3 AIR QUALITY

3.1 INTRODUCTION

This section presents the potential air quality impacts during the construction and operation of the proposed Sha Tin STW Stage III Extension. The key issue is likely to be the potential for nuisance resulting from the emission of odour from the operation of the STW, and hence this is the focus of this section. In addition, qualitative air quality assessments to address the potential dust impacts during the construction phase, and other potential emissions from the Stage III Extension have also been conducted.

3.2 ENVIRONMENTAL LEGISLATION, POLICIES, PLANS, STANDARDS AND CRITERIA

3.2.1 *Introduction*

The criteria for evaluating air quality impacts are specified in the *Technical Memorandum (TM) on Environmental Impact Assessment Process* (EIAOTM). The relevant criteria for this Study are given in the following sections.

3.2.2 *Air Pollution Control Ordinance*

The principal legislation for the management of air quality is the *Air Pollution Control Ordinance* (*APCO*) (Cap 311). The Hong Kong *Air Quality Objectives* (AQOs) stipulate the statutory limits of typical air pollutants and the maximum allowable number of exceedances over specified periods. These AQOs apply to the whole of the Hong Kong SAR and are shown in *Table 3.2a*.

Table 3.2a ***Hong Kong Air Quality Objectives ($\mu g\ m^{-3}$) [a]***

Pollutant	Averaging Time			
	1 Hour[b]	8 Hours[c]	24 Hours[d]	1 Year[e]
Total Suspended Particulates (TSP)	-	-	260	80
Respirable Suspended Particulates (RSP)	-	-	180	55
Sulphur Dioxide (SO_2)	800	-	350	80
Nitrogen Dioxide (NO_2)	300	-	150	80
Carbon Monoxide (CO)	30,000	10,000	-	-

Notes:
(a) Measured at 298K (25°C) and 101.325 kPa (one atmosphere).
(b) Not to be exceeded more than three times per year.
(c) Not to be exceeded more than once per year.
(d) Arithmetic means.
(e) Respirable suspended particulates means suspended particles in air with a nominal aerodynamic diameter of 10 micrometres and smaller.

In addition, the EIAOTM stipulates that an hourly TSP level of 500 $\mu g\ m^{-3}$, measured at 298K and 101.325 kPa, should not be exceeded for construction dust.

3.2.3 *Odours*

In the area of odour assessment, a variety of standards have been adopted worldwide, and, to date, there is no international consensus on this matter. The following provides a brief description of the odour criterion adopted for the present study.

Quantification of Odours

Odours may be measured in odour units (OU). An odour unit is defined as one cubic metre of air containing an odour at the threshold concentration. If an odour was attributable to just one compound present in air, then the odour unit would reflect the threshold concentration for that compound. For example, if the odour threshold for a compound is 2 $\mu g\ m^{-3}$, then air containing a concentration of 20 $\mu g\ m^{-3}$ would contain 10 OUm^{-3}.

The conventional method of determining odour detection thresholds is to expose a panel of subjects to varying concentrations of the odour in air samples, in a laboratory setting. The concentration at which the odour is just detectable by 50% of the panel can be quantified in terms of the number of dilutions with odour-free air required to reach this point. The threshold concentration can be defined as one odour unit per cubic metre (1 OU m^{-3}) and the original sample must therefore contain n OU m^{-3}, where n is equal to the number of dilutions required.

Odour Detection/Odour Nuisance

Odours may be detected over very short timescales but odour nuisance will only occur when an odour is detected at a high enough level sufficiently often that it becomes annoying. Therefore, although an odour may be detected on occasions it may not necessarily constitute a nuisance. For example, the World Health Organisation (WHO) quote an odour detection threshold for one odorous compound associated with sewage treatment works, hydrogen sulphide (H_2S), of 0.2 to 2.0 $\mu g\ m^{-3}$ when in a pure form. However, the WHO also quote an H_2S concentration of 7 $\mu g\ m^{-3}$ (expressed as a half hour average) as being the concentration likely to produce substantial odour complaints amongst persons exposed[(9)]. The concept of nuisance being a function of both the concentration and frequency is enbraced by many standards used elsewhere, which are based on a percentile value, e.g. 2 OUm^{-3} as a 98th percentile of hourly averages.

Odour Criterion Applied to Sha Tin STW Stage III Extension

According to *Annex* 4 of the EIAOTM, a level of 5 OU m^{-3} or above based on an averaging time of 5 seconds at an Air Sensitive Receiver (ASR) is considered an odour nuisance.

3.2.4 *Other Legislation*

Other air pollution regulations which are related to the present study include: *The Air Pollution Control (Construction Dust) Regulation* which stipulates the mitigation measures for construction sites; and the *Air Pollution Control (Fuel*

(9) World Health Organisation (1987) *Air Quality Guidelines for Europe*, WHO Regional Publications, European Series No. 23

Restriction) Regulations which prohibits the use of solid and liquid fuel in Sha Tin, with the exception of use in construction plant.

3.3 DESCRIPTION OF THE ENVIRONMENT

3.3.1 *Introduction*

The Sha Tin Sewage Treatment Works Stage III Extension (the Project) is located within the Sha Tin airshed, in which the dispersion of air pollutants is generally considered to be relatively poor. The nearest EPD fixed Air Quality Monitoring Station (AQMS) is located at the Sha Tin Government Secondary School. The ambient air quality data from the Sha Tin EPD AQMS for the year 1996 are presented in *Table 3.3a*.

Table 3.3a *Background Air Quality at Sha Tin for 1996*

Pollutant	Annual Average ($\mu g\ m^{-3}$)
Total suspended particulates (TSP)	69
Respirable suspended particulates (RSP)	46
Sulphur dioxide (SO_2)	13
Nitrogen dioxide (NO_2)	45
Nitrogen oxides (NO)	31

Measurements are not made of the existing odour concentrations around the Sha Tin STW. Dispersion modelling has been undertaken to determine the off-site odour concentrations from the existing Stage I and II facilities to enable a cumulative assessment to be conducted. The results of this dispersion exercise modelling are presented in *Section 3.6.2*.

3.3.2 *Odour Complaints*

The existing odour climate in the area can be described in terms of the number and frequency of odour complaints made by members of the general public. According to information provided by DSD, it is reported that complaints about odours emanating from the STW are made only infrequently. Accordingly, a complaint has been reported in 1998 by a bus user travelling on the T-6 Bridge which runs over the northern section of the site. In addition, two other odour complaints have been received by the EPD's Territory North Local Control Office in 1998. These were reported from Garden Vista located about 2.5km to the south-west of the STW[10], and from Kam On Court located about 2km to the south-west of the STW[11]. However, it is not clear whether or not these odour complaints were attributable to the Sha Tin STW, as these ASRs are at a long distance from the facility.

3.3.3 *Main Sources of Odours at the Existing Sewage Treatment Works*

Odours arise as a result of biological activity under anaerobic (low oxygen)

(10) Drainage Services Department (1998) ref. (86) in A44
(11) Drainage Services Department (1998) ref. (88) in A44

conditions *ie*, if sewage spends a significant period of time without contact with air. This occurs in pumped sewerage systems, sewers with low flows or high retention times, at the bottom of primary tanks and in sludge storage or retention tanks. The length of time required to develop malodours depends on the organic strength of the waste and the temperature. Odours are typically worse in the summer months when temperatures are high.

The main sources of odour at the existing STW are anticipated to be the inlet works, primary sedimentation tanks, feed channels to the primary sedimentation tanks, sludge holding tanks, and sludge storage tanks containing digested sewage treatment works sludge.

Dosing with iron chloride is currently used at the STW to suppress the formation of hydrogen sulphide, and thus reduce emissions of the characteristic "rotten egg" smell. However, this is only partially effective as a nuisance control measure as other odourous compounds, such as mercaptans, amines, skatoles, indoles etc. are not reduced.

3.3.4 *Other Odour Sources in the Area*

Other sources of odour in the area include the Shing Mun River and, potentially, the stables of the neighbouring Sha Tin Racecourse. According to the report, *River Water Quality in Hong Kong, 1996*, there are still villages which are not connected to the main sewerage system in the Sha Tin catchment area, upstream of the Shing Mun River. Raw sewage from these villages is discharged to the river via the stormwater drainage system. As a result, sediment on the river bed may generate elevated levels of odour, in particular, when the sediment is exposed during times of low water. This issue has been addressed in a recent study commissioned by the EPD, *Environmental Improvement of Shing Mun River Main Channel and Associated Nullahs (June 1998).*

3.4 *SENSITIVE RECEIVERS*

Existing and proposed representative Air Sensitive Receivers (ASRs) have been identified in accordance with the criteria set out in the *Hong Kong Planning Standard and Guidelines* (HKPSG) and the EIAOTM. These ASRs and their horizontal distances from the boundary of the Project Area are listed in *Table 3.4a*. Locations of the ASRs are shown in *Figure 3.4a*.

