APPENDIX 3.7A

ODOUR SURVEY FOR TAI PO SEWAGE TREATMENT WORKS

PolyU Technology & Consultancy
Company Limited 理大科技及顧問有限公司

Technical Report

for

Contract No. SPW 16/2020 – Upgrading of Tai Po Sewage Treatment Works – Investigation – Odour Survey and Analysis

For

Drainage Services Department

Prepared by

Odour Research Laboratory

Department of Civil and Environmental Engineering

The Hong Kong Polytechnic University

Submitted by

PolyU Technology and Consultancy Company Limited

Signed by: ____________________
[Prof. Shun-cheng Lee]

Date: 28/04/2021

1 Introduction

A service to conduct odour sampling and analysis at Tai Po Sewage Treatment Works (TPSTW) and its site boundaries, Refuse Collection Point (RCP) at Dai Kwai Street, and adjacent frontier Air Sensitive Receivers (ASRs) has been invited by Ms. Christina KO at Black & Veatch Hong Kong Limited on behalf of Drainage Services Department, HKSAR on 10th August 2020.

2 Scope of Works

The scope of the works includes:

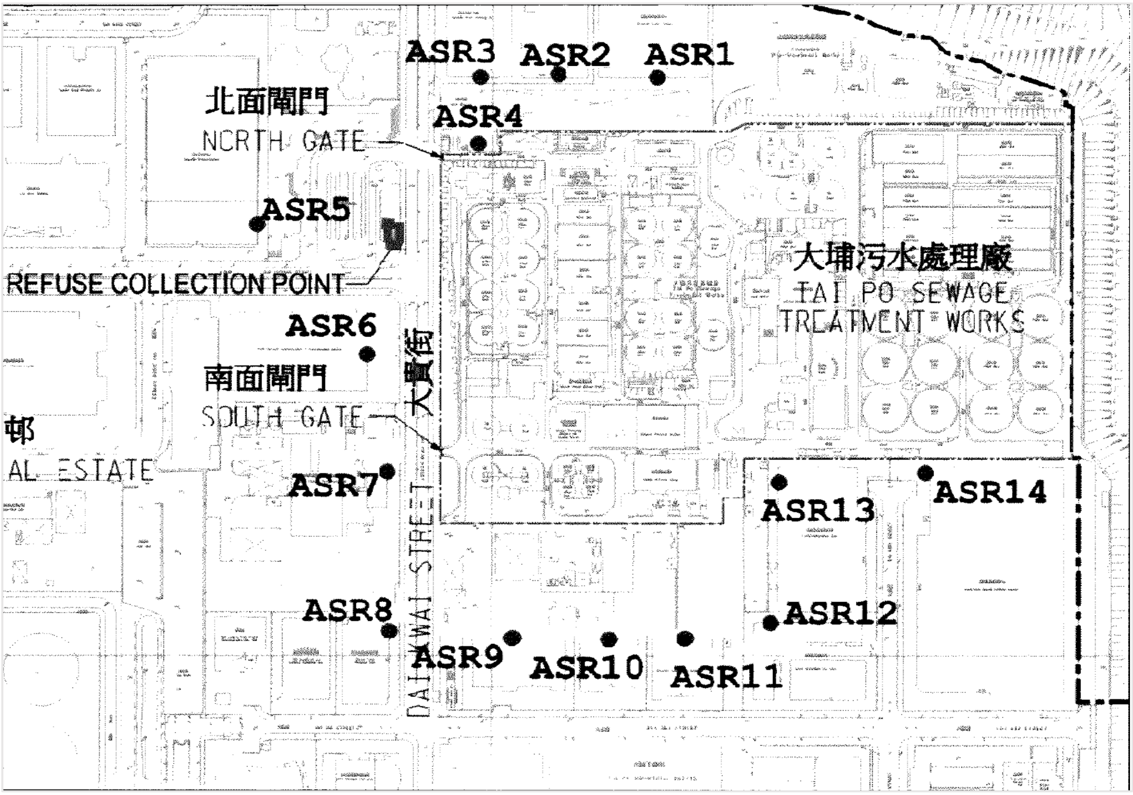
- To conduct odour source sampling at designated locations (including predetermined locations inside TPSTW and Sheun Wan leachate Pre-treatment Works) using flux chamber or wind tunnel sampler, and ambient sampling at frontier ASRs, site boundary, as well as RCP at Dai Kwai Street.
- To conduct laboratory olfactometry analysis for source samples and ambient samples.
- To submit a report of sampling and analysis results of odour emission rates at sources and odour concentrations at different locations.

