Annex B

Derivation of Odour Emission Rates

ANNEX B: DERIVATION OF ODOUR EMISSION RATES FOR SHA TIN STW STAGE III EXTENSION EIA STUDY

1 INTRODUCTION

This annex is a brief method statement for the derivation of odour emission rates for the Sha Tin STW Stage III Extension EIA Study.

The use of dispersion modelling requires inputs to be generated; that is, forecasts of how much odour will be emitted from the processes at the STW, with and without mitigation measures. A review of the available literature on the estimation of odour emission rates for sources which are open to the atmosphere, such as is the case at the Sha Tin STW indicates that to date, there is no consensus on the preferred methods to be adopted.

2 EMISSIONS FROM PRIMARY SEDIMENTATION TANKS, INLET WORKS AND FEED CHANNELS

In some previous EIA studies in Hong Kong, certain empirical formulae for the estimation of odour emission rates from sewage treatment works have been adopted and this approach has been accepted by EPD for odour assessment purposes. In the odour assessment presented in the *North Lantau Development Topic Report TR23, Environmental Impact Assessment of the Tung Chung Main Swage Pumping Station, Final Report* and in the *Outlying Islands Sewerage Stage I Phase I - EIA Study, Final Assessment Report*, odour emission rates from STW were calculated based on two relationships:

- the established relationship between odour concentration and physical factors including temperature and oxidation-reduction potential of the sewage; and
- the volumetric emission flow rate compared with the rate of ventilation.

Based on these relationships, odour emission rates for raw sewage are calculated as follows:

$$DF = 1.6 \times (T/10)^{4.9} \times (ORP + 200)^{-0.59} \quad [Eq. 1]$$

$$E = DF \times A \times (V/3600) \times C_f \quad [Eq. 2]$$

where,

	DF	=	Odour concentration expressed as dilution factor, OUm^{-3}
	T	=	Temperature of sewage, Fehrenheit F
	ORP	=	Oxidation-reduction potential of sewage, mV
	E	=	Emission rate, OU s^{-1}
	A	=	Air volume of the emission source, m^3
	V	=	Ventilation rate, air changes per hour
	C_f	=	Correction factor to adjust emission rates in the ratio of design ventilation rate to that used in the derivation of Eq. 1 (for 10 air changes per hour, $C_f = 0.26$; for 5 air changes per hour, $C_f = 0.52$)

For the purpose of this EIA Study, these empirical formulae are used with the following assumptions:

T	=	30 °C (or 86 F)
ORP	=	50 mV (for septic sewage)[1]
A	=	0.5m x surface area of tank (for primary sedimentation tanks)
		1.0m x surface area of tank (for inlet works and feed channels)[2]
V	=	assumed to be 2 to 5 air changes per hour

By using these assumptions and equations, the odour emission rates for the inlet works, primary sedimentation tanks and the feed channels have been estimated and are presented in *Table B2*.

Table B2 ***Estimated Odour Emission Rates for Primary Sedimentation Tanks, Inlet Works and Feed Channels***

Odour Sources	Dimension of Tank Surface (m)	Surface Area (m^2)	Estimated Emission Rate (OU $m^{-2}s^{-1}$)
Inlet Works		750	1.687
Existing Primary Sedimentation Tanks Tanks 1 - 8	55 x 65	3,575	0.84
Existing Primary Sedimentation Tanks Tanks 9 - 12	55 x 26	1,430	0.84
Stage III Primary Sedimentation Tanks 13 -16	55 x 52	2,860	0.84
Stage III Primary Sedimentation Tanks 17-22	55 x 78	4,290	0.84
Feed Channels for Primary Tanks 1-8	1.2 x 104	124.8	1.687
Feed Channels for Primary Tanks 9-12	1.2 x 52	62.4	1.687
Stage III Feed Channels for Primary Tanks 13-16	1.2 x 52	62.4	1.687
Stage III Feed Channels for Primary Tanks 17-22	1.2 x 78	93.6	1.687

3 EMISSIONS FROM SECONDARY TREATMENT TANKS AND FINAL SETTLING TANKS

The emission of odour from secondary treatment tanks is strongly related to two factors:

(1) For fresh sewage ORP is suggested to be 200mV by the Outlying Islands Sewerage Stage I Phase I EIA Study
(2) The equations are originally designed for sources confined in buildings. Assumptions of 0.5m of air has been made for open area sources in the Outlying Sewerage Stage I Phase I EIA Study.

