3. AIR QUALITY

3.1 Introduction

Within the Study Area Representative Air Sensitive Receivers (ASR's) have been identified and worst case impacts on these receivers have been modelled. The findings are presented in this Section. Dust generation is a key concern during the construction phase. Vehicle emissions from open sections of the road and emissions from the tunnel and noise enclosures are the major sources of pollution during the operational phase. Mitigation measures required to protect the ASRs are recommended, where necessary, to ensure that the legislative criteria and guidelines will be satisfied.

3.2 Government Legislation and Standards

3.2.1 Environmental Impact Assessment Ordinance

The criteria for evaluating air quality impacts are laid out in *Annex 4* of the *Technical Memorandum on Environmental Impact Assessment* (TMEIA). The relevant criteria are given below.

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

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

Pollutant	Average Time			
	1 Hour [ii]	8 Hour [iii]	24 Hour [iii]	1 Year [iv]
Total Suspended Particulates (TSP)	-	-	260	80
Respirable Suspended Particulates (RSP)[v]	-	-	180	55
Nitrogen Dioxide (NO_2)	300	-	150	80
Carbon Monoxide(CO)	30,000	10,000	-	-
Photochemical Oxidants (as Ozone, O_3)[vi]	240	-	-	-

Note:
i. Measured at 298K (25°C) and 101.325 kPa (one atmosphere).
ii. Not to be exceeded more than three time per year.
iii. Not to be exceeded more than once per year.
iv. Arithmetic means.
v. Respirable Suspended Particulates means suspended particles in air with a nominal aerodynamic diameter of 10 micrometers and smaller.
vi. Photochemical oxidants are determined by measurement of ozone only.

The TMEIA also states that the hourly TSP level should not exceed 500μgm^{-3} (measured at 25°C and one atmosphere) for construction dust impact assessment. Mitigation measures from construction sites have been specified in the *Air Pollution Control (Construction Dust) Regulations*.

Under the *Air Pollution Control (Specified Processes) Regulations*, concrete batching plants with processing capacity exceeding 5000 tonnes per annum are considered to be a specified process and a license is required for the operation of such facilities.

In addition to the statutory AQO limits, the Tunnel Air Quality Guidelines (TAQG), specified under the *EPD's Practice Notes on Control of Air Pollution in Vehicle Tunnel*, 1995 should be attained and maintained inside road tunnels. *Table 3.2* presents these guideline values.

Table 3.2 Tunnel Air Quality Guidelines (TAQG)

Air Pollutant	Averaging Time	Maximum Concentration	
		(μgm^{-3})	(ppm)
Carbon Monoxide (CO)	5 minutes	115,000	100
Nitrogen Dioxide (NO_2)	5 minutes	1,800	1
Sulphur Dioxide (SO_2)	5 minutes	1,000	0.4
Note: All limits are expressed as at reference conditions of 298K and 101.325 kPa			

In addition to the foregoing, the visibility in tunnels should be controlled to a maximum level equivalent to an extinction coefficient of 0.005 m^{-1} during any 5 minute interval.

3.3 Baseline Conditions

The Route 10 (NLYLH) (Southern Section) covers the North Lantau, Tsing Lung Tau, Siu Lam and So Kwun Wat areas. The ambient air quality is dominated by vehicle exhaust emissions from the major roads including the North Lantau Highway, Tuen Mun Road and Castle Peak Road.

None of EPD's fixed monitoring stations are located near the alignment. Reference was therefore made to the background concentration of pollutants provided in the STLFS as illustrated in *Table 3.3* below:

Table 3.3 Background Air Quality (μg m^{-3}) [a]

Location	Air Pollutants	Background Concentrations (μgm^{-3})	
		1 Hour Average	24 Hour Average
North Lantau Island	TSP	-	61
	RSP	-	51
	NO_2	36	-
	CO	500	-
Tsing Lung Tau, Siu Lam and So Kwun Wat	TSP	-	53
	RSP	-	51
	NO_2	36	-
	CO	500	-
(a) Final EIA Report, Sham Tseng Link Feasibility Study, Mouchel Asia Ltd, 1998			

It is expected that the traffic flows in North Lantau, Tsing Lung Tau, Siu Lam and So Kwun Wat will increase with traffic generated by the new developments in the NWNT and traffic flow form the Shenzhen-Hong Kong Western corridor and Lingdingyang Bridge. The pollutants generated by the additional traffic trips will affect the air quality of the area. However, without Route 10 (NLYLH) traffic congestion is expected with serious deterioration in air quality.

3.4 Air Sensitive Receivers

Representative ASRs have been identified according to the criteria set out in the TMEIA and through site inspections and a review of land use plans. Domestic premises, hotel, hostel, hospital, clinic, nursery, temporary housing accommodation, school, educational institution, office, factory, shop, shopping center, place of public worship, library, court of law, sports stadium or performing arts center are classified as ASRs. ASRs and their horizontal distance from the alignment have been identified and are summarized in *Table 3.4*. Locations of the ASRs are shown in *Figures 3.1-3.5*.