3 Schedule

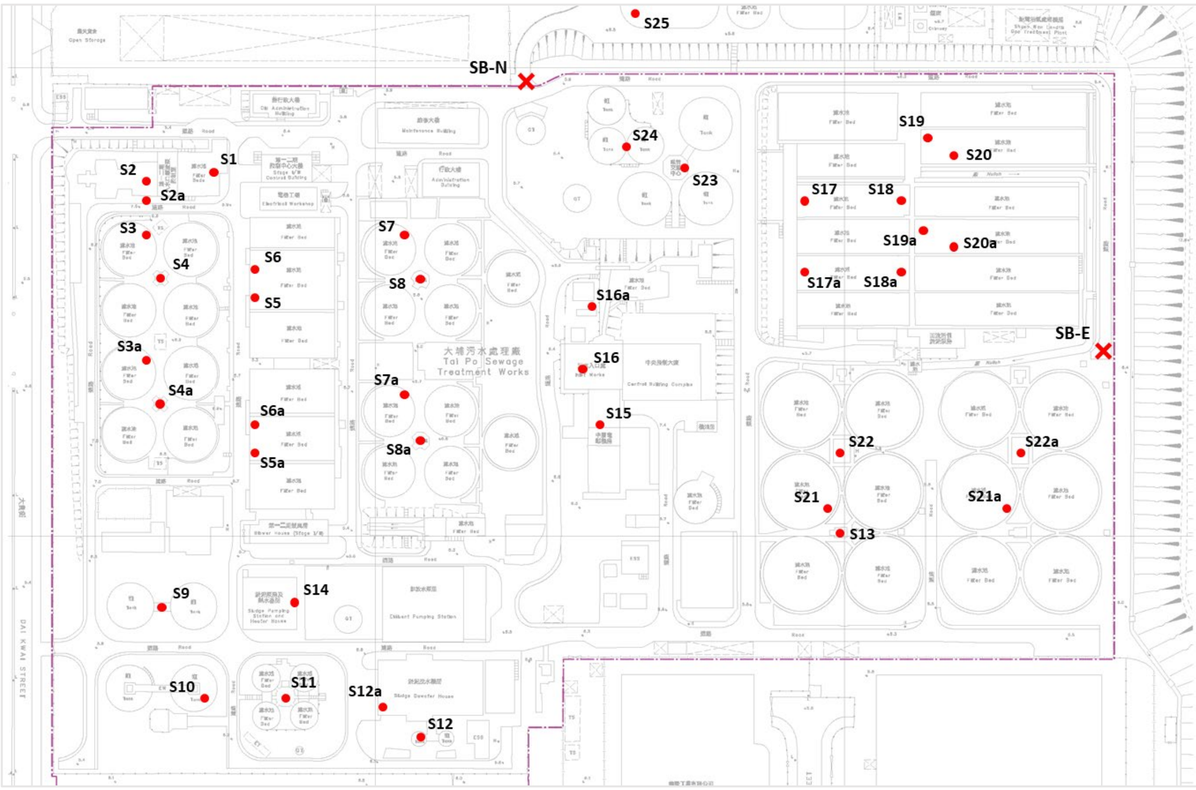
Description	**Period Covered/Date**
Site Inspection	4th September 2020
First Round of Ambient Sampling at ASRs and Site Boundaries	16th September 2020 – 18th September 2020
Second Round of Ambient Sampling at ASRs and Site Boundaries	23rd September 2020 – 24th September 2020
First Round of Source Sampling on-site	7th October 2020 – 23rd October 2020
Second Round of Source Sampling on-site	30th October 2020 – 9th November 2020
Draft Technical Report Submission	7th December 2020
Final Technical Report Submission	28th April 2021

4 Working Plan

Ambient sampling at surrounding ASRs and site boundaries were conducted during the period of 16th September to 24th September 2020. The sampling locations are illustrated in the following figures.



Sampling locations for ASRs in adjacent to TPSTW and site boundaries



Sampling locations for source samples in TPSTW

Following is the working plan of the ambient sampling.

ID	Location	Odour Sample	1st Round		2nd Round	
			16 Sept	18 Sept	23 Sept	24 Sept
ASR1	Watsons Water Centre	4	2			2
ASR2	Hong Kong Yakult Co. Ltd.	4	2			2
ASR3	Maxim's Food Factory 2	4	2			2
ASR4	Government Staff Quarters	4	2		2	
ASR5	Oriental Press Centre	4	2			2
ASR6	PC3 Product Customization & Consolidation Centre	4	2			2
ASR7	Cabot Plastics Hong Kong Ltd.	4	2		2	
ASR8	Winner Food Products Ltd.	4	2		2	
ASR9	Tung Fong Hung (Medicine) Co. Ltd.	4		2		2
ASR10	Arvato Digital Services	4		2		2
ASR11	Process Automation International Ltd.	4		2		2
ASR12	Zama Corporation Ltd.	4		2		2
ASR13	Taclon Industries Ltd.	4		2		2
ASR14	Hung Hing Off-Set Printing	4		2	2	
RCP	Refuse Collection Point at Dai Kwai Street	4	2		2	
SB-E	East Site Boundary of TPSTW	4		2	2	
SB-S	South Site Boundary of TPSTW	4		2	2	
SB-W	West Site Boundary of TPSTW	4	2		2	
SB-N	North Site Boundary of TPSTW	4		2	2	

Source sampling at TPSTW site were conducted during the period of 7th October to 9th November 2020. Following is the working plan of the source sampling.

