3 Air Quality Impact

3.1 Overview

This section describes the potential air quality impacts associated with the construction and operation of the LMC Loop. Construction dust impact has been assessed. With the implementation of practical mitigation measures, adverse construction dust impact is not anticipated.

During operational phase, vehicular emission from the associated road traffic as well as odour emissions from the on-site sewage treatment works have been investigated. The predicted air quality impacts of vehicular emission are well within acceptable levels when comparing to the AQO.

The predicted odour levels of the on-site STW with best practice technology and centralized odour removal system are all in compliance with the odour criterion at the identified ASRs. Adverse odour impacts due to the project are not anticipated.

Exceedance of the odour criterion has however been predicted for the cumulative odour impacts. It is mainly due to the Shenzhen River, which is a non-project factor. A study is currently being jointly conducted by both the Government of HKSAR and Shenzhen Municipal Government to examine applicable technologies and methods to remedy the environmental problems caused by the contaminated sediment in Shenzhen River, and put forward feasible options for joint implementation by the two governments. However, there is no definitive programme on the implementation of remediation under the study at this stage. The project proponent has therefore undertaken to implement bioremediation mitigation along Shenzhen River for within the 500m from the Study Area of the Loop development. In the short to medium term, after the implementation of the bioremediation measures, the cumulative odour impact ranges from 10.8 OU to 14.5 OU, which still exceeds the 5 OU criterion. If buildings with central air conditioning in the development were equipped with an odour removal system (i.e. activated carbon filter or selective catalytic filter etc.) as an interim contingency measure capable of 95% removal efficiency, the residual odour impact would be reduced and the odour criteria would be met inside all interior areas with odour removal system. It is noted that the Shenzhen Municipal Government has already undertaken improvement works at some of the tributaries of Shenzhen River. In the longer term, the Shenzhen Municipal Government would continue to implement improvement works along the Shenzhen River and its tributaries and targeted to achieve 95% coverage of centralised treatment of intercepted sewage in the central urban district of the city of Shenzhen according to the 12th-5 year Plan of Shenzhen Water Supplies Development. Therefore, continual improvements of the Shenzhen River odour issues are anticipated which would help further reduce the residual odour impact. If these improvement works have been implemented, it is predicted that the odour impact on the Loop development will be reduced to 3.5 OU to 4.7 OU, within the criterion of 5 OU.

The air quality impact assessment has been conducted in accordance with the requirements of Annexes 4 and 12 of the TM-EIAO as well as the requirements set out under Clause 3.4.4 of the EIA Study Brief.

3.2 Environmental Legislation, Standards and Guidelines

The relevant legislations, standards and guidelines applicable to the present study for the assessment of air quality impacts include:

- Air Pollution Control Ordinance (APCO) (Cap 311);
- Air Pollution Control (Construction Dust) Regulation;
- Environmental Impact Assessment Ordinance (EIAO) (Cap. 499), Technical Memorandum on Environmental Impact Assessment Process (TM-EIAO), Annex 4 and Annex 12;
- Practice Note on Control of Air Pollution in Vehicle Tunnels; and
- Practice Note for Professional Persons - Control of Air Pollution in Semi-Confined Public Transport Interchanges (ProPECC PN 1/98).

3.2.1 Air Quality Objectives

The principal legislation for controlling air pollutants is the APCO (Cap 311) and its subsidiary regulations, which define statutory Air Quality Objectives (AQOs) for seven common air pollutants. The AQOs for these air pollutants are listed in **Table 3.1** below.

Table 3.1 Hong Kong Air Quality Objectives

Pollutant	**Concentration in micrograms per cubic metre** [1]				
	1 Hour [2]	**8 Hours** [3]	**24 Hours** [3]	**3 Months** [4]	**1 Year** [4]
Sulphur Dioxide (SO_2)	800		350		80
Total Suspended Particulates (TSP)	500 [7]		260		80
Respirable Suspended Particulates [5] (RSP)			180		55
Carbon Monoxide (CO)	30,000	10,000			
Nitrogen Dioxide (NO_2)	300		150		80
Photochemical Oxidants (as ozone) [6]	240				
Lead				1.5	

Notes:

[1] Measured at 298K and 101.325 kPa.
[2] Not to be exceeded more than three times per year.
[3] Not to be exceeded more than once per year.
[4] Arithmetic mean.
[5] Respirable suspended particulates means suspended particulates in air with a nominal aerodynamic diameter of 10 micrometres or smaller.
[6] Photochemical oxidants are determined by measurement of ozone only.
[7] Not an AQO but is a criterion for construction dust impact assessment as stated in Annex 4 of the TM-EIAO.

3.2.2 Air Pollution Control (Construction Dust) Regulation

The Air Pollution Control (Construction Dust) Regulation specifies processes that require special control. Contractors and site agents are required to inform EPD and adopt dust reduction measures while carrying out “Notifiable Works” or “Regulatory Works” as defined under the regulation. Works relevant to this Project include site formation activities of LMC Loop (i.e. total area of 87 hectare) and road works and flushing water service reservoir in adjacent area in Hong Kong outside LMC Loop, etc.

3.2.3 Odour Criteria

In accordance with Annex 4 of TM-EIAO, a limit of 5 odour units based on a time-averaging period of 5 seconds should not be exceeded at any sensitive receivers.

3.3 Description of the Environment

3.3.1 Area for Air Quality Assessment

With reference to the EIA Study Brief, the area for air quality impact assessment should generally be defined by a distance of 500m from the boundary of the Project. **Figure 3.1** shows the proposed landuse, associated works, and 500m assessment boundary. The assessment includes existing, planned and committed sensitive receivers of the EIA study area within the HKSAR boundary. Potential sources of impact within the 500m distance but beyond the HKSAR boundary are also identified, where appropriate.

3.3.2 Baseline Condition

The surrounding areas of the LMC Loop are mainly dominated by rural villages and agricultural lands, and there was no industrial developments identified. Details of the proposed development are discussed in Chapter 2.

There is no available ambient air quality data within 500m from the boundary of the Project. The nearest EPD air quality monitoring station (AQMS) is located in Yuen Long, whilst the nearest station in the PRD Regional Air Quality Monitoring Network that was jointly established by the Hong Kong EPD and Guangdong Provincial Environmental Protection Monitoring Centre is located in Liyuan (a developed town in Lo Wu on the Shenzhen side). As Yuen Long and Liyuan ambient air quality data is much affected by the transport and industrial activities in the area, their representation of the study area is considered inappropriate.

In light of the inappropriate representation of Yuen Long and Liyuan monitoring station for the study area, district-averaging data from a number of monitoring stations under the category of rural and new development as defined in the project Study Brief (No.ESB-238/2011), Appendix B-2, Section 3.2 is adopted. These monitoring stations include Sha Tin, Tai Po and Yuen Long. **Table 3.2** gives the individual monitoring station data and their district average levels.

Table 3.2 District-average air quality monitoring data

Pollutant	Station	Annual Concentration (µg/m^3)					
		2007	2008	2009	2010	2011	5-year mean
NO_2	Shatin	45	44	40	42	45	**48.5**
	Tai Po	53	52	45	46	45	
	Yuen Long	55	56	52	54	54	
RSP	Shatin	52	50	45	45	47	**50.5**
	Tai Po	53	50	46	45	46	
	Yuen Long	64	60	51	49	54	
TSP	Shatin	73	66	60	67	66	**73.1**
	Tai Po	73	73	60	64	69	
	Yuen Long	97	87	77	78	86	
SO_2	Shatin	19	17	11	12	14	**14.3**
	Tai Po	16	17	9	8	8	
	Yuen Long	24	21	14	11	13	

Ambient NO_2, TSP and RSP concentrations from the above district-average data are used to establish future ambient pollutant concentrations.

3.4 Air Sensitive Receivers

With reference to Annex 12 of the TM-EIAO, Air Sensitive Receivers (ASRs) include domestic premises, hotel, hostel, hospital, clinic, nursery, temporary housing accommodation, school, educational institution, office, factory, shop, shopping centre, place of public worship, library, court of law, sports stadium or performing arts centre. Any other premises or place with which, in terms of duration or number of people affected, has a similar sensitivity to the air pollutants as the afforelisted premises and places are also considered to be a sensitive receiver.

Representative ASRs within a distance of 500m from the boundary of the Project and associated works within HKSAR boundary have been identified. They cover all existing, planned and committed sensitive developments for the respective construction and operational phase assessment. ASRs summarized in **Table 3.4** are 1.5m above ground as it is average height of the human breathing zone. As the sources of dust emission as well as vehicular emission are both from ground level, 1.5m above ground is the worst-hit level without chimney emission.

The existing ASRs were identified by means of topographic maps, aerial photos, land status plans and site surveys. Planned / committed ASRs were identified by making reference to the relevant Recommended Outline Development Plan and Revised Preliminary Layout Plan mentioned in **Section 2.3**, and statutory town plans including the Approved San Tin OZP (No. S/YL-ST/8), Kwu Tung North OZP (No. S/NE-KTN/8), the Approved Ngau Tam Mei OZP (No. S/YL-NTM/12) and Ma Tso Lung and Hoo Hok Wai DPA Plan (No. DPA/NE-MTL/2).

The existing and planned ASRs in the vicinity of and within the 500m from the boundary of the Project are listed in **Tables 3.3** and **3.4** and shown in **Figures 3.2** to **3.2d**. The separation distances between the existing ASRs and site boundary of LMC Loop and adjacent area in Hong Kong outside LMC Loop (i.e. Eastern and Western Connection Roads) range from less than 5m to 90m, while planned ASRs are separated in the range 15m to 145m from site boundary of the project. Residential premises are the major existing ASR category with a few other types such as government/ institution/ community (GIC) and places of public worship. High-Tech R&D/Cultural & Creative Industries (R&D/C&C) within LMC Loop area are considered to be less sensitive because there are central-air-conditioning with fresh air intake located on the roof of each building.

As some of the planned ASRs are located within the site boundary of LMC Loop and the population intake would be after the construction of the Project, therefore, these ASRs will not be assessed in the construction phase assessment.

Table 3.3 Existing ASRs identified within 500m from the boundary of the Project

Location of ASRs	Assessment Points	No. of Storey	Nature [1]	Separation Distance between ASR and nearest emission sources (approx.) (m)	Location of the Site Boundary[3]	Affected during Construction Phase	Affected during Operation Phase
Border Road	BR-3	1	R	55	LMCL	✓	✓
	BR-4	2	R	80	LMCL	✓	✓
	BR-5	1	R	45	ECR	✓	✓
Chau Tau Tsuen	CTT-3	3	R	90	WCR	✓	✓
Ha Wan Fisherman San Tsuen	HWFST-2	1	R	15		✓	✓
Ha Wan Tsuen	HWT-1	1	GIC	10		✓	✓
	HWT-2	1	GIC	10		✓	✓
	HWT-4	1	R	30		✓	✓
Ha Wan Tsuen Road	HWTR-1	1	R	5		✓	✓
	HWTR-6	1	R	<5		✓	✓
	HWTR-10	1	R	10		✓	✓
	HWTR-11	1	R	<5		✓	✓
	HWTR-20	1	R	40		✓	✓
Lok Ma Chau Operational Base	LMCOB-1	1	GIC	35	ECR	✓	✓
Lok Ma Chau Police Station	LMCPS-1	3	GIC	20	WCR	✓	✓
Lok Ma Chau Road	LMCR-2	2	R	10		✓	✓
	LMCR-5	2	R	15		✓	✓
	LMCR-8	2	R	20		✓	✓
	LMCR-12	1	R[2]	10		✓	✓
	LMCR-14	3	R	35		✓	✓
	LMCR-15	3	R	80		✓	✓

Location of ASRs	Assessment Points	No. of Storey	Nature [1]	Separation Distance between ASR and nearest emission sources (approx.) (m)	Location of the Site Boundary[3]	Affected during Construction Phase	Affected during Operation Phase
Lok Ma Chau San Tsuen	LMCST-3	1	R	20	LMCL	✓	✓
Lok Ma Chau Tsuen	LMCT-1	3	R	70		✓	✓
Ma Tso Lung	MTL-1	3	R	20	ECR	✓	✓
	MTL-7	2	R	60		✓	✓
	MTL-8	4	R	20		✓	✓
	MTL-9	4	R	45		✓	✓
	MTL-12	4	R	40		✓	✓
	MTL-20	1	R	15		✓	✓
Lo Wu Police Range	PR-1	1	GIC	15		✓	✓
Pun Uk Tsuen	PUT-2	3	R	20	WCR	✓	✓
San Sham Road	SSR-1	2	R	70	DL	✓	✓
Near Wing Ping Tsuen	WPT-1	3	R	30	LMC/STH	✓	✓

Notes:

[1] R – residential; GIC – Government/ Institution/ Community Use

[2] The landuse of LMCR-12 was found different from that stated in the LMC Access Road EA Report.

[3] WCR – Western Connection Road; ECR – Eastern Connection Road; DL – Direct Link to Lok Ma Chau Station; LMC/STH – Lok Ma Chau/ San Tin Highway Connection; LMCL – Lok Ma Chau Loop.

Table 3.4 Planned ASRs identified within 500m from the boundary of the Project

Location of ASRs	Assessment Points	No. of Storey	Nature [1]	Separation Distance between ASR and Site Boundary (approx.) (m)	Location of the Site Boundary[2]	Affected during Construction Phase	Affected during Operation Phase
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	3	[3]	20	DL	✓	✓
Ex-Lung Kai Public School	ELKPS-P1	1	GIC	145	ECR	✓	✓
Eco-Lodge	EL-P1	1	R	15		✓	✓
	EL-P5	1	R	25		✓	✓
Kwu Tung North New Development Area	KTN-P2	6[4]	GIC	20		✓	✓
	KTN-P3	6[4]	GIC	20		✓	✓
Lok Ma Chau Loop	LMCL-P1	8[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P2	8[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P4	10[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P6	9[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P7	9[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P8	6[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P9	6[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P11	6[5]	E[6]	Within LMCL	LMCL	✓	✓
	LMCL-P12	8[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P15	8[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P16	10[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P17	10[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P18	9[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P19	9[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P21	9[5]	E[6]	Within LMCL	LMCL	✗	✓
	LMCL-P23	9[5]	E[6]	Within LMCL	LMCL	✗	✓

Location of ASRs	Assessment Points	No. of Storey	Nature [1]	Separation Distance between ASR and Site Boundary (approx.) (m)	Location of the Site Boundary[2]	Affected during Construction Phase	Affected during Operation Phase
	LMCL-P24	10[5]	E[6]	Within LMCL	LMCL	×	✓
	LMCL-P25	10[5]	E[6]	Within LMCL	LMCL	×	✓
	LMCL-P26	6[5]	E[6]	Within LMCL	LMCL	×	✓
	LMCL-P27	6[5]	E[6]	Within LMCL	LMCL	×	✓
	LMCL-P28	6[5]	E[6]	Within LMCL	LMCL	×	✓
Proposed Fire Station and Ambulance Depot	FS-P1	10[8]	GIC	Within LMCL	LMCL	✓	✓
Lok Ma Chau Tsuen Expansion	LMCTE-P1	3[7]	R	15	WCR	✓	✓
	LMCTE-P4	3[7]	R	15	LMCL	✓	✓
	LMCTE-P6	3[7]	R	10	WCR	✓	✓

Notes:

[1] R – residential; GIC – Government/ Institution/ Community Use; E – Education.

[2] WCR – Western Connection Road; ECR – Eastern Connection Road; DL – Direct Link to Lok Ma Chau Station; LMCL – Lok Ma Chau Loop.

[3] Residential uses are assumed and the uses will be updated when more information is available.

[4] Six storeys are assumed according to the latest Kwu Tung North New Development Area Recommended Outline Development Plan.

[5] No. of storeys according to the latest planning information from the Study.

[6] Educational institutions refer to student hostels, staff quarters, academic, administration buildings, and recreational/sport facilities. Central air conditioning is assumed to be provided for academic and administration buildings.

[7] One storey for Ex-Lung Kai Public school and Eco-lodge, three-storey residential premises for CDWEA in San Tin and Unspecified Use for Hoo Hok Wai, village zone near Chau Tau Tsuen and LMC Tsuen are assumed.

[8] Ten storeys are assumed according to the maximum building height stated in the Recommended Outline Development Plan.

3.5 Assessment Methodology

All assumptions described in the following sub-sections have been confirmed with relevant parties.

3.5.1 Construction Phase

The prediction of dust emissions is based on the typical values and emission factors obtained from United States Environmental Protection Agency (USEPA) Compilation of Air Pollution Emission Factors, AP-42, 5th Edition.

As mentioned in **Section 2.5**, the construction of LMC Loop will be divided into phases including the Advance Works, Phase 1 Infrastructure, Phase 1 Buildings, Phase 2 Infrastructure and Phase 2 Buildings. Each of these phases would be implemented according to the development programme and their associated dusty construction activities will be assessed.

Since the air quality impact due to different construction phases will vary, the assessment identifies the worst case scenario over the entire construction phase to address the specific impacts arisen from the different work areas.

Construction dust assessment for short-term impact (i.e. 1-hour and 24-hour average) will be undertaken by a 2-Tier approach. Tier 1 screening assessment is a theoretical worst case scenario evaluation to identify hot spot areas of construction air quality impact by assuming 100% active construction area for all worksites. The identified hot spot areas will be further assessed by a more focused Tier 2 assessment to predict a more realistic worst case impact by altering the active construction areas to 30% and locating them nearest to the ASRs. Long-term impact (i.e. annual average) will be assessed with 6% active construction area for all work sites. Details discussions are given in the following subsections.

Conservative approach was adopted in the model run.

3.5.1.1 Assessment Years

The construction programme given in **Appendix 2-6** and **Appendix 3-3** have been reviewed to identify the construction phases for inclusion in the assessment.

Dust emission from heavy construction usually arises from dusty construction activities such as site clearance, ground excavation, etc. As shown in **Table 3.5**, most of the site formation and construction of major infrastructure within LMC Loop area will be carried out in Phase 1 Infrastructure.

