2.3 Assessment Methodology

2.3.1 Air quality impact assessment for this EIA Study follows the criteria and guidelines as stated in Annexes 4 and 12 of the EIAO-TM together with other relevant legislation, policies, and guidelines.

2.3.2 *Construction Phase Impact Assessment*

Air Quality Assessment Points

2.3.2.1 Representative existing and planned air quality sensitive receivers in the proximity of SEKD were selected for this air quality impact assessment and are summarised in **Table 2.6** below. Locations of the selected existing and planned air quality sensitive receivers are shown in **Drawing No. 22936/EN/338**. The planned development within 500m from SEKD are shown in **Drawing Nos. 22936/EN/276 A to D**.

Table 2.6 Selected Existing and Planned Air Quality Sensitive Receivers

ASR	Description
1	Laguna Verde
2	Hilder Centre
3	APB Centre
4	Bailey Garden
5	Holy Carpenter Primary School
6	Proposed residential development along Yuk Yat Street
7	Wei Chien Court
8	Merit Industrial Centre / Proposed residential development
9	The HK Society for the Blind - Workshop & Hostel / Proposed CDA development
10	Proposed CDA development along Sung Wong Toi Road
11	Parc 22
12	SKH Holy Trinity Church Centenary Bradbury Centre
13	464 Prince Edward Road East
14	South Mansion
15	Proposed G/IC development along Sa Po Road
16	Lee Kau Yan Memorial School
17	Sir Robert Black Health Centre
18	Kowloon Cognitio College
19	Chiap King Industrial Building
20	San Po Kong Factory Estate
21	Rhythm Garden
22	Proposed CDA development at Tai Hom Village
23	Pik Hoi House, Choi Hung Estate
24	Kam Pik House, Choi Hung Estate
25	Ping Shek Bus Terminus C/R Development
26	Richland Gardens
27	Kai Lok Temporary Housing Area
28	Kai Lok Temporary Housing Area
29	Sino Industrial Plaza

ASR	Description
30	Jing Hin Industrial Building
31	Lower Ngau Tau Kok Estate Redevelopment
32	Upper Ngau Tau Kok Estate Redevelopment
33	Sing Tao Building
34	New Kowloon Bay Vehicle Examination Centre
35	Kowloon Bay Factory Estate
36	World Trade Square
37	Piazza Industrial Building
38	Seapower Industrial Centre
39	Laguna City
40	Proposed Cha Kwo Ling housing development
41	Proposed Yau Tong Bay CDA development

2.3.2.2 The assessment heights were taken as 1.5m above the lowest air sensitive floor of the selected receivers, 1.5m is the average height of human breathing zone.

Emission Inventory

2.3.2.3 The major potential air quality impact during the construction phase of the project will be dust arising from haul road emissions, open site erosion, excavation and filling activities. Civil works related to the demolition of existing structures and construction of infrastructure will also cause emissions. Exhaust emissions from site vehicle and construction site plant are not consider to constitute a significant source of air pollutants based on previous experience from similar construction works.

2.3.2.4 Dust emissions from the construction works will include the following:

- General construction activities
  (including land clearing, ground excavation, cut and fill operations, demolition and construction of structures, and equipment traffic over the site area); and
- Wind erosion of open sites and stockpiling areas.

2.3.2.5 The prediction of dust emissions was based on typical values and emission factors from USEPA *Compilation of Air Pollution Emission Factors (AP-42)*, 5th Edition. A ten-hour working day was assumed during various construction phases of the project. It was assumed that a maximum of 30 percent of the construction site area would be actively operated at any one time during the construction periods.

2.3.2.6 In this assessment, dust suppression measures and estimated mitigation efficiencies were incorporated into the dust emission calculations. A 50 percent reduction of the dust generated from wind erosion and general construction activities may be achieved with twice daily watering of the active site areas with complete coverage as suggested by *AP-42 4th Edition* for general construction activities. If necessary, the watering frequency could be increased to once every 1.5 hours such that the dust reduction efficiency would be increased to 75 percent.

