Outlying Islands Sewerage Stage 2 -
Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities

Calculations of odour emission factors

Room 1 - Preliminary Treatment Unit

Source ID				Total Surface Area (m^2)	Emission rates ($ou/m^2/s$))	Emission rats(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Inlet Works										
	L(m)	=	8.1								
	W(m)	=	2.4								
	No. of units	=	1 (+1 standy)								
				19.4	8.79	170.8776					
S2	Coarse Screen										
	L(m)	=	4								
	W(m)	=	3.65								
	No. of units	=	1 (+1 standy)								
				14.6	8.79	128.3340					
S3	Distribution Tank										
	L(m)	=	14								
	W(m)	=	8								
	No. of units	=	1								
				112.0	8.79	984.4800					
S4	Fine Screen and Grit Chambers										
	L(m)	=	11.45								
	W(m)	=	8.33								
	No. of units	=	1								
				95.4	8.79	838.3770					
S5	Storm Tank										
	L(m)	=	20								
	W(m)	=	10								
	No. of units	=	1 (+1 standy)								
				200.0	8.79	1758.0000	5047.3261	50.473261	5	1009.465223	10.09465223
S6	Flow Distribution Tank										
	L(m)	=	6.26								
	W(m)	=	2.5								
	No. of units	=	1								
				15.7	8.79	137.5635					
S7	1-2mm Fine Screen Channel										
	L(m)	=	6.26								
	W(m)	=	6.88								
	No. of units	=	1								
				43.1	8.79	378.5748					
S8	Wet Well Before MBR Tank										
	L(m)	=	6.26								
	W(m)	=	2.5								
	No. of units	=	1								
				15.7	8.79	137.5635					
S9	Pump House										
	L(m)	=	6.15								
	W(m)	=	9.5								
	No. of units	=	1 (+1 standy)								
				58.4	8.79	513.5558					
	V(ACPH)	=	15			(from engineer)					
	Total emission area (m^2)	=	12			(from engineer)					
	Exhaust exit velocity Velocit	=	2.5			(from engineer)					

Outlying Islands Sewerage Stage 2 -
Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities

Calculations of odour emission factors

Room 2 - Treatment Unit

Source ID				Total Surface Area (m^2)	Emission rates ($ou/m^2/s$))	Emission rats(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Anoxic Tank										
	L(m)	=	8.56								
	W(m)	=	4.25								
	No. of units	=	6 (+2 standy)								
				218.3	8.79	1918.6812					
S2	Aerobic MBR Tank										
	L(m)	=	12.24				1953.2376	19.532376	6	325.5395989	3.255395989
	W(m)	=	4.25								
	No. of units	=	6 (+2 standy)								
				312.1	0.11	34.5564					
	V(ACPH)	=	15			(from engineer)					
	Total emission area (m^2)	=	12.8			(from engineer)					
	Exhaust exit velocity Velocit	=	2.5			(from engineer)					

Room 3 - Sludge Treatment Unit

Source ID				Total Surface Area (m^2)	Emission rates ($ou/m^2/s$))	Emission rats(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Sludge Holding Tank (Pre-thickener)										
	Diameter(m)	=	6.2								
	No. of units	=	2 (+1 standy)								
	Area (m^2)	=	60.381411	60.4	26.4	1595.2769					
S2	Sludge Digester										
	L(m)	=	6.1								
	W(m)	=	6.1								
	No. of units	=	4 (+1 standy)								
	Area (m^2)	=	148.84	148.8	26.4	3932.3528					
S3	Sludge Holding Tank (Post-digester)										
	Diameter(m)	=	4.5								
	No. of units	=	2 (+1 standy)				7239.8736	72.398736	2	3619.936781	36.19936781
	Area (m^2)	=	31.808626	31.8	26.4	840.3839					
S4	Sludge Dewatering House										
	L(m)	=	5.5								
	W(m)	=	2								
	No. of units	=	3								
	Area (m^2)	=	33	33.0	26.4	871.8600					
	V(ACPH)	=	15			(from engineer)					
	Total emission area (m^2)	=	3.5			(from engineer)					
	Exhaust exit velocity Velocit	=	2.5			(from engineer)					