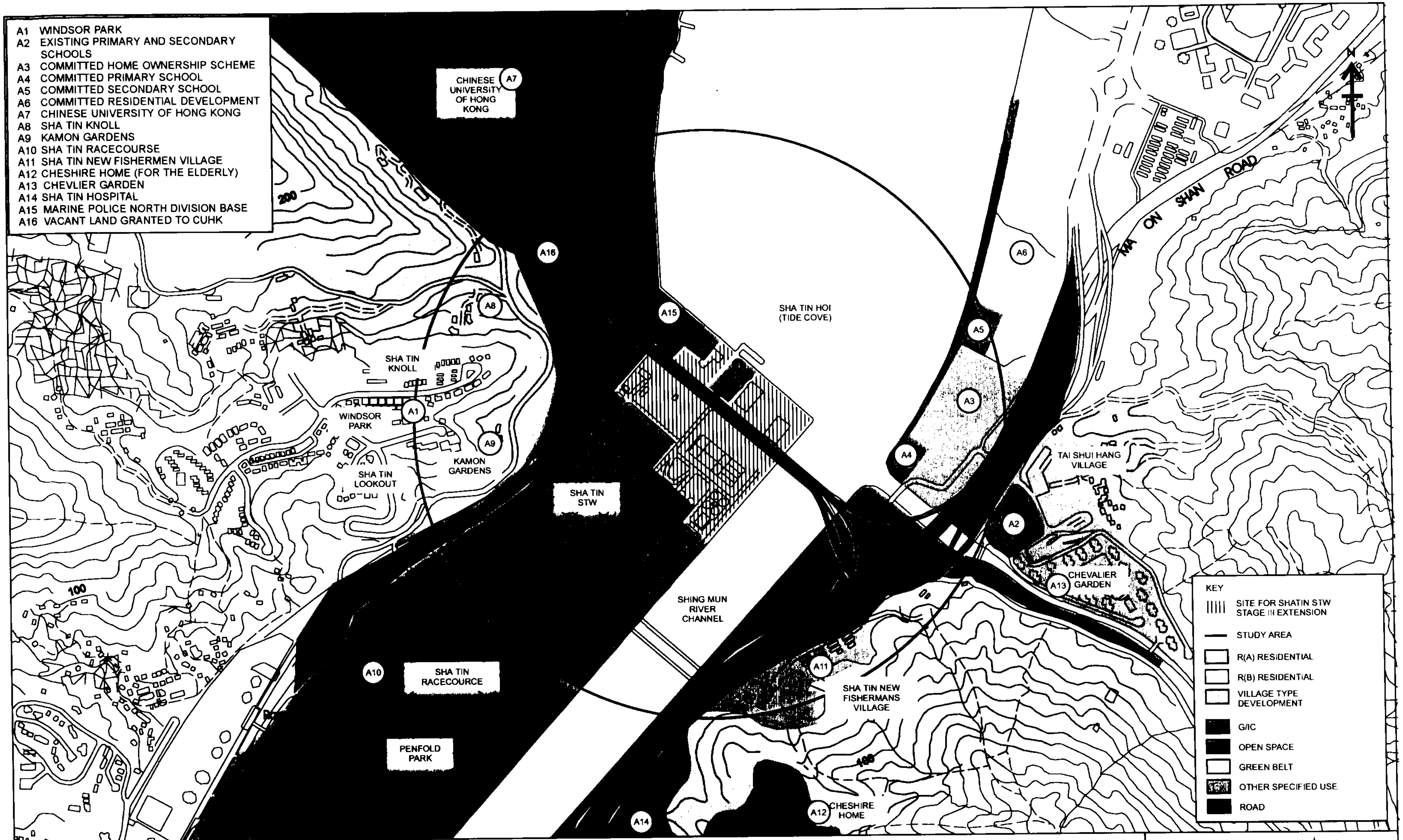

FIGURE 3.4a

LOCATION OF AIR AND NOISE SENSITIVE RECEIVERS

Environmental Resources Management

ERM

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DATE: 04/05/99

Table 3.4a *Location of Representative Existing and Planned Air Sensitive Receivers in and near the EIA Study Area*

ASR	Location	Sensitive Use	Distance from Sha Tin STW Stage III Site Boundary (m)	Direction of ASR from Sha Tin STW	Height (mPD) (m)
A1	Windsor Park	Domestic Premises	500	West	90
A2	Existing primary and secondary schools	Educational Institution	550	North-east	10
A3	Committed Home Ownership Scheme	Domestic Premises	400	North-east	7
A4	Committed Primary School	Educational Institution	250	North-east	7
A5	Committed Secondary School	Educational Institution	475	North-east	7
A6	Committed Residential Development	Domestic Premises	750	North-east	7
A7	Chinese University of Hong Kong	Educational Institution	650	North-west	5.2
A8	Sha Tin Knoll	Domestic Premises	350	West	85
A9	Kamon Gardens	Domestic Premises	150	West	75
A10	Sha Tin Racecourse	Sports Stadium	600	South-west	5
A11	Sha Tin New Fishermen Village	Domestic Premises	400	South-east	10
A12	Cheshire Home (for the elderly)	Hostel	600	South	100
A13	Chevalier Garden	Domestic Premises	750	North-east	10
A14	Sha Tin Hospital	Hospital	550	South	10
A15	Marine Police North Division Base	Office	80	North-west	5
A16	Vacant Land Granted to Chinese University	Educational Institution	400	North-west	10

3.5 CONSTRUCTION PHASE

Construction activities associated with the Sha Tin STW Stage III Extension have the potential to cause the generation of dust emissions. Dust deposition can cause soiling at properties close to construction sites and are controlled via provisions in the *Air Pollution (Construction Dust) Regulation* to ensure that nuisance is avoided. This section assesses the potential dust impacts during the construction period.

3.5.1 *Assessment Methodology*

In order to determine the nature and extent of impacts from the construction of the Project, the construction programme, materials and methods need to be identified. However, due to the considerable distance of the site from existing ASRs, it was agreed with the EPD that the construction phase dust impacts will be qualitatively addressed (refer to *Section 3.7* of the *Inception Report*)[12].

(12) Agreement No. CE90/97. Sha Tin Sewage Treatment Works, Stage III Extension EIA Study: 1st Steering Group Meeting. 44/F, Conference Room, Revenue Tower, 5 August 1998.

3.5.2 *Potential Sources of Impacts*

Introduction

The potential for dust to be emitted during construction activities is, by its nature, very variable, and depends on the following:

- the type of construction activities;
- the extent of application of mitigation measures to reduce emissions;
- the prevalence of dry weather conditions;
- windspeed.

Construction Activities

The types of construction activities associated with the advanced earthworks and the various civil works are:

- grading and levelling of ground;
- removal of spoil;
- site stripping;
- earthworks.

Other construction activities with a potential for dust emissions are as follows:

- site excavations;
- concreting operations;
- site reinstatement and road construction.

Indirect transport of particles, due to dust adhering to the wheels and chassis of vehicles accessing the site and involved in the import and removal of materials, may lead to increased dust emissions along access routes. Further potential for dust generation exists due to blow-off and spillage from vehicles during the export of excavated material and the import of fill materials.

The magnitude of dust emissions from these potential sources, are very dependent on the suppression measures employed during the construction activities. Mitigation measures are discussed in *Section 3.5.4.*

3.5.3 *Prediction and Evaluation of Impact*

Meteorological Conditions and Dust Deposition

At wind speeds above 3 ms^{-1}, particles of dust may become airborne and be transported from their source. Of the particles which become airborne, for a typical mean windspeed of 4 ms^{-1}, those with a diameter greater than 100μm are likely to settle out within 6 to 10m and those with diameters between 30 to 100 μm are likely to settle out within 100m of the source.

Smaller particles, particularly those below 10μm, are more likely to have their settling rate retarded by atmospheric turbulence and to be transported further. In high winds, some of these fine dust particles could be deposited at a distance of 500m from the construction area and high winds will cause more dust to be created at source, when there are dry surfaces. During rainy periods the potential for dust emissions is substantially reduced.

Predicted Impacts

Virtually all particles with a diameter of more than 30μm emitted directly from the construction site are likely to be deposited within a distance of 100m. As indicated in *Table 3.4a*, there are no existing or planned sensitive receivers within 100m of the Project area. Therefore dust nuisance should not be adverse provided that practicable mitigation measures are followed.

The potential for dust being transported off-site as a result of construction vehicles accessing the STW should also be minimised by adherence to mitigation measures discussed in the following section.

3.5.4 *Mitigation Measures*

For the control of potential dust impacts, the following dust control measures, as specified in the *Air Pollution Control (Construction Dust) Regulation*, should be incorporated in the Contract Specifications for the Stage III Extension Project.

- The area in which demolition of the existing structures of the STW takes place should be sprayed with water immediately prior to, during and immediately after the demolition activities to minimise dust generation.

- Any debris from the demolition or construction of the Stage III Extension should be covered entirely by impervious sheeting or stored in a debris collection area sheltered on the top and at three sides.

- Any dusty material remaining after a stockpile of cement or other materials is removed should be wetted and cleared from the surface of roads.

- Any skip hoist for the transport of construction wastes should be properly enclosed.

- Vehicle washing facilities, including a high pressure water jet, should be provided at the designated vehicle exit point. Immediately before leaving the STW construction site, every vehicle should be washed to remove any dusty materials from its body and wheels.