ID	Location	Odour Sample	1st Round				2nd Round			
			7 Oct	9 Oct	19 Oct	23 Oct	30 Oct	2 Nov	3 Nov	9 Nov
West Part of TPSTW										
S1	Inlet pumping station	4	2					2		
S2	Screens house	4	2					2		
S2a	Screens house grit collection tank	4				2	2			
S3	Primary sedimentation tank (outlet)	4	2							2
S3a	Primary sedimentation tank (outlet)	4	2							2
S4	Primary sedimentation tank (inlet)	4	2					2		
S4a	Primary sedimentation tank (inlet)	4	2					2		
S5	Aeration tank (inlet)	4	2							2
S5a	Aeration tank (inlet)	4	2							2
S6	Aeration tank (outlet)	4	2							2
S6a	Aeration tank (outlet)	4	2							2
S7	Final sedimentation tank (outlet)	4		2						2
S7a	Final sedimentation tank (outlet)	4		2	2*					2
S8	Final sedimentation tank (inlet)	4	2							2
S8a	Final sedimentation tank (inlet)	4		2						2
S9	Sludge digestion tank	4				2	2			2*
S10	Sludge consolidation tank	4				2	2			2*

S11	Primary sludge gravity thickener	4				2	2			
S12	Sludge dewatering house (inlet tank)	4				2	2			
S12a	Sludge dewatering house (dry sludge)	4				2	2			
S13	SAS thickening house	4				2	2			
S14	Sludge pumping station	4				2	2			
East Part of TPSTW										
S15	Inlet pumping station	4			2			2		
S16	Screens house	4			2			2		
S16a	Screens house grit collection tank	4				2	2			
S17	Primary sedimentation tank (inlet)	4		2					2	
S17a	Primary sedimentation tank (inlet)	4		2					2	
S18	Primary sedimentation tank (outlet)	4		2					2	
S18a	Primary sedimentation tank (outlet)	4		2					2	
S19	Aeration tank (inlet)	4		2	2*				2	
S19a	Aeration tank (inlet)	4		2	2*				2	
S20	Aeration tank (outlet)	4		2					2	
S20a	Aeration tank (outlet)	4		2					2	
S21	Final sedimentation tank (outlet)	4			2			2		
S21a	Final sedimentation tank (outlet)	4			2			2		
S22	Final sedimentation tank (inlet)	4			2			2		
S22a	Final sedimentation tank (inlet)	4			2			2		
S23	Sludge digestion tank	4			2		2			
S24	Sludge consolidation tank	4			2		2			
Sheun Wan Leachate Pre-treatment Works										
S25	Leachate pre-treatment tank	4		2				2		

*: retake of specific samples.

5 Methodology

5.1 Odour Sampling

Odour gaseous sample is collected by using a specialized odour sampling system (CSD30, 60L, Olfasence GmbH, Germany). During air sampling, an empty sample bag is placed in the sealed sampler, and the sampler is then evacuated at a controlled rate (by setting total sampling time for 5-minute, 10-minute, 15-minute or 30-minute) by the built-in vacuum pump, sample bag will be filled with sample gas due to negative pressure in the sampler.

CSD30 Odour Sampler

In this technique, all "wetted" parts exposed to the odourous gas are to be composed of stainless steel and Teflon tubing. The sample bags are manufactured from PTFE, Tedlar if the bags are to be reuse, or from nalophane NATM if the bags are to be discarded after use.

Dynamic sampling system, which includes an odour-free gas source from a gas cylinder or gas cleaning device, a dynamic flux chamber or wind tunnel sampler, and sample collection system, is suitable for measuring emission rates. The flux chamber or wind tunnel will be placed on the emission surface of selected locations and a stream of odour-free gas from a certified gas cylinder or a gas cleaning device will be supplied to the chamber to simulate a parallel wind blowing above the emission surface. The flow rate of the gas will be measured by a flow meter attached on the gas supply tubing. Odour emission rate is then determined by the air flow through the chamber and the odour concentration of the collected gas sample, according to the following equation:

$$\text{SOER (ou/m}^2\text{/s)} = \frac{\text{Odour Conc. (ou/m}^3\text{)} \times \text{Air Flow Inside Flux Chamber (m}^3\text{/s)}}{\text{Covered Surface Area (m}^2\text{)}}$$

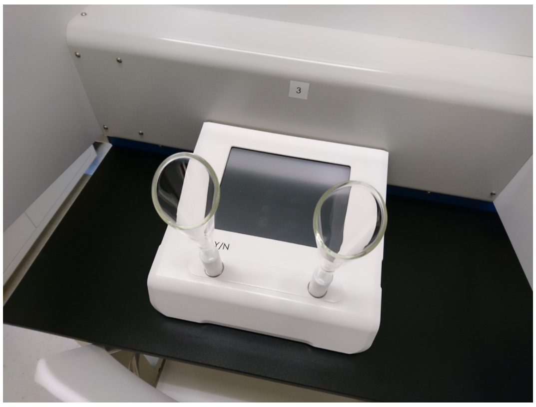
The required flowrate of odour-less nitrogen injected into flux chamber is 5 L/min, hence the dynamic flux chamber will be used for the sampling of source emission. In general, the wind tunnel sampler is capable to obtain average emission rate from low-emission heterogeneous sources (e.g., nullah, seawater surface, etc.) by covering a larger surface area. In this specific project, the odour emission rates from wastewater and sludge surfaces are to be collected, which are with obviously higher emission rates (compared to the natural water bodies) and with more uniform emission rate for each specific sampling location. Also there is are safety considerations on utilizing the bulky wind tunnel sampling on wastewater or sludge surface sampling. Hence, the flux chamber sampler is considered capable for source sampling for this specific project. The effective covering area of the dynamic flux chamber is about 0.13 m^2. In consideration of the sample size, the sampling period of each sample shall be within 10 minutes. Specifically for our CSD30 sampler, the flowrate to sample bag is identical for 5-min and 10-min setting, while the 10-min setting is at intermittent sampling mode. For sample representativeness, the difference between 5-min and 10-min is not significant. Hence, 5-min sampling duration was proposed for the source sampling in this specific project. For supporting a sampling period of 5-min, the lowest flowrate of injected nitrogen gas is suggested to be adjusted to at least 12 L/min, and for the consideration of redundance, a 15 L/min flowrate of nitrogen was adopted for source sampling.