- the condition of the settled sewage, in other words, its odour potential;
- the arrangement of the inlet end of the secondary treatment process.

The optimum inlet configuration to minimise odour release is a mechanically-mixed anoxic or selector zone, because this will allow active bacterial culture to contact the settled sewage and, given sufficient time, to absorb volatile material on the sludge floc before the mixed liquor enters the mass-transfer zone. At the other end of the spectrum are processes where the sewage is aerated before contact with the treatment culture. It may be assumed that the whole of the odour potential is released.

This represents a "worst case" scenario, and real secondary treatment will normally produce considerably less odour than this. It is clear that an anoxic zone is to be used in the Sha Tin STW Stage III Extension, and following calculations have been used accordingly[3][4][5].

$$E_{TON} = 4x10^{-3}\ x\ (0.0103V_{wind}^{1.42} + 2.93V_{liquid})\ x\ OP \qquad [EQ\text{-}3\}$$

where:

OP represents the odour potential[6]
V_{wind} represents wind speed (ms^{-1}) (assumed to be 1 ms^{-1})
V_{liquid} represents velocity of liquid across the tank (ms^{-1})[7]
E_{TON} represents surface emissions (OUs^{-1})

Theoretically, there should be little odour from the final settling tanks. However, for a conservative assumption, a value of 0.017 $OUm^{-2}s^{-1}$ is taken by assuming 50% of the estimated values for the secondary treatment tanks. The estimated emission rates for the secondary treatment tanks and the final settling tanks are presented in *Table B3*.

(3) Toogood, S J and Diaper, J. *Developments in the Assessment of Odours from Sludges*, Nielsen, V CVoorburg, J H and I Hermite P (eds.)

(4) Toogood, S J and Diaper, J. *Odour Prevention and Control of Organic Sludge and Livestock Farming*, Elsevier Applied Science Publishers, 1986

(5) Hobson, J A, *The Odour Potential - a New Tool for Odour Management*, CIWEM symposium on odour control and prevention in the water industry, Bristol 1994.

(6) This will depends on the characteristics of the treated sewage which will in turns depend on temperature and the COD levels.

(7) Calculated based on sewage flow and the dimension of the tank surface.

Table B3 *Estimated Emission Rates for Secondary Treatment and Final Settling Tanks*

Odour Sources	Dimension of Tank Surface (m)	Surface Area (m^2)	Estimated Emission Rate (OU $m^{-2}s^{-1}$)
Existing aeration tanks 1-8	88 x 104	9,152	0.035
Existing aeration tanks 9-12	88 x 52	4,576	0.035
Stage III aeration tanks 13-16	88 x 52	4,576	0.035
Stage III aeration tanks 17-22	88 x 78	6,864	0.035
Existing Final Settling Tanks Feed Channels		550	0.035
Existing Final Settling Tanks (Circular)(24)	27.5 diameter	594	0.017
Stage III Final Settling Tanks (Rectangular((20)	120 x 80	9,600	0.017

4 *EMISSIONS FROM SLUDGE HOLDING TANKS AND SLUDGE STORAGE TANKS*

The above equations are normally used for the estimation of odour emissions from raw and treated sewage effluent. However, based on published literature[8], it was noted that odour concentrations of typical sludge holding tanks and sludge storage tanks are in a similar order to those at the inlet works. As such the emission rates calculated by the above method for the inlet works are assumed to be the same for the sludge holding tanks and the sludge storage tanks.

It should be noted that, as part of the Stage III Extension, the capacity of the sludge 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 due to the more efficient reduction of the sludge volatile solids content. However, a conservative assumption has been made and, the same emission rate has been adopted even after the Stage III Extension is operational. The emission rates used for the assessment are shown in *Table B4.*

Table B4 *Emission Rates for Sludge Holding Tanks and Sludge Storage Tanks*

Odour Sources	Dimension of Tank Surface (m)	Surface Area (m^2)	Estimated Emission Rate (OU $m^{-2}s^{-1}$)
Sludge Holding Tanks	20m diameter	314	1.687
Sludge Storage Tanks	23m diameter	415	1.687

(8) Shanahan, IMedla (a993). Odour Control in Wastewater Treatment Processes, Institution of Water Officers Journal, April 1993.