Table 3.4 Air Sensitive Receivers

Section	ASR	Location	Distance from the Alignment (m)	Relative Height from the Alignment (m)
North Lantau	A1	Fa Peng	100	0
	A2	Tso Wan	160	0
Tsing Lau Tau	A3	Hong Kong Garden	250	0
	A4	Squatter Area Northwest to Hong Kong Garden	250	+20
	P1	Proposed R(C) Site	150	-30
Tai Lam Chung	A7	Correctional Institution Staff Quarters	140	-20
	A8	Correctional Institution Clinic	75	-30
	A9	Tai Lam Chung Tsuen	110	-30
	A10	Scattered Development to the West of Tai Lam Chung Road	180	-30
	A11	CDA Site to the South of Tai Lam Chung Viaduct	270	0
	A12	"V" Zone to the South of Tai Lam Chung Viaduct	110	-30
Siu Lam to So Kwun Wat	A13	Psychiatric Centre	180	0
	A14	CSD Staff Quarters at Hong Fai Road	180	+20
	A15	Village Houses at Siu Lam	250	-40

Section	ASR	Location	Distance from the Alignment (m)	Relative Height from the Alignment (m)
	A16	Home for the Aged at Siu Lam	200	-30
	P2	Planned G/IC Site	120	0
	P3	Planned CDA Site	140	0
So Kwun Wat Interchange	A17	So Kwun Wat Sun Tsuen	80	-30
	A18	So Kwun Wat Tsuen	140	-35
	A19	So Kwun Wat Lee Uk Tsuen	70	-28
	A20	Lo Tsing Shen Tsuen	40	-10
	A21	So Kwun Wat Ching Uk Tsuen	110	-30
	A22	Scattered Houses to the North of Tuen Mun Road Interchange	100	0
	A23	Scattered Houses at So Kwun Wat	30	-20
	A24	Scattered House to the West of Poseidon Court	30	+15
	A25	Correctional Institution	30	+50
	P4	PSPS Development in Area 56	50	0
	P5	R(C) Site in Area 55	10	0
	P6	Area 56 CDA Site	180	0
	P7	Area 48 Residential Site	10	0

3.5 Construction Phase

3.5.1 Potential Sources of Impact

Impacts arising from the construction of Route 10 (NLYLH) primarily relate to dust nuisance and gaseous emissions from construction plant and vehicles, with dust generation being the major concern. Reclamation, blasting, excavation, materials handling, concrete batching, stockpiling and vehicle movements on unpaved site roads are expected to be the main sources of dust. Major worksites have been identified along the alignment and shown in *Figures 2.2-2.4.* Activities to be undertaken at the worksites are discussed below and summarised in *Table 3.5.*

Advance Works

The Kwai Shek headland will be removed to form the work site for the bridge anchorage and tower under the Advance Works Contract. Blasting and excavation will be required to remove the headland, and the spoil generated will be transported away by barge. It is estimated that about 2.4Mm^3 (now reduced through refinement of preliminary design to 1.7Mm^3 however for the purposes of the assessment the volume of 2.4Mm^3 remains as a worst case assessment) of spoil will be excavated for the tower base and bridge anchorage. The nearest ASRs in North Lantau and Tsing

Lung Tau are located at more than 1km from Kwai Shek, and dust impacts at the ASRs are expected to be low.

Major Works

On North Lantau, the toll plaza will be formed by reclaiming an area of land off the headland between Tso Wan and Fa Peng. It is expected that 0.65 Mm^3 of mud will be removed at the toll plaza site. Barges will be employed for the transportation of mud and spoil off-site for re-use or disposal. A volume of 2.9 Mm^3 of spoil material will be required for filling and sea wall construction. The marine mud and fill materials will contain high moisture content and dust emission from the site will be limited.

At Tsing Lung Tau, three work sites have been identified for the Tsing Lung Bridge anchorage and tunnel construction. The area to the west of Grand Bay Villa will be reclaimed as a worksite (*Figure 2.3*) to facilitate the construction of the northern tower of the Tsing Lung Bridge. A concrete batching plant is expected to be in operation at this worksite.

The Tai Lam Chung Tunnel will be excavated by the drill and blast method over a period of 115 weeks with 0.5 Mm^3 of spoil being generated. Two possible worksites, the southern portal area in Tsing Lung Tau and the northern portal area in Tai Lam Chung have been identified for the tunneling works (*Figures 2.3 & 2.4*). In Tsing Lung Tau, the excavated spoil from the tunnel will be transported away by means of conveyor belt to the reclaimed area for onward transport by barge. A small stockpile is expected near the tunnel portal to facilitate the operations. In view of the heavy flow of traffic on the Tuen Mun Road and Castle Peak Road, the conveyor belt will be completely enclosed to avoid falling rock or spoil and to minimise dust emissions.

At the northern portal in Tai Lam Chung, about 1,000 m^3 of spoil will be excavated per day and transported off-site by truck. It is expected that the road will be paved to reduce dust emissions.

Batching plants, rock crushers and stockpiles may be required for the worksites at the tunnel portals.

Cutting and blasting will be required to form the slope at Siu Lam. The 1.1 Mm^3 of excavated spoil from the Siu Lam cutting will be stored on site in stockpiles or transported away by means of conveyor belt. The conveyor belt will be completely enclosed to avoid falling rock or spoil and to minimise dust emissions.

The So Kwun Wat interchange is mainly on viaduct. Roadwork construction including cutting, filling and material handling will be the major construction activities in the area.

SO_2 and NO_2 will be emitted from the diesel-powered mechanical equipment. However, since the amount of such plant will be limited, gaseous emissions are expected to be minor and no exceedance of the AQO is expected.

Radon gas would also be emitted from soils and rocks, particularly granite. However, as tunnel ventilation requirements will address this issue from a health and safety perspective, no adverse impact from radon gas is expected.

Table 3.5 Construction Activities at the Major Worksites

Worksite Area	Major Construction Activities
Advance Works	
Kwai Shek	• excavation for Tsing Lung Bridge anchorage • blasting and excavation • truck haulage
Major Works	
North Lantau	• reclamation of Toll Plaza
Tsing Lung Tau	• reclamation • blasting and excavation for Tsing Lung Bridge anchorage • concrete batching • blasting and excavation of Tai Lam Chung Tunnel • stockpile of excavated spoils • material handling
Tai Lam Chung	• blasting and excavation Tai Lam Chung Tunnel • stockpile of excavated spoils • haulage of trucks over paved roads
Siu Lam	• material handling • stockpile of excavated spoils • blasting
So Kwun Wat	• roadwork construction

3.5.2 Assessment Methodology

Dust impacts have been predicted using the USEPA approved model *Fugitive Dust Model* (FDM) and the latest construction programme. Meteorological data for 1997 from Tsing Yi weather station, operated by Hong Kong Observatory, were employed for the model run to simulate 1-hour and 24-hour averaged TSP concentration at the ASRs. Emission factors and the associated particle size distributions were obtained from the *Compilation of Air Pollutant Emission Factors, (AP42) 5th Edition* developed by *USEPA*. The emission factors used in the assessment for each worksite are listed in *Table 3.6*.