Dynamic Flux Chamber

For the purpose of Quality Assurance & Quality Control (QA/QC), during each sampling day, a control sample with odour-less nitrogen purged into sample back will be collected for olfactometry analysis. During the date of ambient sampling, nitrogen gas was directly injected to sample bags by connecting CSD30 sampler with the gas cylinder. While during the date of source sampling, nitrogen gas was injected to the cleaned flux chamber sampler first, and QA/QC samples were collected by CSD30 sampler from the cleaned flux chamber with nitrogen gas cylinder connected. Odour concentrations of ambient samples and source samples were validated by the QA/QC sample results obtained on the same day.

5.2 Olfactometry Analysis

The odour concentration of a gaseous sample is determined by presentation to a panel of observers, with known acuity to odour, in varying dilutions. The odour concentration is then expressed in multiples of dilution. Odour concentration is determined by a forced-choice dynamic olfactometer (Odournet TO Evolution) in full accordance with the European Standard Method (EN13725). This European Standard is applicable to the measurement of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The range of measurement including pre-dilution prior to the olfactometry analysis is typically from 10^1 ou/m^3 to 10^7 ou/m^3. This analysis technique provides directly comparable data for different odour types, and used for input into dispersion models to determine odour impact in terms of annoyance and abatement efficiency assessments.



Odournet TO Evolution Olfactometer

The TO Evolution Olfactometer at Odour Research Laboratory, The Hong Kong Polytechnic University has undergone regularly factory calibration. Calibration certificate could be provided upon request.

6 On-site Sampling

6.1 Photos illustrating sampling activities for ambient samples.

	
Sampling at ASR1	Sampling at ASR2
	
Sampling at ASR3	Sampling at ASR4
	
Sampling at ASR5	Sampling at ASR6

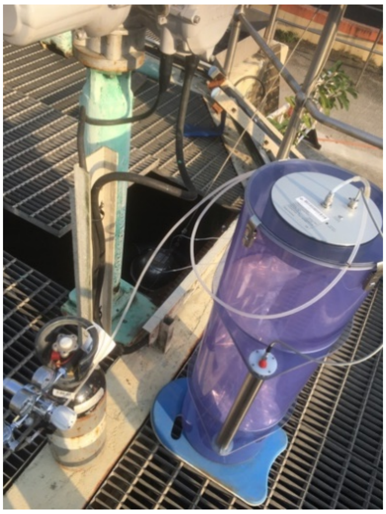
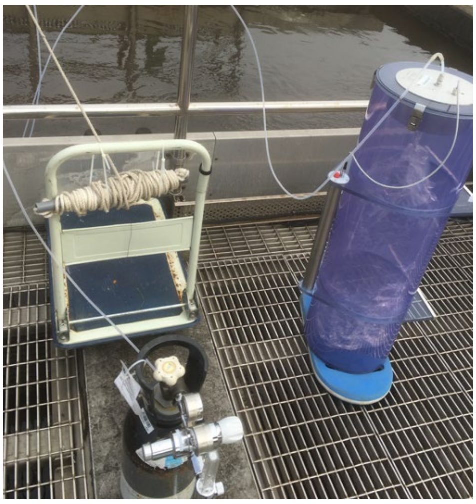
	