According to the construction programme given in **Appendix 2-6**, major construction activities including the site formation of LMC Loop and essential infrastructure works (e.g. Western Connection Road and Lok Ma Chau Station Connection) at adjacent area in Hong Kong outside LMC Loop will occur in Year 2016. In addition, during the construction of Western Connection Road, some major site activities will occur in proximity to the existing ASRs (e.g. village house near Ha Wan Tsuen Road) and significant air quality impact is therefore anticipated. In light of the programme schedule of major construction activities and proximity of the activities to the ASRs, Year 2016 is considered as the worst case scenario for the assessment.

Since sensitive receivers along the Eastern Connection Road are less likely affected by the construction dust impact due to Phase 1 Infrastructure, the dusty construction activities associated with the Phase 2 Infrastructure have also been assessed to check compliance of this phase of the construction programme.

Table 3.5 Summary of heavy construction works

Phases	Construction Period	Major Construction Activities
Phase 1 Infrastructure	End 2014 to early 2019	• Site formation, clearance and ground excavation in all zones within LMC Loop area (Figure 2.24). • Construction of the associated facilities for Internal Transport Network, Drainage Discharge Points, Fire Station cum Ambulance Depot, District Cooling System (Western) and Sewage Treatment Works. • Construction works for West Connection Road (including Lok Ma Chau / San Tin Highway). • Junction improvement works (Lok Ma Chau Road – Castle Peak Road) • Construction of Direct Link to Lok Ma Chau station.
Phase 2 Infrastructure	End 2024 to early 2027	• Construction works for Eastern Connection Road. • Construction works for the District Cooling System (Eastern). • Construction works for the Proposed Flushing Water Service Reservoir and the corresponding connection roads.

3.5.1.2 Construction Vehicle Access

Dust emission from construction vehicle movement within the site and the temporary construction access have been taken into account.

The LMC Loop is a net fill intake project. It is assessed that the peak construction traffic occurs during the site formation stage for fill import and surplus surcharge export. Based on the estimated fill import volume divided by the truck capacity, the working hour per month and the scheduled construction programme for site formation, it was established that 50 trucks per hour (one-way only) for fill transportation would be required for supporting the construction rate to meet the first population intake in Year 2020. On top of the fill transportation traffic, an additional 10 trucks per hour (one-way only) was allowed for miscellaneous minor construction traffic like machinery and staff transportation. The assessment therefore adopted 60 trucks/hour travelling into and out of the project site through the construction access during working hours.

Effective from September 2009, all loaded dump trucks, including grab-mounted dump trucks travelling into and out of construction sites should be equipped with suitable covers before the trucks leaving the site. It is expected that dust emission from dump trucks travelling on the temporary construction access road outside the site would be minimal. Construction dust emission from vehicle movement inside the site are included in the assessment.

3.5.1.3 Operating Hours

Heavy construction working during weekdays and 8 hours per day (9a.m. to 5p.m.) have been assumed according to the mitigation requirement for ecology in **Section 12.7.6.2** for most parts within the project, except for the area near San Tin Interchange which will be allowed for 12 operating hours per day (7a.m. to 7p.m.). Construction works during restricted hours might be required for the construction crossing over San Tin Highway and San Sham Road. The two construction works are:

- The elevated structure of Western Connection Road (i.e. the portion of Lok Ma Chau Road/ San Tin Highway Connection) across San Tin Highway (expressway); and
- The elevated structure of Direct Link to LMC Spur line Station across San Sham Road.

In general, the construction works that need to be conducted during restricted hours include falsework and formwork erection, formwork launching and concrete casting. Given these activities would not generate significant dust emission, they were not considered in the assessment.

3.5.1.4 Tier 1 Screening Assessment

In terms of the construction programme, it should be noted that the sequencing of works activities from individual work sites or areas will be determined by the Contractor and is not known at this stage. However, due to the size of the works site and the need for orderly sequencing of construction activities, active construction activities will occur at different locations of the work site at different time periods. Therefore, it is not possible to pinpoint the exact locations of individual dust emission sources in the entire work site.

Tier 1 screening assessment is to establish a theoretical worst case scenario for identifying hot spot areas with potential short term 1-hour and 24-hour impacts on ASRs. The basis of the Tier 1 screening assessment for short term impact evaluation has assumed a 100% active work area for all worksites. Areas within the criteria contour are considered hot spot locations for which a focused Tier 2 assessment will be conducted.

3.5.1.5 Tier 2 Assessment

Based on the experience of the Engineer, there would be no more than 30% of active work area in each work site during any short period of time. Any short-term 1-hour and 24-hour periods, construction works activities would also occur at different locations of the entire work site. Hence, the chance of all 30% active works area in an individual work site occurring next to an ASR at any short time period is unlikely.

In Tier 2 assessment, each hot spot area is assumed with 30% active works areas occurring nearest to the potentially worst affected ASRs, while emissions from all other work sites outside the hot spot area will remain at 100% active as in Tier 1. Results of Tier 2 assessment are still conservative as noted by the experience of the Engineer though it serves a representation of the worst case construction dust impact prediction for the study.

3.5.1.6 Long-term Annual Predictions

Dust modelling assessment for long term annual predictions assumes that the work activities would evenly distribute across the whole area of each site over the year with an effective 6% active work area. In the modelling analysis, the dust emission rates are proportionally reduced to produce this effect in the assessment. **Appendices 3-1** and **3-3** present the justifications for the percentage of active areas and tentative construction programme respectively.

3.5.1.7 Dust Dispersion Modelling

Dust impact assessment was undertaken using the Fugitive Dust Model developed by USEPA and approved by EPD. It is a Gaussian plume model for computing air dispersion due to fugitive dust emission. Modelling parameters including dust emission factors, particle size distributions, surface roughness, etc can be referred to EPD guideline entitled "Guideline on Choice of Models and Model parameters in Air Quality Assessment" and the USEPA AP-42. The density of dust was assumed to be 2.5g/m^3. The 5-year mean of the annual averaged TSP concentration of relevant EPD's air quality monitoring stations will be taken as the background concentration. As mentioned in **Section 3.3.2**, the TSP background concentration of 73.1 ug/m^3 is adopted for the fugitive dust modelling. A surface roughness of 100 cm is assumed in the model to represent the terrain.

During daytime working hours (9am to 5pm), it is assumed that dust emissions would be generated from all dust generating activities and site erosion. During night-time non-working hours (5pm to 9am of the next day), Sunday and public holidays, dust emission would be from site erosion only as there would be no construction activities during these hours.

The worst-case 1-hour, 24-hour and annual average TSP concentrations were predicted with Year 2010 meteorological data from Ta Kwu Ling Weather Station and mixing height from King's Park Station.

Fugitive dust modelling was conducted at 1.5m above ground level as all the dusty activities would be located at ground level only.

Table 3.6 Modelling parameters

Parameters	Input	Remark
Particle size distribution	1.25um = 7% 3.75um = 20% 7.5um = 20% 12.5um = 18% 22.5um = 35%	Reference from S13.2.4.3 of USEPA AP-42
Background Concentration	Recent 5-year average value of monitoring stations of rural and new development category	Sha Tin, Tai Po and Yuen Long air quality data have been adopted for background concentration

Parameters	Input	Remark
Modelling mode	Flatted terrain	-
Meteorological data	Data recorded in 2010 at Ta Kwu Ling (TKL) meteorological station	-
Anemometer Height	13m at TKL	-
Surface Roughness	100cm	-
Emission period	General construction activities during daytime working hours (9 am to 5 pm Monday to Saturday except Sundays and general public holidays) Wind erosion at all times during construction period.	-
ASR calculating levels	1.5m only	-

3.5.1.8 Dust Emission Factors and Assumptions

Dust emission factors and assumptions used in the assessment for different dust generating activities are listed in **Table 3.7**. Detailed calculations of the emission factors are given in **Appendix 3-3**.

Table 3.7 References of dust emission factors for different construction activities

Construction Activities	Reference	Operating Sites	Emission Factors and Assumptions
Heavy construction activities including land clearance, site formation, ground excavation, construction of associated facilities etc.	USEPA AP-42, Section 13.2.3.3	All construction and excavation sites	E = 2.69 Mg/hectare/month of activities
Wind erosion	USEPA AP-42, Table 11.9.4	All open construction sites, any stockpile areas, barging points etc.	E = 0.85 Mg/hectare/year

3.5.2 Operational Phase

The prediction of operational air quality impact covers road traffic emission, chimney emission and odour emission due to the operation of LMC BCP, Phase 1 Infrastructure, Phase 2 Infrastructure and the cumulative odorous sources from Shenzhen River and Binhe Wastewater Treatment Plant.

3.5.2.1 Determination of Assessment Year

According to Section 3.4.4.3 (v) (a) of the EIA Study Brief, vehicular emissions impact shall assess the worst scenario of the future road traffic within 15 years upon commissioning of the Project. The completion year for Phase 1

Infrastructure will be Year 2020 while for Phase 2 Infrastructure will be Year 2027. Therefore, Year 2035 and Year 2042 (i.e. 15 years upon commissioning of each phase) are considered respectively as interim and ending year for between the worst year determination period of Year 2020 and Year 2042. Results indicate that Year 2020 is the worst assessment year as it generates the highest vehicular emission within the Study Area when compared with the other three years. Given Year 2020 is within the assessment period of Phase 2 buildings, Year 2027 which has the 2nd highest vehicular emission, is also assessed to predict the air quality impact of the entire development for both Phases. **Appendix 3-4** presents the detailed methodology and Section 3.6.2.1 presents the details for selecting the worst assessment year of 2020.

3.5.2.2 Determination of Key Parameters

Nitrogen Dioxide (NO_2)

Nitrogen oxides (NOx) is known to be one of the pollutants emitted by vehicles. According to the 2011 Hong Kong Emission Inventory Report published by EPD (http://www.epd.gov.hk/epd/english/environmentinhk/air/data/files/2011HKEIReport.pdf) which is the latest available information by the time of preparing this report, the dominant source of NOx generated in HK is the navigation which constitutes about 33% of the total in 2011. Road transport is the second largest NOx emission group, accounting for about 29% of the total (see **Table 3.8** below).

Table 3.8: The emission percentage and the amount of NOx in Hong Kong (2011)

Pollutant Source Categories	NO_x Emission %[1]	NO_x Emission (tonnes)[1]
Public Electricity Generation	26%	30,000
Road Transport	29%	32,700
Navigation	33%	37,700
Civil Aviation	4%	4,770
Other Fuel Combustion	8%	9,290
Total	100%	114,000

Notes:
[1] Figures extracted from 2011 Hong Kong Emission Inventory Report (http://www.epd.gov.hk/epd/english/environmentinhk/air/data/files/2011HKEIReport.pdf)

Together with VOC and in the presence of O_3 under sunlight, NOx would be transformed to NO_2. As discussed in Section 3.3.2, the latest 5-year average of annual NO_2 concentrations in Shatin, Tai Po and Yuen Long is 60.6% of the AQO.

The operation of LMC Loop would increase the traffic flow and hence the NOx emission and subsequently the NO_2 concentrations near to the roadside. Hence, NO_2 is one of the key / representative pollutants for the operational air quality assessment of the Project. 1-hour, 24-hour and annual average concentrations at each identified ASR would be assessed and compared with the relevant AQO to determine their compliance.

Respirable Suspended Particulates (RSP or PM10)

Respirable Suspended Particulates (RSP or PM10) refers to suspended particulates with a nominal aerodynamic diameter of 10µm or less. According to the EPD's data, (http://www.epd.gov.hk/epd/english/environmentinhk/air/data/files/2011HKEIReport.pdf), and other research studies (Tian et al., 2011 & Wie-Zhen et al., 2008), road vehicles, particularly diesel vehicles, are one of the sources of RSP in Hong Kong.

According to the latest statistics of 2011 Hong Kong Emission Inventory Report (http://www.epd.gov.hk/epd/english/environmentinhk/air/data/files/2011HKEIReport.pdf), road transport is the second largest source of RSP accounting for 19% of the total emissions. As discussed in Section 3.3.2, the latest 5-year average of the annual RSP concentration in Shatin, Tai Po and Yuen Long is about 91.8% of the AQO.

Table 3.9: The emission percentage and the amount of RSP in Hong Kong (2011)

Pollutant Source Categories	RSP Emission % [1]	RSP Emission (tonnes)[1]
Public Electricity Generation	16%	998
Road Transport	19%	1,180
Navigation	37%	2,310
Civil Aviation	<1%	58
Other Fuel Combustion	12%	745
Non-combustion	15%	934
Total	[2]	6,220

Note:
[1] Figures extracted from 2011 Hong Kong Emission Inventory Report (http://www.epd.gov.hk/epd/english/environmentinhk/air/data/files/2011HKEIReport.pdf)
[2] Figures are directly extracted from the report and may not be added to 100% or the total sum of the emission from all source categories.

The operation of LMC Loop would increase the traffic flow and hence the RSP concentrations near to the roadside. Hence, RSP is also one of the key representative pollutants for the operational air quality assessment of the Project. The 24-hour and annual average concentrations at each identified ASR would be assessed and compared with the relevant AQOs to determine their compliance.

Carbon Monoxide (CO)

CO is one of the primary pollutants emitted by road transport which contributed about 67% of total CO emission in 2011. Despite road transportation being the dominant source of CO emission, however, the air quality impact from CO is relatively minor considering its monitoring stations data records. In year 2011, the highest 1-hr concentration was 4030 $\mu g/m^3$ as for Causeway Bay and the highest 8-hr concentration is 3309 $\mu g/m^3$ as for Causeway Bay as well, both of which were well below the AQO standard of 30,000 (1-hour) and 10,000 (8-hour) respectively. It is therefore not a key parameter for assessment.

Sulphur Dioxide (SO_2)

According to the latest statistics of 2011 Hong Kong Emission Inventory Report [3-2], the dominant source of SO_2 in Hong Kong is from navigation, which constitutes about 54% of the total emissions. Only <1% of the total emissions comes from road transport. The introduction of ultra low sulphur diesel for vehicle fleet has further reduced the SO_2 emission from road transport in Hong Kong. Given the low contribution of SO_2 from transportation sector, it is also not considered a key parameter in this assessment.

Ozone (O_3)

Unlike other pollutants such as NOx, O_3 is not a primary pollutant emitted from man-made sources but is formed by a set of complex chain reactions between various chemical species, including NOx and VOC, in the presence of sunlight. According to Sun et al.[3-2] the rate of formation of O_3, also known as Ozone Production Efficiency, depends not only on NOx and VOC levels, but atmospheric oxidation, temperature, radiation, and other meteorological factors in the atmosphere of different regions. The formation of O_3 generally takes several hours to proceed (EPD, 2011)[3-3] and therefore O_3 recorded locally could be attributed to emissions generated from places afar.

According to "A Study to Review Hong Kong's Air Quality Objectives" (http://www.epd.gov.hk/epd/english/environmentinhk/air/studyrpts/aqor_report.html), due to the abundance of its precursors (VOC and NOx) from a great variety of sources such as motor vehicles, industries, power plants and consumer products, etc., ozone can be widely formed in the region and can be transported over long distance. The general rising trend of ozone levels in Hong Kong over the past years reflects an aggravation in the photochemical smog problem on a regional scale. All these indicate that local traffic emission is not a dominant controlling factor in O_3 formation.

In addition, the EPD's "Air Quality in Hong Kong 2011" report stated that NOx emissions from motor vehicles have the potential to react with and remove O_3 in the air, and regions with heavy traffic normally have lower ozone levels than areas with light traffic. It is therefore possible that the Project may contribute to a decrease in O_3 in the immediate area along main roads. O_3 is therefore not considered as a key parameter in this assessment.

Lead (Pb)

As leaded petrol had been banned in Hong Kong in 1999, it is no longer considered as a primary source in Hong Kong. According to the "Annual Air Quality Monitoring Results - Air Quality in Hong Kong 2011" from EPD (http://www.epd-asg.gov.hk/english/report/files/AQR2011e_final.pdf), the measured 3-month averaged lead level ranged from 0.020 $\mu g/m^3$ (Kwun Tong and Central/ Western) to 0.104 $\mu g/m^3$ (Yuen Long). The measured concentration is much lower than the 3-month AQO of 1.5 $\mu g/m^3$. Therefore, lead is not considered as a key air pollutant for assessment.

In summary, NO_2 and RSP are concluded to be the representative air pollutants for the assessment.

3.5.2.3 Vehicular Emission from Open Road

In the Hong Kong context, NO_2 and RSP are considered key vehicular emissions pollutants for the purpose of air quality assessment under the EIAO, as the others emitted pollutants are rather insignificant based on their current monitoring station data trend records.

EMFAC-HK was used to calculate the vehicular tailpipe emission in lieu of the traditional fleet average emission factors. The road grouping for this assessment is shown in **Figure 3.3**. Emission factors for Year 2020, Year 2027, Year 2035 and Year 2042 were determined.

Vehicular tailpipe emissions from open roads are derived from the EPD EMFAC-HK model v2.1 at the time of assessment (end 2012). Later model versions EMFAC-HK v2.5 and v.2.5.1 have since been released by EPD in January and March 2013 respectively. According to EPD website, changes to v2.5 involved the output file formats, output file name and input file unit for vehicle milage travel, the overall effect on emission estimates are insignificant. Similarly, it has also stated that v2.5.1 will not result in any changes in predicted emission rates. Therefore, the vehicular tailpipe emission rates generated from v2.1 remain applicable for adoption in this assessment.

Vehicular emissions for cross-boundary vehicles have followed the same methodology adopted in the approved EIA report "Hong Kong - Zhuhai - Macao Bridge Hong Kong Link Road" (Register No. AEIAR-144/2009). The HZMB EIA report stated that cross-boundary vehicles had to go through the vehicle-registration process in Hong Kong. As such, all motor vehicles seeking first registration in Hong Kong must comply with the requirements of the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations. Without a programme on policy review, it implies that cross-boundary vehicles on LMC BCP would meet the same emission standards as local vehicles of similar types. It is therefore not unreasonable to assume that cross-boundary vehicles would have the same emission characteristics as local vehicles.

Estimated traffic flow in Year 2020 is presented in **Appendix 3-4**. It shows that the traffic flow is relatively higher for "PM peak hour" than "AM peak hour". Hence, traffic flow during PM peak is adopted as the worst case. **Appendix 3-4** presents the key assumptions for the EMFAC-HK modelling. A 24-hour daily profile in terms of total traffic flow will be assumed for all vehicle classes. **Appendix 3-5** presents the detailed estimation of the vehicular emission factors for NO_2 and RSP within the 500m from the boundary of the Project. Assessment points are shown in **Table 3.3** and **3.4** and **Figures 3.2 to 3.2d** respectively.