Table 3.6 Emission Factors for Construction Activities at the Major Worksites

Worksite Area	Activity	Emission Rate [1]	Remarks
Advance Works			
Kwai Shek	Material Handling	1.85 g Mg^{-1}	• maximum 225,000 m^3 per month • moisture content: 0.7%
	Wind Erosion	0.85 Mg $hectare^{-1}$ yr^{-1}	
	Blasting [2]	0.00022$A^{1.5}$ kg $blast^{-1}$	• A = horizontal area • 2 blasts per day
Major Works			
North Lantau	Material Handling	4.7 x 10^{-3} g Mg^{-1}	• moisture content: 50% • maximum 200,000 m^3 spoil per month
	Wind Erosion	0.85 Mg $hectare^{-1}$ yr^{-1}	
	Road Construction	3.89 x 10^{-5} g s^{-1} m^{-2}	• 30% of the site is active
Tsing Lung Tau	Material Handling	1.85 g Mg^{-1}	• moisture content: 0.7% • 1000 m^3 per day
	Wind Erosion	0.85 Mg $hectare^{-1}$ yr^{-1}	
	Blasting	0.00022$A^{1.5}$ kg $blast^{-1}$	• A = horizontal area • 2 blasts per day per tunnel
	Batching Plant	0.164 kg Mg^{-1}	• capacity: 100 m^3hr^{-1}
	Stone Crushing Plant	1.2 g Mg^{-1}	• 1000 m^3 per day
	Screening for Crushing Plant	7.6 g Mg^{-1}	• 1000 m^3 per day
Tai Lam Chung and Siu Lam	Blasting	0.00022$A^{1.5}$ kg $blast^{-1}$	• A = horizontal area • 2 blasts per day per tunnel
	Batching Plant	0.164 kg Mg^{-1}	• capacity: 100 m^3hr^{-1}
	Material Handling	1.85 g Mg^{-1}	• moisture content: 0.7% • 200,000 m^3 spoil per month
	Wind Erosion	0.85 Mg $hectare^{-1}$ yr^{-1}	
	Truck Haulage	1.94 x 10^{-3} g m^{-1} s^{-1}	• no of truck: 20 veh hr^{-1} • silt content: 10% • vehicle speed: 30 km hr^{-1} • vehicle weight: 25 Mg
	Stone Crushing Plant	1.2 g Mg^{-1}	• 200,000 m^3 spoil per month
	Screening for Crushing Plant	7.6 g Mg^{-1}	• 200,000 m^3 spoil per month
Siu Lam	Material Handling	1.85 g Mg^{-1}	• moisture content: 0.7% • 100,000 m^3 spoil per month
	Blasting	0.00022$A^{1.5}$ kg $blast^{-1}$	• A = horizontal area • 2 blasts per day
	Wind Erosion	0.85 Mg $hectare^{-1}$ yr^{-1}	

Worksite Area	Activity	Emission Rate (1)	Remarks
So Kwun Wat	Road Construction	3.89×10^{-5} g s^{-1} m^{-2}	• assume 30% of the site is active
Notes : (1) from Compilation of Air Pollutant Emission Factors, USEPA, (AP-42) 5th Edition (2) blasting will not be carried out concurrently with other activities			

It is expected that the above construction works will generally be carried out during daytime. However, the bridge and tunnel construction will require night-time working.

3.5.3 Evaluation of Impact

Construction dust impacts were modelled using the *Fugitive Dust Model* (*FDM*) with worst case assumptions as input data, and at ground level. Predicted hourly and daily TSP concentrations at the ASRs are shown in *Table 3.7* below:

Table 3.7 Predicted Hourly and Daily TSP Concentrations (μgm^{-3}) (a)

Area	ASRs	Location	Average Hourly TSP Level	Average Daily TSP Level
Major Works				
North Lantau	A1	Fa Peng	170	92
	A2	Tso Wan	204	101
Tsing Lung Tau	A3	Hong Kong Garden	**679** (b)	96
	A4	Squatter Area Northwest to Hong Kong Garden	**771**	145
Tai Lam Chung	A7	Correctional Institution Staff Quarters	**1481**	**470**
	A8	Correctional Institution Clinic	**2799**	**623**
	A9	Tai Lam Chung Tsuen	**1635**	**378**
	A10	Scattered Development to the West of Tai Lam Chung Road	**1685**	**306**
	A11	CDA Site to the South of Tai Lam Chung Viaduct	**1477**	**411**
	A12	"V" Zone to the South of Tai Lam Chung Viaduct	**1592**	**376**

Area	ASRs	Location	Average Hourly TSP Level	Average Daily TSP Level
Siu Lam to So Kwun Wat	A13	Psychiatric Center	278	113
	A14	CSD Staff Quarters at Hong Fai Road	324	141
	A15	Village Houses at Siu Lam	**719**	**270**
	A16	Home for the Aged at Siu Lam	**526**	221
So Kwun Wat Interchange	A17	So Kwun Wat Sun Tsuen	**814**	**303**
	A18	So Kwun Wat Tsuen	399	160
	A19	So Kwun Wat Lee Uk Tsuen	502	219
	A20	Lo Tsing Shen Tsuen	411	214
	A21	So Kwun Wat Ching Uk Tsuen	**616**	246
	A22	Scattered Houses to the North of Tuen Mun Road Interchange	**675**	**289**
	A23	Scattered Houses at So Kwun Wat	**984**	**394**
	A24	Scattered House to the West of Poseidon Court	**725**	**305**
	A25	Correctional Institution	**696**	241
	Dust Criteria		**500**	**260**

(a) Background TSP concentration included in the results.
(b) Bold figure exceeds dust criteria.
(c) ASRs P1 - P7 are planned receivers and no construction impacts expected.