- The area where vehicle washing takes place and the section of the road between the washing facilities and the exit point, as well as the main haul road to the Stage III works site should be paved with concrete, bituminous materials, hardcore or metal plates and kept clear of dusty materials.

- The main haul road to the Stage III site should be sprayed with water to keep the entire road surface wet and to minimise dust generation.

- Every stock of more than 20 bags of cement should be covered entirely by impervious sheeting or placed in an area sheltered on the top and at 3 sides.

- Cement bags or any other dusty materials collected during the work should be disposed of in totally enclosed containers.

- 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.

- Every belt conveyor used for the transfer of dusty materials should be enclosed. Every transfer point between any two belt conveyors should be totally enclosed.

It is expected that with the above measures in place, dust emissions from various construction activities and materials handling will be reduced to levels within the requirements specified in the EIAO TM. However, special attention has to be paid to the enforcement of the above mitigation measures. The works have to be carried out under tight supervision and monitoring by DSD and actions should be imposed on the contractors should there be any violation of these measures during the construction period. Arrangement of the monitoring and audit activities will be detailed in the *Environmental Monitoring and Audit (EM&A) Manual* for this EIA Study.

3.6 OPERATION PHASE

3.6.1 *Assessment Methodology*

Introduction

Odorous emissions from the Sha Tin STW Stage III Extension were assessed quantitatively using dispersion modelling techniques, to predict odour concentrations at the ASRs identified in *Section 3.4*. The methodology for the dispersion modelling is described in detail in this section.

Climate as it Influences Dispersion

The most important meterological parameters governing the atmospheric dispersion of emissions are as follows.

- *Wind direction* broadly determines the transport of the plume and the sector of the compass into which the plume is dispersed.

- *Wind speed* affects the initial dilution of emissions and plume rise. Plume rise is enhanced by an increase in the momentum of the emission and its thermal buoyancy (if any), and reduced by an increase in wind speed. Plume rise can be a very important determinant of the location of the maximum ground level concentration. Increased plume rise ensures greater dispersion and, therefore, lower ground level concentrations.

- *Atmospheric stability* is a measure of turbulence in the context of surface layers, and, in particular, of the vertical motions present. For dispersion modelling purposes, stability is classified by Pasquill stability categories, referred to as Stabilities A to F. "A" is the unstable extreme, representing very convective conditions with large vertical motions; "F" is a very stable category, in which the temperature increases markedly with height and all vertical motion is suppressed. Stability D refers to neutral conditions, where mechanically-generated turbulence is similar to that due to buoyancy effects. Based on the meteorological data from the Sha Tin and other meteorological stations operated by the Hong Kong Observatory, Stability F does not happen very frequently in Hong Kong. Furthermore, the use of Pasquill stability category system will probably over-estimate the frequency with which Stability F arises in the SAR.

Local Climate at Sha Tin

The characteristics of the local climate clearly have an important influence on the dispersion of plumes emitted from both stack and area sources. To undertake dispersion modelling for emissions from the Sha Tin STW, it is therefore important to have meteorological data which are representative of the local climate.

For the dispersion modelling exercise, a climate data set in the form of a Pasquill stability analysis is required. Such data are available from the Sha Tin Meteorological Station, located at the Sha Tin Racecourse to the south-west of the works. The meteorological data recorded at Sha Tin are considered to be representative of the climate experienced at the works.

Mixing heights are recorded at only one meteorological station in Hong Kong, at King's Park. Mixing heights recorded at King's Park have therefore been used in conjunction with other meteorological parameters recorded at Sha Tin, for the modelling exercise.

The predominant wind directions recorded at Sha Tin are from the north to easterly quadrant, accounting for approximately 55% of all winds recorded.

The Dispersion Model

In order to estimate the likely ground level concentrations resulting from the emissions, the Industrial Source Complex (ISC) dispersion model (Version 3) has been used. The model describes the plume emitted from a source as a Gaussian distribution both horizontally and vertically. The model has been developed and validated by the United States Environmental Protection Agency (US EPA). The ISC dispersion model has been used extensively, for regulatory purposes, in the United States (US). Its use for assessing air quality impacts from various facilities has also been widely accepted by the Hong Kong EPD. Of relevance to this assignment is the fact that this model has been used for numerous other odour assessments in Hong Kong and overseas.

Hourly data are supplied by the Hong Kong Observatory for input into the ISC3 dispersion model, and contain the following information:

- year, month, day and hour of observation;
- flow vector, *ie*, direction towards which the wind is blowing;
- wind speed;
- ambient temperature;
- stability class.

Key features of the ISC models are as follows.

- Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions (Note: The modelling assumed that odour is emitted as a non-buoyant plume due to the evaporation of the odourous compounds).

- A procedure for calculating transitional plume rise.

- Procedures for evaluating stack-tip downwash.

- Variation with height of wind speed (wind-profile exponent law).
- A method to account for buoyancy-induced dispersion.
- Rural dispersion coefficients (see below).

Rural and Urban Dispersion Coefficients

Rural or urban coefficients may be utilised when using the ISC dispersion models. Urban dispersion coefficients are representative of the conditions in an area where there is a high proportion of buildings or structures affecting the air flow (ie, high surface roughness). Rural conditions represent areas which have a high proportion of open areas or areas which may be populated but not by high rise buildings (*ie*, low surface roughness).
The US EPA offers guidance on the selection of rural or urban dispersion modes in the operation of the ISC models as follows[13]:

> "*... if land use, for more than 50% of the area [within 3 km of the source] is categorized as heavy or medium industry, commercial or multi-family residential, use urban dispersion [coefficients].*"

Current and future land use around Sha Tin STW was derived from the 1:20,000 survey map and the Outline Zoning Plans of the area. The percentage of residential and industrial landuses is summarised in *Table 3.6a*.

Table 3.6a ***Current and Future Land Use in the Region of Sha Tin Sewage Treatment Works***

Land Use	**Current**	**Future**
Water/open space/green belt	62%	57%
Residential and industrial	38%	43%

Since the committed residential and industrial and uses, taking account of the current and planned developments, amount to 43%, according to the US EPA land use classification system, the region surrounding the Sha Tin STW may be classified as rural for the purpose of dispersion modelling. However, the US EPA also suggests another procedure to determine the dispersion coefficients based on the population density. The criterion for this procedure is that if the average population density in an area within 3km of the source (about 28 km^2) is greater than 750 people km^{-2}, the urban dispersion coefficients can be used. To meet this criterion the population in 28 km^2 will have to exceed 21,000 people. As the 3km radius of this Project covers part of the new towns in Ma On Shan, Sha Tin and the Fo Tan Industrial Area, the population will greatly exceed 21,000. As such, the Study Area could also be considered as urban according to this alternate USEPA procedure. The density of the populated areas will give rise to significant anthropogenic heating effects which are most closely simulated by running the model in the urban mode[14]. On balance, two of the three means of determining the mode in which the model is to be run indicate that the urban mode should be used and on this basis the urban mode was selected.

(13) US EPA (1986) **Guidance on Air Quality Models** (Revised)
(14) Correspondence from Trinity Consultants Incorporated dated 20 October 1997. Copy from EPD/APG

Building Downwash Structures

The potential for building downwash to affect plume dispersion from any stack emissions is an important consideration, particularly when the stack is less than 2.5 times the height of a nearby building.

Terrain

The presence of elevated terrain can result in significantly higher ground level pollutant concentrations as a result of stack emissions than would be experienced without it. This can occur when a plume impinges on an area of elevated terrain, and is particularly important under stable atmospheric conditions. Terrain data have been incorporated into the modelling of emissions from the Sha Tin STW.

Odour Emission Rates

Odour emission rates from the various facilities associated with the existing Stage I & II and the proposed Stage III Extension are required as inputs to the dispersion model.

The odour emission rates used for this EIA Study are derived based on the empirical formulae employed in other EIA studies in Hong Kong. These depend on the septicity and oxidation-reduction potential of the raw sewage. The methodology has previously been used in the *Outlying Islands Sewerage Stage I Phase I - EIA Study, Final Assessment Report* and the *North Lantau Development Topic Report TR23, Environmental Impact Assessment of the Tung Chung Main Sewage Pumping Station.* Details of the methodology are presented in *Annex B*. *Table 3.6b* presents the odour emission rates derived by this methodology and which have been adopted in this Study.

Table 3.6b ***Odour Emission Rates Adopted for the Sha Tin STW Stage III Extension EIA Study***

Emission Source	**Odour Emission Rate (OU $m^{-2}s^{-1}$)**
Inlet works	1.69
Feed channels for primary tanks	1.69
Primary sedimentation tanks	0.84
Aeration tanks	3.5×10^{-2}
Final settling tanks	1.7×10^{-2}
Sludge holding tanks	1.69
Sludge storage tanks	1.69

It should be noted that since the methodology in these previous studies was applied principally for the determination of odour from raw sewage, the estimated odour emission rates from the sludge holding tanks and sludge storage tanks were assumed to be the same as those from the inlet works.

Operation of the Works

It was assumed that Stages I and II of the works continuously emit odours at the rates shown in *Table 3.6b* in the absence of any additional mitigation measures.