The air dispersion model, CALINE4 developed by the California Department of Transport and approved by USEPA was used to assess vehicular emission impacts from the existing and planned road network. In view of the limitation of the model, elevated roads higher than 10m were set to the maximum height of 10m to represent the condition, albeit in a more conservative manner.

Based on EPD's Guidelines for Local-Scale Air Quality Assessment Using Models (http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model_g1 .html), surface roughness was estimated to be 10% of the average height of physical structures within 1km of the study area. On the Shenzhen side, the area is mainly dominated by high-rise residential and commercial buildings. On the other hand, the Loop development will be occupied by taller developments located at the southwestern corner with lower building heights along the SZ River, it is intended that building heights should step up gradually from the SZ River to the centre of the site and gradually stepping down towards the eastern part of the site, so a surface roughness of 100cm was appropriately assumed.

Meteorological data recorded at the Ta Kwu Ling Weather Station and mixing heights at King's Park Station in 2010 was adopted. The standard deviation of wind direction was determined according to the Guideline on Air Quality Models

(Revised), EPA-450/2/78/027R USEPA, July1986. 20% of NO_x was assumed to be NO_2 in accordance with the Ambient Ratio Method.

3.5.2.4 Portal Emission from Underpass connecting LMC Loop and Eastern Connection Road

Upon completion of the Phase 2 Infrastructure, there will be a short underpass section connecting the Loop internal road to Eastern Connection Road across the meander and Ecological Area. As advised by the Tunnel Engineer, only jet fan will be installed in this underpass and no ventilation building is required. ISCST3 Model was adopted to estimate the portal emission from the underpass in accordance with the Permanent International Association of Road Congress Report (PIARC, 1991), where it is assumed that the pollutant will be ejected from the portal as a portal jet such that 2/3 of the total emission will be dispersed within first 50m, and the rest 1/3 of the total emission within the next 50m.

3.5.2.5 Air Quality Inside Underpass

In accordance with the *"Practice Note on Control of Air Pollution in Vehicle Tunnels"*, the air quality inside the tunnel should achieve the EPD recommended limit of 1ppm NO_2 concentration. This criterion is adopted in this assessment. As advised by tunnel engineer, only jet fan will be installed in the underpass and no ventilation building is required. The in-tunnel air quality assessment is given in **Appendix 3-6**. Results indicate the EPD recommended limit will be achieved. The emission rate of CO is approximately 10-20 times of the NO_2 emission rate with reference to vehicular emission derived from EMFAC Mode using EMFAC-HK v2.1 (I&M), however, the ratio of guideline standard of CO (5-minute) concentration to NO_2 (5-minute) concentration in $\mu g/m^3$ is 64 to 1. Therefore, CO would also comply with the standard. Under the Air Pollution Control (Motor Vehicle Fuel) Regulation, the sulphur content of diesel fuel is required to be less than 0.005%. in view of the low emission rates relative to the statutory limit, SO_2 would also comply with the tunnel air quality limit.

3.5.2.6 Vehicular Emission from Idling Vehicles at LMC BCP

LMC BCP is located within 500m from the boundary of the Project. The calculation of emission factors from idling engines in the kiosks and loading/unloading bay at LMC BCP has followed the methodology of PIARC 2004 paper on road tunnels. The locations of Kiosks and Loading/Unloading Bay at LMC BCP are shown in **Figure 3.4**. Detailed calculations of idling emissions and locations of emission sources are presented in **Appendix 3-7**. The latest implementation programme of vehicle emission standard, vehicle age distribution and technology fraction of different engine types have been taken into account in the calculations of vehicular emissions.

For conservative analysis, buses and coaches were assumed to have the same idling emission factor as heavy goods vehicles. A more conservative idling emission factor of 0.2g/min for NO_x as given in the Consultation Paper - A Proposal to Ban Idling Vehicles with Running Engines was assumed for private cars. **Table 3.9** summarizes the idling emission factors adopted for different vehicle types in the assessment years of 2020 and 2027.

Table 3.9 NOx and RSP emission factors for various types of vehicles

Vehicle Type	Year 2020 Idling Emission Factor		Year 2027 Idling Emission Factor	
	NOx (g/min-veh)	RSP (g/min-veh)	NOx (g/min-veh)	RSP (g/min-veh)
Passenger Car	0.2	Negligible	0.2	Negligible
Goods vehicle & Container Truck	1.229	0.032	1.036	0.024
Bus / Coach	1.229	0.032	1.036	0.024
Taxi	0.2	Negligible	0.2	Negligible

Similar to the methodology of vehicular emission from open road, the potential air quality impact due to idling emissions at LMC BCP was assessed by the approved model, CALINE4. Emissions from the kiosks as well as at the loading/unloading bays were modelled as "parking lot" mode.

3.5.2.7 Vehicular Emission from Public Transport Interchanges (PTI)

With reference to the "Motor Vehicle Idling (Fixed Penalty) Ordinance (Cap. 611)", the driver of a motor vehicle is prohibited from causing or permitting any internal combustion engine ("ICE") which forms part of a motor vehicle to operate for more than three minutes in aggregate within any continuous sixty-minute period while the vehicle is stationary ("idling prohibition"), unless an exemption applies. Therefore, idling emission is not identified within the PTI.

A TI is proposed above the existing LMC Station Public Transport Interchange. It would be an open TI with passengers taking and dropping operations. Provision for mechanical ventilation is not required for this TI and the existing LMC Station Public Transport Interchange. For the two proposed TI within the LMC Loop development, the design of the two proposed TI should comply with "Practice Note for Professional Persons – Control of Air Pollution in Semi-Confined Public Transport Interchange". With reference to S.2.4.2.4, in consideration of the worst case scenario for traffic impact assessment, free vehicle movements were assumed within the internal transport networks.

3.5.2.8 Chimney Emission

An initial desktop study and site surveys had been carried out on 9 and 12 December 2009. Based on verification findings from subsequent reconnaissance survey on 2 March 2012, it is confirmed that no industrial chimney was identified within the 500m from the boundary of the Project on Hong Kong side. On Shenzhen side, the nearest potential industrial land use is located within the Futian Bonded Zone in Futian District at more than 500m away from the Project boundary.

In addition, as the LMC Loop site is being planned for the development of a mixture of educational institutions and high-technology industry park, chimney emission from the area is not anticipated. To the east of the site at Sandy Ridge, three cremators were proposed, however, their locations are outside 500m of the Project boundary, and so potential chimney emission impact is not anticipated.

3.5.2.9 Odour Emission

From the desktop review and reconnaissance site surveys undertaken on 11 January, 16 January, and 16 March of 2010, odour emission along the Shenzhen River was identified in the vicinity of the LMC Loop. On 23 April 2010, another site survey was conducted to identify other odour generating industries within 500m from Loop development on Hong Kong side, in which the planned ASRs will be located. There were no active odour generating industries identified. Details of the literature review and reconnaissance site surveys are given in **Appendix 3.8**.

In addition, the future STW within the LMC Loop and the Binhe WWTP at about 1.8 km upstream from the boundary of LMC Loop on Shenzhen side are potential odour sources and have been included in the assessment. All the major pollution sources are shown in **Figure 3.5**.

The Lagrangian model, ISCST was adopted to assess compliance of the odour criterion.

Hourly meteorological data including wind speed, wind direction, air temperature and stability classes at the Ta Kwu Ling Weather Station and the mixing height from the King's Park Weather Station in Year 2010 was adopted for the assessment. The future land use for industrial, commercial and residential uses will account for over 50% of area within 3 km radius from the odour emission source within the LMC Loop. Hence, urban dispersion coefficients are adopted in the ISC3 model.

The predicted hourly odour concentrations were converted into the 5-second odour concentrations and compared to the stipulated odour criterion, i.e. 5 odour unit. The conversion factors used were made reference to the study of "Agreement No. CE43/2005 (EP) Harbour Area Treatment Scheme Stage 2A EIA Study – Investigation", which adopted the New South Wales Approved Method stipulated in "*Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales*", these conversion factors are shown in **Table 3.10**.

Table 3.10 Conversion factors for hourly average to 5-sec average of odour concentration

Emission Sources	Pasquill Stability Class	Conversion Factor (From 1 hour to 5 seconds)
Binhe WWTP	A – D	2.3
	E – F	1.9
Future STW within the Loop	A – F	2.3
Shenzhen River	A – D	2.5
	E – F	2.3

Upon the operation of LMC Loop, the surrounding of future STW would be surrounded by low to medium-rise buildings and building wake effect on the dispersion of odour emission is anticipated. Hence, the conversion factor for wake-affected point source is adopted.

In respect of the odour emission from Shenzhen River, the emission rates were established through in-situ odour sampling and subsequent laboratory olfactometry analysis. The steps taken for determination of emission rates from Shenzhen River and assumptions for Binhe WWTP and on-site STW are discussed as follows:

Shenzhen River Odour Emission

Step 1 - Sampling Locations

In view of the identified odour emission sources along the Shenzhen River, odour emission sampling has been proposed to evaluate the odour emission strength. Sampling locations along the Shenzhen River are shown in **Figures 3.6** to **3.6e**. Seven locations were selected and verified by an odour specialist prior to the actual sampling works. At each sampling location, the following samples have been collected.

Shenzhen Side

- 1 odour sample for exposed sediment.
- 1 odour sample on water surface.

Hong Kong Side

- 1 odour sample on water surface.

The selected sampling locations were summarised below:

- downstream of the LMC Loop at the boundary of the study area (Location 1 in **Figure 3.6**);
- off the North-Western boundary of the LMC Loop (Location 2 in **Figure 3.6**);
- upstream of Location 2 within the LMC Loop (Location 3 in **Figure 3.6**);
- upstream of Location 3 near the boundary of the associated infrastructure in the adjacent area in Hong Kong outside LMC Loop (Location 4 in **Figure 3.6**);
- upstream of Location 4 and located at within 500m from the boundary of Loop development (Location 5 in **Figure 3.6**);
- upstream of Location 5 to the west of the Binhe WWTP (Location 6 in **Figure 3.6**); and
- upstream of Location 6 and near the Binhe WWTP (Location 7 in **Figure 3.6**);

Odour samplings have been carried out at these seven locations during the low tide periods on 6th, 19th and 22nd of August 2010 when the ambient temperatures were above 32^{o}C such that a reasonable worst scenario could be established. Sediment profile of the Shenzhen River in 2009, obtained from the Drainage Services Department, is also shown in **Figures 3.6 - 3.6e**.

Step 2 - Odour Sampling

To determine the specified odour emission rate (SOER) from the Shenzhen River, the odour concentration (ou/m^3) was measured at the identified sampling locations.

Odour sampling along the Shenzhen River were carried out by an odour specialist, who had also verified the selected sampling locations shown in **Figure 3.6** prior to the actual sampling works.

Meteorological data such as ambient temperature, relative humidity, wind speed, wind direction and tidal data were taken from Hong Kong Observatory or recorded on site.

Air samples were collected by positioning a wind tunnel device on the selected odour emitting surface (i.e. on water or sediment surface). Nitrogen gas from a certified gas cylinder was then directed into the hood to simulate parallel air flow at a fixed velocity through the wind tunnel device.

Collected samples had undergone olfactometry analysis in the laboratory to determine odour concentrations. The odour measurement report for Hong Kong side of the Shenzhen River by Hong Kong Polytechnics University is given in **Appendix 3-9** whereas the report for Shenzhen side of the Shenzhen River by Zhongshan University (中山大學) has been provided to EPD but omitted in the appendix due to data confidentiality reason.

Step 3 - Emission Rate Determination

The emission rate was determined by the air flow rate through the hood and the odour concentration of the exit air. Specific odour emission rates (SOER) of each area source were estimated by the equation below:

$$SOER(OU/m^2/s) = \frac{odour\ concentration\ (OU/m^3)\ \times air\ flow\ rate\ throught\ the\ hood(m^3/s)}{water\ surface\ area\ covered\ by\ the\ hood(m^2)}$$

On-site Sewage Treatment Works within the LMC Loop

The on-site STW within the LMC Loop was identified to be a potential odour emission source to the sensitive receivers.

As in-situ sampling from a planned STW is not possible, odour emission rates were made reference to the measured data of existing STWs with similar mode of operation. In this project, the operation of the proposed STW is considered similar to the decentralized design of the Sha Tin Sewage Treatment Works (STSTW). Hence, the measured emission rates in the STSTW were adopted for the assessment. The emission rates for different facilities of the proposed STW are summarised in **Table 3.11**.

Table 3.11 Summary of base emission rates for proposed LMC STW

LMC on-site STW Facilities	Basis of odour emission factors in STSTW	SOER Adopted ($ou/m^2/s$ or ou/s)[1]
Deodorization Unit 1		**442.02**
Inlet Pumping Station (Pump)	Influent Channel PST	7.80
Screens and Grit Traps	Grit Surface, Inlet Work	5.72
Primary Sedimentation Tanks	Sedimentation Tank Surface PST	5.68
Membrane Bioreactor (Bioreactor) including fine screen	Aerobic Zone, Aeration Tanks	0.6
Membrane Bioreactor (Membranes)		
Pump Compound		
Deodorization Unit 2		**1989.02**
Equalization Tank	Sedimentation Tank Surface PST	5.68
Primary Sludge Storage Tank	Tank Surface, Sludge Holding Tank	15.15
Primary Sludge Thickeners		

LMC on-site STW Facilities	Basis of odour emission factors in STSTW	SOER Adopted (ou/m^2/s or ou/s)[1]
MBR Sludge Storage Tanks	Sludge Transfer Pumping Station, Sludge Storage Tank	3.90
Dissolved Air Flotation Units	Tank Surface FST	0.42
Aerobic Sludge Digestion Tanks	Overflow Box Sludge Digester	33.97
Sludge Filter Press House	Dewatered Sludge Tank Surface, Sludge Dewatering building No. 2	5.58

Note:
[1] Emission rate from the deodorization units is given in ou/s, which is estimated based on the emission rates of individual facilities and their respective emission areas. Two deodorization units 1 and 2 would serve the plant. Refer to **Appendix 3-12** for SOER calculation. Emission rates adopted in the model are in **bold**.

According to the engineering design of the on-site STW, it will be equipped with two deodorization units, each serves different facilities within the STW. Emission rates from the deodorization units were derived from the sum of unmitigated emission sources rates listed above for the facilities with a 95% odour removal efficiency applied. 95% of odour removal efficiency was assumed by making reference to "Code of Practice on Assessment and Control of Odour Nuisance from Waste Water Treatment Works, April 2005", which was also adopted in the approved EIA for Harbour Area Treatment Scheme (HATS)[3-9]. The mitigated emission rates for deodorization units 1 and 2 are determined as 442.02 ou/s and 1989.02 ou/s respectively.

Binhe Wastewater Treatment Plant (WWTP)

An on-site inspection, together with PlanD and CEDD, to Binhe WWTP was conducted on 21 June 2010. Binhe WWTP was built in 1983 and is operated by Shenzhen Water (Group) Co. Ltd. (深圳市水務集團有限公司). To further improve the effluent discharge quality and environmental conditions, Shenzhen Water (Group) Co. Ltd has been upgrading Binhe WWTP since October 2007. The ultimate goal of the upgrading works is to increase the wastewater treatment capacity to 300,000m^3/day and meet the GB 18918-2002 Class IA Standard (城鎮污水處理廠污染物排放標準), i.e. odour concentration of 10 OU at the boundary of the WWTP.

The upgrading works consists of two portions. The first portion is the decommissioning of the existing Phases I and II wastewater treatment facilities and construction of a similar facility with a handling capacity of 180,000m^3/day. Biological deodorization systems have been installed to various wastewater treatment facilities including inlet pumping stations, fine grit removal, aerated sedimentation tanks, primary and secondary sedimentation tanks and biological reaction tanks.

The second portion is the upgrading works of the existing Phase III wastewater treatment facilities so as to increase the handling capacity to 120,000m^3/day. Chemical deodorization systems will be installed to wastewater treatment facilities including, inlet grit removal, upgrading pumps, aeration tanks etc.

Apart from the newly installed odour removal units, most wastewater facilities, including the primary and secondary sedimentation tanks, biological treatment tanks, and activated sludge tanks, have been enclosed, and some facilities have landscaping feature or open garden above, to mitigate odour nuisance. There are 16 deodorization units installed for a combination of several processes including inlet pumping station, influent channel, primary sedimentation tank, bioreactor and sludge pumping station, and an additional one for dewatering tank and sludge digester. These emissions are simulated as 17 point sources. Other facilities are either uncovered or covered with hollow plastic covers. They are simulated as area sources. Details of the Binhe WWTP and photos of some of these facilities taken from the on-site inspection can be found in **Appendix 3-10**.

Since there is no available odour data for Binhe WWTP, the odour emission rates of the Shatin STW measured in 2006[3-5] were adopted for modelling the odour emission from Binhe WWTP. The Shatin STW adopts secondary treatment using activated sludge process which is similar to the Binhe WWTP. Odour emission rates were made reference to the measured data of existing STWs, including facilities of inlet works, primary sedimentation tanks, aeration tanks, sludge holding tanks, sludge storage tanks, sludge digestion tanks, sludge dewatering house and final sedimentation, as appropriate. A comparison of Binhe WWTP and Sha Tin STW is presented in **Table 3.12** below. Measured emission rates for different facilities of the Shatin STW are given in **Appendix 3-11.**

Table 3.12: Comparison of Binhe WWTP and Shatin STW

	Binhe WWTP	Sha Tin STW
Daily capacity (m3/day)	300,000	340,000
Sewage characteristic	Domestic	Domestic
Treatment method	Secondary	Secondary

In view of the similar treatment process as well as the flow capacity between Shatin STW and Binhe WWTP, measured emission rates from Shatin STW were adopted for representation of Binhe WWTP in the odour impact assessment.

