6 AIR QUALITY

6.1 General

This assessment focuses on the two proposed options for terminal construction. The fully dredged option, identified since the LAPH and LPD Stage I Preliminary Design and Ancillary Works studies, involves the removal of marine sediments prior to reclamation by sandfill. The drained option, which was considered in the earlier assessments, is based on sediments being left in place. The construction programme for this option has since been up-dated. In the earlier studies it was assumed that a 9 metre surcharge would be required for the drained option to speed consolidation. The engineering team now advise that a 12 metre surcharge is required. For the dredged option only 4 metres of surcharge are required. The material to be handled in dredged and drained options is 10 Mm^3 and 30 Mm^3 respectively. The approach outlined in the LPD Stage I Preliminary Design Study has been adopted to determine the air quality impacts of the fully dredged and drained options. Cumulative effects have also been considered by inclusion of the results of the Ancillary Works study.

Air quality impacts of reclamation activities are primarily concerned with dust emissions arising from: haulage truck movements on unpaved road, surcharge handling and wind erosion of the open site area. In this case, dust is used as a generic term for total suspended particulates (TSP) and respirable suspended particulates (RSP).

Given the levels of activity and the isolated and open nature of the site, vehicle exhaust emissions are not considered to offer significant air quality impact.

6.2 Review of Previous Studies

6.2.1 LPD Stage 1 Container Terminals 10 & 11 Preliminary Design Study

The study report, issued in January 1995 made the following conclusions. Reclamation activities and the creation of large expanses of unsealed surfaces have a high potential to create adverse air quality impact. The key air quality impact is from dust generated during reclamation activity. The assessment assumed concurrent construction of CT10 & 11 measured against 1 hour, 24 hour and annual average TSP concentrations. The non statutory 1 hour guideline is used in the assessment since it gives a better appreciation of construction phase impact. The most critical sensitive receiver was identified as China Light and Power within Penny's Bay. Assessment suggests that for concurrent CT10 / CT11 construction there would be no exceedence of the 24 hour and Annual Average TSP AQO or 1 hour guideline. Cumulative impact did not form part of the study and it was proposed that good site practise (GSP) should be adopted to minimise potential for impact. The results of this study were used in the Ancillary Works (Design) to predict cumulative impact effects. The results of the assessment assumed a 9 metre surcharge, a 12 metre surcharge is now assumed.

6.2.2 LPD Stage I Container Terminals 10 & 11 Ancillary Works (Design)

The study report, issued in December 1994, carried out construction impact assessment associated with works within Penny's Bay and for the advance works. The study included cumulative impact assessment of concurrent terminal and

ancillary works which identified exceedence of the AQO for 1 hour and 24 hour average concentrations if no mitigation was applied. However if mitigation, including paving of haul routes and watering, was applied the assessment criteria could be met. The study also carried out modelling and assessment for the advance works which concluded that the assessment criteria could be met if watering of unsealed areas was carried out. It is noted that the assessment was based on the assumption that only 9 metres of surcharge would be required. This has been amended to 12 metres and therefore additional material rehandling will be required.

6.3 Assessment Criteria

The Air Pollution Control Ordinance (APCO) (Cap. 311, 1983) provides authority for controlling air pollutants from a variety of stationary and mobile sources, including fugitive dust emissions from construction sites, and encompasses a number of Air Quality Objectives (AQO). Currently AQOs stipulate concentrations for sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and total and respirable suspended particulates (TSP/RSP) in ambient air over the Territory, listed in the following table.

Table No 6.1 : Hong Kong Air Quality Objectives (AQOs)

Parameter	Maximum Average Concentration µg/m³			
	1-Hour*	8-Hour	24-Hour**	Annual
SO_2	800	--	350	80
CO	30000	10000	--	--
NO_2	300	--	150	80
TSP	500***	--	260	80
RSP	--	--	180	55

* Not to be exceeded more than three times per year
** Not to be exceeded more than once per year
*** In addition to the above established legislative controls, it is generally accepted that an hourly average TSP concentration of 500 µg/m³ should not be exceeded. Such a control limit is particularly relevant to construction work and has been imposed on a number of construction projects in Hong Kong in the form of contract clauses.

The TSP objective and guideline are considered to be the most critical when carrying out construction phase impact assessment.

6.4 Existing Conditions

The LAPH studies conducted baseline air quality monitoring between 14 November 1991 and 18 December 1991. During this period ambient concentrations of sulphur dioxide (SO_2), oxides of nitrogen (NO/NO_2), total suspended particulates (TSP) and respirable suspended particulates (RSP) were measured at sites in Cheung Chau and Discovery Bay. No monitoring of Carbon Monoxide (CO) was carried out. It was considered the parameters monitored were reflective of the traffic, industrial and construction activities at the monitoring sites. The monitoring results are reproduced in following tables. It

was noted that all the measured pollutant concentrations met the pertinent AQO.