In addition, the following assumptions about the existing and proposed works have been made in the modelling exercise.
Existing Stage I&II Works:

The following main elements of the existing Stage I & II works were assumed to be in use:

- two of the four flow measurement and control channels at the inlet works;
- five of numbers 1 to 8 primary sedimentation tanks;
- two of numbers 9 to 12 primary sedimentation tanks;
- all of the aeration tanks, final settlement tanks and sludge holding tanks.

These assumptions were based on the actual operating conditions at the existing works and have been used to model the baseline conditions. Emission parameters for the existing works are presented in *Table 3.6c*.

Stage III Extension

The following assumptions about the operation of the Stage III Extension have been made for the purposes of dispersion modelling:

- all ten new primary sedimentation tanks and aeration tanks will be in permanent use;

- all twenty new rectangular final settlement tanks will be in permanent use.

One of the key design changes relates to the sludge collection system of the Stage III primary sedimentation tanks. This will be changed from the travelling bridge type, employed for Stages I and II, to a chain-and-flight collection system. The chain-and-flight scraping system will have a continuous sludge removal mechanism and should reduce odour emissions. However, as a conservative assumption the same emission rate adopted for the Stage I and II works was used also for Stage III.

As part of the Project, the capacity of the anaerobic digestors will be significantly increased. The existing and the Stage III digestors (a total of 14 digestors compared to 8 at present) will provide enhanced sludge treatment capacity. This allows for a longer sludge retention time and thus reduces odour generation rates due to the more efficient reduction of the sludge volatile solids content. As such, the odour emission rates at the existing sludge holding tanks would be anticipated to be reduced when the Stage III digestors are commissioned. However, as a conservative assumption, the emission rates from these tanks are assumed to be the same before and after the commissioning of the Stage III Extension. The odour emission parameters for the Stage III Extension are presented in *Table 3.6d*.

Table 3.6c ***Emission Parameters for the Existing Sha Tin STWs (Stage I & II)***

Emission Source	Odour Emission Rate ($OU\ m^{-2}\ s^{-1}$)	Length x Breadth (m)	Height [i] (m)	Area (m^2)
Inlet works	1.69	750 m^2 [a]	6.8	750
Primary sedimentation tanks (12)				
• Tanks 1-8	0.84	55 x 65 [b]	4.8	3575
• Tanks 9-12	0.84	55 x 26 [c]	4.8	1430
Feed channels for primary sedimentation tanks				
• Channels for tanks 1-8	1.69 [d]	1.2 x 104	4.9	124.8
• Channels for tanks 9-12	1.69 [d]	1.2 x 52	4.9	62.4
Aeration tanks (12)				
• Tanks 1-8	3.5×10^{-2}	88 x 104	4.2	9152
• Tanks 9-12	3.5×10^{-2}	88 x 52	4.2	4576
Final settlement tanks (circular) (24)	1.7×10^{-2}	27.5 [e]	3.0	594
Final settlement tank feed channels (3)	3.5×10^{-2} [f]	550 m^2 [g]		550
Sludge holding tanks (4)	1.69	20 [e]	9.5	314
Sludge storage tanks (2)				
• Tanks 1&2	1.69 [h]	23 [e]	13	415

Notes:

(a) Estimated area of the inlet works which is exposed to air and contains effluent. The estimated area is based on the layout plan combined with observation during field visit.
(b) Assumed that 5 tanks in use
(c) Assumed that 2 tanks in use
(d) Assumed same as emission rate at inlet works as the feed channels connect the inlet works with the primary sedimentation tanks prior to primary treatment
(e) Diameter of each tank
(f) Assumed same as emission rate as aeration tanks
(g) Estimated area per channel. The estimated area is based on the dimensions shown on the layout plan combined with observation during field visit.
(h) Tank containing digested sewage treatment work sludge
(i) Assumed as the stack height for the modelling

Table 3.6d ***Emission Parameters for Sha Tin STWs Stage III Extension***

Emissions Source	Odour Emission Rate ($OU\ m^{-2}\ s^{-1}$)	Length x Breadth (m)	Height (m)
Primary sedimentation tanks (10)			
• Tanks 13-16	0.84	55 x 52	4.8
• Tanks 17-22	0.84	55 x 78	4.8
• Feed channels for tanks 13-16	1.69	1.2 x 52	4.9
• Feed channels for tanks 17-22	1.69	1.2 x 78	4.9
Aeration tanks (10)			
• Tanks 13-16	3.5×10^{-2}	88 x 52	4.2
• Tanks 17-22	3.5×10^{-2}	88 x 78	4.2
Final settlement tanks (20)	1.7×10^{-2}	120 x 80	3.0

Notes:

(a) Diameter of each tank

Alternative Design for Stage III Extension

As stated in *Section 2.4.4*, there is an option for the inclusion of an extra aerated grit channel and flow control and measurement channel at the inlet works as part of the Project. However, since this change is not envisaged to impact the modelling work to a significant degree, the alternative design was not evaluated.

Conversion of Dispersion Model Outputs to 5 Second Mean Odour Concentrations

The odour assessment criterion is defined as 5 OU m^{-3} as a 5 second mean, in accordance with guidance provided by the EPD.

The ISCST3 dispersion model has been used to predict an output which is described by the model as a maximum 1 hour mean concentration. In actual fact, this output corresponds more closely to a maximum 3 minute average. This matter relates to the Pasquill-Gifford vertical dispersion parameter used in the ISCST model and is fully documented in the *Workbook on Atmospheric Dispersion Estimates*. To provide a margin of error it has been conservatively assumed that concentration calculated by ISCST can be equated to a 15 minute mean, as agreed with EPD[(15)].

In order to convert the model outputs to maximum 5 second mean concentrations, a two-step conversion process has been defined by EPD.

Step 1:

Conversion of the model output to a maximum three minute mean, using the power law formula proposed by Duffee *et al*[(16)], which is reproduced below:

$$X_l = X_s(t_s/t_l)^p$$

where:

X_l = the concentration for the longer time averaging time;
X_s = the concentration for the shorter averaging time;
t_s = the shorter averaging time;
t_l = the longer averaging time; and
p = the power law exponent, which depends on the Pasquill stability class, and is detailed in *Table 3.6e*.

Table 3.6e ***Power Law Exponents***

Pasquill Stability Class	***p***
A	0.5
B	0.5
C	0.333
D	0.2
E	0.167
F	0.167

(15) Sha Tin Sewage Treatment Works, Stage III Extension, EPD Letter dated 18 September 1998.
(16) RA Duffee, MA O'BRIEN & N Ostojic, **Odour Modelling - Why and How, in Recent Developments and Current Practices in Odor, Regulations, Controls and Technology**, Transaction of the Air & Waste Management Association, ED. DR Derenzo & A Gnyp

Step 2:

Conversion of 3 minute means to 5 second means using the approach suggested by the Warren Spring Laboratory (WSL) [17], which states:

> *"Typical maximum or peak 5-second average concentrations within any 3-minute period appear to be of the order of 5 times the 3-minute average. During very unstable conditions larger ratios, perhaps 10:1, are more appropriate...."*

It should be noted that the ratios provided in the WSL approach refer to peak to mean concentrations for emissions from stacks; emissions from low-level area sources such as primary sedimentation tanks will fluctuate far less and therefore the peak to mean ratios will be much reduced. The use of the peak to mean ratios provided in the WSL report therefore provides a further element of conservatism to the prediction 5 second mean concentrations for area sources. The resulting factors for converting the model outputs to 5 second means, are presented in *Table 3.6f.*

Table 3.6f ***Factors for Converting Model Outputs to Maximum 5 Second Mean Odour Concentrations***

Pasquill Stability Class	Conversion 15 minute to 3 minute mean	Conversion 3 minute to 5 second mean	Overall Conversion Factor
A	2.23	10	**22.3**
B	2.23	10	**22.3**
C	1.70	5	**8.50**
D	1.38	5	**6.90**
E	1.31	5	**6.55**
F	1.31	5	**6.55**

3.6.2 *Prediction and Evaluation of Impacts*

Predicted Ground Level Odour Concentrations - Existing Sewage Treatment Works (Stage I & II)

The predicted maximum 1 hour and 5 second mean ground level odour concentrations at Air Sensitive Receivers (ASRs) as a result of emissions from the existing sewage treatment facilities (Stage I&II) are presented in *Table 3.6g*. As described in *Section 3.6.1*, these concentrations are the highest 1 hour and 5 second mean concentrations predicted to occur in a year. Concentrations during other hours will be lower (in many cases considerably so) and hence these predictions are representative of the worst case situation.

Data are also presented in more detail for three ASRs close to the site, see *Table 3.6h*. As well as presenting the maximum ground level concentrations for the cumulative emissions, the table also presents maximum concentrations for emissions from each element of the works. This enables the major odour sources to be readily identified and, if necessary, prioritised for mitigation.