For those covered sewage treatment facilities in Binhe WWTP, 95% of odour removal efficiency was assumed by making reference to "Code of Practice on Assessment and Control of Odour Nuisance from Waste Water Treatment Works, April 2005", which was also adopted in the approved EIA for Harbour Area Treatment Scheme (HATS)[3-9]. For those uncovered sewage treatment facilities in Phase III of Binhe WWTP, unmitigated odour emission rates from Shatin STW were directly adopted. A summary of the adopted emission rates for Binhe WWTP is presented in **Table 3.13**.

Table 3.13 Summary of base emission rates for Binhe WWTP

Facilities[1]	Base Emission Rate ($ou/m^2/s$) Shatin STW	Mitigated SOER ($ou/m^2/s$ or ou/s)[2] Adopted for Binhe WWTP
Area Sources		
Aeration Tank [Aerobic Zone Aeration Tank]	0.6	**0.6**
Final Sedimentation Tank (Western) [Tank Surface FST]	0.39	**0.39**
Aerobic Zone Aeration Tank [Aerobic Zone Aeration Tank]	0.6	**0.6**
Final Sedimentation Tank (Eastern)	0.39	**0.39**

Facilities[1]	Base Emission Rate ($ou/m^2/s$) Shatin STW	Mitigated SOER ($ou/m^2/s$ or ou/s)[2] Adopted for Binhe WWTP
[Tank Surface FST]		
Point Sources		
Deodorization Unit 1-16[3]		**148.2**
Inlet Pumping Station [Influent Channel PST]	7.80	0.39
Influent Channel [Influent Channel PST]	7.80	0.39
Primary Sedimentation Tank [Sedimentation Tank Surface PST]	5.68	0.284
Bioreactor and Sludge Pumping Station [Anoxic Zone Aeration Tank]	0.59	0.0295
Deodorization Unit 17[4]		**84.54**
Dewatering Tank and Sludge Digester [Tank Surface Sludge Holding Tank]	15.15	0.7575

Note:
[1] Description in "[ ]" indicates the facilities where emission rates were adopted from STSTW.
[2] Emission rates from the deodorization units is given in ou/s, which is estimated based on the emission rates of individual facilities listed underneath and their respective emission areas. Emission rates adopted in the model are in **bold**.
[3] Deodorization unit 1-16 represent the 16 Deodorization units that serve the covered processes of inlet pumping station & influent channel, primary sedimentation tank, bioreactor and sludge pumping station at Binhe WWTP. Refer to **Appendix 3-12** for SOER calculation.
[4] Deodorization unit 17 covers the dewatering tank and sludge digester at Binhe WWTP. Refer to **Appendix 3-12** for SOER calculation.

3.6 Identification and Evaluation of Environmental Impacts

3.6.1 Construction Phase

Besides the development of LMC Loop, the following Designated Projects (DPs) have been included in the dust impact assessment for construction phase:

- Ecological Area (DP1)
- Western Connection Road (DP2)
- Direct Linkage to LMC Station (DP3)
- Drainage System (under Internal Transport Networks) (DP4)
- Sewage Treatment Works (DP5)
- Eastern Connection Road (DP6)
- Flushing Water Service Reservoir (DP7)

3.6.1.1 Project Emission

Dust impact assessments have been carried out based on conservative assumptions of general construction activities which include the following:

Phase 1 Infrastructures

- Site formation and clearance and ground excavation in all zones within LMC Loop area (**Figures 2.25a** to **d**)
- Construction of the associated facilities for Internal Transport Network, Drainage Discharge Points, Fire Station cum Ambulance Depot, District Cooling System (Western) and Sewage Treatment Works
- Construction access along LMC Road, Direct Linkage to Lok Ma Chau Station and Western Connection Road (including Lok Ma Chau / San Tin Highway Connection); and
- Wind erosion of all open sites.

Phase 2 Infrastructures

- Construction of Eastern Connection Road, District Cooling System (Eastern), Flush Water Service Reservoir and the corresponding connection roads; and
- Wind erosion of all open sites.

Potential dust impact from other construction activities such as the utilities works, building and landscape works within the LMC Loop is considered to be minor. Locations of the dust emission sources mentioned above for Phase 1 Infrastructure and Phase 2 Infrastructure are shown in **Appendix 3-3**.

3.6.1.2 Concurrent Construction Activities

According to the best available information at the time of this study, the only concurrent projects activities for cumulative air quality assessment are the site formation from the construction work on the NENT NDA during Year 2024. Hence, the concurrent construction activities are included in the construction impact assessment.

3.6.2 Operational Phase

Operational air quality impact assessments have been carried out based on conservative assumptions of the following projects and the development of LMC Loop and their cumulative impacts:

- Western Connection Road (DP2)
- Direct Linkage to LMC Station (DP3)
- Drainage System under Internal Transport Networks (DP4)
- Sewage Treatment Works (DP5)
- Eastern Connection Road (DP6)

3.6.2.1 Vehicular Emission

During operational phase of the Project, major sources of vehicular emission in different phases of development include:

Phase 1 Buildings

- Vehicular emission from road networks within 500m of LMC Loop Area, including Internal Transport Network and road connections to the Drainage Discharge Points, Fire Station cum Ambulance Depot, District Cooling System (Western) and Sewage Treatment Works;
- Vehicular emission from road network within 500m of Direct Link to Lok Ma Chau Station; and
- Vehicular emission from road network within 500m of Western Connection Road (including Lok Ma Chau/San Tin Highway Connection);

Phase 2 Buildings

- Vehicular emission from road networks within 500m of LMC Loop Area, including the road connections to the District Cooling System (Eastern) and Flush Water Service Reservoir; and
- Vehicular emission from road network within 500m of Eastern Connection Road.

Vehicular emissions from open roads are determined by the EMFAC-HK model. As mentioned in Section 3.5.2.3, EMFAC-HK v2.1 was employed at the time of assessment (end 2012). Traffic data prepared by traffic engineer have been endorsed by the Transport Department. **Appendix 3-4** presents the methodology and assumptions adopted in estimating the emission factors. The results have concluded that Year 2020 is the worst assessment year for Phase 1 Infrastructure Development while Year 2027 is the worst assessment year when all roads are completed. **Table 3.14** below summarizes the total daily emissions in the Study Area for each assessment year.

Table 3.14 Summary of total daily air pollutant emissions for LMCL

Year of Assessment	Total Daily NOx Emission (kg/day)	Total Daily RSP Emission (kg/day)	Remark
2020	252	12	Commencement of Phase 1 Buildings
2027	146	8	Commencement of Phase 2 Buildings
2035	96	7	15 years after commencement of Phase 1 Buildings
2042	92	6	15 years after commencement of Phase 2 Buildings

3.6.2.2 Chimney Emission

Based on the verification findings from subsequent reconnaissance survey on 2 March, 2012, no industrial chimney was identified within the 500m from the boundary of the Project on Hong Kong side. According to the Draft Comprehensive Planning of Shenzhen City (2007-2020), the existing land use of Shenzhen within 500m from the Project boundary comprises mainly residential, commercial, government and community uses. The nearest potential industrial land use is located in Futian Bonded Zone in Futian District at more than 500m away from the Project boundary. In addition, Futian Bonded Zone is a free trade zone with hi-technology and modern logistics industries. According to the information from the Administration of Shenzhen Free Trade Zone, a plan to develop Futian Bonded Zone into the National Ecological Industrial Park was proposed to the Guangdong Environmental Protection Bureau in 2007 (http://www.szftz.gov.cn). Potential industrial emission impact is therefore not expected.

3.6.2.3 Odour Emission

During operational phase of the Project, major odour emission sources include:

- Odour emission from the proposed STW within the LMC Loop Area;
- Odour emission from the existing Binhe WWTP in Shenzhen to the east of the LMC Loop; and
- Odour emission from the Shenzhen River.

3.6.2.4 Concurrent Operational Activities

Other concurrent projects, which may have cumulative air quality impacts during operation, have been identified. They include:

- Increased traffic flow induced from the opening of FCA; and
- Increased traffic flow induced from the proposed new road networks from the KTN NDA.

3.7 Prediction and Evaluation of Environmental Impacts

3.7.1 Construction Phase

3.7.1.1 Assessment Results – Unmitigated Scenario for Phase 1 Infrastructures

Under the unmitigated Phase 1 Infrastructures, the maximum predicted 1-hour, 24-hour and annual average TSP levels due to the construction of the Project are summarised in **Table 3.15**. Results show exceedances of the relevant AQOs at the majority of the ASRs locations. Mitigation measures are therefore necessary to reduce the predicted dust impacts. **Figures 3.7** to **3.9** show the contours of cumulative unmitigated 1-hour, 24-hour, and annual TSP concentrations in the LMC Loop development area.

Table 3.15 Predicted unmitigated cumulative 1-hour, 24-hour, and Annual TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m³)

Location of ASRs	Assessment Points	TSP Concentrations (μg/m³)		
		1-hour	24-hour	Annual
AQO Standard		**500**	**260**	**80**
Existing ASRs				
Border Road	BR-3	**6555.8**	**1338.3**	77.3
	BR-4	**7917.0**	**1047.3**	76.4
	BR-5	**4742.8**	**370.6**	73.9
Chau Tau Tsuen	CTT-3	**3060.8**	**600.9**	74.5
Ha Wan Fisherman San Tsuen	HWFST-2	**4578.4**	**848.9**	76.5
Ha Wan Tsuen	HWT-1	**13982.1**	**1325.2**	**84.8**
	HWT-2	**9718.7**	**791.8**	76.5
	HWT-4	**9294.9**	**989.7**	76.7
Ha Wan Tsuen Road	HWTR-1	**13364.7**	**1490.9**	**82.6**
	HWTR-6	**5696.0**	**1187.9**	**86.9**
	HWTR-10	**7351.3**	**1593.8**	**84.0**
	HWTR-11	**4926.8**	**1039.3**	**85.4**
	HWTR-20	**9014.0**	**1408.6**	78.0
Lok Ma Chau Operation Base	LMCOB-1	**4821.8**	**396.0**	73.7
Lok Ma Chau Police Station	LMCPS-1	**4994.5**	**980.7**	75.8
Lok Ma Chau Road	LMCR-2	**5371.9**	**1171.2**	**83.7**
	LMCR-5	**6309.7**	**1052.4**	**82.3**
	LMCR-8	**4505.5**	**858.4**	76.2
	LMCR-12	**4772.9**	**969.3**	76.6
	LMCR-14	**3805.6**	**763.4**	75.7
	LMCR-15	**3452.9**	**623.4**	75.2
Lok Ma Chau San Tsuen	LMCST-3	**5651.0**	**1032.0**	77.0
Lok Ma Chau Tsuen	LMCT-1	**6109.9**	**1348.9**	77.1
Ma Tso Lung	MTL-1	**3227.5**	**270.6**	73.3
	MTL-7	**2989.3**	231.8	73.3
	MTL-8	**2807.6**	216.9	73.3
	MTL-9	**2723.2**	200.2	73.3
	MTL-12	**2713.7**	195.3	73.3
	MTL-20	**2983.9**	257.1	73.3
Lo Wu Police Range	PR-1	**2390.2**	180.0	73.2
Pun Uk Tsuen	PUT-2	**3679.7**	**670.9**	74.9
San Sham Road	SSR-1	**8707.5**	**638.1**	77.0
Near Wing Ping Tsuen	WPT-1	**3062.8**	**470.8**	74.5
Planned ASRs				
Comprehensive	CDWEA-P1	**6666.4**	**468.1**	74.9

Location of ASRs	Assessment Points	TSP Concentrations (µg/m^3)		
		1-hour	24-hour	Annual
AQO Standard		**500**	**260**	**80**
Development and Wetland Enhancement Area				
Ex-Lung Kai Public School	ELKPS-P1	**2612.1**	200.3	73.3
Eco-Lodge	EL-P1	**4494.2**	**358.6**	73.6
	EL-P5	**4046.7**	**348.4**	73.5
KTN NDA	KTN-P2	**2676.7**	193.8	73.3
	KTN-P3	**2850.4**	220.5	73.3
LMC Loop	LMCL-P1	N/A[2]	N/A[2]	N/A[2]
	LMCL-P2	N/A[2]	N/A[2]	N/A[2]
	LMCL-P4	N/A[2]	N/A[2]	N/A[2]
	LMCL-P6	N/A[2]	N/A[2]	N/A[2]
	LMCL-P7	N/A[2]	N/A[2]	N/A[2]
	LMCL-P8	N/A[2]	N/A[2]	N/A[2]
	LMCL-P9	N/A[2]	N/A[2]	N/A[2]
	LMCL-P11	N/A[2]	N/A[2]	N/A[2]
Proposed Fire Station and Ambulance Depot	FS-P1	N/A[2]	N/A[2]	N/A[2]
Lok Ma Chau Tsuen Expansion	LMCTE-P1	**6730.5**	**1396.3**	77.3
	LMCTE-P4	**7435.5**	**1559.4**	78.1
	LMCTE-P6	**5580.0**	**1179.1**	76.5

Notes:

[1] Values which exceeded AQO are shown as bolded characters.

[2] The premises are located within the works site boundary hence the population intake would be after the construction of the Phase 1 Infrastructures of the Project, i.e. no impact from the Project under Phase 1 Infrastructure.

[3] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

3.7.1.2 Assessment Results – Unmitigated Scenario for Phase 2 Infrastructures

Under the unmitigated Phase 2 Infrastructures, the maximum predicted 1-hour, 24-hour and annual average TSP levels due to the construction of the Project are summarised in **Table 3.16**. Results show exceedances of the relevant AQOs at the majority of the ASR locations. Mitigation measures are therefore necessary to reduce the predicted dust impacts. **Figures 3.10** to **3.12** show the contours of cumulative unmitigated 1-hour, 24-hour, and annual TSP concentrations in the LMC Loop development area.

Table 3.16 Predicted unmitigated cumulative 1-hour, 24-hour, and Annual TSP concentrations at 1.5m above ground (including background concentration of 73.1µg/m^3)

Location of ASRs	Assessment Points	TSP Concentrations (µg/m^3)		
		1-hour	24-hour	Annual
AQO Standard		**500**	**260**	**80**
Existing ASRs				
Border Road	BR-3	**1614.7**	156.5	73.7
	BR-4	**3565.2**	**328.8**	75.3
	BR-5	**9254.8**	**1499.5**	**82.6**
Chau Tau Tsuen	CTT-3	**542.1**	124.7	73.2
Ha Wan Fisherman San Tsuen	HWFST-2	**620.0**	102.4	73.2
Ha Wan Tsuen	HWT-1	**809.8**	138.1	73.3
	HWT-2	**688.7**	104.2	73.3
	HWT-4	**738.5**	105.2	73.2
Ha Wan Tsuen Road	HWTR-1	**716.9**	130.0	73.3
	HWTR-6	**668.0**	101.1	73.2
	HWTR-10	**544.8**	98.6	73.2
	HWTR-11	**551.7**	97.8	73.2
	HWTR-20	**652.4**	105.8	73.3
Lok Ma Chau Operation Base	LMCOB-1	**2532.4**	**469.8**	77.2
Lok Ma Chau Police Station	LMCPS-1	**748.5**	111.1	73.3
Lok Ma Chau Road	LMCR-2	**570.1**	99.7	73.2
	LMCR-5	**596.6**	100.8	73.2
	LMCR-8	**620.8**	102.3	73.2
	LMCR-12	**590.3**	101.1	73.2
	LMCR-14	**540.6**	101.3	73.2
	LMCR-15	**533.9**	113.8	73.2
Lok Ma Chau San Tsuen	LMCST-3	**691.0**	102.1	73.2
Lok Ma Chau Tsuen	LMCT-1	**850.3**	110.1	73.3
Ma Tso Lung	MTL-1	**4500.1**	**461.9**	77.1
	MTL-7	**7666.2**	**1670.9**	**81.0**
	MTL-8	**8153.6**	**1875.6**	**87.3**
	MTL-9	**5862.6**	**1124.3**	**80.7**
	MTL-12	**5877.0**	**974.7**	79.1
	MTL-20	**6464.9**	**644.5**	78.9
Lo Wu Police Range	PR-1	**7845.8**	**1106.9**	77.9
Pun Uk Tsuen	PUT-2	**574.0**	117.3	73.2
San Sham Road	SSR-1	**695.5**	128.1	73.3
Near Wing Ping Tsuen	WPT-1	386.9	101.0	73.2
Planned ASRs				
Comprehensive	CDWEA-P1	491.5	110.1	73.2

Location of ASRs	Assessment Points	TSP Concentrations (µg/m³)		
		1-hour	24-hour	Annual
AQO Standard		**500**	**260**	**80**
Development and Wetland Enhancement Area				
Ex-Lung Kai Public School	ELKPS-P1	**7021.9**	**1290.5**	**80.3**
Eco-Lodge	EL-P1	**4645.3**	**651.8**	77.5
	EL-P5	**2740.2**	**617.0**	77.4
KTN NDA	KTN-P2	**7271.4**	**1310.6**	**81.7**
	KTN-P3	**8256.2**	**2211.1**	**86.3**
LMC Loop	LMCL-P1	**853.8**	119.0	73.6
	LMCL-P2	**1284.3**	133.9	73.8
	LMCL-P4	**1596.6**	163.7	74.0
	LMCL-P6	**1147.8**	169.4	74.0
	LMCL-P7	**1243.8**	176.8	73.5
	LMCL-P8	**1007.8**	155.7	73.4
	LMCL-P9	**1257.6**	177.9	73.5
	LMCL-P11	**1443.6**	195.4	73.9
Proposed Fire Station and Ambulance Depot	FS-P1	**3834.5**	**492.1**	78.1
Lok Ma Chau Tsuen Expansion	LMCTE-P1	**766.2**	112.5	73.3
	LMCTE-P4	**1089.6**	129.1	73.4
	LMCTE-P6	**822.5**	108.3	73.3

Note:

[1] Values which exceeded AQO are shown as bolded characters.

[2] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

3.7.1.3 Cumulative Dust Impacts

Without any mitigation measures in place, cumulative dust impact would be anticipated. Hence, mitigation measures are recommended.