Pak She Sewage Pumping Station

Source ID				Total Surface Area (m^2)	Emission rates ($ou/m^2/s$))	Emission rats(ou/s)	Total original emission (ou/s)	99% removal efficiency (ou/s)	No. of emission points	Emission rate for each emission points (without Deodorzation unit)	Emission rate for each emission points (with Deodorzation unit)
S1	Bar Screen										
	L(m)	=	2.26								
	W(m)	=	1.14								
	No. of units	=	1								
	Area (m^2)	=	2.5764	2.6	8.79	22.6466					
S2	Screw pump										
	L(m)	=	9.7								
	W(m)	=	1.4				380.7512	3.8075116	1	380.751156	3.80751156
	No. of units	=	3								
	Area (m^2)	=	40.74	40.7	8.79	358.1046					
	V(ACPH)	=	15			(from engineer)					
	Total emission area (m^2)	=	3.5			(from engineer)					
	Exhaust exit velocity Velocit	=	2.5			(from engineer)					

Modelling Input of odour emission sources

Appendix 3.4

ID	Description	X-Coordinate	Y-Coordinate	Elevation (meters)	Emission Rate (Unmitigated)	Emission Rate (Mitigated)	Emission Point Hight(m)	Temperature (K)	Exit Velocity (m/s)
SRC2	Rm1_1	820477.9	808281	4.5	1009.465	10.095	2.50	303	2.5
SRC3	Rm1_2	820476.1	808277.5	4.5	1009.465	10.095	2.50	303	2.5
SRC4	Rm1_3	820474.2	808273.7	4.5	1009.465	10.095	2.50	303	2.5
SRC5	Rm1_4	820472.9	808270.4	4.5	1009.465	10.095	2.50	303	2.5
SRC6	Rm1_5	820471.4	808267.4	4.5	1009.465	10.095	2.50	303	2.5
SRC7	Rm2_1	820482.4	808324.8	4.5	325.540	3.255	2.50	303	2.5
SRC8	Rm2_2	820486.6	808323.1	4.5	325.540	3.255	2.50	303	2.5
SRC9	Rm2_3	820490.6	808321.2	4.5	325.540	3.255	2.50	303	2.5
SRC10	Rm2_4	820493.8	808319.5	4.5	325.540	3.255	2.50	303	2.5
SRC11	Rm2_5	820497.6	808314.4	4.5	325.540	3.255	2.50	303	2.5
SRC12	Rm2_6	820494.8	808308.5	4.5	325.540	3.255	2.50	303	2.5
SRC13	Rm3_1	820402.25	808284.87	4.5	3619.937	36.199	2.50	303	2.5
SRC14	Rm3_2	820400.95	808282.17	4.5	3619.937	36.199	2.50	303	2.5
SRC1	Pumping Station	820702.9	808174.1	4.5	380.751	3.808	2.50	303	2.5

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Re: Report for odour emission Factor at STW (Law Wu)

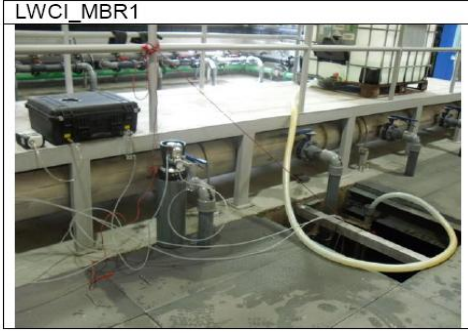
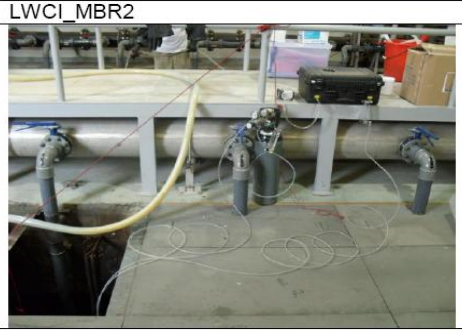
The gas sampling and Odour/ H2S analysis provided by the Odour and Air Laboratories of PolyU as follows:

The service includes on-site gas sampling, sample transport, and odour/H2S analysis in PolyU with an analytical report. To determine an odour emission rate from an area surface source, air sampling can use a "hood" method as shown below, whereby either a dynamic flux hood is placed on the odour emission surface of selected locations, and odour-free air either from a gas cylinder or by passing through an activated carbon filter is blown through it. The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air.