2.3.2.7 References for the calculations of dust emission factors from different dust generating activities and tabulated in **Table 2.7** below.

Table 2.7 References on Dust Emission Factors from Different Activities

Activities	References (AP-42, 5th Edition)
General construction activities	Section 13.2.3
Wind erosion of open site	Table 11.9.4

Dispersion Modelling

2.3.2.8 The USEPA approved ISCST3 model was used to model air quality dispersion. The model was assumed the algorithm for the "Urban" mode, with the dry depletion and gradual plume rise options.

2.3.2.9 For the purpose of this assessment, it is considered that dust emissions from vehicles moving on unpaved road surfaces would constitute the major dust source for most of the construction sites. Since no site specific information was available relating to particle size distribution, and the unpaved road emission equation from AP-42 (5^{th} Edition) is applicable for different geographical conditions, the particle size distribution used in the ISCST3 model was estimated based on the particle size multipliers for the unpaved road emission equation. With particle size classes of 0-2.5 µm, 2.5-5 µm, 5-10 µm, 10-15 µm and 15-20 µm, the percentage in each class was estimated to be 9.5%, 10.5%, 16%, 14% and 50% respectively.

2.3.2.10 During daytime working hours (8am to 6pm), it was assumed that dust emissions would be generated from both general construction activities and site erosion. Worst-case meteorological condition was taken as atmospheric stability class D with wind speed of 1m/s. During nighttime non-working hours (6pm to 8am of the next day), it was assumed that dust emissions would only be generated from site erosion. Worst-case meteorological condition was taken as atmospheric stability class F with wind speed of 1m/s.

Concentration Calculations

2.3.2.11 The worst-case 1-hour average TSP concentrations and the worst-case 24-hour average TSP concentrations were calculated at each air quality assessment point to check the compliance with the respective guideline and AQO.

2.3.2.12 The maximum concentration among the worst-case daytime and worst-case nighttime 1-hour average concentrations was taken as the worst-case hourly average TSP concentration for each air quality assessment point. The worst-case 24-hour average TSP concentration was taken as the average of 10 hours with worst-case daytime 1-hour average concentration and 14 hours with worst-case nighttime 1-hour average concentration.

2.3.2.13 After all, background TSP concentrations of $98\mu gm^{-3}$ was added to the results calculated above to produce the worst-case concentrations. The background concentration was derived from the EPD monitoring data for urban area.

2.3.2.14 More details on the construction dust air quality modeling are included in **Appendix 2B**.

2.3.3 *Operational Phase Impact Assessment*

Air Quality Assessment Points

2.3.3.1 Air quality assessment points for planned sensitive receivers within SEKD were selected along the outermost boundary of each development area within the SEKD area. These locations represent the areas that would be subjected to the highest impacts from surrounding pollution sources. Locations of the air quality assessment points are shown in **Drawing Nos. 22936/EN/337A to F**.

2.3.3.2 Representative existing and planned air quality sensitive receivers in the proximity of SEKD were also selected for this air quality impact assessment and are summarised in **Table 2.6**. Locations of the selected existing and planned air quality sensitive receivers are shown in **Drawing No. 22936/EN/338**. The planned development within 500m from SEKD are shown in **Drawing Nos. 22936/EN/276 A to D**.

2.3.3.3 For low-rise receivers including schools and other G/IC facilities, the assessment heights were taken as 1.5m, 10m, 25m, and 40m above local ground level. For high-rise receivers including most of the residential developments, the assessment heights were taken as 1.5m, 10m, 25m, 50m, 75m, and 100m above local ground level. 1.5m is the average height of human breathing zone. For existing receivers, instead of 1.5m above ground level, the lowest assessment height was taken as 1.5m above the lowest air sensitive floor of the selected receiver.

2.3.3.4 The selected assessment heights covered the entire height of most sensitive receivers. Potential impacts due to traffic emissions at lower level, and industrial chimneys and vent shafts emissions at middle to higher levels could therefore be revealed in this assessment.