Table No 6.2 : Mean Measured Pollutant Concentrations at Cheung Chau

Pollutant	Arithmetic Mean ($\mu g/m^3$)	Geometric Mean ($\mu g/m^3$)	Standard Deviation
SO_2	8.3	--	12.0
NO	2.4	--	6.9
NO_2	28.4	--	20.9
TSP	--	73.0	--
RSP	--	57.6	--

Table No 6.3 : Mean Measured Pollutant Concentrations at Discovery Bay

Pollutant	Arithmetic Mean ($\mu g/m^3$)	Geometric Mean ($\mu g/m^3$)	Standard Deviation
SO_2	10	--	12.9
NO	3	--	10.5
NO_2	41	--	28.9
TSP	--	90.6[1]	--
RSP	--	75	--

Note

1) This value of 90.6 $\mu g/m^3$ was taken as the background level in the LPD Stage I Container Terminals 10 & 11 Ancillary Works (Design) study

Table No 6.4 : Air Pollutant Concentrations Compared to Air Quality Objectives

Pollutant	Averaging Time	Air Quality Objective ($\mu g/m^3$)	Maximum ($\mu g/m^3$) at Cheung Chau	Maximum ($\mu g/m^3$) at Discovery Bay
SO_2	1 hr 24 hr	800 350	90 28	129 19
NO	1 hr 24 hr	-- --	69 12	98 13
NO_2	1 hr 24 hr	300 150	127 51	134 45
TSP	24 hr	260	119	134
RSP	24 hr	180	99	104

6.5 Assessment Methodology

6.5.1 Sensitive Receivers

The sensitive receivers for dust impacts used in the last study are retained in this study, they are identified in the following table :

Table No 6.5 : Locations of Sensitive Receivers

Sensitive Receiver	Location
1	CLP Station, Penny's Bay
2	Cheoy Lee Shipyard,Penny's Bay
3	Fa Peng, east side TCT Peninsula
4	Tso Wan, east side TCT Peninsula
5	Tsing Chau Tsai, north side TCT Peninsula
6	Ma Wan
7	Peng Chau
8	Discovery Bay

Predicted air quality at the SR locations of Penny's Bay Shipyard and the CLP Station are considered indicative of impacts which could be experienced by the planned developments within Penny's Bay. Peng Chau, Discovery Bay and Ma Wan have been selected to represent the main centres of population in the area. Fa Peng, Tso Wan and Tsing Chau Tsai have been selected as indicators for dust migration. The Sensitive Receivers are identified in Figure 2.1

6.5.2 Modelling Procedure

Air quality computer simulation modelling used the USEPA approved Fugitive Dust Model (FDM) dispersion model to assess potential dust impacts from the reclamation activities. This model is used in preference to the Industrial Source Complex (ISCST) model as it is specifically designed for estimation of impacts from fugitive dust sources using wind-dependent emission and advanced gradient-transfer deposition algorithms. This model is recommended by EPD for this type of study.

Concurrent construction of CT10 & 11 has been assumed in this assessment as identified in the construction programmes which are set out in Chapter 3 of this report. Modelling was undertaken to establish TSP concentrations at sensitive receivers for 1-hour, 24-hour and annual average time periods, based on wind speed and direction data from the Shell Tsing Yi Installation weather station (Jan 1990 to Dec 1992) which represents the closest weather station to the study site. These observations have been combined with surface observations recorded at the Royal Observatory to obtain the best available data set.

The major pollutant emission of concern from reclamation activities is particulate matter. Vehicle and plant exhaust emissions from the site are not considered to constitute a significant source of air pollutants.

The CT10 and CT11 reclamations, including the terminals and the backup areas, will be filled strip by strip according to the filling programmes identified in Chapter 3 of this report. For the drained option reclamation above sea-level will be carried out by a technique called "rainbowing" or by pumping. This involves spraying a sand / water mixture (approximately 50% water). Surcharging and removal of surcharge operation will be carried out by land-based machinery and haulage trucks. For the dredged option 4 metres of surcharge are required; for the drained scheme 12 metres are required.