Advance Works

At North Lantau, the ASRs are located at least 100 m from the worksite and maximum dust levels of 204 μgm^{-3} (hourly average) and 101 μgm^{-3} (daily average) have been predicted at the ASRs, which are well within the dust criteria. The Kwai Shek worksite is located at more than 1 km from the receivers and dust impact on the ASRs are thus expected to be low.

Major Works

At Tsing Lung Tau, dust levels are predicted to be high due to the extensive earthwork and construction activities, and the close proximity of the ASRs to the worksites. The hourly TSP concentration ranges from 679-771 μgm^{-3}, and the daily concentration from 96-145 μgm^{-3}.

In Tai Lam Chung, the hourly TSP concentration ranges from 1477-2799 μgm^{-3}, and the daily concentration from 306-623 μgm^{-3} have been predicted. Also, the proximity of the haul road to the ASRs, including Tai Lam Chung Tsuen (A9) and the Correctional Institution Clinic (A8), and the high volume of haul road traffic (20 vehicles per hour) in the area also contribute to the high dust levels at the ASRs. The concrete batching plant in Tai Lam Chung is also the major source of dust in the area.

For Siu Lam area, blasting and material handling operations associated with Siu Lam Cutting would generate hourly TSP levels at 278-719 μgm^{-3}, and daily TSP between 113-270 μgm^{-3}.

For the construction of So Kwun Wat and Siu Lam Link Roads, dust generating activities associated with construction of the alignment would result in hourly dust levels of 399-984 μgm^{-3} with daily dust levels of 160-394 μgm^{-3} predicted at the ASRs.

It is predicted that the guidelines for dust at the Tsing Lung Tau, Tai Lam Chung and So Kwun Wat area would be exceeded at some receivers. Dust suppression measures are recommended to reduce emissions from the site to ensure the criteria would not be exceeded.

3.5.4 Recommended Mitigation Measures

At some ASRs along the alignment, in Tsing Lung Tau, Tai Lam Chung, Siu Lam and So Kwun Wat, it is expected that dust levels would exceed the specified criteria and thus dust control measures are required. Dust control measures as outlined in the *Air Pollution Control (Construction Dust) Regulation* are recommended to reduce dust impacts to within the acceptable levels arising from the works:

- where breaking of rock/concrete is required, watering should be implemented to suppress dust generation;
- water spray should be used during the handling of excavated and fill material where dust is likely to be created;
- the height from which excavated materials are dropped should be controlled to a minimum practical height to limit fugitive dust generation from unloading;
- all dusty materials should be sprayed with water immediately prior to any loading, unloading or transfer operation so as to maintain the dusty materials wet;
- any stockpiles of aggregate or spoil should be covered and water applied;
- the haul road should be located away from sensitive receivers with vehicle speed limited to 20 kph,
- every vehicle should be washed to remove any dusty materials from its body and wheels before leaving a construction site;
- the load on the vehicles should be covered entirely by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle; and

- the working area of any excavation should be sprayed with water before, during and immediately after the operation so as to maintain the entire surface wet.

The following control measures are recommended during blasting:

- the areas within 30 m of the blasting area shall be wetted with water prior to blasting;
- wire mesh, gunny sacks and sandbags should be used on top of the blast area at each shot to prevent flying rock and dust;
- water the surface of the blast area to increase its moisture content; and
- dust filters should be fitted to the tunnel construction ventilation systems.

According to the EPD's *Best Practicable Means Requirements for Cement Works (Concrete Batching Plant)*, the following mitigation measures are required for concrete batching plants:

- the loading, unloading, handling, transfer or storage of cement, pulverised fuel ash or other equally dusty materials should be carried in a enclosed system;
- all dust-laden air or waste gas generated by the process operations should be properly extracted and vented to fabric filtering system;
- cement, pulverised fuel ash or other equally dusty materials should be stored in storage silos fitted with audible high level alarms to warn of over-filling. The high-level alarm indicators shall be interlocked with the material filling line;
- vents of all silos and weighing scales shall be fitted with fabric filtering system; and
- seating of pressure relief valves of all silos shall be checked, and the valves reseated if necessary, before each delivery.

If stone crushing plant is deployed on site it should comply with EPD's *Notes on Best Practicable Means Requirements for Mineral Works (Stone Crushing Plants)* and a licence will be required for its operation. The following control measures are required for a stone crushing plant and screens:

- the outlet of all primary crushers, and both the inlet and outlet of all secondary and tertiary crushers should be enclosed and ducted to a dust extraction and collection system such as a fabric filter;
- the inlet hopper of the primary crushers should be enclosed on top and three sides to contain the emissions during dumping of rocks from trucks. The rocks, while still on the trucks, should be wetted before dumping;
- water sprayers should be installed and operated in strategic locations at the feeding inlet of crushers;

- crusher enclosures should be rigid and be fitted with self-closing doors and close-fitting entrances and exits. Where conveyors pass through the crusher enclosures, flexible covers should be installed at entries and exits of the conveyors to the enclosure;

- all vibratory screens should be totally enclosed in a housing. Screenhouses should be rigid and reasonably dust tight with self-closing doors or close-fitted entrances and exits. Where conveyors pass through the screenhouse, flexible covers should be installed at entries and exits of the conveyors to the housing. Where containment of dust within the screenhouse structure is not successful then a dust extraction and collection system should be provided; and

- particulate concentration at the exhaust outlet of the dust collectors should not exceed 50 mgm^{-3}.