Emission Inventory

Chimney Emissions

2.3.3.5 There are existing industrial areas located next to SEKD area, namely To Kwa Wan, San Po Kong, Kowloon Bay, Kwun Tong and Hung Hom districts. Plume impingement due to industrial chimney emissions is considered as the major air quality interface issue of concern. We note that the adjacent industrial land use is also undergoing some changes to other non-industrial use in due course. The existing industrial uses in Kwun Tong, Kowloon Bay, San Po Kong, and Kowloon City areas are separated from the SEKD by 50m to 100m wide of existing and planned public roads. The only concern would be the To Kwa Wan and Hung Hom areas. Nevertheless, the planned sensitive uses are all separated from existing industrial uses by planned and existing open spaces. Adverse industrial / residential interface problem is therefore not anticipated.

2.3.3.6 The inventory of industrial chimneys maintained by EPD (received in March 2000) was taken to assess the impacts from the industrial chimney emissions on the selected air quality assessment points in SEKD area. The inventory contains updated information on the nature of the discharge and the physical characteristics of the chimneys together with details of chimney locations, chimney heights, chimney top diameters, fuel consumption rates, and gas exit temperature for some of the chimneys. Gas exit velocities are not available. The locations of the industrial chimneys considered in this assessment are shown in **Drawing No. 22936/EN/339**.

2.3.3.7 In order to simulate the potential impacts due to chimney emissions from the proposed hospital in Area 5L, an additional chimney was included in the dispersion model. The emission rate of the chimney was made reference to other existing hospitals of similar scale in the territory.

2.3.3.8 Amongst the pollutants emitted from industrial chimneys, SO_2 is the critical emission for determining compliance with the AQOs. From the USEPA *Compilation of Air Pollutant Emission Factors* (AP-42), the CO, NO_X and particulates generation rates for any given fuel consumption rate for fuel of 0.5% sulphur content (which is the maximum sulphur content in liquid fuels under the *Fuel Restriction Regulations* implemented in July 1990) would be 7%, 28% and 3% of the SO_2 generation. If the AQO for SO_2 were achieved, the AQOs for CO, NO_2 and particulates would also be met.

2.3.3.9 In this assessment, the emission rate of sulphur dioxide was calculated in accordance with USEPA *Compilation of Air Pollutant Emission Factors* (AP-42). For this assessment, gas exit velocities were taken as $6ms^{-1}$ and gas exit temperatures, if not available, were taken as 373K.

2.3.3.10 Elevated air quality impacts due to chimney emissions are mainly at middle to upper levels and the major air pollutant of concern is sulphur dioxide. Whereas the air quality impacts due to traffic emissions are mainly at lower levels and the major air pollutants of concern are nitrogen dioxide and RSP. Cumulative impacts of sulphur dioxide were addressed by the sum of chimney emissions modelling results and sulphur dioxide background level. Whereas the cumulative impacts of nitrogen dioxide and RSP were addressed by the sum of traffic emissions (open road and vent shaft emissions) and industrial chimney emissions modelling results plus the nitrogen dioxide and RSP background levels.

Traffic Emissions from Open Roads

2.3.3.11 The vehicle fleet is divided into three vehicle categories, namely private cars and taxis, buses, and other vehicles. Vehicle emission factors were taken from the Fleet Average Emission Factors - EURO3 Model provided by EPD. The fleet average emission factors of year 2011 (the last future year forecast) were adopted in this assessment as conservative estimates for the emissions 15 years after the full occupation of SEKD estimated at year 2031. The use of year 2031 traffic flow with year 2011 Fleet Average Emission Factors is a conservative estimate of the impact without taking into account the improvement in the Fleet Average Emission Factors between year 2011 and 2031.

2.3.3.12 In the current development program, all the trunk roads and distributor roads in SEKD will be commissioned in year 2011 or later. Besides, a positive traffic growth factor is suggested by the traffic engineer from year 2011 onwards. Therefore, year 2031 traffic flow with fleet average emission factors of 2011 would present the worst case scenario as adopted in this assessment.