(17) AWC Keddie, **Dispersion** of Odours, in **Odour Control - A Concise Guide**, Warren Spring Laboratory (1980)

Table 3.6g ***Stage I & II Odour Emissions: Predicted Maximum 1 Hour and Maximum 5 Second Mean Ground Level Odour Concentrations at Sensitive Receivers (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.52	3.41
A2	Primary & Secondary School	0.40	2.62
A3	Committed HOS Housing	0.54	3.55
A4	Committed Primary School	0.69	4.55
A5	Committed Secondary School	0.51	3.31
A6	Committed Residential Development	0.33	2.14
A7	Chinese University of Hong Kong	0.25	1.67
A8	Sha Tin Knoll	0.47	3.05
A9	Kamon Gardens	0.65	4.29
A10	Sha Tin Racecourse	0.59	3.86
A11	Sha Tin New Fisherman's Village	0.68	4.46
A12	Cheshire Home	0.50	3.29
A13	Chevalier Garden	0.35	2.32
A14	Sha Tin Hospital	0.64	4.18
A15	Marine Police North Division Base	0.67	4.40
A16	Vacant Land Granted to CUHK	0.49	3.22
Max	**Committed Primary School (A4)**	**0.69**	**4.55**

Table 3.6h ***Predicted Ground Level Odour Concentrations (OU m^{-3}): Emissions from Existing Sha Tin Sewage Treatment Works (Stage I & II)***

	Max 5 Second Mean (OUm^{-3})		
Existing Facility	**East Edge of Windsor Park (A1)**	**Existing Primary & Secondary School (A2)**	**Committed HOS Housing (A3)**
Inlet works	0.75	0.54	0.54
Primary sedimentation tanks	2.22	1.24	1.87
Aeration tanks	0.26	0.14	0.18
Final settlement tanks	0.17	0.09	0.12
Sludge holding tanks	1.44	1.11	1.34
Sludge storage tanks	0.96	1.04	1.68
All existing sources	**3.41**	**2.62**	**3.55**

The dispersion modelling results for the existing STW Stages I and II indicate the following.

- The highest predicted ground level odour concentrations as a result of emissions from the existing facilities are predicted to occur at the committed Primary School at the eastern bank of the Shing Mun River (A4). This is followed by the Sha Tin New Fisherman Village (A11) and Marine Police North Division Base (A15).
- The existing primary sedimentation tanks, sludge holding tanks and the sludge storage tanks are predicted to be the main contributors to the predicted odour concentrations at these ASRs.
- The highest concentrations due to emissions from most of the existing sources are predicted to occur under stable atmospheric conditions (Pasquill Stability Category F) and low wind speeds (less than or equal to 1 m s^{-1}).
- Predicted maximum 5 second mean concentrations at all ASRs from the existing Stage I and II works are below the assessment criterion stipulated by the EPD.

Predicted Ground Level Odour Concentrations - Stage III Extension

Predicted maximum 1 hour mean and 5 second mean ground level odour concentrations for emissions from the Stage III Extension are presented in *Table 3.6i* for all the ASRs identified in *Section 3.4*. No mitigation has been assumed in these estimates.

The dispersion modelling results for emissions from the Stage III Extension indicate the following.

- The highest ground level odour concentrations are predicted to occur at the committed primary school (A4), which is about 250m from the nearest part of the STW, on the eastern bank of the Shing Mun River channel. This is followed by the Marine Police North Division Base (A15) about 80m to the north-west from the STW.
- The highest ground level odour concentrations are predicted to occur under stable atmospheric conditions (Pasquill Stability Category F) and low wind speeds (less than or equal to 2.5 m s^{-1}).
- Predicted maximum 5 second mean concentrations at three ASRs (the committed primary and secondary schools, as well as the committed HOS housing) (ASRs 3, 4 and 5) are in excess of the 5 OU m^{-3} assessment criterion.

Table 3.6i ***Stage III Odour Emissions: Predicted Maximum 1 Hour and 5 Second Mean Ground Level Odour Concentrations at Sensitive Receivers (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.41	2.70
A2	Primary & Secondary School	0.64	4.17
A3	Committed HOS Housing	1.03	6.78
A4	Committed Primary School	1.56	10.24
A5	Committed Secondary School	0.81	5.29
A6	Committed Residential Development	0.65	4.28
A7	Chinese University of Hong Kong	0.24	1.58
A8	Sha Tin Knoll	0.48	3.17
A9	Kamon Gardens	0.59	3.87
A10	Sha Tin Racecourse	0.36	2.38
A11	Sha Tin New Fisherman's Village	0.66	4.36
A12	Cheshire Home	0.40	2.60
A13	Chevalier Garden	0.56	3.70
A14	Sha Tin Hospital	0.37	2.40
A15	Marine Police North Division Base	1.54	10.12
A16	Vacant Land Granted to CUHK	0.50	3.29
Max	**Committed Primary School (A4)**	**1.56**	**10.24**

A contour plot of the maximum 5-second mean odour concentrations as a result of emissions from the Stage III Extension is presented in *Figure 3.6a*.

Predicted Ground Level Odour Concentrations - Cumulative Impact of Emissions from Existing Stage I&II and Proposed Stage III Facilities

The cumulative effects of odour emissions from the existing Stage I & II and the proposed Stage III facilities are presented in *Table 3.6j*. It is evident that the cumulative impact at six ASRs is predicted to exceed the 5 OU m^{-3} odour criterion. These exceedences are largely influenced by the emission from the Stage III Extension as this will shorten the buffer distance between the STW and future ASRs located at Area 77 in Ma On Shan, along the eastern bank of the Shing Mun River channel.

Summary of Predicted Ground Level Odour Concentrations

Examination of the data presented in *Tables 3.6g* to *3.6j* indicates that the predicted maximum 5 second mean odour criterion of 5 OU m^{-3} is exceeded at three planned ASRs in Area 77 of the Ma On Shan New Town as a result of emissions from the Stage III Extension. The Stage III Extension will contribute significantly to the cumulative impact, which is predicted to lead to exceedences

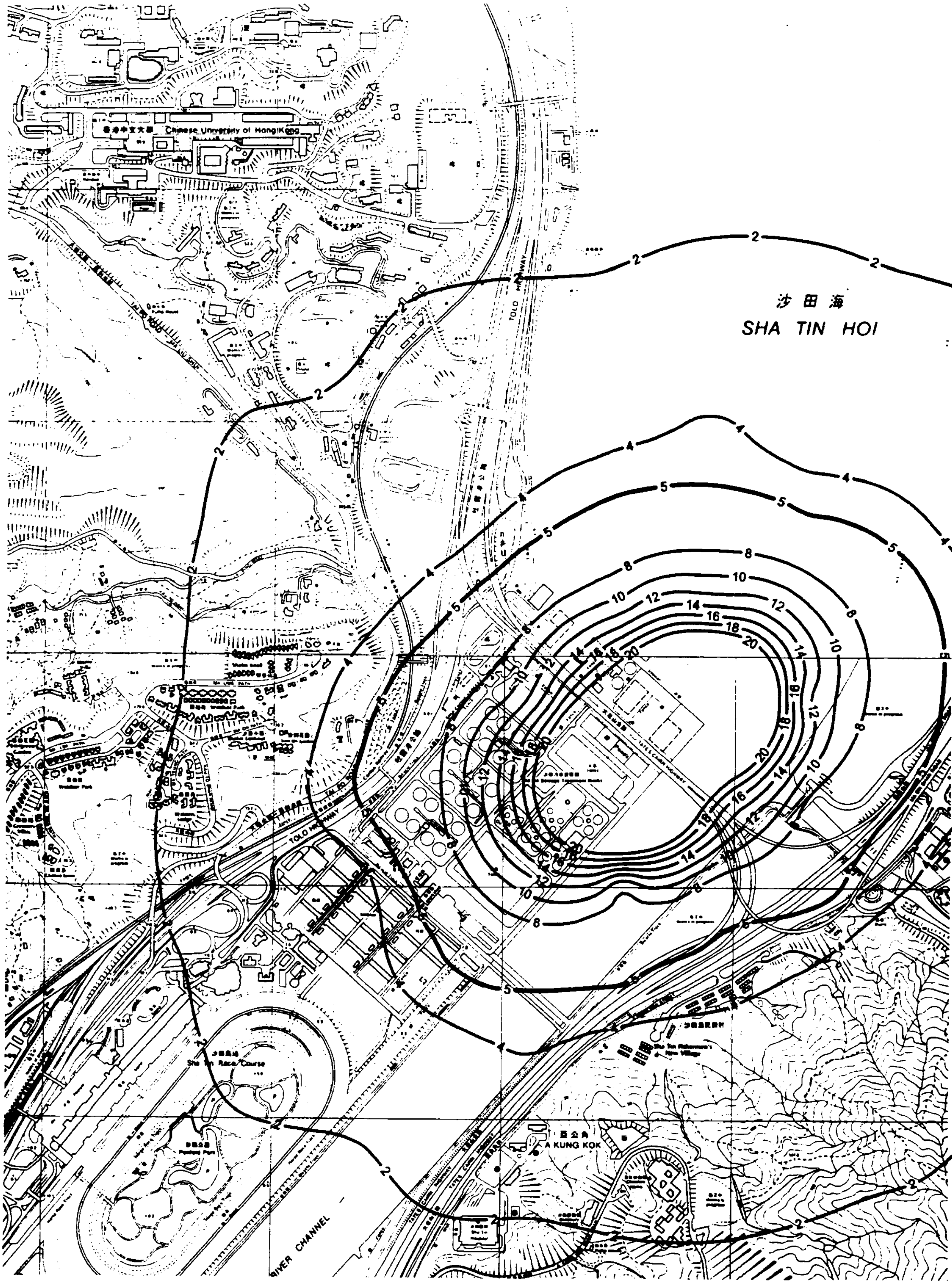

FIGURE 3.6a

PREDICTED MAXIMUM 5 SECOND ODOUR CONCENTRATION FOR STAGE III EXTENSION (NO MITIGATION)

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of the odour criterion at six ASRs. Impacts to the Marine Police North Division Base which is only 80m from the STW are predicted to be significant. Mitigation measures are required to bring the predicted impacts to an acceptable level.