Sampling at ASR7	Sampling at ASR8
	
Sampling at ASR9	Sampling at ASR10
	
Sampling at ASR11	Sampling at ASR12

	
Sampling at ASR13	Sampling at ASR14
	
Sampling at RCP	Sampling at SB-E
	
Sampling at SB-S	Sampling at SB-W

	
Sampling at SB-N	

6.2 Photos illustrating sampling activities for source samples.

	
Sampling at S1	Sampling at S2
	
Sampling at S2a	Sampling at S3
	
Sampling at S3a	Sampling at S4

	
Sampling at S4a	Sampling at S5
	
Sampling at S5a	Sampling at S6
	
Sampling at S6a	Sampling at S7

	
Sampling at S7a	Sampling at S8
	
Sampling at S8a	Sampling at S9
	
Sampling at S10	Sampling at S11

Sampling at S12

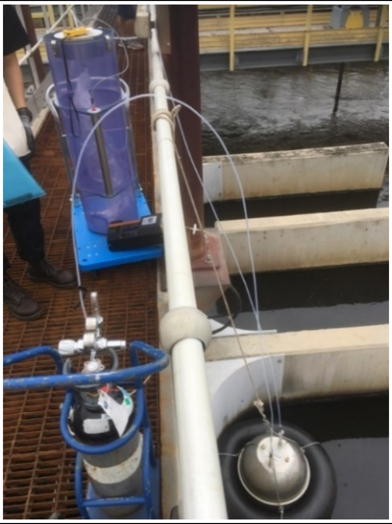
Sampling at S12a

Sampling at S13

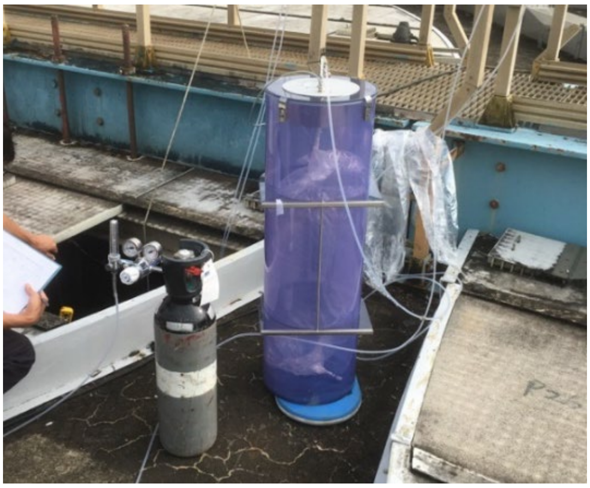
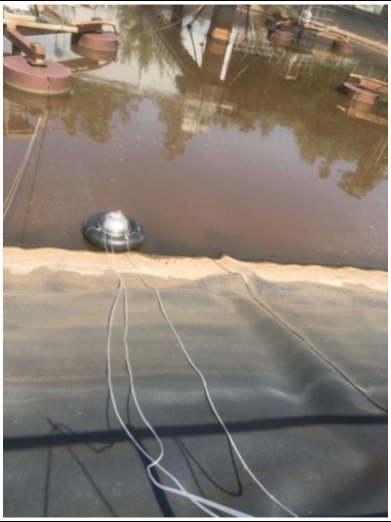
Sampling at S14

Sampling at S15

Sampling at S16

	
Sampling at S16a	Sampling at S17
	
Sampling at S17a	Sampling at S18
	
Sampling at S18a	Sampling at S19

	
Sampling at S19a	Sampling at S20
	
Sampling at S20a	Sampling at S21
	
Sampling at S21a	Sampling at S22

	
Sampling at S22a	Sampling at S23
	
Sampling at S24	Sampling at S25

7 Laboratory Analysis

Specific odour emission rates (SOER, OU/m^2/s) can be calculated by the following equation:

$$\text{SOER}\ (\text{ou/m}^2/\text{s}) = \frac{\text{Odour Conc.}\ (\text{ou/m}^3) \times \text{Air Flow Inside Flux Chamber}\ (\text{m}^3/\text{s})}{\text{Covered Surface Area}\ (\text{m}^2)}$$

For the current setting of sampling, the air flowrate inside flux chamber is 15 L/min, i.e., 0.00025 m^3/s, for all source sampling. The covered surface area by the flux chamber is 0.132 m^2. Odour concentration from the samples are determined by the olfactometry analysis.