2.3.3.13 The highest emission factors among the vehicle types included in each vehicle category were taken for conservative assessment. Among the traffic pollutants, oxides of nitrogen (NOx) and respirable suspended particulates (RSP) are the two major air pollutants of concern in Hong Kong and were assessed. The fleet average emission factors for NO_X and RSP for different vehicle categories are summarised in **Table 2.8** below. No speed correction or other adjustments were made.

Table 2.8 Basic Vehicle Emission Factors

Vehicle Type	Emission Rate (g/km/vehicle)	
	NOx	RSP
	2011 (for 2031)	2011 (for 2031)
Private Car & Taxi	0.73	0.03
Bus	6.80	0.69
Other Vehicle	3.84	0.53

2.3.3.14 Projected morning peak hour traffic flows for year 2031, that is, 15 years after full occupation of SEKD, prepared by the traffic and transportation team, were adopted for this assessment. The 2016 peak hour traffic forecast is included in **Appendix 3B** of this report. A growth factor of 1% per year suggested by the traffic engineer was taken in estimating the year 2031 traffic flow. The traffic on all the existing and planned roads within SEKD and its surrounding areas were included in this assessment. Free flowing traffic with no queuing was assumed. Free flow traffic conditions are normally adopted for traffic air quality impact assessments to represent the prevailing traffic conditions on the roads over the averaging period of 1 hour or 24 hours although occasional short-term congestion could occur.

Vent Shaft Emissions from Vehicular Tunnels

2.3.3.15 The proportion of traffic emissions expelled from the portals and the vent shaft(s) of a vehicular tunnel will depend on the ventilation design of each tunnel. For the purpose of this assessment, the total emissions from the tunnel were calculated based on the predicted 2031 morning peak hour traffic flow and the traffic composition from the traffic forecast. The required exhaust rate to achieve the tunnel air quality criteria was also calculated and inserted into the computer models. Total emission from each tunnel was assumed to be distributed evenly among the vent shafts for each tunnel. One exception is the Central Kowloon Route

(CKR) tunnel in which 50% of the total tunnel emission would be emitted from the East Vent Building in SEKD in accordance with the current design assumption. The NO_2 composition was taken as 10% of NOx within the tunnel. It was assumed that all the tunnel emissions would be exhausted from the vent shafts and there would be no portal emissions and this is taken as a proposed control measures included in the implementation schedule of the EIA Report to be implemented in the design and operation stages.

2.3.3.16 Locations of the vent shafts within SEKD are shown in **Drawing No. 22936/EN/340**. The emission rates of the vent shafts calculated from the approach described above are summarised in **Table 2.9** below.

Table 2.9 Estimated Traffic Emissions from Vent Shafts Located within SEKD

Tunnel	Tunnel Length	No. of Vent Shaft within SEKD	Exhaust Height Above Ground (m)	Vent Shaft Exhaust Velocity (m/s)	Total NOx emission per vent shaft (g/s)	Total RSP emission per vent shaft (g/s)
Airport Tunnel	0.9km	1	20	10	2.36	0.217
D5	1.0km	2	6	10	0.38	0.028
D4	1.7km	4	6	10	0.17	0.014
T2	1.3km	2	24m for the northern vent and 6m for the southern vent	10	2.10	0.215
CKR Tunnel	3.8 km	1	33	10	10.66	1.160

Dispersion Modelling

Chimney Emissions

2.3.3.17 The USEPA approved ISCST3 model was used to model air quality dispersion. The model was assumed the algorithm for the "Urban" mode, with the stack tip downwash component. The gradual plume rise option was also adopted.

2.3.3.18 The general load factors recommended by EPD based on daily fuel consumption figures of an updated sample of diesel oil-fired furnaces in Hong Kong were adopted. Load factors of 41% and 23% of maximum hourly fuel consumption rate were applied to daytime and nighttime operation respectively.