3.7.2 Operational Phase – Vehicular Emission

The air quality impact from maximum 1-hour, maximum 24-hour & annual concentration of NO_2 and maximum 24-hour & annual concentration of RSP at the identified existing/planned ASRs for the worst assessment year (i.e. Year 2020) are summarised in **Tables 3.17** to **3.18.**

Table 3.17 Summary of 1-hour, 24-hour and Annual cumulative concentration of NO_2 at the identified ASRs in Year 2020 (including background concentration of 48.5 μg/m³)

Location of ASRs	Assessment Points	NO_2 Concentrations (μg/m³)		
		1-hour	24-hour	Annual
AQO Standard		**300**	**150**	**80**
Existing ASRs				
Border Road	BR-3	76	53	49
	BR-4	70	52	49
	BR-5	68	51	49
Chau Tau Tsuen	CTT-3	101	55	51
Ha Wan Fisherman San Tsuen	HWFST-2	124	58	51
Ha Wan Tsuen	HWT-1	122	59	52
	HWT-2	154	64	52
	HWT-4	155	63	52
Ha Wan Tsuen Road	HWTR-1	120	60	51
	HWTR-6	123	64	57
	HWTR-10	122	60	55
	HWTR-11	126	63	57
	HWTR-20	114	63	51
Lok Ma Chau Operation Base	LMCOB-1	67	51	49
Lok Ma Chau Police Station	LMCPS-1	104	55	50
Lok Ma Chau Road	LMCR-2	148	61	55
	LMCR-5	151	61	54
	LMCR-8	145	59	51
	LMCR-12	158	66	52
	LMCR-14	142	60	51
	LMCR-15	141	58	51
Lok Ma Chau San Tsuen	LMCST-3	134	63	52
Lok Ma Chau Tsuen	LMCT-1	99	58	50
Ma Tso Lung	MTL-1	62	50	49
	MTL-7	61	51	49
	MTL-8	62	50	49
	MTL-9	65	51	49
	MTL-12	66	51	49
	MTL-20	63	50	49
Lo Wu Police Range	PR-1	62	50	49
Pun Uk Tsuen	PUT-2	137	56	51
San Sham Road	SSR-1	137	61	51
Near Wing Ping Tsuen	WPT-1	115	61	54
Planned ASRs				
Comprehensive	CDWEA-P1	183	68	52

Location of ASRs	Assessment Points	NO_2 Concentrations (µg/m^3)		
		1-hour	24-hour	Annual
AQO Standard		**300**	**150**	**80**
Development and Wetland Enhancement Area				
Ex-Lung Kai Public School	ELKPS-P1	65	50	49
Eco-Lodge	EL-P1	66	51	49
	EL-P5	64	50	49
KTN NDA	KTN-P2	65	51	49
	KTN-P3	62	50	49
LMC Loop	LMCL-P1	83	56	50
	LMCL-P2	80	56	50
	LMCL-P4	78	53	49
	LMCL-P6	76	53	49
	LMCL-P7	87	55	50
	LMCL-P8	92	57	50
	LMCL-P9	89	55	50
	LMCL-P11	74	53	49
	LMCL-P12	77	56	50
	LMCL-P15	78	55	50
	LMCL-P16	76	52	50
	LMCL-P17	74	52	50
	LMCL-P18	72	52	49
	LMCL-P19	71	52	49
	LMCL-P21	73	52	49
	LMCL-P23	75	52	49
	LMCL-P24	76	53	49
	LMCL-P25	80	53	49
	LMCL-P26	72	52	49
	LMCL-P27	71	52	49
	LMCL-P28	71	52	49
Proposed Fire Station and Ambulance Depot	FS-P1	81	56	51
Lok Ma Chau Tsuen Expansion	LMCTE-P1	102	59	50
	LMCTE-P4	85	54	50
	LMCTE-P6	103	56	50

Table 3.18 Summary of 24-hour and Annual cumulative concentration of RSP at identified ASRs in Year 2020 (including background concentration of 50.5 μg/m³)

Location of ASRs	Assessment Points	RSP Concentrations (μg/m³)	
		24-hour	Annual
AQO Standard		**180**	**55**
Existing ASRs			
Border Road	BR-3	51	51
	BR-4	51	51
	BR-5	51	51
Chau Tau Tsuen	CTT-3	52	51
Ha Wan Fisherman San Tsuen	HWFST-2	52	51
Ha Wan Tsuen	HWT-1	52	51
	HWT-2	53	51
	HWT-4	52	51
Ha Wan Tsuen Road	HWTR-1	52	51
	HWTR-6	53	52
	HWTR-10	52	51
	HWTR-11	52	52
	HWTR-20	53	51
Lok Ma Chau Operation Base	LMCOB-1	51	51
Lok Ma Chau Police Station	LMCPS-1	51	51
Lok Ma Chau Road	LMCR-2	52	51
	LMCR-5	52	51
	LMCR-8	52	51
	LMCR-12	53	51
	LMCR-14	52	51
	LMCR-15	52	51
Lok Ma Chau San Tsuen	LMCST-3	52	51
Lok Ma Chau Tsuen	LMCT-1	52	51
Ma Tso Lung	MTL-1	51	51
	MTL-7	51	51
	MTL-8	51	51
	MTL-9	51	51
	MTL-12	51	51
	MTL-20	51	51
Lo Wu Police Range	PR-1	51	51
Pun Uk Tsuen	PUT-2	52	51
San Sham Road	SSR-1	52	51
Near Wing Ping Tsuen	WPT-1	54	52
Planned ASRs			
Comprehensive Development and	CDWEA-P1	53	51

Location of ASRs	Assessment Points	RSP Concentrations ($\mu g/m^3$)	
		24-hour	Annual
AQO Standard		**180**	**55**
Wetland Enhancement Area			
Ex-Lung Kai Public School	ELKPS-P1	51	51
Eco-Lodge	EL-P1	51	51
	EL-P5	51	51
KTN NDA	KTN-P2	51	51
	KTN-P3	51	51
LMC Loop	LMCL-P1	51	51
	LMCL-P2	51	51
	LMCL-P4	51	51
	LMCL-P6	51	51
	LMCL-P7	51	51
	LMCL-P8	52	51
	LMCL-P9	51	51
	LMCL-P11	51	51
	LMCL-P12	51	51
	LMCL-P15	51	51
	LMCL-P16	51	51
	LMCL-P17	51	51
	LMCL-P18	51	51
	LMCL-P19	51	51
	LMCL-P21	51	51
	LMCL-P23	51	51
	LMCL-P24	51	51
	LMCL-P25	51	51
	LMCL-P26	51	51
	LMCL-P27	51	51
	LMCL-P28	51	51
Proposed Fire Station and Ambulance Depot	FS-P1	51	51
Lok Ma Chau Tsuen Expansion	LMCTE-P1	52	51
	LMCTE-P4	51	51
	LMCTE-P6	52	51

Since Eastern Connection Road would commence operation in Year 2027, the assessment results in **Table 3.16** and **Table 3.17** have not included the emission from Eastern Connection Road. Based on assessment year determination findings, Year 2027 generates the second highest vehicular emission within the study area. Hence, air quality impact at Year 2027 was also assessed to predict the air quality impact due to Phase 2 infrastructure. The assessment results are summarised in **Tables 3.19** to **3.20**.

Table 3.19 Summary of 1-hour, 24-hour and Annual cumulative concentration of NO_2 at identified ASRs in Year 2027 (including background concentration of 48.5 μg/m^3)

Location of ASRs	Assessment Points	NO_2 Concentrations (μg/m^3)		
		1-hour	24-hour	Annual
AQO Standard		**300**	**150**	**80**
Existing ASRs				
Border Road	BR-3	73	52	49
	BR-4	67	51	49
	BR-5	65	50	49
Chau Tau Tsuen	CTT-3	93	52	50
Ha Wan Fisherman San Tsuen	HWFST-2	112	55	50
Ha Wan Tsuen	HWT-1	113	57	51
	HWT-2	136	61	51
	HWT-4	140	60	51
Ha Wan Tsuen Road	HWTR-1	111	57	50
	HWTR-6	113	61	53
	HWTR-10	114	56	52
	HWTR-11	117	58	53
	HWTR-20	106	61	51
Lok Ma Chau Operation Base	LMCOB-1	65	50	49
Lok Ma Chau Police Station	LMCPS-1	97	54	49
Lok Ma Chau Road	LMCR-2	136	56	52
	LMCR-5	139	58	52
	LMCR-8	130	56	50
	LMCR-12	140	61	51
	LMCR-14	128	57	50
	LMCR-15	128	55	50
Lok Ma Chau San Tsuen	LMCST-3	120	60	51
Lok Ma Chau Tsuen	LMCT-1	93	57	49
Ma Tso Lung	MTL-1	57	50	49
	MTL-7	59	50	49
	MTL-8	56	50	49
	MTL-9	58	50	49
	MTL-12	61	50	49
	MTL-20	61	50	49
Lo Wu Police Range	PR-1	60	50	49
Pun Uk Tsuen	PUT-2	125	54	50
San Sham Road	SSR-1	125	59	51
Near Wing Ping Tsuen	WPT-1	106	57	51
Planned ASRs				
Comprehensive	CDWEA-P1	162	64	51

Location of ASRs	Assessment Points	NO_2 Concentrations (µg/m^3)		
		1-hour	24-hour	Annual
AQO Standard		**300**	**150**	**80**
Development and Wetland Enhancement Area				
Ex-Lung Kai Public School	ELKPS-P1	58	50	49
Eco-Lodge	EL-P1	63	51	49
	EL-P5	62	50	49
KTN NDA	KTN-P2	60	50	49
	KTN-P3	58	50	49
LMC Loop	LMCL-P1	78	55	50
	LMCL-P2	75	55	50
	LMCL-P4	74	52	49
	LMCL-P6	72	52	49
	LMCL-P7	82	54	49
	LMCL-P8	86	55	50
	LMCL-P9	84	54	49
	LMCL-P11	70	52	49
	LMCL-P12	74	55	50
	LMCL-P15	75	54	50
	LMCL-P16	72	52	50
	LMCL-P17	70	52	49
	LMCL-P18	69	51	49
	LMCL-P19	68	51	49
	LMCL-P21	69	51	49
	LMCL-P23	72	52	49
	LMCL-P24	73	52	49
	LMCL-P25	76	52	49
	LMCL-P26	69	51	49
	LMCL-P27	68	51	49
	LMCL-P28	68	51	49
Proposed Fire Station and Ambulance Depot	FS-P1	80	56	51
Lok Ma Chau Tsuen Expansion	LMCTE-P1	95	57	50
	LMCTE-P4	80	53	49
	LMCTE-P6	96	55	50

Table 3.20 Summary of 24-hour and Annual cumulative concentration of RSP at identified ASRs in Year 2027 (including background concentration of 50.5 μg/m³)

Location of ASRs	Assessment Points	RSP Concentrations (μg/m³)	
		24-hour	Annual
AQO Standard		**180**	**55**
Existing ASRs			
Border Road	BR-3	51	51
	BR-4	51	51
	BR-5	51	51
Chau Tau Tsuen	CTT-3	52	51
Ha Wan Fisherman San Tsuen	HWFST-2	51	51
Ha Wan Tsuen	HWT-1	52	51
	HWT-2	52	51
	HWT-4	52	51
Ha Wan Tsuen Road	HWTR-1	52	51
	HWTR-6	52	51
	HWTR-10	52	51
	HWTR-11	52	51
	HWTR-20	52	51
Lok Ma Chau Operation Base	LMCOB-1	51	51
Lok Ma Chau Police Station	LMCPS-1	51	51
Lok Ma Chau Road	LMCR-2	52	51
	LMCR-5	52	51
	LMCR-8	51	51
	LMCR-12	52	51
	LMCR-14	52	51
	LMCR-15	52	51
Lok Ma Chau San Tsuen	LMCST-3	52	51
Lok Ma Chau Tsuen	LMCT-1	51	51
Ma Tso Lung	MTL-1	51	51
	MTL-7	51	51
	MTL-8	51	51
	MTL-9	51	51
	MTL-12	51	51
	MTL-20	51	51
Lo Wu Police Range	PR-1	51	51
Pun Uk Tsuen	PUT-2	51	51
San Sham Road	SSR-1	52	51
Near Wing Ping Tsuen	WPT-1	53	52
Planned ASRs			
Comprehensive	CDWEA-P1	53	51

Location of ASRs	Assessment Points	RSP Concentrations ($\mu g/m^3$)	
		24-hour	Annual
AQO Standard		**180**	**55**
Development and Wetland Enhancement Area			
Ex-Lung Kai Public School	ELKPS-P1	51	51
Eco-Lodge	EL-P1	51	51
	EL-P5	51	51
KTN NDA	KTN-P2	51	51
	KTN-P3	51	51
LMC Loop	LMCL-P1	51	51
	LMCL-P2	51	51
	LMCL-P4	51	51
	LMCL-P6	51	51
	LMCL-P7	51	51
	LMCL-P8	51	51
	LMCL-P9	51	51
	LMCL-P11	51	51
	LMCL-P12	51	51
	LMCL-P15	51	51
	LMCL-P16	51	51
	LMCL-P17	51	51
	LMCL-P18	51	51
	LMCL-P19	51	51
	LMCL-P21	51	51
	LMCL-P23	51	51
	LMCL-P24	51	51
	LMCL-P25	51	51
	LMCL-P26	51	51
	LMCL-P27	51	51
	LMCL-P28	51	51
Proposed Fire Station and Ambulance Depot	FS-P1	51	51
Lok Ma Chau Tsuen Expansion	LMCTE-P1	52	51
	LMCTE-P4	51	51
	LMCTE-P6	51	51

The cumulative 1-hour, 24-hour and annual NO_2 concentrations and 24-hour and annual RSP concentrations caused by vehicular emission have been assessed at the height of 1.5m above ground (which is the average height of the human breathing zone) for the Study Area. **Figures 3.13** to **3.15** and **Figures 3.16** to **3.18** show the 1-hour, 24-hour and annual NO_2 concentrations at 1.5m above ground in Year 2020 and Year 2027 respectively. **Figures 3.19** to **3.20** and **Figures 3.21** to **3.22** show the 24-hour and annual RSP concentrations at 1.5m above ground in Year 2020 and Year 2027 respectively.

The assessment results for NO_2 concentration are summarised in **Table 3.17** and **Table 3.19.** In Year 2020, the 1-hour cumulative concentration ranges from 61 µg/m^3 to 183 µg/m^3, 24-hour cumulative ranges from 50 µg/m^3 to 68 µg/m^3 and annual average ranges from 49 µg/m^3 to 57 µg/m^3; In Year 2027, the 1-hour cumulative concentration ranges from 56 µg/m^3 to 162 µg/m^3, 24-hour cumulative ranges from 50 µg/m^3 to 64 µg/m^3 and annual average ranges from 49 µg/m^3 to 53 µg/m^3 which were below the stipulated criteria of 300, 150 and 80 µg/m^3 respectively for Year 2020 and Year 2027. The assessment results for RSP concentration are summarized in **Table 3.18** and **Table 3.20.** In Year 2020, the 24-hour cumulative ranges from 51 µg/m^3 to 54 µg/m^3, annual average ranges from 51 µg/m^3 to 52 µg/m^3; In Year 2027, the 24-hour cumulative ranges from 51 µg/m^3 to 53 µg/m^3, annual average ranges from 51 µg/m^3 to 52 µg/m^3 which were below the stipulated criteria of 180 and 55 µg/m^3 for Year 2020 and Year 2027.

The air quality implications of the proposed noise barriers have also been considered. Since the ASRs within the assessment area are low-rise structures, the inclusion of noise barriers into the assessment will not materially affect the worst scenario air quality impact at the ASRs. Therefore, the effect of noise barriers are excluded in the assessment. The predicted air quality impacts due to vehicular emission are well within acceptable levels when comparing to the AQO.

For the in-tunnel emission at the underpass connecting LMC Loop and Eastern Connection Road, the concentration of NO_2 is 328.38 µg/m^3, which is much lower than the 1,800 µg/m^3 stated in the "*Practice Note on Control of Air Pollution in Vehicle Tunnels*".

3.7.3 Operational Phase - Chimney Emission

No industrial chimney was identified within 500m from the boundary of the Project on Hong Kong side and the nearest potential industrial land use on Shenzhen side is located at more than 500m away from the Project. Chimney emission impact is not anticipated.

3.7.4 Operational Phase - Odour Emission

Cumulative odour impact assessment has been conducted for the on-site STW, Binhe WWTP and Shenzhen River. Odour emission rates for on-site STW and Binhe WWTP have followed their respective assumptions shown in **Tables 3.11** and **3.13**. The scenario assessments have evaluated the unmitigated, short to medium term and long term situation of cumulative odour contribution from Shenzhen River.

Under the unmitigated Shenzhen River scenario, modelling results for cumulative odour impact are in the range of 47.2 OU to 153.5 OU at the LMC Loop development area, which have exceeded the 5 OU criterion. (**Figure 3.23a**)

In the short to medium term, the project proponent has undertaken to implement bio-remediation along the section of Shenzhen River approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total) **(Figure 3.23b)** before populations intake of the development. Cumulative odour impacts with bioremediation for the extent will be reduced to 10.8 OU to 14.5 OU, but still exceeds the 5 OU criterion. (**Figure 3.23b**)

In the longer term, residual impact would be reduced by the continual improvement of the Shenzhen River odour issues in view of the improvement works already undertaken or to be implemented in the major tributaries of the Shenzhen River. **Table 3.21** shows the implementation schedule provided by Shenzhen Municipal Water Affairs Bureau as well as the commitment in the 12th 5-year plan on centralised treatment of intercepted sewage for the City of Shenzhen.