8 Analytical Results

8.1 Analytical Results for Ambient Sampling (Calibrated with Odour Concentration of QA/QC Samples Deducted)

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	Odour Concentration (ou/m^3)	Remarks
ASR1	Watsons Water Centre	R1-ASR1-A	16 Sept 2020	10:09 - 10:15	34	1.3	W260°	85.7	<10	/
		R1-ASR1-B	16 Sept 2020	10:19 - 10:24	32.4	1.3	W263°	81.2	14	/
		R2-ASR1-A	24 Sept 2020	12:42 - 12:47	32.0	0.6	E90°	74.7	<10	/
		R2-ASR1-B	24 Sept 2020	12:51 - 12:56	31.5	1.3	E83°	77.5	<10	/
ASR2	Hong Kong Yakult Co. Ltd.	R1-ASR2-A	16 Sept 2020	11:11 - 11:16	32.2	0.9	NE50°	82.7	22	/
		R1-ASR2-B	16 Sept 2020	11:18 - 11:24	34.5	1.3	W280°	78.2	15	/
		R2-ASR2-A	24 Sept 2020	12:30 - 12:35	32.1	0.5	WNW285°	75.1	25	/
		R2-ASR2-B	24 Sept 2020	12:37 - 12:42	31.2	0.6	W280°	75.7	13	/
ASR3	Maxim's Food Factory 2	R1-ASR3-A	16 Sept 2020	10:44 - 10:49	32.3	1.0	NNE30°	80.3	55	Bakery & wastewater
		R1-ASR3-B	16 Sept 2020	10:51 - 10:57	33.6	1.2	NE40°	77.6	53	Bakery & wastewater
		R2-ASR3-A	24 Sept 2020	12:06 - 12:12	32.7	1.1	E82°	71.5	62	Bakery & garbage
		R2-ASR3-B	24 Sept 2020	12:14 - 12:20	32.6	1.3	ENE58°	75.7	50	Bakery & garbage
ASR4	Government Staff Quarters	R1-ASR4-A	16 Sept 2020	11:41 - 11:47	31.5	0.9	E91°	83.9	43	Refuse smell
		R1-ASR4-B	16 Sept 2020	11:48 - 11:54	30.7	0.4	SE136°	87.2	92	Refuse smell
		R2-ASR4-A	23 Sept 2020	09:49 - 09:55	32.7	1.1	ENE66°	72.8	11	/
		R2-ASR4-B	23 Sept 2020	09:56 - 10:02	33.8	0.9	ENE69°	71.1	16	/
ASR5	Oriental Press Centre	R1-ASR5-A	16 Sept 2020	12:18 - 12:24	33.8	0.5	S175°	77.5	40	Refuse smell
		R1-ASR5-B	16 Sept 2020	12:25 - 12:31	32.4	1.6	E79°	81.9	45	Refuse smell
		R2-ASR5-A	24 Sept 2020	10:29 - 10:34	30.7	1.0	N9°	74.1	17	/
		R2-ASR5-B	24 Sept 2020	10:36 - 10:41	32.0	0.9	NE50°	70.1	14	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	Odour Concentration (ou/m^3)	Remarks
ASR6	PC3 Product Customization & Consolidation Centre	R1-ASR6-A	16 Sept 2020	15:34 - 15:39	32.4	0.4	W273°	78.1	134	Sewage smell
		R1-ASR6-B	16 Sept 2020	15:41 - 15:46	32.6	0.6	SW217°	77.8	109	Sewage smell
		R2-ASR6-A	24 Sept 2020	11:44 - 11:50	33.6	1.0	SSW207°	66.6	<10	/
		R2-ASR6-B	24 Sept 2020	11:51 - 11:56	33.3	0.8	S180°	69.1	<10	/
ASR7	Cabot Plastics Hong Kong Ltd.	R1-ASR7-A	16 Sept 2020	15:17 - 15:23	34.2	0.4	WSW244°	74.5	84	Sewage smell
		R1-ASR7-B	16 Sept 2020	15:25 - 15:30	32.8	0.9	ESE112°	76.9	81	Sewage smell
		R2-ASR7-A	23 Sept 2020	11:52 - 11:58	33.8	0.4	SW225°	70.8	52	Sewage smell
		R2-ASR7-B	23 Sept 2020	11:59 - 12:05	33.4	1.1	ENE60°	70.1	19	Sewage smell
ASR8	Winner Food Products Ltd.	R1-ASR8-A	16 Sept 2020	14:59 - 15:05	32.4	0.6	N2°	75.4	23	Fuel smell from trucks
		R1-ASR8-B	16 Sept 2020	15:07 - 15:12	32.5	0.7	S175°	76.7	19	Fuel smell from trucks
		R2-ASR8-A	23 Sept 2020	11:36 - 11:42	33.9	2.0	WSW240°	68.2	15	/
		R2-ASR8-B	23 Sept 2020	11:43 - 11:49	32.9	1.0	SSW208°	71.8	14	/
ASR9	Tung Fong Hung (Medicine) Co. Ltd.	R1-ASR9-A	17 Sept 2020	10:12 - 10:18	31.2	0.8	NE52°	81.1	18	/
		R1-ASR9-B	17 Sept 2020	10:20 - 10:25	31.0	0.4	NE39°	83.5	<10	/
		R2-ASR9-A	24 Sept 2020	10:47 - 10:53	30.0	0.8	WNW290°	78.1	14	/
		R2-ASR9-B	24 Sept 2020	10:54 - 10:59	30.5	1.1	WNW283°	78.6	10	/
ASR10	Arvato Digital Services	R1-ASR10-A	17 Sept 2020	15:19 - 15:25	30.7	2.0	ENE62°	80.3	11	Scrap metal smell
