation are insignificant, mitigation measures are not required.

3.7 Residual Impacts

No residual impacts are predicted for the construction or operation of the Project.

3.8 Environmental Monitoring and Audit

Although the proposed Project is not expected to generate excessive dust levels, an environmental monitoring and audit is recommended to ensure the compliance of construction dust with the criteria and the proper implementation of mitigation measures. Details are discussed in the EM&A Manual.

3.9 Conclusions and Recommendations

The construction of the Project may lead to dust generation. It is predicted that various construction activities associated with the earthworks, material handling and tunnel construction would cause temporary minor impacts. “Best practice measures” as discussed in Section 3.6.1 are recommended to suppress dust emissions from construction activities through good site practice.

3.10 References

Environmental Protection Department, Modelling Section, Air Policy Group (2000) *Guidelines on Assessing the 'TOTAL' Air Quality Impacts* (Accessed October 2003).

http://www.epd.gov.hk/epd/textonly/english/environmentinhk/air/guide_ref/guide_aqa_model_g2.html

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