Table 3.6j ***Cumulative Odour Emissions (Stage I & II & III): Predicted Maximum 1 Hour and 5 Second Mean Ground Level Odour Concentrations at Sensitive Receivers (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.52	3.41
A2	Primary & Secondary School	0.73	4.80
A3	Committed HOS Housing	1.26	8.25
A4	Committed Primary School	1.60	10.51
A5	Committed Secondary School	1.31	8.60
A6	Committed Residential Development	0.97	6.33
A7	Chinese University of Hong Kong	0.39	2.56
A8	Sha Tin Knoll	0.58	3.79
A9	Kamon Gardens	0.74	4.84
A10	Sha Tin Racecourse	0.78	5.08
A11	Sha Tin New Fisherman's Village	0.86	5.60
A12	Cheshire Home	0.50	3.29
A13	Chevalier Garden	0.67	4.42
A14	Sha Tin Hospital	0.74	4.86
A15	Marine Police North Division Base	1.55	10.17
A16	Vacant Land Granted to CUHK	0.60	3.94
Max	**Committed Primary School (A4)**	**1.60**	**10.51**

3.6.3 Biogas Emissions

In addition to odour emissions, there are other minor air emission sources at the Sha Tin STW. These include the dual fuel engines which combust biogas and diesel, to provide heat to aid the sludge digestion process. This section assesses the potential impact of these sources on air quality in the Study Area.

During normal operation, all biogas will be burned in these engines; however, in an emergency, if the dual-fuel engines are not operating, biogas may be flared via the biogas burners. The stacks associated with the six dual fuel engines are located on the southern edge of the power house.

There are two existing biogas burners (for Stages I and II) located near the primary sedimentation tanks. According to the preliminary design, it is proposed that a Stage III biogas burner will replace the Stage I burner.

Emission Parameters for Biogas Combustion

The available emission parameters for the dual fuel engines and the biogas burners are provided in *Table 3.6k*.

Table 3.6k *Emission Parameters for Dual Fuel Engines and Biogas Burners*

Parameter	Dual Fuel Engines	Stage I Biogas Burner	Stage II Biogas Burner	Proposed Stage III Burner [b]
Number of stacks	6	1	1	1
Stack height (m)	15	6	10	10
Burning rate of biogas ($Am^3 s^{-1}$)	0.13	0.08	0.28	0.28
Concentration of H_2S in biogas (ppm)	< 500	< 1,000	< 1,000	<1,000
SO_2 emission rate for biogas ($g s^{-1}$) [a]	< 0.2	< 0.2	< 0.7	<0.7

Notes:

(a) Assuming all H_2S in the biogas generates SO_2 upon combustion

(b) The proposed Stage III burner would replace the existing Stage I biogas burner

Assessment of Stack Emissions

The combustion of biogas and/or diesel produces mainly carbon dioxide (CO_2) and water vapour (H_2O). In addition, small quantities of nitrogen oxides (NO_x) and sulphur dioxide (SO_2) are produced. When diesel is combusted, small quantities of particulate matter are released. Biogas combustion releases only trace quantities of particulate matter. The nitrogen oxides released from the stacks are mainly in the form of nitrous oxide (NO), which is gradually oxidised to nitrogen dioxide (NO_2) in the atmosphere. Some NO_2 is also released directly from the stacks. With respect to potential concerns relating to the impact of the biogas combustion on human health, the only pollutants emitted from the stacks which require consideration are nitrogen dioxide and sulphur dioxide.

The stacks associated with the dual-fuel engines are 15 m high, but they are located next to the power house, so emissions from the stacks will be subject to downwash effects caused by the 13m building. In addition, two of the engine stacks are capped. As a result of downwash effects and the capping of the stacks, the highest ground level concentrations of NO_2 and SO_2 are most likely to occur close to the power house, on the STW site.

Emissions from the biogas burners are vented via stacks 6 m or 10 m high. Owing to the fact that these stacks are small, the highest ground level NO_2 and SO_2 concentrations from their emissions will also occur close to the stacks. The estimated SO_2 emission rates presented in *Table 3.6k* are very small (less than 1 g s^{-1}). Data are not available for emissions of NO_2, although the emission rates are also likely to be small. As a result, the effect of these emissions upon ambient air quality in the vicinity are predicted to be insignificant.

Reference to *Tables 3.2a* and *3.3a* clearly shows that background air quality in the Study Area complies with the annual average AQOs for SO_2 and NO_2. These data include any contribution made to the background levels by emissions from the Stage I and II facilities. By virtue of the very low emission rates reported in *Table 3.6k* and the design of the stacks, which prevent off-site impacts, the Stage III Extension is not predicted to cause breaches of the AQOs when in operation.

3.6.4 *Mitigation of Environmental Impacts*

Introduction

The dispersion modelling results presented in the previous section indicate that odour emissions from the Sha Tin STW Stage III Extension result in predicted ground level concentrations at some ASRs that are well in excess of the odour nuisance assessment criterion of 5 OU m^{-3} as a maximum 5 second average. Such impacts are predicted to arise both due to the Stage III Extension in isolation and cumulatively with the existing Stage I and II works. This section explores the various options to mitigate odour impact from the Stage III Extension and from the existing Stage I & II operations.

Potential Methods of Odour Control

Indicative odour control methods for sewage treatment processes are presented as a matrix in *Table 3.6l.* Due to the relatively long sewage residence time and their large cross-sectional area, the primary sedimentation tanks are expected to be one of the key odour sources and this is confirmed by the data presented in *Table 3.6h.* This may particularly be the case when the actual flows are considerably less than the design flows, which can lead to the development of septicity. The problem may be further compounded by the presence of septic conditions in the raw sewage.

One of the least disruptive mitigation measures is to aerate the sewage flow by oxygen injection. *Table 3.6m* shows the effect of oxygen injection upstream of the inlet works on ground level odour concentrations attributable to the Stage III Extension. Oxygen injection upstream of the primary sedimentation process, at the inlet works, can be expected to achieve a reduction of emission rates of approximately 50%. Examination of the modelling results for this scenario indicated that, oxygen injection at the inlet works can reduce the predicted odour concentrations at the committed secondary schools (A5) and the committed HOS housing area (A3) at Ma On Shan Area 77 to within the 5 OU m^{-3} criterion. However, the predicted odour concentration at the committed primary school (A4) (5.12 OU m^{-3}) and the Marine Police North Division Base (A15) (5.06 OU m^{-3}) will still exceed the criterion.

However, if oxygen can be injected at the pumping stations upstream of the STW (ie only at the Sha Tin and Ma On Shan Sewage Pumping Stations and omitting at the inlet works), the estimated emission rates can be decreased by a maximum of approximately 75% of the unmitigated rate. After a series of sensitivity tests, it was determined that if oxygen injection can be applied at the upstream pumping stations to achieve an odour reduction of 55%, odour concentrations at all sensitive receivers can be reduced to within the 5OUm^{-3} criteria.

The results of this mitigation measure on ground level concentrations attributable to emissions from the Stage III Extension are presented in *Table 3.6n*. *Figure 3.6b* shows a contour plot of the predicted maximum 5-second mean concentration under this scenario. Other than oxygen injection, air injection or chemical addition, with chemicals such as nitrates, would also have similar odour reducing effect.

By applying oxygen injection (or air injection or nitrate addition) at the inlet works or at the pumping stations, the Stage I and II works would also benefit from the reductions in emission rates. The improvements in the predicted concentrations from the Stage III Extension, cumulatively from Stage I, II &III, as well as the contribution from the existing Stage I&II facilities under this mitigation scenario are shown in *Tables 3.6n, Table 3.6p and Table 3.6q* respectively. As indicated in these tables, the predicted cumulative odour concentrations at all ASRS will be in compliance of the odour criterion if oxygen injection or equivalent mitigation is applied at the pumping stations. A contour plot of the predicted maximum 5-second mean concentration which shows the cumulative impact after mitigation is presented in *Figure 3.6c*. (It should be noted that cumulative impact of odour is not calculated by simple addition of the predicted worst case concentrations from individual sources. Rather, the predicted worst case concentrations are dependent on a combination of factors including the location of the sources, the worst case wind direction, and other atmospheric conditions, and so on. *Figure 3.6b* and *Figure 3.6c* are contour plots of the worst case predicted concentrations at sensitive receivers on a 100m x 100m grid. The predicted concentrations at selected ASRs may be predominantly influenced by Stage I&II or by Stage III. In these two figures, the shape of the contour plot showing cumulative impacts appear to be similar to the plot for Stage III alone. This is a result of the supplementary effect of the different worst case conditions for the two groups of sources in the model. For direct comparison of predicted odour concentrations at discrete receptors, it is advised that *Table 3.6n* and *Table 3.6p* should be referenced.)