		R1-ASR10-B	17 Sept 2020	15:26 - 15:32	30.1	2.5	E90°	85.5	<10	Scrap metal smell
		R2-ASR10-A	24 Sept 2020	11:06 - 11:11	30.2	0.9	ENE75°	75.0	<10	Iron smell
		R2-ASR10-B	24 Sept 2020	11:12 - 11:17	31.4	1.1	ENE76°	71.4	<10	Iron smell
ASR11	Process Automation International Ltd.	R1-ASR11-A	17 Sept 2020	15:42 - 15:48	30.4	0.6	E87°	85.5	26	Plastic processing smell
		R1-ASR11-B	17 Sept 2020	15:49 - 15:55	30.5	1.0	ENE78°	82.9	12	Plastic processing smell
		R2-ASR11-A	24 Sept 2020	11:25 - 11:31	30.8	1.1	E101°	76.3	<10	/
		R2-ASR11-B	24 Sept 2020	11:32 - 11:37	30.2	0.8	ESE102°	78.5	<10	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	Odour Concentration (ou/m^3)	Remarks
ASR12	Zama Corporation Ltd.	R1-ASR12-A	17 Sept 2020	11:19 - 11:25	32.0	0.6	SE141°	83.4	30	VOC or chemical smell
		R1-ASR12-B	17 Sept 2020	11:34 - 11:40	31.0	0.9	WSW243°	88.0	48	VOC or chemical smell
		R2-ASR12-A	24 Sept 2020	15:56 - 16:01	32.3	1.4	SW227°	72.2	<10	/
		R2-ASR12-B	24 Sept 2020	16:03 - 16:09	32.4	1.3	WSW239°	70.7	<10	/
ASR13	Taclon Industries Ltd.	R1-ASR13-A	17 Sept 2020	16:06 - 16:12	30.3	3.0	NE38°	81.1	11	/
		R1-ASR13-B	17 Sept 2020	16:13 - 16:19	30.8	2.2	E81°	81.1	<10	/
		R2-ASR13-A	24 Sept 2020	16:25 - 16:31	31.0	0.8	E80°	74.6	<10	/
		R2-ASR13-B	24 Sept 2020	16:32 - 16:37	31.7	1.1	E81°	72.1	<10	/
ASR14	Hung Hing Off-Set Printing	R1-ASR14-A	17 Sept 2020	10:55 - 11:01	32.5	0.7	NNW344°	80.4	16	/
		R1-ASR14-B	17 Sept 2020	11:03 - 11:10	33.8	0.7	W275°	75.9	<10	/
		R2-ASR14-A	23 Sept 2020	11:18 - 11:24	34.5	1.1	WNW290°	66.9	14	/
		R2-ASR14-B	23 Sept 2020	11:25 - 11:31	35.1	0.7	W278°	65.0	16	/
RCP	Refuse Collection Point at Dai Kwai Street	R1-RCP-A	16 Sept 2020	12:01 - 12:06	30.5	0.9	W274°	86.5	85	Refuse smell
		R1-RCP-B	16 Sept 2020	12:08 - 12:14	33.5	0.7	WNW300°	84.7	61	Refuse smell
		R2-RCP-A	23 Sept 2020	09:31 -09:37	30.8	1.2	N6°	77.1	28	Refuse smell
		R2-RCP-B	23 Sept 2020	09:39 - 09:45	31.5	1.0	NNW346°	76.8	22	Refuse smell
SB-E	Site Boundary – East	R1-SB-E-A	17 Sept 2020	12:44 - 12:49	32.3	0.6	WSW241°	84.3	26	/
		R1-SB-E-B	17 Sept 2020	12:51 - 12:56	32.9	0.7	WSW255°	77.4	20	/
		R2-SB-E-A	23 Sept 2020	10:07 - 10:12	32.5	0.9	N1°	78.0	17	/
		R2-SB-E-B	23 Sept 2020	10:13 - 10:19	32.9	0.8	N9°	75.1	14	/
SB-S	Site Boundary – South	R1-SB-S-A	17 Sept 2020	12:03 - 12:08	33.6	1.3	SW220°	88.8	32	Sludge smell
		R1-SB-S-B	17 Sept 2020	12:10 - 12:16	31.8	1.9	WSW253°	83.0	22	Sludge smell
		R2-SB-S-A	23 Sept 2020	10:58 - 11:04	33.3	1.1	WNW299°	72.1	32	/
		R2-SB-S-B	23 Sept 2020	11:05 - 11:11	33.0	1.1	SW222°	72.8	20	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	Odour Concentration (ou/m^3)	Remarks
SB-W	Site Boundary – West	R1-SB-W-A	16 Sept 2020	14:41 - 14:46	31.5	1.2	NE41°	72.6	17	/
		R1-SB-W-B	16 Sept 2020	14:48 - 14:54	32.6	1.2	NE50°	72.0	15	/
		R2-SB-W-A	23 Sept 2020	10:41 - 10:47	32.8	1.8	NNE21°	70.5	47	Sludge smell
		R2-SB-W-B	23 Sept 2020	10:47 - 10:53	33.4	0.6	NNE23°	72.5	47	Sludge smell
SB-N	Site Boundary – North	R1-SB-N-A	17 Sept 2020	12:24 - 12:30	31.6	1.7	NE39°	80.4	113	/
		R1-SB-N-B	17 Sept 2020	12:31 - 12:36	32.5	0.7	N350°	78.0	150	/
		R2-SB-N-A	23 Sept 2020	10:24 - 10:30	34.1	1.4	NNE28°	71.3	57	/
		R2-SB-N-B	23 Sept 2020	10:30 - 10:36	34.1	0.7	NNW340°	72.8	32	/