Through the implementation of the above mitigation measures, dust levels can be reduced. It is estimated that a 50% reduction in dust levels would be achieved for material handling, road construction and vehicle movements, with a 30% reduction during blasting with the introduction of frequent surface watering and compacting on active areas on the site. A 90% reduction in dust levels can be achieved from concrete batching by following the requirements of the *BPM Notes for Concrete Batching Plant.* Also about 80% dust reduction for stone crushing and screening can be achieved by following dust suppression measures from the *BPM Notes for Stone Crushing Plant.* The predicted mitigated hourly and daily TSP levels at ground level are shown in *Table 3.8.*

Table 3.8 Mitigated Hourly and Daily TSP Concentrations (μgm^{-3}) [a]

Area	ASRs	Location	Hourly TSP Level	Daily TSP Level
Major Works				
North Lantau	A1	Fa Peng	96	73
	A2	Tso Wan	114	76
Tsing Lung Tau	A3	Hong Kong Garden	150	63
	A4	Squatter Area Northwest to Hong Kong Garden	161	69
Tai Lam Chung	A7	Correctional Institution Staff Quarters	279	109
	A8	Correctional Institution Clinic	434	127
	A9	Tai Lam Chung Tsuen	346	111
	A10	Scattered Development to the West of Tai Lam Chung Road	356	141
	A11	CDA Site to the South of Tai Lam Chung Viaduct	410	210

Area	ASRs	Location	Hourly TSP Level	Daily TSP Level
	A12	"V" Zone to the South of Tai Lam Chung Viaduct	456	197
Siu Lam to So Kwun Wat	A13	Psychiatric Center	140	79
	A14	CSD Staff Quarters at Hong Fai Road	172	94
	A15	Village Houses at Siu Lam	259	135
	A16	Home for the Aged at Siu Lam	223	122
So Kwun Wat Interchange	A17	So Kwun Wat Sun Tsuen	362	162
	A18	So Kwun Wat Tsuen	165	93
	A19	So Kwun Wat Lee Uk Tsuen	224	124
	A20	Lo Tsing Shen Tsuen	195	124
	A21	So Kwun Wat Ching Uk Tsuen	275	138
	A22	Scattered Houses to the North of Tuen Mun Road Interchange	333	163
	A23	Scattered Houses at So Kwun Wat	484	214
	A24	Scattered House to the West of Poseidon Coast	319	164
	A25	Correctional Institution	293	136
	Dust Criteria		**500**	**260**

Notes:
(a) Background TSP concentration included in the results.

In Tai Lam Chung, the mitigated dust level at the Correctional Institution Clinic (A8) has been reduced by 85% mainly by dust suppression measures for the concrete batching plant. The predicted results show that with the inclusion of mitigation measures dust levels at all ASRs will comply with both the hourly and daily dust criteria.

3.5.5 Residual Impacts

There are no residual impacts predicted associated with the construction of Route 10 (NLYLH) (Southern Section) for either the Advance Works or the Major Works packages.

3.5.6 EM&A Requirement

Full compliance with the dust criteria will be achieved at all ASRs with the implementation of mitigation measures. Dust monitoring is recommended to ensure that the dust levels do not exceed the criteria during the construction phase. EM&A locations and requirements are discussed in Section 13 and the EM&A Manual.

3.6 Operational Phase

3.6.1 Potential Source of Impact

Vehicular exhaust emissions from open road sections are one of the major air pollutant sources during the operation of the Route 10 (NLYLH). In addition, pollutants accumulated inside the Tai Lam Chung Tunnel and the proposed noise enclosures at So Kwun Wat and Siu Lam will be emitted and dispersed via portals and will affect the air quality. It is expected that the tunnel air will be emitted horizontally under the action of jet fans. Ventilation buildings located at both portals will be used to supply fresh air to the tunnels, and no exhaust gas will be emitted into the atmosphere via the ventilation buildings. The design of the ventilation system will ensure that the TAQG are met within the tunnel.

Low levels of radon gas may be released from the granite in the tunnel and road users could potentially be affected. However, tunnel ventilation will ensure that adverse impacts from radon gas is not a problem.

3.6.2 Assessment Methodology

Open Road Section

The USEPA approved air dispersion model, *CALINE4* was used to predict the pollutant levels of NO_2, RSP and CO from the open section of Route 10 (NLYLH). The hourly average of pollutants at two affected heights, the ground and alignment levels, were modelled in the assessment to take account of elevation and those ASR's which are high rise buildings.

Fleet emission factors based on the EUROIII criteria have been used for this assessment. Emission factors beyond 2011 are not available and 2011 vehicle emission factors were therefore assumed for traffic beyond 2011. It is however believed that emission rates beyond 2011 will be lower than 2011 as more stringent controls will be put in place and more vehicles will be fitted with advanced emission control systems. The predicted results are therefore believed to be conservative.

Peak PM hourly traffic flows within 15 years after the operation of Route 10 (NLYLH) (2011, 2016 & 2022) have been predicted and details are contained within the Traffic Impact Assessment Report. Comparison of vehicle emission for different scenario years have been conducted and are shown in *Table 3.9*. Year 2022 traffic flows produce the highest level of pollutant and thus this data has been used in the assessment as the worst case scenario.

Table 3.9 Worst Case Traffic Flow

Year	Traffic Flow (veh hr^{-1})	Estimated Total Emission (g km^{-1} hr^{-1})		
		NOx	CO	RSP
2011	8490	17415	34174	1967
2016*	8690	18456	35885	2117
2022*	9780	19989	39471	2259
* estimated figure based on 2011 emission rate				

Peak hour traffic will occur during the daytime and the worst case scenario of neutral meteorological conditions was assumed in the model run. Typical input parameters for the model are listed below:

- wind speed $1 ms^{-1}$;
- wind direction worst case for each receivers;
- stability class D;
- mixing height 500 m;
- standard deviation of wind direction 18.6 degree;
- surface roughness 110 cm; and
- temperature $25^{0}C$.