Table 3.21: Status of remediation for tributaries to Shenzhen River

Tributaries	Proposed/ Completion Year	Status of Remediation
Buji River (布吉河)	2009	布吉河特區內流域污水截排二期工程 (English Translation: Phase 2 Buji River District Sewage Interception Works) reduces 80% to 85% sewage loading into Buji River.
	2013	Phase 1 of the 布吉河水環境綜合工程 (English translation: Buji River Water Environment Enhancement Works) was 95% completed in 2012.
	2014	Phase 2 of the 布吉河水環境綜合工程 (English translation: Buji River Water Environmental Enhancement Works)
Futian River (福田河)	2012	福田河綜合治理工程 (English translation: Futian River Remediation Works)
Xinzhou River (新洲河)	2010	新洲河綜合整治工程 (English translation: Xinzhou River Remediation Works) was completed in 2010 and reached Category V of the Surface Water Quality Standard
Shenzhen River (深圳河)	2015	Sewage collection and sewage treatment in central urban districts are committed to reach 95%
	2017	治理深圳河第四期工程 (English translation: Phase 4 of Shenzhen River Improvement Works)

With the implementation of above improvement works, it is anticipated that significant reduction of residual impact due to odour generation from Shenzhen River will be effected. A test scenario has been conducted to assess the long term conditions of the residual impact if the proposed improvement measures and centralised sewage treatment by Shenzhen Municipal Government were materialised. To predict the odour level at the Loop development in the long term scenario will require certain assumptions on the changes affected by these improvement works. While it is not unreasonable to assume a low odour emitting situation for Shenzhen River, a more conservative approach has been adopted for the assessment. It assumes the odour emission rates measured along the Shenzhen side of the Shenzhen River will resemble those taken at the opposite locations along the Hong Kong side.

With the bioremediation works to be implemented by the project proponent along the defined section of Shenzhen River, assessment shows that if the odour emission rates at the sewage discharge points along Shenzhen side of the Shenzhen River are assumed to be reduced by 92% as a conservative estimate of the committed 95% centralised sewage treatment target in the 12th 5-year plan[3-1] for the City of Shenzhen (**Figure 3.23c**), the residual odour impacts on the Loop development will be reduced to 3.5 to 4.7 OU, within the criterion of 5 OU in the long run.

Individual and cumulative impacts of odour concentration level at ASRs located 1.5m above ground are summarised in **Table 3.22**. Contributions from Shenzhen River remain the highest under both unmitigated and mitigated scenarios. Further contingency enhancement measure which the developer could be considered enhancing the odour reduction inside the buildings is discussed in **Section 3.8**.

Table 3.22 Predicted odour concentration on ASRs for individual and cumulative odour assessment at 1.5m above ground

Location of ASRs	Assessment Points	Scenario – Odour Unit (ou/m^3)[2]				
		Binhe WWTP Only (95% reduction)	**On-site STW Only (95% mitigation)**	**Unmitigated (cum)**	**98% SZR [500m] Scenario (cumulative)[4] (Short-medium Term)**	**98% SZR [500m] Long Term Scenario (cumulative) (Long Term)[5]**
EIAO – TM Standard		**5 OU – 5s averaging time**				
Planned ASRs						
LMC Loop	LMCL-P1	0.373	0.021	**153.505**	**14.462** (2.2%)	4.160
	LMCL-P2	0.410	0.031	**136.349**	**14.409** (2.4%)	4.319
	LMCL-P4	0.330	0.031	**89.204**	**13.139** (2.6%)	3.929
	LMCL-P6	0.359	0.038	**67.280**	**12.218** (1.6%)	4.174
	LMCL-P7	0.287	0.017	**66.234**	**12.625** (1.0%)	4.450
	LMCL-P8	0.248	0.016	**55.365**	**12.796** (1.0%)	4.714
	LMCL-P9	0.300	0.016	**63.344**	**12.389** (1.6%)	4.484
	LMCL-P11	0.384	0.032	**60.605**	**11.924** (1.6%)	4.189
	LMCL-P12	0.387	0.038	**103.815**	**13.097** (2.4%)	4.524

Location of ASRs	Assessment Points	Scenario – Odour Unit (ou/m^3)[2]				
		Binhe WWTP Only (95% reduction)	**On-site STW Only (95% mitigation)**	**Unmitigated (cum)**	**98% SZR [500m] Scenario (cumulative)[4] (Short-medium Term)**	**98% SZR [500m] Long Term Scenario (cumulative) (Long Term)[5]**
EIAO – TM Standard		**5 OU – 5s averaging time**				
	LMCL-P15	0.321	0.047	**62.974**	**12.966** (3.0%)	4.215
	LMCL-P16	0.351	0.053	**70.209**	**12.509** (2.4%)	4.211
	LMCL-P17	0.515	0.088	**72.446**	**11.325** (2.6%)	3.511
	LMCL-P18	0.403	0.109	**51.595**	**12.342** (2.4%)	3.458
	LMCL-P19	0.416	0.089	**61.739**	**12.006** (2.2%)	3.698
	LMCL-P21	0.393	0.048	**55.052**	**12.130** (1.6%)	3.916
	LMCL-P23	0.287	0.046	**72.937**	**12.535** (2.1%)	3.820
	LMCL-P24	0.442	0.050	**72.996**	**13.052** (2.5%)	3.523
	LMCL-P25	0.460	0.053	**92.935**	**13.035** (2.6%)	3.591
	LMCL-P26	0.434	0.061	**47.188**	**11.869** (1.6%)	3.948
	LMCL-P27	0.455	0.090	**58.651**	**11.860**	3.759

Location of ASRs	Assessment Points	Scenario – Odour Unit (ou/m^3)[2]				
		Binhe WWTP Only (95% reduction)	**On-site STW Only (95% mitigation)**	**Unmitigated (cum)**	**98% SZR [500m] Scenario (cumulative)[4] (Short-medium Term)**	**98% SZR [500m] Long Term Scenario (cumulative) (Long Term)[5]**
EIAO – TM Standard		**5 OU – 5s averaging time**				
					(2.1%)	
	LMCL-P28	0.448	0.060	**55.885**	**11.876** (2.1%)	3.826
Proposed Fire Station and Ambulance Depot	FS-P1	0.487	0.078	**54.652**	**10.809** (3.1%)	3.811

Note:
[1] Relevant environmental standards/ criteria: Annex 4 of TM-EIAO.
[2] The averaging time of odour concentration level is 5s.
[3] Exceedance is indicated in the table in **Bold** form.
[4] Percentage of exceedance, if any, is expressed in bracket for each ASR in % of time in a year.
[5] Long term scenario indicates the likely odour impact with the implementation of mitigation measures by the Shenzhen Government in the long run.

3.7.5 Review of Odour Removal Effectiveness of Bioremediation Works in Hong Kong

A review of past sediment odour remediation projects in Hong Kong and the on-going Shenzhen River Contaminated Sediment Remediation Strategy Joint Study was conducted to support and justify the practicability of achieving 98% odour removal efficiency for Shenzhen River and its justifications.

Case Review of Past and Ongoing Bioremediation Projects in Hong Kong

Bioremediation is a newly emerging technology for contaminated sediment treatment. The principle is that biochemical reactions are initialized through in-situ injection of suitable oxidants into sediment, which would lead to oxidation of acidic volatile sulfide (AVS) in sediment, increase in sediment microorganism activity, promotion of degradation of organic pollutants in sediment, and control and mitigate the odour generating capacity of contaminated sediment. Three successful cases at Shing Mun River, Kai Tak Approach Channel and Sam Ka Tsuen Typhoon Shelter as well as the proposed bioremediation at Shenzhen River under the on-going "Shenzhen River Contaminated Sediment Remediation Strategy Joint Study" are discussed below.

Bioremediation in Shing Mun River

Shing Mun River is one of the major tidal river in the northeastern part of Hong Kong. Similar to Shenzhen river, it is a 7 km long, 200m wide engineered river channel for drainage and is connected with a poorly flushed embayment of Tolo Harbour. During 1980s and 1990s, Shing Mun River had once been heavily polluted from the indiscriminated discharges from livestock, industrial, commercial and domestic sources. Due to excessive influxes of pollutants, Shing Mun River had received repeated complaints regarding odour nuisance. The sediment has been identified as the main sources of the river's unpleasant smell, resulting from the contamination by industrial, livestock and domestic discharges. Through the implementation of different control measures including re-diversion of pollutant discharge to public sewer, bioremediation and selected dredging, the water quality of Shing Mun River was progressively improving and the odour smell was finally under-control.

Bioremediation in Kai Tak Approach Channel

Kai Tak Approach Channel (KTAC) is a semi-enclosed seawater channel which is formed during the construction of Hong Kong Kai Tak International Airport. It is a 1.4km long and 200m wide artificial channel for flood relief drainage in East Kowloon area. In the past 40-50 years, organic pollutant from surrounding industrial facilities, maintenance workshop and distributaries (e.g. Jordon Valley Culvert) continued to discharge into KTAC. Due to the poor water circulation and high pollution loading in KTAC, contaminated sediments were deposited in the seabed resulting in generation of foul-smelling gas. As the approach channel is part of the Victoria Harbour and that huge amount of sediment was involved, conventional sediment treatment through reclamation or sediment dredging were simply not an option. Hence, in-situ bioremediation was considered as the most appropriate sediment treatment method to alleviate the odour problem in KTAC. The bioremediation in KTAC involves dredging of sediment settled in the shallow water areas followed by the injection of oxidant into the seabed to accelerate degradation of organic pollutants. The results were very effective with average of 96.47% odour emission reduction.

Bioremediation in Sam Ka Tsuen Typhoon Shelter

Sam Ka Tsuen Typhoon Shelter (SKTTS) are embayments which are largely surrounded by artificial sea wall with low tidal flushing. It is a major tourist attraction, renowned for its vibrant seafood stalls and restaurants, and is home to many fishermen. Hence, heavy water pollution problem was found in SKTTS due to the domestic sewage discharge from restaurants and residents in the vicinity. Complaints from public had been received due to the odorous gas generating from contaminated sediment high in organic pollutant but low in oxygen. In year 2004, a combined dredging and bioremediation technique for remediation was adopted for sediment treatment to mitigate the odour problem. As a result, Over 18,000m^2 of malodorous sediments were treated and odour was greatly suppressed.

Bioremediation in Shenzhen River

Similar to Shing Mun River, Shenzhen River is a tidal river between the border of Shenzhen and Hong Kong and is connected with a semi-enclosed shallow bay area (Deep Bay) with limiting flushing capability. It is a 13 km long and 210m wide (80m wide at upper stream) artificial re-engineered river channel for carrying flood discharge. Along with the rapid economic boom and industrial development of Shenzhen at 1990s, domestic sewage, livestock wastewater and industrial effluent were continually discharged into the Shenzhen River and caused the heavy pollution problem. Under the heavy pollution loading combining with the heavy sediment deposition since the completion of first and second phase of the Shenzhen Regulation Project, the sediment quality at the bottom of main river channel of the Shenzhen River was deteriorating rapidly resulting in unpleasant smell. According to latest information of the Shenzhen River Contaminated Sediment Remediation Strategy Joint Study, in-situ bioremediation is recommended to remedy the odour nuisance due to the contaminated sediment.

By making reference to relevant study papers and approved EIA report, comparison of site characteristic, major odour source, sediment treatment target between different bioremediation projects have been made and are summarised in **Table 3.23**.

Table 3.23 Comparison between different bioremediation projects/ study

		KTAC	**SKTTS**	**Shing Mun River**	**Shenzhen River**
Nature		Engineered seawater channel	Semi-enclosed embayment	Engineered River Channel	Engineered River Channel
Odour Sources		Domestic Sewage, Industrial Sewage and deposited sediments	Domestic Sewage and deposited sediments	Domestic Sewage, Industrial Sewage and deposited sediments	Domestic Sewage , Industrial Sewage and deposited sediments
Odour Treatment Method	Re-diversion of	Yes	Yes	Yes	Yes

		KTAC	**SKTTS**	**Shing Mun River**	**Shenzhen River**
	pollutant discharge to public sewer				
	Sediment treatment	Dredging and Bioremediation	Dredging and Bioremediation	Dredging and Bioremediation	Bioremediation
AVS Removal Efficiency	Target	95%	90%	90%	90%
	Bench-scale Study	-	-	97%	97.62%[3-8]
	Final	>95%[3-7]	>95%[3-7]	>99%[3-7]	To be determined
Odour Removal Efficiency	Average	>96%[3-7]	No odour could be detected	95%-99%[3-7][1]	To be determined

Note:
[1] In reference [3-8], odour removal efficiency indicated is based on the AVS removal, the correlation between odour concentration removal and AVS removal for Shenzhen River will be established at the detailed design stage. Refer to EM&A manual for more information.

In view of the similar nature site characteristic, odorous sources and sediment treatment method for both Shenzhen River and Shing Mun River, the successful experience from in-situ bioremediation study at Shing Mun River is considered to be a good benchmark for the bioremediation works at Shenzhen River Contaminated Sediment Remediation Strategy Joint Study. Hence, the information from bioremediation of Shing Mun River will be referenced for assessing the practicability of achieving the 98% odour removal efficiency for odour mitigation in the project area of LMC Loop Development.

Practicability Evaluation of Odour Removal Efficiency

According to Annex A[3-6] in the approved EIA for Kai Tak Development, contaminated sediment with high level of organic pollutant would generate odorous gas such as hydrogen sulphide (H_2S) or mercaptans by anaerobic reaction as shown in the following:

Organic matter + sulphate → energy + hydrogen sulphide + water (1)

Organic matter with sulphide → energy + mercaptans + water (2)

The mechanisms are characterized in the presence of high sulphide content in terms of acid volatile sulphide (AVS). AVS refer to the major component of sulphide bearing substances and is an indicator to determine the capability of odour release from sediment. The difference in AVS content before and after oxidant treatment is a direct indicator for the effectiveness of the bioremediation. Percentage of AVS removal was taken as the primary acceptance criteria of the odour remediation works at Shing Mun River and SKTTS.

For bioremediation, utilization of oxidant such as calcium nitrate could oxidise AVS. Hence, the dosage of calcium nitrate used should be proportional to the amount of AVS removal from the sediment. In the ongoing Shenzhen River Contaminated Sediment Remediation Strategy Joint Study, sediment samples have been collected for bench-scale testing to determine the appropriate dosage of different oxidant used. Based on regression analysis of the collected data, the relationship between the amount of AVS removal and the dosage of calcium nitrate used have been plotted and is shown in **Figure 3.24**.

Figure 3.24 indicates there is a strong statistical relationship between the amount of AVS removal and dosage of calcium nitrate (R^2 value of 0.95). Furthermore, data collected from the monthly sediment quality report from bioremediation study in Shing Mun River indicates AVS removal of >99% could be achieved at most of the treated area under the optimum dosage control of calcium nitrate. **Figure 3.25** summarizes the dosage use of calcium nitrate and their corresponding AVS removal from different areas of Shing Mun River.

In accordance with the successful experience from in-situ bioremediation in Shing Mun River, an average odour removal efficiency of over 95%-100% was achieved, corresponding to the equivalent AVS removal. Using Shing Mun River as the benchmark for Shenzhen River section, it is anticipated that the future average odour removal efficiency for Shenzhen River bioremediation could fall within the range of 95%-99%, corresponding to achieving 99% of AVS removal in the in-situ bioremediation of Shenzhen River.

In fact, odorous gas released from AVS is complicated. According to a study paper[3-6] from bioremediation in Hong Kong, odorous gas released from AVS is dependent on numerous factors, such as:

- Ambient temperature
- Wind directions and speed
- Tides and water depths
- pH of sediment and water

Further AVS reduction could be achieved through increasing the dosage use of oxidant/chemical. This implies that, one can boost up the odour removal efficiency of bioremediation by using higher dosage of oxidant/chemical to achieve any desired odour mitigation result, subject to cost effectiveness. With optimisation in the detailed planning and design of the bioremediation works, the relationship between odour emission and other major odour indicator in-term of AVS and Redox potential will be established to determine the limit and action level for preventing recurrent odour exceedance before and during operation of the LMC Loop development and with a monitoring programme in place to confirm compliance.

<u>Progress of In-situ Bioremediation of Shenzhen River</u>

The joint study between Hong Kong and Shenzhen Government, namely 《Shenzhen River Contaminated Sediment Remediation Strategy Joint Study 深圳河污染底泥治理策略合作研究》, has commenced since Year 2009 to examine applicable technologies and methods to remedy the environmental problems created by the contaminated sediment, and put forward feasible options for joint implementation by the two governments.

Based on the abovementioned 《Shenzhen River Contaminated Sediment Remediation Strategy Joint Study – Proposed Work Plan for Contaminated Sediment Investigation 深圳河污染底泥治理策略合作研究 - 底泥污染調查建

議工作計劃》[3-10], the treatment strategy for Shenzhen River sediment is targeted to achieve minimum 90% sediment AVS removal efficiency through in-situ bioremediation. According to the study, the effectiveness of bioremediation would depend on various factors including chemical dosage use on contaminated sediment, depth of injection, frequency of injection etc. Depending on the application condition, higher removal efficiency is possible through adjusting the dosage of chemical use.

3.8 Mitigation Measures

3.8.1 Construction Phase

In order to reduce the dust emission from the Project and achieve compliances of TSP criteria at ASRs, mitigation measures by regular watering from good site practice should be adopted. In accordance with the "Control of Open Fugitive Dust Sources" (USEPA AP-42) as given in **Appendix 3-2**, watering once per hour on exposed worksites and haul road is proposed to achieve dust removal efficiency of 92.1%. These dust suppression efficiencies are derived based on the average number of on-site vehicle access, average evaporation rate and an assumed application intensity of 1.6 L/m^2 for the respective watering frequencies (see **Appendix 3-2**). Any potential dust impact and watering mitigation would be subject to the actual site conditions. For example, a construction activity that produces inherently wet conditions or in cases under rainy weather, the above water application intensity may not be unreservedly applied. While the above watering frequencies are to be followed, the extent of watering may vary depending on actual site conditions but should be sufficient to maintain an equivalent intensity of no less than 1.6 L/m^2 to achieve the respective dust removal efficiencies. The dust levels would be monitored and managed under an EM&A programme as specified in the EM&A Manual.