2.3.3.19 For the modelling of SO_2 concentrations, historical meteorological data of years 1991 to 1994 recorded at the Kai Tak Runway weather stations were taken in ISCST3 model to predict the maximum 1-hour and 24-hour average concentrations. For the modelling of NO_2 and RSP concentrations, the modelling results of chimney emissions under worst-case daytime and nighttime meteorological conditions were combined with those of traffic emissions to produce the worst-case cumulative concentrations.

Traffic Emissions from Open Roads

2.3.3.20 The USEPA approved CALINE4 dispersion model was used to assess traffic emissions impact from existing and planned road network. In the dispersion model, meteorological conditions of Pasquill stability class D, mixing height of 500 metres, and horizontal wind direction standard deviation of 18 degrees were adopted for daytime hours (7am to 7pm). For nighttime hours (7pm to 7am the following day), meteorological conditions of Pasquill stability class F, mixing height of 500 metres, and horizontal wind direction standard deviation of 5.5 degrees were adopted. Surface roughness coefficient of 100cm was taken in the CALINE4 model to calculate the worst-case 1-hour average concentrations. Modeling was undertaken for wind angles from 0 degree to 350 degree at 10 degrees increment. Similar worst-case meteorological conditions were taken in the ISCST3 model for the modeling of vent shaft and industrial chimney emissions.

2.3.3.21 Secondary air quality impacts arising from the implementation of roadside noise mitigation measures namely vertical noise barriers, vertical noise barriers with canopies, and semi and full noise enclosures were incorporated into the air quality model.

2.3.3.22 It was assumed that, with the installation of vertical noise barriers, all the traffic pollutants generated from the mitigated road section would be emitted from the top of the noise barriers. In the CALINE4 model, the elevation of the mitigated road section was set to the elevation of the barrier top, the width of mixing zone was set to the actual width of the road due to physical obstruction of the barrier walls, and the road type was set to 'fill'. No correction or adjustment to the receiver heights was made in the model.

2.3.3.23 For vertical noise barriers with canopies and semi noise enclosures, it is assumed that the dispersion of the traffic pollutants would in effect be similar to physically shifting the mitigated road section towards the central divider. The traffic pollutants were assumed to be emitted from the top of the canopies or semi enclosures. In the CALINE4 model, the alignment of the mitigated road section was shifted by a distance equal to the covered extent, the elevation of the mitigated road section was set to the elevation of the barrier top, the width of mixing zone was set to the actual width of the road due to physical obstruction of the barrier walls, and the road type was set to 'fill'. No correction or adjustment to the receiver heights was made in the model.

2.3.3.24 For full noise enclosures, the portal emissions were calculated in accordance with the PIARC report. The total emissions within the enclosure were distributed into two sets of volume sources outside the portal. Total emissions from volume sources at 0 to 50m from the portal equal to 2/3 of the total emissions within the enclosure. Whereas total emissions from volume sources at 50 to 100m from the portal equal to 1/3 of the total emissions within the enclosure. The portal emissions were modelled as volume sources in ISCST3 model.

Vent Shaft Emissions from Vehicular Tunnels

2.3.3.25 Emissions from the vent shafts of the vehicular tunnels were modelled as point sources using USEPA approved ISCST3 model. "Urban" mode algorithm, stack tip downwash component, and gradual plume rise option were taken in the model.

Concentration Calculations

2.3.3.26 The worst-case 1-hour average NO_2 concentrations and the worst-case 24-hour average NO_2 and RSP concentrations were calculated at each air quality assessment point at different assessment heights to check the compliance with the respective AQOs.

2.3.3.27 The maximum concentration among the daytime and nighttime peak hour 1-hour average concentrations was taken as the worst-case hourly average NO_2 concentration for each air quality assessment point. The hourly average concentrations of the NO_2 were calculated using the Ozone Limiting Method. For vehicle emissions, tailpipe NO_2 / NOx ratio of 7.5% was taken. For vent shaft emissions from vehicular tunnels, a NO_2 / NOx ratio of 10% was assumed at the vent shaft emission points. For industrial chimneys, in accordance with USEPA AP-42, a 5% NO_2 / NOx ratio was assumed at the chimney emission points (Chapter 1.3 of USEPA AP-42 refers). The background concentration of ozone was taken as $62\mu gm^{-3}$ derived from the EPD monitoring data for urban area.