The NO_x gas is assumed to be inert and levels of NO_2 were taken as 20% of total NO_x emissions.

Portal Emissions

Portal emissions were assessed based on the procedures stated in Section III of the *Permanent International Association of Road Congresses (PIARC), 1991.* It has been assumed that emissions will emerge as an air jet which will keep to the axis of the road so that only well diluted parts gradually shear off. It was assumed that the pollutant would disperse first as an air jet and then as a plume [1]. The empirical formulae developed by Ukeguchi[2] and Larssen[3] were employed for assessing the dispersion of tunnel portal jet. It is estimated that the transition between jet and plume phases would take place at 160 m from the portal.

It is assumed that the portal jet will be discharged at a velocity of 8 ms^{-1} and ventilation rate of 1000 m^3s^{-1} under the action of jet fans. It is assumed that the worst case emission of NO_2 from the tunnel is 1,800 μgm^{-3} and for CO is 115,000 μgm^{-3}, as specified *EPD's Practice Notes on Control of Air Pollution in Vehicle Tunnel*, 1995.

Worst case daytime neutral meteorological conditions of stability class D and wind speed of 1 ms^{-1} at the worst case wind angle blowing directly onto the receivers have been used to simulate the worst case short-term impacts on the ASRs.

The conversion of NO_x to NO_2 was assumed to be 10% inside tunnels and 20% outside.

(1) Permanent International Association of Road Congresses in the publication "Road Tunnels - XIX th World Road Congress, 1991"

(2) Ukeguchi N. et al, Prediction of Vehicular Emission Pollution around a Tunnel Month, Proceedings 4th International Clean-air Congress Tokyo, 1977.

(3) Larseen S, Car Exhaust Emission and Dispersion from Tunnel Portal in Oslo, Norway, OECD Seminar on Road Tunnels, 1990.

Emissions from Noise Enclosures

Five full enclosures have been proposed along the alignment at So Kwun Wat and Siu Lam in Section 4.64 (see *Figure 4.14 & 4.16*) to protect the noise sensitive receivers. There are two full enclosures on the So Kwun Wat Link Road, one on Road LR2 and two on the Siu Lam Link Road, all with uni-directional traffic. The *ISCST3* air dispersion model was used to predict the portal emissions from these noise enclosures. The portal emissions were assessed based on the procedures stated in Section III of PIARC, 1991 and portal air plumes of 100m have been assumed along the axis of roads with only well diluted parts gradually becoming sheared off. Meteorological data for 1997 from the Hong Kong Observatory's Tsing Yi weather station were employed for the model run. The emission rates for NO_2, CO and RSP have been calculated based on the peak hour traffic flow as given in *Table 3.10* below:

Table 3.10 Portal Emission Rate Calculation For Noise Enclosure

Enclosures	So Kwun Wat Link Road	Siu Lam Link Road		
	EB	LR2	NB	SB
Length of Enclosure (m)	230	230	230	230
Peak Hourly Traffic Flow (veh/hr)	3260	1640	2210	2130
Fleet Emission of NO_x (g/km/veh)	2.06	2.05	2.18	2.39
Total NO_x Emission Rate (g/s)	0.43	0.21	0.31	0.33
Fleet Emission of CO (g/km/veh)	4.04	4.03	4.24	4.48
CO Emission Rate (g/s)	0.84	0.42	0.6	0.61
Fleet Emission of RSP (g/km/veh)	0.23	0.23	0.25	0.29
RSP Emission Rate (g/s)	0.048	0.024	0.035	0.07
Notes: (i) The emission rate is calculated from fleet emission factors based on year 2011 of EURO III. NO_2 emission rate is assumed to be 20% of the total NO_x emission.				

The two enclosures on the So Kwun Wat Link Road are separated by a 50 m open road with 5 m vertical barriers on both sides and the plume from the first enclosure is therefore assumed to be 5 m elevated.

Emissions from Toll Plaza

Greater volumes of pollutants may be emitted at North Lantau due to acceleration/deceleration and idling operations of vehicles at the Toll Plaza. The *ISCST3* air dispersion model was used to predict the emission from the Toll Plaza. Area source of 680m x 110m (area of Toll Plaza) was input into the model. Meteorological data for 1997 from the Tsing Yi weather station were employed for the model run. Vehicle idling emission factors provided by EPD were used as average emission factors for the vehicle operations and are shown in *Table 3.11* below. The levels of NO_2 were taken as 20% of total NO_x emissions. RSP emission is considered negligible as referenced to AP42 RSP emission factor for heavy-duty diesel engines (0.043 g/min-veh) developed by the USEPA and was therefore not included in the assessment.

Table 3.11 Vehicle Idling Emission Factors (g/min-veh)

Pollutants	PLB, LGV	Bus, MGV, HGV	Taxi	Private Car
NO_x	0.5	2.0	0.5	0.2
CO	0.3	2.0	0.3	4.0

3.6.3 Evaluation of Impacts

Open Section of Road

Vehicular emissions from open sections of the road are one of the major sources of pollutants and will mainly affect air quality at lower levels. Pollutant levels at the two worst affected heights, ground and at the elevated alignment level, have been modelled and the results are presented in *Table 3.12*. Both the existing and planned road networks have been included in the model.