In addition to the abovementioned, the Contractor is also obliged to follow the procedures and requirements given in the Air Pollution Control (Construction Dust) Regulation. It 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 following dust suppression measures should also be incorporated by the Contractor to control the dust nuisance throughout the construction phase:

- Any excavated or stockpile of dusty material should be covered entirely by impervious sheeting or sprayed with water to maintain the entire surface wet and then removed or backfilled or reinstated where practicable within 24 hours of the excavation or unloading;
- Any dusty materials remaining after a stockpile is removed should be wetted with water and cleared from the surface of roads;
- A stockpile of dusty material should not be extended beyond the pedestrian barriers, fencing or traffic cones;
- The load of dusty materials on a vehicle leaving a construction site should be covered entirely by impervious sheeting to ensure that the dusty materials do not leak from the vehicle;

- Where practicable, vehicle washing facilities with high pressure water jet should be provided at every discernible or designated vehicle exit point. The area where vehicle washing takes place and the road section between the washing facilities and the exit point should be paved with concrete, bituminous materials or hardcores;
- When there are open excavation and reinstatement works, hoarding of not less than 2.4m high should be provided as far as practicable along the site boundary with provision for public crossing. Good site practice shall also be adopted by the Contractor to ensure the conditions of the hoardings are properly maintained throughout the construction period.
- The portion of any road leading only to construction site that is within 30m of a vehicle entrance or exit should be kept clear of dusty materials;
- Surfaces where any pneumatic or power-driven drilling, cutting, polishing or other mechanical breaking operation takes place should be sprayed with water or a dust suppression chemical continuously;
- Any area that involves demolition activities should be sprayed with water or a dust suppression chemical immediately prior to, during and immediately after the activities so as to maintain the entire surface wet;
- Where a scaffolding is erected around the perimeter of a building under construction, effective dust screens, sheeting or netting should be provided to enclose the scaffolding from the ground floor level of the building, or a canopy should be provided from the first floor level up to the highest level of the scaffolding;
- Any skip hoist for material transport should be totally enclosed by impervious sheeting;
- Every stock of more than 20 bags of cement or dry pulverised fuel ash (PFA) should be covered entirely by impervious sheeting or placed in an area sheltered on the top and the 3 sides;
- Cement or dry PFA delivered in bulk should be stored in a closed silo fitted with an audible high level alarm which is interlocked with the material filling line and no overfilling is allowed;
- Loading, unloading, transfer, handling or storage of bulk cement or dry PFA should be carried out in a totally enclosed system or facility, and any vent or exhaust should be fitted with an effective fabric filter or equivalent air pollution control system; and
- Exposed earth should be properly treated by compaction, turfing, hydroseeding, vegetation planting or sealing with latex, vinyl, bitumen, shortcrete or other suitable surface stabiliser within six months after the last construction activity on the construction site or part of the construction site where the exposed earth lies.

These requirements should be incorporated into the Contract Specification for the civil work. In addition, an audit and monitoring programme during the construction phase should be implemented by the Project Proponent to ensure that the construction dust impacts are controlled to within the HKAQO. Detailed requirements for the audit and monitoring programme are given separately in the EM&A manual.

3.8.1.1 Assessment Results – Mitigated Scenarios for Phase 1 Infrastructures

Short-term Assessment (Tier 1)

The maximum 1-hour and 24-hour TSP concentrations from Tier 1 screening assessment have been predicted. **Table 3.24** below summarises the cumulative 1-hour and 24-hour TSP impact (Tier 1) at the identified ASRs. The results indicate that, for the majority of ASRs, exceedance of 1-hour and 24-hour TSP criteria would not be anticipated even with this theoretical worst case situation, whereby the entire worksites were assumed active (i.e. 100%). However, for the ASRs at the residential premises located at the south-west of Area A (i.e. near Border Road, Ha Wan Tsuen, Lok Ma Chau Tsuen and Lok Ma Chau Tsuen Expansion), exceedance of 1-hour TSP criterion is still predicted. As the Tier 1 assessment is for screening purposes only and does not reflect the actual on-site activities, a more focused Tier 2 assessment has been undertaken.

Figures 3.26 to **3.27** show the contours of Tier 1 1-hour and 24-hour TSP concentrations.

Table 3.24 Tier 1 assessment - predicted cumulative 1-hour and 24-hour TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m³) under mitigated scenario.

Location of ASRs	Assessment Points	TSP Concentrations (μg/m³)	
		1-hour	24-hour
AQO Standard		**500**	**260**
Existing ASRs			
Border Road	BR-3	**585.3**	183.8
	BR-4	**692.8**	151.4
	BR-5	442.0	102.5
Chau Tau Tsuen	CTT-3	309.1	118.2
Ha Wan Fisherman San Tsuen	HWFST-2	429.0	137.2
Ha Wan Tsuen	HWT-1	**1172.0**	175.0
	HWT-2	**835.2**	132.0
	HWT-4	**801.7**	146.1
Ha Wan Tsuen Road	HWTR-1	**1123.2**	187.7
	HWTR-6	**517.3**	167.5
	HWTR-10	**648.1**	205.1
	HWTR-11	456.6	154.9
	HWTR-20	**779.5**	188.8
Lok Ma Chau Operation Base	LMCOB-1	448.3	104.2
Lok Ma Chau Police Station	LMCPS-1	461.9	149.7
Lok Ma Chau Road	LMCR-2	491.7	167.2
	LMCR-5	**565.8**	157.9
	LMCR-8	423.3	137.5

Location of ASRs	Assessment Points	TSP Concentrations (µg/m^3)	
		1-hour	24-hour
AQO Standard		**500**	**260**
	LMCR-12	444.4	146.2
	LMCR-14	368.0	129.5
	LMCR-15	340.1	120.3
Lok Ma Chau San Tsuen	LMCST-3	**513.8**	153.1
Lok Ma Chau Tsuen	LMCT-1	**550.0**	178.4
Ma Tso Lung	MTL-1	322.3	90.4
	MTL-7	303.5	88.3
	MTL-8	289.1	87.0
	MTL-9	282.5	85.7
	MTL-12	281.7	84.3
	MTL-20	303.1	89.8
Lo Wu Police Range	PR-1	256.2	82.0
Pun Uk Tsuen	PUT-2	358.0	124.2
San Sham Road	SSR-1	**755.3**	122.1
Near Wing Ping Tsuen	WPT-1	309.3	105.5
Planned ASRs			
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	**594.0**	104.5
Ex-Lung Kai Public School	ELKPS-P1	273.7	85.3
Eco-Lodge	EL-P1	422.4	100.8
	EL-P5	387.0	98.2
Kwu Tung North New Development Area	KTN-P2	278.8	85.0
	KTN-P3	292.5	87.2
Lok Ma Chau Loop	LMCL-P1	N/A[2]	N/A[2]
	LMCL-P2	N/A[2]	N/A[2]
	LMCL-P4	N/A[2]	N/A[2]
	LMCL-P6	N/A[2]	N/A[2]
	LMCL-P7	N/A[2]	N/A[2]
	LMCL-P8	N/A[2]	N/A[2]
	LMCL-P9	N/A[2]	N/A[2]
	LMCL-P11	N/A[2]	N/A[2]
Proposed Fire Station and Ambulance Depot	FS-P1	N/A[2]	N/A[2]
Lok Ma Chau Tsuen Expansion	LMCTE-P1	**599.1**	183.0
	LMCTE-P4	**654.8**	195.8
	LMCTE-P6	**508.2**	164.3

Notes:

[1] Values which exceeded AQO are shown as bolded characters

[2] The premises are located within the works site boundary hence the population intake would be after the construction of the Phase 1 Infrastructures of the Project, i.e. no impact from the Project under Phase 1 Infrastructure.

[3] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the

Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

Short-term Assessment (Tier 2)

A more focused Tier 2 assessment has been conducted with the assumed 30% active works areas in the hot spot area nearest to the potentially worst affected ASRs, and emissions from the rest of all other worksites still at 100% as in Tier 1 assumption.

The maximum 1-hour and 24-hour TSP concentrations have been assessed. **Table 3.25** summarises the cumulative 1-hour and 24-hour TSP impact (Tier 2). Results show that, the cumulative 1-hour and 24-hour TSP concentrations would comply with the respective criteria and as such, adverse short-term construction dust impact is not anticipated.

Contours have been plotted for 1-hour (Tier 2), and 24-hour (Tier 2) TSP concentrations at 1.5m above ground to illustrate the short-term dust impact on the ASR, as presented in **Figures 3.28** to **3.29** respectively.

Table 3.25 Tier 2 assessment - predicted cumulative 1-hour and 24-hour TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m^3) under mitigated scenario

Location of ASRs	Assessment Points	TSP Concentrations (μg/m^3)	
		1-hour	24-hour
AQO Standard		**500**	**260**
Existing ASRs			
Border Road	BR-3	279.0	108.6
	BR-4	356.0	91.0
Ha Wan Tsuen	HWT-1	484.1	114.1
	HWT-2	340.6	94.8
	HWT-4	343.4	101.0
Ha Wan Tsuen Road	HWTR-1	489.6	119.3
	HWTR-6	360.1	131.1
	HWTR-10	446.5	168.3
	HWTR-20	354.7	119.3
Lok Ma Chau Road	LMCR-5	335.1	120.0
Lok Ma Chau San Tsuen	LMCST-3	232.8	99.9
Lok Ma Chau Tsuen	LMCT-1	247.4	111.1
San Sham Road	SSR-1	324.9	91.6
Planned ASRs			
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	253.6	86.0
Lok Ma Chau Tsuen Expansion	LMCTE-P1	277.5	111.8
	LMCTE-P4	310.1	109.2
	LMCTE-P6	237.8	103.9

Long-term Assessment

The maximum predicted annual TSP concentrations at the identified ASRs in the study area are given in **Table 3.26**. In summary, the predicted annual TSP concentrations at all ASRs would comply with the criterion of 80µg/m^3 where 6% of the entire worksites were assumed active (see **Appendix 3-1**), hence, there is no adverse long-term impact anticipated. Contour of annual TSP concentrations at 1.5m above ground is shown in **Figure 3.30**.

Table 3.26 Long-term assessment - predicted cumulative Annual TSP concentrations at 1.5m above ground (including background concentration of 73.1µg/m^3) under mitigated scenario

Location of ASRs	Assessment Points	Annual TSP Concentrations (µg/m^3)
AQO Standard		**80**
Existing ASRs		
Border Road	BR-3	73.6
	BR-4	73.5
	BR-5	73.2
Chau Tau Tsuen	CTT-3	73.3
Ha Wan Fisherman San Tsuen	HWFST-2	73.5
Ha Wan Tsuen	HWT-1	74.4
	HWT-2	73.5
	HWT-4	73.5
Ha Wan Tsuen Road	HWTR-1	74.2
	HWTR-6	74.4
	HWTR-10	74.3
	HWTR-11	74.4
	HWTR-20	73.7
Lok Ma Chau Operation Base	LMCOB-1	73.2
Lok Ma Chau Police Station	LMCPS-1	73.4
Lok Ma Chau Road	LMCR-2	74.3
	LMCR-5	74.2
	LMCR-8	73.5
	LMCR-12	73.5
	LMCR-14	73.4
	LMCR-15	73.3
Lok Ma Chau San Tsuen	LMCST-3	73.6
Lok Ma Chau Tsuen	LMCT-1	73.6
Ma Tso Lung	MTL-1	73.1
	MTL-7	73.1
	MTL-8	73.1
	MTL-9	73.1
	MTL-12	73.1
	MTL-20	73.1
Lo Wu Police Range	PR-1	73.1
Pun Uk Tsuen	PUT-2	73.3
San Sham Road	SSR-1	73.5
Near Wing Ping Tsuen	WPT-1	73.2

Location of ASRs	Assessment Points	Annual TSP Concentrations (µg/m³)
AQO Standard		**80**
Planned ASRs		
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	73.3
Ex-Lung Kai Public School	ELKPS-P1	73.1
Eco-Lodge	EL-P1	73.2
	EL-P5	73.2
Kwu Tung North New Development Area	KTN-P2	73.1
	KTN-P3	73.1
Lok Ma Chau Loop	LMCL-P1	N/A[1]
	LMCL-P2	N/A[1]
	LMCL-P4	N/A[1]
	LMCL-P6	N/A[1]
	LMCL-P7	N/A[1]
	LMCL-P8	N/A[1]
	LMCL-P9	N/A[1]
	LMCL-P11	N/A[1]
Proposed Fire Station and Ambulance Depot	FS-P1	N/A[1]
Lok Ma Chau Tsuen Expansion	LMCTE-P1	73.6
	LMCTE-P4	73.7
	LMCTE-P6	73.5

Note:

[1] The premises are located within the works site boundary hence the population intake would be after the construction of the Phase 1 Infrastructures of the Project, i.e. no impact from the Project under Phase 1 Infrastructure.

[2] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

3.8.1.2 Assessment Results – Mitigated Scenarios for Phase 2 Infrastructure

An assessment of Phase 2 Infrastructure was conducted to assess the worst-case scenario for the ASRs near the Eastern Connection Road as described in **Section 3.5.1.1.**

Short-term Assessment (Tier 1)

The maximum 1-hour and 24-hour TSP concentrations from Tier 1 screening assessment have been predicted. **Table 3.27** below summarises the cumulative 1-hour and 24-hour TSP impact (Tier 1) at the identified ASRs. The results indicate that, for the majority of ASRs, exceedance of 1-hour and 24-hour TSP criteria would not be anticipated even with this theoretical worst case situation, whereby the entire worksites were assumed active (i.e. 100%). However, for the ASRs at the residential premises located near the KTN NDA (e.g. Ma Tso Lung and Lo Wu Police Range), exceedance of 1-hour and 24-hour TSP criterion is still predicted. As the Tier 1 assessment is for screening purposes only and does not reflect the actual on-site activities, a more focused Tier 2 assessment has been undertaken.

Contours have been plotted for 1-hour (Tier 1), and 24-hour (Tier 1) TSP concentrations at 1.5m above ground to illustrate the short-term dust impact on the ASRs for Phase 2 Infrastructures, as presented in **Figures 3.31** to **3.32** respectively.

Table 3.27 Tier 1 assessment - predicted mitigated cumulative 1-hour and 24-hour TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m³)

Location of ASRs	Assessment Points	TSP Concentrations (μg/m³)	
		1-hour	24-hour
AQO Standard		**500**	**260**
Existing ASRs			
Border Road	BR-3	194.9	79.8
	BR-4	349.0	96.4
	BR-5	**798.5**	188.6
Chau Tau Tsuen	CTT-3	110.2	77.2
Ha Wan Fisherman San Tsuen	HWFST-2	116.3	75.8
Ha Wan Tsuen	HWT-1	131.3	78.5
	HWT-2	121.7	75.7
	HWT-4	125.7	75.7
Ha Wan Tsuen Road	HWTR-1	124.0	77.8
	HWTR-6	120.1	75.5
	HWTR-10	110.4	75.5
	HWTR-11	110.9	75.4
	HWTR-20	118.9	75.7
Lok Ma Chau Operation Base	LMCOB-1	267.4	108.4
Lok Ma Chau Police Station	LMCPS-1	126.5	76.6
Lok Ma Chau Road	LMCR-2	112.4	75.5
	LMCR-5	114.5	75.6
	LMCR-8	116.4	75.7
	LMCR-12	114.0	75.6
	LMCR-14	110.0	75.4
	LMCR-15	109.5	76.3
Lok Ma Chau San Tsuen	LMCST-3	121.9	75.5
Lok Ma Chau Tsuen	LMCT-1	134.5	76.1
Ma Tso Lung	MTL-1	422.8	107.2
	MTL-7	**672.9**	217.8
	MTL-8	**711.4**	242.9
	MTL-9	**530.4**	167.0
	MTL-12	**531.5**	156.0
	MTL-20	**578.0**	121.7
Lo Wu Police Range	PR-1	**688.1**	177.1
Pun Uk Tsuen	PUT-2	112.7	76.6

Location of ASRs	Assessment Points	TSP Concentrations (µg/m^3)	
		1-hour	24-hour
AQO Standard		**500**	**260**
San Sham Road	SSR-1	122.3	77.7
Near Wing Ping Tsuen	WPT-1	97.9	75.3
Planned ASRs			
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	106.2	76.2
Ex-Lung Kai Public School	ELKPS-P1	**622.0**	188.6
Eco-Lodge	EL-P1	434.3	124.1
	EL-P5	283.8	120.5
Kwu Tung North New Development Area	KTN-P2	**641.7**	188.6
	KTN-P3	**719.5**	**268.5**
Lok Ma Chau Loop	LMCL-P1	134.8	77.6
	LMCL-P2	168.8	79.5
	LMCL-P4	193.5	81.8
	LMCL-P6	158.0	81.2
	LMCL-P7	165.6	81.8
	LMCL-P8	146.9	80.0
	LMCL-P9	166.7	81.8
	LMCL-P11	181.4	83.3
Proposed Fire Station and Ambulance Depot	FS-P1	370.3	111.1
Lok Ma Chau Tsuen Expansion	LMCTE-P1	127.9	76.2
	LMCTE-P4	153.4	77.5
	LMCTE-P6	132.3	76.0

Notes:

[1] Values which exceeded AQO are shown as bolded characters

[2] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

Short-term Assessment (Tier 2)

A more focused Tier 2 assessment has been conducted with the assumed 30% active works areas in the hot spot area nearest to the potentially worst affected ASRs, and emissions from the rest of all other worksites still at 100% as in Tier 1 assumption.

The maximum 1-hour and 24-hour TSP concentrations have been assessed. **Table 3.28** summarises the cumulative 1-hour and 24-hour TSP impact (Tier 2). Results show that, the cumulative 1-hour and 24-hour TSP concentrations would comply with the respective criteria and as such, adverse short-term construction dust impact is not anticipated.

Contours have been plotted for 1-hour (Tier 2), and 24-hour (Tier 2) TSP concentrations at 1.5m above ground to illustrate the short-term dust impact on the ASR, as presented in **Figures 3.33** to **3.34** respectively.

Table 3.28 Tier 2 assessment - predicted mitigated cumulative 1-hour and 24-hour TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m³)

Location of ASRs	Assessment Points	TSP Concentrations (μg/m³)	
		1-hour	24-hour
AQO Standard		**500**	**260**
Existing ASRs			
Border Road	BR-5	256.0	106.6
Ma Tso Lung	MTL-7	327.0	127.5
	MTL-8	444.0	149.4
	MTL-9	244.7	113.8
	MTL-12	273.1	107.8
	MTL-20	280.2	91.6
Lo Wu Police Range	PR-1	189.2	88.2
Planned ASRs			
Ex-Lung Kai Public School	ELKPS-P1	260.4	99.4
Kwu Tung North New Development Area	KTN-P2	392.0	126.0
	KTN-P3	256.4	121.0

Long-term Assessment

The maximum predicted annual TSP concentrations at the identified ASRs in the study area are given in **Table 3.29**. In summary, the predicted annual TSP concentrations at all ASRs would comply with the criterion of 80μg/m³ where 6% of the entire worksites were assumed active (see **Appendix 3-1**), hence, there is no adverse long-term impact anticipated. Contour of annual TSP concentrations at 1.5m above ground is shown in **Figure 3.35**.