In the assessment, rainbowing or pumping of "semi-liquid" material was not considered to be a dust generating activity. Emission points for dust release from reclamation activities included the following:

- Loading of trucks from excavators
- End-tipping of surcharge material from trucks
- Bulldozing surcharge material
- Truck travel on unpaved roads
- Wind erosion of stockpiles and open site

The estimation of dust emissions was based on typical values and emission factors from USEPA *AP-42*. Marine sand silt content was taken as 3.5 percent, which is the average of the marine fill in ten reclamation sites in Hong Kong. Unpaved site road surface material silt content was taken as 5 percent; this was based on the results of a particle size analysis of samples of typical site road surface material.

In the assessment, dust suppression measures and the estimated mitigation efficiencies have been incorporated into the dust emission calculations. The mean vehicle speed of the haulage trucks within the site area is assumed to be reduced to 15 $kmhr^{-1}$ by speed control. In addition a 50% reduction of the dust generated from wind erosion and vehicle movements on dusty roads resulting from twice daily watering with complete coverage of all site roads and open site area is assumed (from *USEPA AP-42*).

The assessment considered emissions due to surcharging, removal of surcharge and site erosion from each strip and the entrustment area of each terminal at different stages of the project according to the construction programme. Emission from site erosion was only considered for the active operating unpaved site area.

6.5.3 Dispersion Modelling

Particle size distributions assumed in the modelling were composed of 10% RSP fraction and consisted of five separate particle size classes : 0-2.5, 2.5-5, 5-10, 10-20, 20-30 micrometers which contributed to fractions of 0.0198, 0.0289, 0.0513, 0.1609 and 0.7392 respectively. Wind speed and direction data for the year 1991 from the Shell Tsing Yi Installation meteorological station were combined with surface observations recorded at the Royal Observatory to obtain the best available data set. Wind speed used in the modelling was adjusted to the level of the reclamations.

For the calculation of 1-hour, 24-hour and annual average TSP concentrations, a detailed assessment was undertaken by modelling all the possible emissions on the reclamations at once. The 12 month period of maximum reclamation activities,

considered in the detailed assessment, was identified from an initial screening study. For the fully dredged option this was December 1997 to November 1998 and for the drained option, January 1998 to December 1998. Detailed modelling of the months December 1997, February 1998, April 1998, June 1998, August 1998, October 1998 and December 1998 was undertaken and maximum 1-hour, 24-hour and annual average TSP concentrations were predicted at the sensitive receivers.

No specific assessment was undertaken to calculate RSP concentrations. It is normally assumed that RSP generation is approximately 10 percent of the TSP.

6.6 Impact on Receivers

The maximum 1-hour, 24-hour and annual average TSP levels at the sensitive receivers during the period of reclamation are tabulated below. No background dust concentration was incorporated into the calculations as background information is not available for all the sensitive receiver locations. However, the implications of including the background level of 91μgm^{-3} assumed in the LPD Ancillary works study are discussed. All the predicted TSP levels are solely due to the activities of CT10 & 11 reclamations, including the terminals and the backup areas. The cumulative effects on dust concentration of construction activities associated with the CT10 & CT11 reclamations and the LPD Ancillary works are also considered below.

Table No 6.6 : TSP Concentration at SR - Reclamation Only (μgm^{-3})

Receiver	Fully Dredged Option (A)			Drained Option (B)		
	1-hour Average	24-hour Average	Annual Average	1-hour Average	24-hour Average	Annual Average
Air Quality Objective (AQO)	***500[1]***	***260***	***80***	***500[1]***	***260***	***80***
CLP	133	68	22	367	208	74
Pennys Bay	52	26	8	130	52	15
Fa Peng	127	57	9	318	166	25
Tso Wan	85	35	5	207	90	13
Tsing Chau Tsai	49	20	3	118	42	7
Ma Wan	38	14	2	100	33	4
Peng Chau	44	13	1	84	20	1
Discovery Bay	57	13	1	150	24	3

Note
1) The 1 hour standard is not a statutory requirement but is used as an indicator of adverse construction impact

The modelling results indicate that there would be no exceedence of either the 1-hour average TSP guideline level or the 24-hour and annual average TSP AQOs at the sensitive receivers. The concentrations predicted for the fully dredged option are significantly lower than for the drained option. This can be largely

attributed to the difference in the number of plant employed and the duration of the dust generating activities associated with each option. In addition, the changes to the construction programme for the drained option have resulted in an increase in the predicted concentrations from those originally determined for this scheme in the LPD Stage 1 Container Terminals 10 & 11 Preliminary Design Study.