Table 3.12 Predicted Hourly Air Quality Impacts from Open Road ($\mu g/m^3$)

ASR	Predicted Hourly Concentration (i)					
	Ground Level			Alignment Level		
	NO_2	CO	RSP (ii)	NO_2	CO	RSP (ii)
A1 (iii)	104	1190	67	-	-	-
A2 (iii)	77	960	61	-	-	-
A3	92	1075	70	89	960	69
A4	153	1535	84	145	1535	82
A7 (iii)	81	960	67	-	-	-
A8 (iii)	104	1190	73	-	-	-
A9 (iii)	96	1075	71	-	-	-
A10 (iii)	70	845	64	-	-	-
A11	62	730	63	62	730	63
A12	89	960	69	-	-	-
A13	126	1305	72	126	1305	72
A14	96	1075	65	96	1075	65
A15 (iii)	134	1420	74	-	-	-
A16	104	1190	67	-	-	-
A17 (iii)	119	1305	71	-	-	-
A18 (iii)	77	960	61	-	-	-
A19 (iii)	107	1190	67	-	-	-
A20 (iii)	104	1190	66	-	-	-
A21 (iii)	107	1190	68	-	-	-
A22	175	1765	83	168	1765	80
A23	183	1880	85	171	1765	81
A24	209	2110	92	201	1995	90
A25	186	1880	87	175	1765	83
P1	47	615	60	47	615	59
P2	168	1765	82	160	1765	80
P3	138	1420	75	134	1420	73
P4	156	1650	78	153	1535	77
P5	126	1305	72	122	1350	71

ASR	Predicted Hourly Concentration (i)					
	Ground Level			Alignment Level		
	NO_2	CO	RSP (ii)	NO_2	CO	RSP (ii)
P6	190	1880	86	183	1880	84
P7	198	1995	88	175	1765	82
Criteria	**300**	**30,000**	**180**	**300**	**30,000**	**180**

Notes:
(i) Background pollutants concentration included in the results
(ii) Predicted daily concentration
(iii) Receivers with height less than alignment level and only concentration at ground level was predicted

Full compliance with the AQO's is expected at all the ASRs for the hourly scenario. On Lantau, the receivers are located at the same level as the alignment, and the maximum NO_2 concentration is predicted to be 104 μgm^{-3} at Fa Peng (A1).

At Tsing Lung Tau, only the Hong Kong Garden (A3) and the Squatter Area northwest of Hong Kong Garden (A4) will be at the same elevation as the highway. A maximum NO_2 concentration of 164 $\mu gm^{-3}$is predicted at ground level. At Siu Lam, the concentration predicted at ground level and the elevation of the alignment are similar. The maximum NO_2 concentration is 168 μgm^{-3} at the planned G/IC site (P2).

For the So Kwun Wat area, the maximum NO_2 concentration predicted is 198 μgm^{-3} at Area 48 Residential Site (P7) and 209 μgm^{-3} at the scattered houses to the West of Poseidon Coast (A24), due to the emissions from vehicles using both the Tuen Mun and Castle Peak Roads.

Interpretation of the model results indicates that there will be no adverse air quality impacts associated with the open sections of the route. However, pollution loads will be emitted from the tunnel portals and noise enclosures. Greater volumes of pollutants may also be emitted at North Lantau due to acceleration/deceleration and idling operations of vehicles at the Toll Plaza. Cumulative impacts from both open road and emissions from tunnels, enclosures, and the Toll Plaza are discussed in the following sections.

Tunnel Portal Emission

Tunnel vehicle exhaust is discharged at the southern portal at Tsing Lung Tau and northern portal at Tai Lam Chung. Concentrations of NO_2 and CO at various distances from the tunnel portals have been calculated at the alignment level and the results are shown in *Figures 3.6 & 3.7.*

The dispersion of pollutants with respect to height follows the principles of Gaussian dispersion and typical correction factors are shown in *Table 3.13.*

Table 3.13 Correction Factors with Height at Different Downwind Distances

Relative Height (m)	100 m	200 m	300 m
+60	1×10^{-25}	8.8×10^{-8}	0.0003
+40	8×10^{-12}	0.0007	0.028
+20	0.002	0.16	0.4
+10	0.2	0.64	0.8
0	1	1	1
-10	0.2	0.64	0.8
-20	0.002	0.16	0.4
-40	8×10^{-12}	0.0007	0.028
-60	1×10^{-25}	8.8×10^{-8}	0.0003

The effects of portal emissions on ASR's at the roof and alignment levels in Tsing Lung Tau and Tai Lam Chung are shown in *Table 3.14*.

Table 3.14 Predicted Pollutant Concentration from Portal at ASRs (i)

ASR	NO_2 Concentration (μgm^{-3})		CO Concentration (μgm^{-3})		RSP Concentration (μgm^{-3})	
	Roof Level	Alignment Level	Roof Level	Alignment Level	Roof Level	Alignment Level
Tsing Lung Tau						
A3	- (ii)	82	3	2632	-	13
A4	31	53	976	1701	5	8
P1	-	131	-	4170	-	21
Tai Lam Chung						
A7	-	206	-	6590	-	33
A8	-	451	-	14406	-	72
A9	-	276	-	8799	-	44
A10	-	122	-	3908	-	19
A11	-	108	-	3455	-	17
A12	-	307	-	9816	-	49

Note:
(i) Background level and vehicle exhaust emissions from surrounding roads not included in the prediction.
(ii) Negligible concentration

Figures 3.6 & 3.7 show that the concentration of pollutant drops exponentially to 1/3 of original concentration during the jet dispersion phase. Following this, in the plume phase, the concentration of pollution will gradually decline. Although ASRs A8 and A12 are predicted to be affected by a high concentration of NO_2 at the alignment level, as their receiver heights are below the alignment level, adverse air quality impacts at these ASRs is not expected.

Emission from Enclosures

Full enclosures have been proposed along the highway at So Kwun Wat and Siu Lam in Section 4.64 to protect the noise sensitive receivers. Pollutant level at the nearby ASRs at the worst affected height, which is the elevated alignment level, were modelled and the results are presented in *Table 3.15*.