The dosage of oxygen/air injection or nitrate addition should be determined prior to the commissioning of the Stage III Extension. However, according to DSD's experience, although these mitigation measures are effective in controlling odour, they may affect the biological treatment processes of the STW to a certain extent. Therefore, it would be appropriate to optimise the dosage rate to achieve the 55% odour reduction at source and the $5OUm^{-3}$ criterion at the ASRs with the minimal disruption to the treatment process.

To determine the optimal dosage of oxygen/air/nitrate, performance tests will be carried out during the early commissioning stage of the Stage III Extension. For instance, if nitrate addition is to be used, this will be made at the Sha Tin and Ma On Shan pumping stations. The nitrate content in the raw sewage at the inlet of the STW will be determined by the daily routine laboratory testing carried out at the Sha Tin STW. Concurrently, hydrogen sulphide monitoring will be carried out at the inlet works of the STW to review the odour level (i.e. location W1 of *Figure 5.2b* of the *EM&A Manual*). The optimum dosage to achieve the target 55% odour reduction will then be ascertained by analysing the performance test results. As the performance test results will be available within 24 hours, any exceedance of the odour level will be promptly rectified by increasing the dose rate. This optimal dosage will then be utilised on a continuous basis.

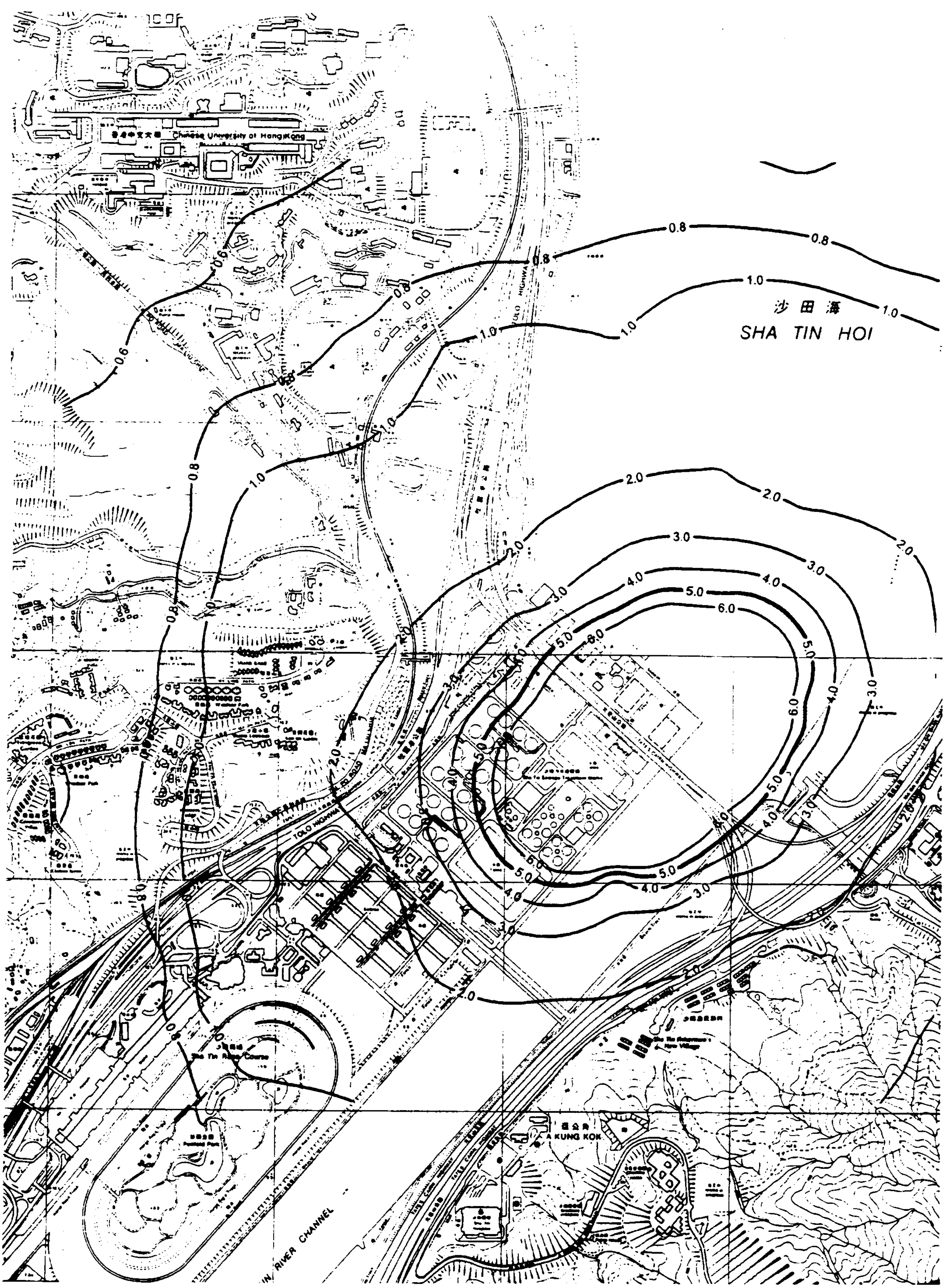

FIGURE 3.6b

PREDICTED MAXIMUM 5 SECOND ODOUR CONCENTRATION FOR STAGE III EXTENSION (WITH 55% ODOUR REDUCTION)

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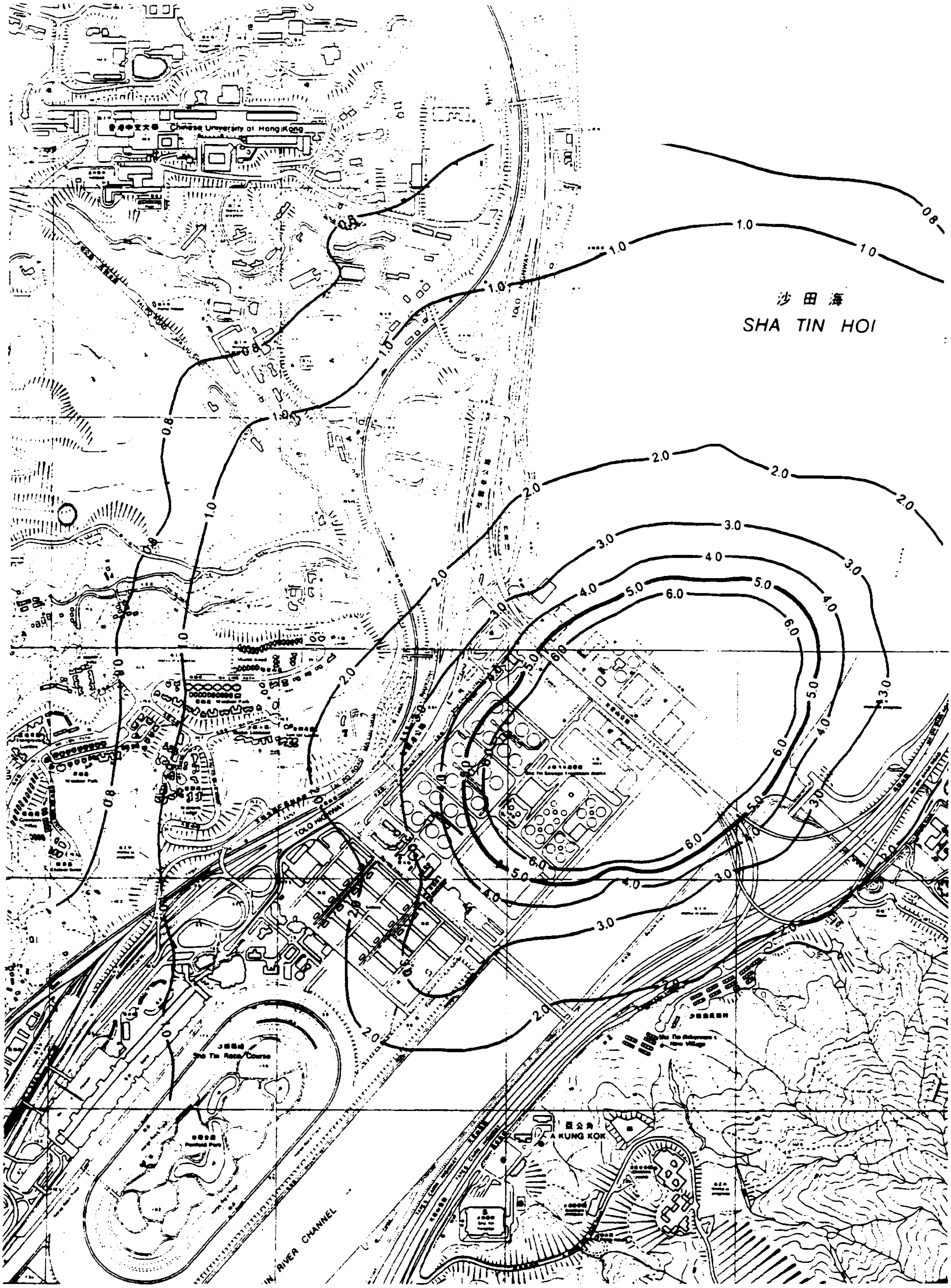