2.3.3.28 The worst-case hourly average concentrations calculated by the dispersion models were based on the 2031 morning peak hour traffic flow. In order to calculate the 24-hour average concentration, some global traffic factors for the whole of SEKD suggested by the traffic engineer were taken. The peak hour traffic flow was taken as 7% of the daily traffic flow. The total traffic flow during daytime hours (0700-1900) was taken as 70% of the total daily traffic flow. The CALINE4 and ISCST3 daytime and nighttime hourly average concentrations due to emissions from the road network, and the vent shaft emissions were adjusted by these global traffic factors to produce the 24-hour average concentration. With reference to the traffic count data from the Traffic Census, the traffic profiles for urban areas are relatively flat during the daytime hours. A large proportion of the daily traffic flow is within the daytime hours. The application of a flat traffic profile for the calculation of 24-hour average concentrations in this assessment is considered a reasonable approach.

2.3.3.29 For the calculation of 24-hour average concentration, instead of assuming a worst-case wind direction for the entire 24-hour period, concentration for each hour of a day was calculated based on the historical wind data recorded at Kai Tak Runway for year 1997. For recorded wind speed of less than 2m/s, a wind speed of 1m/s was taken in the dispersion models. For recorded wind speed at or above 2m/s, a wind speed of 2m/s was taken in the dispersion models to produce conservative predictions. The worst-case 24-hour average concentration was then taken as the highest daily value within the year.

2.3.3.30 Ozone Limiting Method was used in the calculation of the 24-hour average NO_2 concentrations. It should be noted that this is a conservative approach and was taken in this assessment as a screening exercise. The reason is that the calculated worst-case 24-hour average NO_2 and RSP concentrations assumed worst-case meteorological conditions, i.e. stable atmospheric conditions and low wind speed for the entire 24-hour period.

2.3.3.31 Cumulative impacts were calculated by adding the predicted concentrations from:

- CALINE4 modelling results of open roads traffic emissions (NOx and RSP);
- ISCST3 modelling results of vent shaft emissions (NOx and RSP); and
- ISCST3 modelling results of industrial chimney emissions (SO_2, NOx, and RSP).

2.3.3.32 After all, background NO_2, RSP, and SO_2 concentrations of 59μgm^{-3}, 60μgm^{-3} ,and 21μgm^{-3} respectively were added to the results calculated above to produce the worst-case concentrations. These background concentrations were derived from the EPD monitoring data for urban area.

2.3.3.33 More details on the operational phase air quality modeling are included in **Appendix 2B**.

2.4 Identification, Prediction and Evaluation of Potential Impacts

2.4.1 *Construction Phase Impact Assessment*

Construction Dust Impact

2.4.1.1 The modeling results for the mitigated and unmitigated scenarios are presented in **Table 2.10**. For the mitigated scenario, 50% dust reduction by twice daily watering with complete coverage was assumed for the entire active construction area. For areas within 200m from nearby sensitive receivers, 75% dust reduction by the implementation of watering every 1.5 hours was assumed. The predicted worst-case TSP concentrations for the unmitigated and mitigated scenarios are also presented in the form of concentration contours as shown in **Drawing Nos. 22936/EN/389 to 392**. The TSP concentration contours are presented at the height of 1.5m above ground. 1.5m is the average height of human breathing zone.

Table 2.10 Predicted Worst-case 1-hour Average and 24-hour Average TSP Concentrations for Unmitigated and Mitigated Scenarios

ASR	Unmitigated Scenario		Mitigated Scenario	
	Worst-case 1-hour Average TSP (μgm^{-3})	Worst-case 24-hour Average TSP(μgm^{-3})	Worst-case 1-hour Average TSP (μgm^{-3})	Worst-case 24-hour Average TSP (μgm^{-3})
1	467.4	259.7	251.2	171.8
2	487.4	**267.9**	280.7	188.0