Cumulative dust impacts at the sensitive receivers can only be predicted by incorporating the background dust concentration and other dust generating activities within Penny's Bay in the models. The background dust level of 91μgm^{-3} is a 24-hour average obtained from monitoring in Discovery Bay and this is therefore expected to be the minimum value of the corresponding 1-hour average concentration in this area. It is also not directly applicable to the other sensitive receiver locations. Incorporation of this data on the background dust concentration would result in dust levels within the 1-hour TSP guideline and TSP AQOs for the fully dredged option but would be close to these levels for the drained option.

The predicted TSP concentrations for the period of the revised Ancillary Works construction programme which overlaps with the CT10 & 11 construction are reproduced in Table 6.7 below. These data can be found in Table E5.1 of Appendix E5 to the Ancillary Works Study. All modelling assumptions, with the exception of the 10$kmhr^{-1}$ speed limit imposed on haul routes, are comparable with those of the current study. The cumulative air quality impacts, determined from these data and the data in Table No. 6.6, are also presented in Table No. 6.8.

Table No 6.7 : TSP[1] Concentration at SR - Ancillary Works Only (μgm^{-3})

Receiver	1-hour Average	24-hour Average	Annual Average
Air Quality Objective (AQO)	***500***	***260***	***80***
CLP	129	49	21
Pennys Bay[2]	-	-	-
Fa Peng	36	12	2
Tso Wan	28	9	2
Tsing Chau Tsai[2]	-	-	-
Ma Wan	16	5	1
Peng Chau	14	3	0.3
Discovery Bay	14[3]	3[3]	0.6[3]

Note
1) Background dust concentration not included
2) No comparable data available
3) Average of all data for Discovery Bay receivers.

Table No 6.8 : TSP[1] Concentration at SR (Reclamation and Ancillary Works) (μgm^{-3})

Receiver	Fully Dredged Option (A)			Drained Option (B)		
	1-hour Average	24-hour Average	Annual Average	1-hour Average	24-hour Average	Annual Average
Air Quality Objective (AQO)	***500***	***260***	***80***	***500***	***260***	***80***
CLP	262	116	42	496	257	94
Pennys Bay[2]	181	74	29	259	100	36
Fa Peng	162	70	12	354	178	28
Tso Wan	113	44	7	235	99	14
Tsing Chau Tsai[3]	77	29	5	146	51	17
Ma Wan	54	19	2	116	38	4
Peng Chau	58	17	1	98	24	2
Discovery Bay	71	16	2	165	27	3

Note
1) Background dust concentration not included
2) Ancillary Works data for CLP used
3) Ancillary Works data for Tso Wan used

The cumulative air quality impacts are predicted to be within the 1-hour TSP guideline and 24-hour and annual average TSP AQOs for the fully dredged option at all sensitive receivers. For the drained option, infringements of these standards are expected at the CLP works, once a background dust level is included. The infringement of the Annual Average AQO indicates that there is a major dust problem which simple operational measures will be unable to remedy. Reductions in vehicle speeds could be considered, speeds of 8 $Kmhr^{-1}$ have been identified in other studies but enforcement of such limits will be problematic and the lower speeds have programming implications. One mitigation measure which could be considered is a commitment for haul roads to be kept *permanently* wet to reduce emissions from this source. Such watering should ensure that the AQO's will be met at the Power Station in Penny's Bay for the drained option. Beyond this, the only option is to reduce intensity of activity with consequent programme implications. It is noted that in last round of EIA studies on LPD activities associated with a 9 metre surcharge could be carried out within the AQO.

RSP concentrations in the area are unlikely to be high in view of the fact that particulate matter produced during reclamation using sand is of relatively large particle size.

6.7 Mitigation

A commitment to adopt good operational practices for dust minimisation by the contractor will minimise the dust nuisance. A number of practical measures are listed below:

- Areas of reclamation should be completed, including final compaction, as quickly as possible consistent with good practice to limit the creation of wind blown dust.

- All exposed site area and haul roads should be watered and cleaned regularly, at least twice daily with complete coverage, particularly during dry weather.

- Frequently used site roads should be watered on a regular basis.

- Vehicles should use wheel wash facilities or should be hosed before leaving the site.

- Wind shield and dust extractor should be provided at the loading point.

- Water sprinkler should be used at the loading area.

- Open stockpiles should be avoided or covered.

- Speed controls for on-site vehicles should be applied and enforced. Average vehicle speed of 15 $kmhr^{-1}$ is recommended.

6.8 Conclusion

The results of the modelling study carried out for this assessment indicate that exceedences of the 1-hour guideline level and 24-hour and annual average Air Quality Objectives for TSP may occur during construction of the drained option. No exceedences of these standards are predicted for the fully dredged option. The dust generating activities are identical for the two methods of construction and the difference in their air quality impacts arises mainly from the duration and intensity of these activities for the respective options.