FIGURE 3.6c

PREDICTED MAXIMUM 5 SECOND ODOUR CONCENTRATION FOR THE CUMULATIVE SOURCES (WITH 55% ODOUR REDUCTION)

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Table 3.6l ***Matrix of Potential Odour Control Methods***[18]

Process	Chemical, Air or O_2 Addition Upstream of Plant	Aeration	Chemical Addition	Covering, Collection & Air Treatment	Improved Hydraulics to Avoid Turbulence	Improved O & M
Preliminary Treatment						
Screening	X			X		X
Grit removal	X			X		X
Preaeration	X			X		
Liquid Stream Treatment						
Primary Clarifier	X		X	X		X
Phys/chem systems			X	X	X	X
Secondary clarification			X			X
Sidestream returns		X	X		X	
Sludge Treatment						
Gravity thickening			X	X		
Blending and Storage			X	X	X	X
Anaerobic digestion				X		
Chemical stabilisation						
Mechanical dewatering			X	X		
Septage receiving/ holding		X	X	X	X	

[18] Bowker, P.G., Robert & Smith, John M., *Odour and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants*, Hemisphere Publishing Corporation, 1989

Table 3.6m ***Stage III Odour Emission: Effect of Oxygen Injection (Air Injection/ Nitrate Addition) at a Point Upstream of the Inlet Works (50% Reduction of Emission Rates) (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.21	1.35
A2	Primary & Secondary School	0.32	2.09
A3	Committed HOS Housing	0.52	3.39
A4	Committed Primary School	0.78	5.12
A5	Committed Secondary School	0.40	2.65
A6	Committed Residential Development	0.33	2.14
A7	Chinese University of Hong Kong	0.12	0.79
A8	Sha Tin Knoll	0.24	1.59
A9	Kamon Gardens	0.30	1.94
A10	Sha Tin Racecourse	0.18	1.19
A11	Sha Tin New Fisherman's Village	0.33	2.18
A12	Cheshire Home	0.20	1.30
A13	Chevalier Garden	0.28	1.85
A14	Sha Tin Hospital	0.18	1.20
A15	Marine Police North Division Base	0.77	5.06
A16	Vacant Land Granted to CUHK	0.26	1.71
Max	**Committed Primary School (A4)**	**0.78**	**5.12**

Table 3.6n ***Stage III Odour Emission: Effect of Oxygen Injection (Air Injection/Nitrate Addition) at Pumping Stations Only (55% Reduction of Emission Rates) (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.19	1.22
A2	Primary & Secondary School	0.29	1.88
A3	Committed HOS Housing	0.47	3.05
A4	Committed Primary School	0.70	4.61
A5	Committed Secondary School	0.36	2.38
A6	Committed Residential Development	0.29	1.93
A7	Chinese University of Hong Kong	0.11	0.71
A8	Sha Tin Knoll	0.22	1.43
A9	Kamon Gardens	0.27	1.74
A10	Sha Tin Racecourse	0.16	1.07
A11	Sha Tin New Fisherman's Village	0.30	1.96
A12	Cheshire Home	0.18	1.17
A13	Chevalier Garden	0.25	1.67
A14	Sha Tin Hospital	0.16	1.08
A15	Marine Police North Division Base	0.40	2.65
A16	Vacant Land Granted to CUHK	0.25	1.65
Max	**Committed Primary School (A4)**	0.70	4.61

Table 3.6o ***Cumulative Odour Emissions (Stage I & II & III): Predicted Concentrations at Sensitive Receivers After Mitigation (Oxygen Injection or Equivalent Mitigation at Inlet Works - 50% Odour Reduction) (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.26	1.71
A2	Primary & Secondary School	0.37	2.40
A3	Committed HOS Housing	0.63	4.13
A4	Committed Primary School	0.80	5.26
A5	Committed Secondary School	0.66	4.30
A6	Committed Residential Development	0.48	3.17
A7	Chinese University of Hong Kong	0.20	1.28
A8	Sha Tin Knoll	0.29	1.90
A9	Kamon Gardens	0.37	2.42
A10	Sha Tin Racecourse	0.39	2.54
A11	Sha Tin New Fisherman's Village	0.43	2.81
A12	Cheshire Home	0.25	1.65
A13	Chevalier Garden	0.34	2.21
A14	Sha Tin Hospital	0.37	2.43
A15	Marine Police North Division Base	0.78	5.12
A16	Vacant Land Granted to CUHK	0.31	2.04
Max	**Committed Primary School (A4)**	**0.80**	**5.26**

Table 3.6p ***Cumulative Odour Emissions (Stage I & II & III): Predicted Concentrations at Sensitive Receivers After Mitigation (Oxygen Injection or Equivalent Mitigation at Pumping Station Only - 55% Odour Reduction) (OU m^{-3})***

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.23	1.54
A2	Primary & Secondary School	0.33	2.16
A3	Committed HOS Housing	0.57	3.71
A4	Committed Primary School	0.72	4.73
A5	Committed Secondary School	0.59	3.87
A6	Committed Residential Development	0.44	2.85
A7	Chinese University of Hong Kong	0.18	1.15
A8	Sha Tin Knoll	0.26	1.71
A9	Kamon Gardens	0.33	2.17
A10	Sha Tin Racecourse	0.35	2.29
A11	Sha Tin New Fisherman's Village	0.39	2.52
A12	Cheshire Home	0.23	1.48
A13	Chevalier Garden	0.30	1.99
A14	Sha Tin Hospital	0.33	2.19
A15	Marine Police North Division Base	0.72	4.72
A16	Vacant Land Granted to CUHK	0.31	2.01
Max	**Committed Primary School (A4)**	**0.72**	**4.73**

Table 3.6q *Stage I & II Odour Emissions: Predicted Concentrations at Sensitive Receivers After Mitigation (Oxygen Injection or Equivalent Mitigation at Pumping Station Only - 55% Odour Reduction) (OU m^{-3})*

Receiver Number	Name	Maximum 1 Hour Mean	Maximum 5 Second Mean
A1	Windsor Park	0.23	1.54
A2	Primary & Secondary School	0.18	1.18
A3	Committed HOS Housing	0.24	1.60
A4	Committed Primary School	0.31	2.04
A5	Committed Secondary School	0.23	1.49
A6	Committed Residential Development	0.15	0.96
A7	Chinese University of Hong Kong	0.11	0.75
A8	Sha Tin Knoll	0.21	1.37
A9	Kamon Gardens	0.29	1.93
A10	Sha Tin Racecourse	0.27	1.74
A11	Sha Tin New Fisherman's Village	0.31	2.01
A12	Cheshire Home	0.23	1.48
A13	Chevalier Garden	0.16	1.05
A14	Sha Tin Hospital	0.29	1.88
A15	Marine Police North Division Base	0.35	2.28
A16	Vacant Land Granted to CUHK	0.24	1.54
Max	**Marine Police North Division Base (A15)**	**0.35**	**2.28**

3.7 DEFINITION AND EVALUATION OF RESIDUAL ENVIRONMENTAL IMPACTS

As presented in *Tables 3.6l* to *3.6p*, the effect of applying mitigation measures for the Stage III Extension have been assessed. The modelling results indicate that with oxygen/air injection, nitrate addition or its equivalent mitigation at the pumping stations of the Sha Tin STW, the criterion of 5 OU m^{-3} as a maximum 5 second mean concentration has been predicted to achieved at all ASRs. However, in order to ensure the prediction is valid, an odour registration system as well as an odour monitoring programme are recommended to ensure no residual odour impacts exist during the operation of the Stage III Extension. Details of this will be provided in the *EM&A Manual.*

3.8 ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENT

During the construction phase, it is recommended that an environmental audit program should be carried out to ensure the mitigation measures recommended in *Section 3.5.4* enforced and are as effective as predicted. Monitoring of dust during the construction phase is not recommended as all of the ASRs are more than 150m away from the Project area.

It is recommended that an odour monitoring and complaint registration programme to be carried out before and after the Stage III Extension comes into operation. The details of the monitoring programme will be presented in the *EM&A Manual,* which will be compiled as part of the EIA Study.

3.9 CONCLUSION AND RECOMMENDATIONS

The air quality assessment of the Stage III Extension has considered the construction phase dust impacts qualitatively. The conclusion is that provided the mitigation measures proposed in this report and as specified in the *Air Pollution Control (Construction Dust) Regulation* are followed, dust nuisance at sensitive receivers will not be significant. An environmental audit programme is recommended to ensure that appropriate mitigation measures for dust control during construction are implemented.

For the operation phase, odour dispersion modelling was carried out to predict the potential impact of the Stage III Extension on sensitive receivers. As a result of the predicted elevated odour concentrations at sensitive receivers due to emissions from the Stage III Extension, odour mitigation measures such as oxygen injection (air injection or nitrate addition) at the pumping stations are recommended. These mitigation measures will have benefits not only in terms of reducing emissions from the Stage III Extension but also for the existing Stage I and II works. If these mitigation measures are implemented, the cumulative impact following the commissioning of the Stage III Extension is predicted to be in compliance of the odour criterion as stipulated in the EIAO TM.