Table 3.15 Predicted Pollutants Levels from Noise Enclosures

ASRs	Hourly NO_2 Concentration (μgm^{-3})	Hourly CO Concentration (μgm^{-3})	Daily RSP Concentration (μgm^{-3})
A13	31	306	2
A14	43	417	2
A15	48	472	3
A16	36	355	2
A17	60	592	2
A18	71	698	3
A19	97	957	4
A20	95	931	4
A21	49	475	1
A22	67	662	3
A23	78	762	6
A24	40	391	3
A25	78	762	6
P2	52	508	3
P3	43	425	3
P4	56	547	4
P5	57	557	11
P6	59	581	9
P7	72	706	4

Note:
(i) Background level and vehicle exhaust emissions from surrounding roads not included in the prediction.

Emissions from Toll Plaza

Emissions from the acceleration/deceleration and idling operations may generate greater volume of pollutants. The predicted pollutants concentration at the ASRs in North Lantau are shown in *Table 3.16* below:

Table 3.16 Predicted Hourly Pollutants Concentration from the Toll Plaza

ASRs	NO_2 Concentration (μgm^{-3})	CO Concentration (μgm^{-3})
A1	79	996
A2	60	786

Notes:
(i) Background level and vehicle exhaust emissions from surrounding roads not included in the prediction.

3.6.4 Cumulative Impacts

The cumulative impacts of NO_2 and CO from open roads, portal emission and Toll Plaza of Route 10 (NLYLH) are shown in *Table 3.17*.

Table 3.17 Cumulative Hourly Pollutants Concentration ($\mu g/m^3$)

ASRs	Cumulative Hourly Concentration (i)					
	Ground Level			Alignment Level		
	NO_2	CO	RSP (iii)	NO_2	CO	RSP (iii)
A1 (ii)	180	2186	67	-	-	-
A2 (ii)	138	1746	61	-	-	-
A3	92	1078	70	171	3592	82
A4	153	2511	89	198	3236	90
A7 (ii)	81	960	67	-	-	-
A8 (ii)	104	1190	73	-	-	-
A9 (ii)	96	1075	71	-	-	-
A10 (ii)	70	845	64	-	-	-
A11	62	730	63	170	4185	80
A12 (ii)	89	960	69	-	-	-
A13	180	1807	77	180	1807	77
A14	139	1492	68	139	1492	67
A15 (ii)	182	1892	76	-	-	-
A16	140	1545	70	140	1545	69
A17 (ii)	179	1897	73	-	-	-
A18 (ii)	148	1658	64	-	-	-
A19 (ii)	205	2147	71	-	-	-
A20 (ii)	199	2121	70	-	-	-
A21 (ii)	157	1675	69	-	-	-
A22	243	2427	86	235	2427	84
A23	260	2642	91	249	2527	88
A24	267	2646	97	259	2531	97
A25	264	2642	93	253	2527	89
P1	47	615	60	178	4785	80
P2	219	2273	84	212	2273	83
P3	181	1845	78	177	1845	76
P4	212	2197	82	209	2082	81
P5	183	1862	83	179	1862	82
P6	250	2461	95	242	2461	93
P7	270	2701	92	247	2471	86

Notes:
(i) Background pollutant concentrations included in the results.
(ii) Receivers with height less than alignment level.
(iii) RSP levels for portal emission is negligible and included in the table.

The cumulative hourly NO_2, CO and RSP concentrations from the open roads and portal emissions show full compliance with the AQO's at all ASRs. Conservative approaches have been used to calculate the cumulative impacts from the open roads and portal emissions. Compliance with the AQO's has been demonstrated at all ASR's. A high value of CO has been predicted, however it is still within the hourly AQO criteria of 30,000 $\mu g/m^3$ (less than 16%), while the NO_2 comprises 90% of AQO for this worst case scenario.

Isopleths of the critical pollutant (NO_2) at both alignment ground levels are shown in *Figures 3.8-3.13*. It is shown that the NO_2 concentration within 300 m from the portals will exceed the AQO. However, as the affected ASRs are low rise developments and are well separated from the portal, predicted concentrations at the ASRs will comply with the AQO criteria.

3.6.5 Residual Impacts

There are no residual impacts associated with the operation.

3.6.6 EM&A Requirement

Monitoring of the pollutants concentrations inside the tunnel will be required to ensure the compliance of the TAQG. Monitoring requirements are described in Section 13 and the EM&A Manual.

3.7 Conclusions

3.7.1 Construction Phase

Dust will be the major pollutant during the construction of Route 10 (NLYLH). Site clearance, ground excavation, materials handling, blasting, concrete batching, stone crushing and vehicle movements on haul roads are expected to be the major dust sources. Air quality impacts during construction were assessed, and dust levels are predicted to be high near the Tsing Lung Tau and Tai Lam Chung worksites. Mitigation measures in accordance with the *APCO (Construction Dust) Regulation, Notes on BPM Requirements for Cement Works (Concrete Batching Plant)* and *Notes on Requirements on Stone Crusher* have been recommended to reduce the dust impacts and with the implementation of such measures it has been concluded that the dust criteria will be satisfied at all ASRs. Environmental monitoring and audit of dust should also be conducted to ensure that the dust criteria will not be exceeded.

3.7.2 Operational Phase

Vehicle exhaust from open sections of road and portal emissions from tunnels and noise enclosures are the major pollution sources during the operation of Route 10 (NLYLH). Air quality modeling has been carried out to assess their impacts from the open road and portals of the alignment as well as emission from the Toll Plaza. The cumulative impact at all ASRs will satisfy the AQO requirements. Monitoring of the air pollution concentrations inside the tunnel will be required to ensure compliance with the TAQG.