Dynamic Flux Hood

During collection of odorous gas, the air velocity inside wind tunnel shall match with the actual wind speed at the water surface. The wind speed, temperature and humidity shall be recorded during sampling. Method by using "Hood" Method with Flux Hood) per Location (If the area of the odour source is known, the odour emission rate can be calculated accordingly based on your measured/ calculated SOER (ou/m2/s)).

Site photos

LWCI_MBR1	LWCI_MBR2
	

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Results:

General Information				
Date	8/6/2012	(dd/mm/yy)		
Ambient Temp.	30.8 ~ 33.0 °C		Humidity:	65 ~ 78 %
Weather:	Fine		Wind Direction:	S-SE

Sample Name	Time	Sampling Method	Ambient Temp. °C	Humidity %	H2S (ppb) In Lab.	OC OUE/m³	SOER OU/m².s
1-butanol-352						1489.0	
LWCI_MBR2-080612	10:05	FH	31.5	74.4	0.3	37.0	0.0245
LWCI_MBR1-1-080612	11:00	FH	32.3	68.0	0.6	46.0	0.0304
LWCI_MBR1-2-080612	11:55	FH	32.8	68.9	0.5	40.0	0.0264

Professor S.C. Lee
Odour Research Laboratory at PolyU

Variation of Odour Emission from MBR tank with Different Surface Flow Rate

The measured odour emission rate collected from the current Lo Wu Correctional Institution Sewage Treatment Plant (LWCISTP) will need to be corrected for estimating rate of the further upgraded Cheung Chau Sewage Treatment Works (CCSTW) to be adopted in the odour impact prediction. The factor for changes of surface flow rate under operation scenario of LWCISTP and CCSTW were calculated by the following equation (Design Manual: Odor and Corrosion Control in Sanitary Sewerage and Treatment Plants (1985), USEPA).

$$F = 0.7\,(n^2V^3 / R^{4/3})^{3/8}\,[H_2S]$$
$$F = V^{9/8}\,K$$

Where $K = 0.7\,(n^2 / R^{4/3})^{3/8}\,[H_2S]$

F = odour flux (g/m^2-hr)

n = Mannings' Coefficient (0.014 was assumed)

V = velocity of sewage (m/s)

R = hydraulic radius (m)

$[H_2S]$ = H_2S molecule concentration in sewage

Summary of Odour flux under different surface flow rates during operation at LWCISTP and CCSTW

	Current Operation at LWCISTP	Proposed Operation at CCSTW
Average flow rate (m^3/day)	775	9800
Effective surface area of MBR tank, m^2	96	312
Surface flow rate(m/hr) in normal operation	0.336	1.308
Percentage change of odour flux compare with LWCISTP	--	389%

Correction Factor for Ambient Temperature

To determine the worst case scenario for odour impact assessment, temperature adjustments on the measured odour emission rates at LWCISTP were required. The odour surveys at LWCISTP were carried out on 8-June-2012 and the averaged daytime temperature was 32.2˚C. Based on Year 2007 to 2011 meteorological data from the Hong Kong Observatory, the mean daily maximum ambient temperature in the summer (June – September) were in the range of 29 to 33˚C. With reference to the Hydrogen Sulphide Control Manual (Technological Standing Committee on Hydrogen Sulphide Corrosion in Sewage Works, 1989), the equation below presented by Pomeroy and Parkurst was taken to estimate the variation of odour emissions due to temperature changes:

$$G = M[BOD_5]1.07^{T-20}$$

where G sulphide flux from wall slimes, g/m^2h

$[BOD_5]$ 5-day biochemical oxygen demand

T temperature, °C

M coefficient, m/h

Based on the above equation, the sulphide flux increased by about 5.6% when temperature increased from 32.2˚C to 33˚C. Therefore, 5.6% increase or a 1.056 correction factor was applied in the measured odour emission rate at LWCISTP to estimate the odour emission in CCSTW.

Therefore, the odour emission rate of MBR in proposed CCSTW is calculated to be:

Average measured SOER x 389% x 1.056
= 0.0271 x 389% x 1.056
= $0.11 OU/m^2/s$