Table 3.29 Long-term assessment - predicted mitigated cumulative Annual TSP concentrations at 1.5m above ground (including background concentration of 73.1μg/m³)

Location of ASRs	Assessment Points	Annual TSP Concentrations at 1.5m (μg/m³)
AQO Standard		**80**
Existing ASRs		
Border Road	BR-3	73.2
	BR-4	73.3
	BR-5	74.2
Chau Tau Tsuen	CTT-3	73.1
Ha Wan Fisherman San Tsuen	HWFST-2	73.1
Ha Wan Tsuen	HWT-1	73.1
	HWT-2	73.1
	HWT-4	73.1
Ha Wan Tsuen Road	HWTR-1	73.1
	HWTR-6	73.1

Location of ASRs	Assessment Points	Annual TSP Concentrations at 1.5m (µg/m^3)
AQO Standard		**80**
	HWTR-10	73.1
	HWTR-11	73.1
	HWTR-20	73.1
Lok Ma Chau Operation Base	LMCOB-1	73.6
Lok Ma Chau Police Station	LMCPS-1	73.1
Lok Ma Chau Road	LMCR-2	73.1
	LMCR-5	73.1
	LMCR-8	73.1
	LMCR-12	73.1
	LMCR-14	73.1
	LMCR-15	73.1
Lok Ma Chau San Tsuen	LMCST-3	73.1
Lok Ma Chau Tsuen	LMCT-1	73.1
Ma Tso Lung	MTL-1	73.6
	MTL-7	74.0
	MTL-8	74.6
	MTL-9	73.9
	MTL-12	73.7
	MTL-20	73.8
Lo Wu Police Range	PR-1	73.6
Pun Uk Tsuen	PUT-2	73.1
San Sham Road	SSR-1	73.1
Near Wing Ping Tsuen	WPT-1	73.1
Planned ASRs		
Comprehensive Development and Wetland Enhancement Area	CDWEA-P1	73.1
Ex-Lung Kai Public School	ELKPS-P1	73.9
Eco-Lodge	EL-P1	73.6
	EL-P5	73.6
Kwu Tung North New Development Area	KTN-P2	74.0
	KTN-P3	74.5
Lok Ma Chau Loop	LMCL-P1	73.2
	LMCL-P2	73.2
	LMCL-P4	73.2
	LMCL-P6	73.2
	LMCL-P7	73.2
	LMCL-P8	73.1
	LMCL-P9	73.1
	LMCL-P11	73.2
Proposed Fire Station and Ambulance Depot	FS-P1	73.8
Lok Ma Chau Tsuen Expansion	LMCTE-P1	73.1
	LMCTE-P4	73.1
	LMCTE-P6	73.1

Notes:

[1] For ASR LMCL-P12 to LMCL-P28, the premises are located within the works site boundary and the population intake would be after the construction of both Phase 1 and Phase 2 Infrastructures of the Project, i.e. no impact from the construction phase of the Project and therefore not included in the construction dust assessment.

3.8.2 Operational Phase

3.8.2.1 Vehicular Emission

Based on the assessment results, air quality impacts within 500m from the boundary of the Project is not anticipated, thus no mitigation measure would be required.

3.8.2.2 Chimney Emission

No industrial chimney was identified within the 500m from the boundary of the Project on Hong Kong side and the nearest potential industrial land use on Shenzhen side is located at more than 500m away from the boundary of the Project. Therefore, no chimney emission impact is anticipated.

3.8.2.3 Odour Emission

The on-site STW will incorporate odour control design of 95% odour removal efficiency. In addition, the project proponent will undertake to implement bioremediation of 98% odour removal efficiency along Shenzhen River within 500m from the study area of the Loop development as shown in **Figure 3.23b**. The work will involve injection of calcium nitrate to remove AVS from the contaminated sediment to achieve 98% odour removal efficiency. Reference for the above findings has been made to the on-going《Shenzhen River Contaminated Sediment Remediation Strategy Joint Study 深圳河污染底泥治理策略合作研究》.

An in-situ trial test to assess the effectiveness on AVS and odour removal of bioremediation works will be conducted. The relationship between odour emission and other major odour indicator in-term of AVS and Redox potential will be established. The established AVS versus odour relationship will be made use for implementation of Shenzhen River bioremediation work committed by the project proponent.

As a short-term enhancement and contingency measure for reduction of indoor odour level before the completion of mitigation measures on Shenzhen River (**Figure 3.23c**), the developers could consider to install odour removal system (i.e. activated carbon filter or selective catalytic filter etc.) capable of 95% removal efficiency in buildings with central air conditioning in the development. If the odour removal system were in place, the odour criterion would be met inside all internal spaces.

3.9 Residual Environmental Impacts

3.9.1 Fugitive Dust

With the implementation of the mitigation measures as stipulated in the Air Pollution Control (Construction Dust) Regulation, dust control measures and good site practices, the predicted 1-hour, 24-hour and annual TSP concentrations at the ASRs would comply with the relevant criteria. Hence, no adverse residual dust impact is anticipated.

3.9.2 Vehicular Emission

Based on the assessment result, no exceedance was shown within 500m of the Project boundary. There is no constraint on future land use planning. No mitigation measures are therefore required and no adverse residual impact is anticipated.

3.9.3 Odour Emission

With the implementation of bioremediation along the Shenzhen River within the 500m from the study area of the Loop development, exceedance of odour limit will still be experienced at some planned ASRs at times during the initial phase of the development. Short-/ medium- term residual odour impacts are anticipated on the external spaces of LMC Loop development during operational phase of the project, while odour removal system is proposed for the buildings with central air conditioning during this period to achieve the odour criterion inside all internal spaces as an interim contingency measure.

In accordance with Section 4.4.3 of the TM-EIAO, the predicted residual odour impacts at these ASRs are assessed as follows:

(i) Effects on public health and health of biota or risk to life

In this assessment, the odour emission rates obtained in Year 2010 were under worst case conditions with the sampling exercise carried out during the low tide periods and ambient temperatures were above 32 ^{o}C. The predicted highest mitigated odour concentrations at the representative ASRs was 14.5 ou/m^3. With reference to the detailed laboratory testing results for Kai Tak Development Engineering Study cum Design and Construction of Advance Works (CE 35/2006, S3.6.16(i)), the ratio of H_2S concentration (in ppb) to odour concentration (ou/m^3) is ranged from 0.38% to 2.00%. Conservatively, if 2.00% is adopted, the short term maximum odour concentration of 14.5 ou/m^3 is equivalent to H_2S concentration of about 0.00029 ppm.

In terms of human health effects of hydrogen sulphide, respiratory, neurological, and ocular effects are the most sensitive end-points in humans following inhalation exposures. Available data on carcinogenicity of hydrogen sulphide is also not adequate. Exposure of H_2S at 2.0 ppm would cause bronchial constriction in asthmatic individuals; while exposure of 3.6 ppm H_2S would cause increase eye complaints for general population; and exposure of 20 ppm H_2S would cause fatigue, loss of appetite, headache, irritability, poor memory and dizziness. Besides, with reference to the Integrated Risk Information System (IRIS) of USEPA, the reference concentration of H_2S for daily chronic inhalation exposure to human population without an appreciable risk of deleterious effects during a lifetime is 2 x 10^{-3} mg/m^3 (0.00142 ppm).

As mentioned before, the short term maximum odour concentration of 14.5 ou/m^3 is equivalent to H_2S concentration of about 0.00029 ppm, which is more than 6500 times below the H_2S concentration of 2.0ppm, the threshold of health symptom on asthmatic individuals. It is also significantly below the chronic inhalation exposure average over a lifetime. Adverse health impact to human for exposure under such a low concentration of H_2S is not expected.

(ii) The magnitude of adverse environmental impacts

The predicted worst-case odour concentration ranges from 10.8 OU to 14.5 OU. Detailed information at the representative ASRs are given in **Table 3.22**. Odour concentration contributed solely by on-site STW ranges from 0.29 OU to 1.99 OU, which contributes 2.25% to 16.1% to the total odour concentration at planned ASRs.

(iii) The geographic extent on the adverse environmental impacts

The extent of exceedance of the odour criterion are shown in **Figures 3.23b**.

(iv) The duration and frequency of the adverse environmental impacts

The frequency of exceedance of odour criterion at the representative ASRs under the short-/medium- term mitigated scenario is tabulated in **Table 3.22**. The predicted frequency of exceedance for the scenario with 98% odour removal along Shenzhen River of approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total) is ranged from 1.0% - 3.1% in a year. However, it should be noted that these frequencies of exceedances are determined with real meteorological data over the year, yet assuming a hypothetical worst-case odour emission condition established in the peak summer season (i.e. Low tide periods with high ambient temperature). Odour monitoring will be conducted and further bio-remediation action will be taken if required. Thus, the duration, frequency, and chance of impact and also the potential impacts should be further reduced / unlikely.

(v) The likely size of the community or the environment that may be affected by the adverse impacts

As indicated in **Figure 3.23b**, with the implementation of bioremediation along Shenzhen River within approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total), the odour concentrations in the vicinity of LMC Loop would be reduced substantially as compared with the unmitigated scenario. However, exceedances of the odour criterion are still predicted at planned ASRs within the Loop development. The estimated population in the affected buildings is approximately 53,000 including students and staff. However, if the central air conditioning buildings would be equipped with the odour removal system as an interim contingency measure, only population residing in student hostels (approximately 12,000) will be affected. To minimize the residual impact, student residences may be placed within education zone at the southern part of LMC Loop subject to the future planning.

Besides, during peak summer seasons, most of the students would unlikely stay in student hostels during the peak summer seasons (i.e. worst case scenario) since most of them will stay in the campus with air conditioning and/or may not be in the student hostels due to the summer holidays etc. Therefore the size of the community that may be affected should be further reduced.

(vi) The degree to which adverse environmental impacts are reversible or irreversible

The existing odour nuisance at the ASRs will be improved with the implementation of the bioremediation along Shenzhen River of approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total) proposed under this assessment. Further improvement works on Shenzhen River in the long run will be carried out by others. With the continuously improvement on the conditions of Shenzhen River, the poor background odour problem will also be continuously improved (i.e. unlikely reverse) and the odour nuisance at the ASRs will be insignificant.

(vii) The ecological context

The implementation of bioremediation along Shenzhen River of approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total) of LMC Loop development is considered acceptable as net increase in waterbird numbers is expected ultimately.

(viii) The degree of disruption to sites of cultural heritage

The predicted exceedance would not involve any cultural heritage context.

(ix) International and regional importance

With the implementation of bioremediation along Shenzhen River of approximately 1.9km downstream of, 1km upstream of and 1.3km along the Loop development (i.e. approximately 4.2 km in total), the odour condition will be improved over the existing condition. Residual impact of odour on regional and international context is insignificant.

(x) Both the likelihood and degree of uncertainty of adverse environmental impacts

The degree of certainty of the predicted odour impacts depends on the accuracy of the estimated odour emission rates and the air dispersion modelling. The number of air samples collected as well as the intrinsic limitations of the air sampling technique and the olfactometry analysis would also affect the accuracy of odour emission rate estimation.

Given that the odour surveys were carried out in a limited number of days, the measured odour concentrations are snapshot values. However, the odour emission rates obtained from the survey were under worst case conditions with the sampling exercise carried out during days in summer season of 2010 with high ambient temperature (>30°C) and areas without odour emission measurements have emission rates derived from interpolation between two measurement points. It is believed that the estimated odour emission rates are representing hypothetical worst case conditions.

Air sampling is an important step in the process of measuring the odour concentrations of the sources, it would affect the quality and reliability of the results. All the odour sampling was carried out by the odour sampling team of Hong Kong Polytechnic University (HKPU) and Zhongshan University, which have the most extensive local experience in odour sampling. The potential error associated with odour sampling process is considered to be on the low side.

It should be noted that all the odour concentrations (in ou/m^3) and hence area source emission rate (in ou/m^2/s) were derived by olfactometry analysis conducted at HKPU and Zhongshan University in accordance with the European Standard Method (EN13725). This European Standard Method specifies a method for the objective determination of the odour concentration of a gaseous sample using dynamic olfactometry with human assessors. The detection limit for this European Standard Method is 10 ou/m^3. Yet the detection limit of this European Standard Method could vary between laboratories. Therefore, in reviewing the odour concentration results (in ou/m^3), it should be noted that a measured low odour concentration value would normally has a higher degree of error due to the inherent properties of the olfactometry analysis method.

Besides, the degree of certainty of the predicted odour impacts under mitigation scenarios would depend on the accuracy of the estimated mitigated odour emission rates. As discussed in the section related to duration and frequency of the adverse environmental impacts, the unmitigated emission rates are hypothetical worst-case condition, therefore the emission rates for the mitigated scenarios also have the assumption of modelling the hypothetical worst-case condition.

In the long term, if measures such as improvement works at tributaries of Shenzhen River and centralised sewage treatment by the Shenzhen Municipal Government are materialised according to the 12th 5-year Plan of Shenzhen Water Supplies Development, odour concentrations at key ASRs will reduce to a range from 3.5 OU to 4.7 OU, which comply with the odour criterion could be achieved.

3.10 Level of Uncertainty

3.10.1 Construction Phase – Construction Dust

Several assumptions may affect the level of uncertainty of the construction dust assessment, such as background concentration, weather condition etc. The worst case construction dust impact assessment conditions were adopted in the model. Since the air quality impact due to different construction phases will vary, the assessment identifies the worst case scenario over the entire construction phase to address the specific impacts arisen from the different work areas.

Construction dust assessment for short-term impact (i.e. 1-hour and 24-hour average) has been undertaken by a 2-Tier approach. Tier 1 screening assessment is a theoretical worst case scenario evaluation to identify hot spot areas of construction air quality impact by assuming 100% active construction area for all worksites. The identified hot spot areas have been further assessed by a more focused Tier 2 assessment to predict a more realistic worst case impact by altering the active construction areas to 30% and locating them nearest to the ASRs. Long-term impact (i.e. annual average) has been assessed with 6% active construction area for all work sites. The active construction areas used in the construction dust assessment were still overestimated for both the short-term and long-term impact assessment. In addition, as there is a decreasing trend in the concentration of pollutants measured, the 5-year average of background concentration for Year 2007 to 2011 represents the worst case scenario. Therefore, the assessment may overestimate the actual construction dust impact.

3.10.2 Operation Phase – Vehicular Emission

Several assumptions may affect the level of uncertainty of the vehicular impact assessment, such as background concentration, weather condition etc. The worst case traffic impact assessment conditions were adopted in the model. As there is a decreasing trend in the concentration of pollutants measured, the 5-year average of background concentration for Year 2007 to 2011 represents the worst case scenario. Therefore, the assessment may overestimate the actual vehicular emission impact.

3.10.3 Operational Phase – Chimney Emission

No industrial chimney was identified within 500m from the boundary of the Project on Hong Kong side and the nearest potential industrial land use on Shenzhen side is located at more than 500m away from the Project. Chimney emission impact is not anticipated.

3.10.4 Operational Phase – Odour Emission

The level of uncertainties of odour emission has been addressed in the point (x) under **Section 3.9.3**.

3.11 Conclusion

An air quality impact assessment has been conducted to evaluate the air quality impact based on the RODP and the associated infrastructure.

The fugitive dust assessment for construction has concluded that watering in all works areas once per hour during working hours would be required to control the fugitive dust impact. In addition, the Contractor is also recommended to adopt good site practices and is required to follow the procedures and requirements given in the Air Pollution Control (Construction Dust) Regulation.

Results indicate that, the predicted 1-hour and 24-hour and annual TSP concentrations at the identified ASRs would comply with the respective criteria. Hence, it is concluded that there are no adverse residual air quality impacts during construction phase.

For operational phase vehicular emission at open road and underpass, 1-hour, 24-hour and annual NO_2 and 24-hour and annual RSP would comply with the AQO. The in-tunnel NO_2 concentration would comply with the standard stated in "*Practice Note on Control of Air Pollution in Vehicle Tunnels*". Therefore, no adverse air quality impacts during operational phase from vehicular emission.

On-site STW will be equipped with odour removal system of 95% odour removal efficiency as a mitigation measure.

With the implementation of bioremediation along the section of Shenzhen River approximately 1.9km downstream and 1km upstream (i.e. approximately 4.2 km) of the Loop development at 98% odour removal efficiency, short-medium term residual impact of odour at the ASRs within the LMC Loop area were predicted. During this period, if buildings with central air conditioning in the development would be equipped with odour removal system capable of 95% removal efficiency as an interim contingency measure depending on the prevailing circumstances at the time, the residual odour impact would be reduced and the odour criterion inside all internal spaces. In the long term, with continuous improvement of Shenzhen River, the residual odour impact would be further reduced resulting odour criterion being achieved.

In order to assure the 98% odour removal efficiency along the Shenzhen River within 500m from the boundary of the study area, the relationship between AVS reduction percentage and odour removal efficiency will be established by in-situ testing during the detailed design stage. At the same time, the optimum chemical dosage and injection frequency for the bioremediation work will also be established. If the removal efficiency of bioremediation is lower than 98%, chemical dosage and frequency during bioremediation works will be increased to restore the difference.

3.12 Reference

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Figures

Appendix 3-1

Justification for the Percentage of Active Area

Appendix 3-2

Calculation of Dust Suppression Efficiency from Watering

Appendix 3-3

Details of Dust Emission Sources and Calculations

Appendix 3-4

Key Assumptions for EMFAC Modelling

Appendix 3-5

Vehicle Emission Factors for 2020 and 2027

Appendix 3-6

Detailed Calculations of In-tunnel Air Quality Assessment

Appendix 3-7

Detailed Calculations of Idling Emissions

Appendix 3-8

Odour Emission Literature Review and Reconnaissance Site Surveys

Appendix 3-9

Measurement Reports for Odour Sampling at Shenzhen River (PolyU)

Appendix 3-10

Binhe WWTP Site Inspection

Appendix 3-11

Measured Emission Rates
Adopted for Shatin STW

Appendix 3-12

Emission Rates for Odour Impact Assessment