8.2 Analytical Results for Source Sampling (Calibrated with Odour Concentration of QA/QC Samples Deducted)

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER ($ou/m^2/s$)	Remarks
S1	Inlet pumping station (West part of TPSTW)	R1-S1-A	7 Oct 2020	11:08 - 11:14	28.5	0.8	SSW194°	72.0	6.31	/
		R1-S1-B	7 Oct 2020	11:16 - 11:22	28.8	1.0	SW220°	71.0	5.55	/
		R2-S1-A	2 Nov 2020	10:45 - 10:51	32.2	1.1	WSW240°	58.5	8.27	/
		R2-S1-B	2 Nov 2020	10:52 - 10:58	32.2	0.8	SSW203°	53.1	7.71	/
S2	Screens house (West part of TPSTW)	R1-S2-A	7 Oct 2020	10:45 - 10:51	30.5	1.2	SSW207°	83.8	10.79	House covered
		R1-S2-B	7 Oct 2020	10:52 - 10:58	30.5	0.4	S175°	90.0	8.64	House covered
		R2-S2-A	2 Nov 2020	11:08 - 11:14	31.8	0.7	SSW204°	57.8	20.46	House covered
		R2-S2-B	2 Nov 2020	11:15 - 11:21	32.8	1.0	S188°	71.7	14.64	House covered
S2a	Screens house grit collection tank (West part of TPSTW)	R1-S2a-A	23 Oct 2020	15:51 - 15:57	27.8	1.1	SE144°	48.5	1.03	House covered
		R1-S2a-B	23 Oct 2020	15:59 - 14:05	26.7	0.2	SSE149°	49.0	0.84	House covered
		R2-S2a-A	30 Oct 2020	9:42 - 9:48	25.9	1.8	SE138°	88.8	4.64	House covered
		R2-S2a-B	30 Oct 2020	9:49 - 9:55	26.4	0.6	SE131°	88.0	4.00	House covered
S3	Primary sedimentation tank (outlet) (West part of TPSTW)	R1-S3-A	7 Oct 2020	11:34 - 11:40	28.5	0.5	SE145°	66.8	/	Invalid due to abnormal values obtained.
		R1-S3-B	7 Oct 2020	11:41 - 11:47	29.7	0.6	S190°	65.0	/	
		R2-S3-A	9 Nov 2020	15:10 - 15:16	29.3	0.6	ESE114°	44.9	/	
		R2-S3-B	9 Nov 2020	15:17 - 15:23	30.0	1.3	ESE113°	45.2	/	
S3a	Primary sedimentation tank (outlet) (West part of TPSTW)	R1-S3a-A	7 Oct 2020	11:56 - 12:02	28	0.5	NE40°	73.9	1.90	/
		R1-S3a-B	7 Oct 2020	12:03 - 12:09	31.8	0.5	NE36°	60.2	1.82	/
		R2-S3a-A	9 Nov 2020	14:50 - 14:56	30.0	0.9	NE52°	47.0	4.65	/
		R2-S3a-B	9 Nov 2020	14:57 - 15:03	29.1	1.3	ENE67°	48.9	2.38	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S4	Primary sedimentation tank (inlet) (West part of TPSTW)	R1-S4-A	7 Oct 2020	16:21 - 16:27	27.6	0.7	NNE21°	69.3	1.61	/
		R1-S4-B	7 Oct 2020	16:28 - 16:34	27.4	0.7	NNE31°	69.2	1.55	/
		R2-S4-A	2 Nov 2020	15:44 - 15:50	31.6	2.4	NNW337°	54.9	1.83	/
		R2-S4-B	2 Nov 2020	15:51 - 15:57	32.1	1.9	NNW339°	52.5	1.74	/
S4a	Primary sedimentation tank (inlet) (West part of TPSTW)	R1-S4a-A	7 Oct 2020	16:00 - 16:06	28.3	2.2	NNW329°	67.3	2.21	/
		R1-S4a-B	7 Oct 2020	16:07 - 16:13	26.8	3.1	NNE18°	70.1	2.77	/
		R2-S4a-A	2 Nov 2020	16:08 - 16:14	31.2	1.6	NNE33°	53.0	3.72	/
		R2-S4a-B	2 Nov 2020	16:15 - 16:21	30.5	1.8	ENE59°	54.7	3.72	/
S5	Aeration tank (inlet) (West part of TPSTW)	R1-S5-A	7 Oct 2020	14:42 - 14:48	28.7	1.6	NNE14°	65.8	2.07	/
		R1-S5-B	7 Oct 2020	14:49 - 14:55	28.5	0.7	NNE19°	69.7	2.21	/
		R2-S5-A	9 Nov 2020	14:04 - 14:10	28.8	1.3	ENE66°	48.4	3.02	/
		R2-S5-B	9 Nov 2020	14:11 - 14:17	29.7	1.4	E96°	49.9	9.03	/
S5a	Aeration tank (inlet) (West part of TPSTW)	R1-S5a-A	7 Oct 2020	15:03 - 15:09	28.6	0.4	NNE12°	68.3	2.67	/
		R1-S5a-B	7 Oct 2020	15:10 - 15:16	29.3	0.8	NNW340°	65.1	2.52	/
		R2-S5a-A	9 Nov 2020	14:29 - 14:35	30.2	1.2	ENE64°	45.7	5.78	/
		R2-S5a-B	9 Nov 2020	14:36 - 14:42	29.7	1.8	ENE70°	45.5	5.56	/
S6	Aeration tank (outlet) (West part of TPSTW)	R1-S6-A	7 Oct 2020	15:37 - 15:43	29.2	0.7	NNE18°	66.1	0.30	/
		R1-S6-B	7 Oct 2020	15:44 - 15:50	30.0	0.6	NE34°	61.9	0.11	/
		R2-S6-A	9 Nov 2020	11:26 - 11:32	31.8	2.1	SSE147°	39.5	0.19	/
		R2-S6-B	9 Nov 2020	11:33 - 11:39	32.4	2.0	SE139°	41.0	0.15	/
S6a	Aeration tank (outlet) (West part of TPSTW)	R1-S6a-A	7 Oct 2020	15:21 - 15:27	28.2	2.7	N359°	68.1	0.20	/
		R1-S6a-B	7 Oct 2020	15:28 - 15:34	28.1	1.0	NNW333°	66.7	0.17	/
		R2-S6a-A	9 Nov 2020	11:01 - 11:07	34.1	1.5	E97°	33.8	0.12	/
		R2-S6a-B	9 Nov 2020	11:08 - 11:14	33.4	1.8	SE144°	34.7	0.10	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m^2/s)	Remarks
S7	Final sedimentation tank (outlet) (West part of TPSTW)	R1-S7-A	9 Oct 2020	16:05 - 16:11	30.1	0.9	ENE57°	60.4	0.26	/
		R1-S7-B	9 Oct 2020	16:12 - 16:18	30.7	0.9	ENE76°	57.6	0.24	/
		R2-S7-A	9 Nov 2020	9:33 - 9:39	25.9	1.0	SSE168°	48.1	0.34	/
		R2-S7-B	9 Nov 2020	9:41 - 9:47	26.0	2.2	E101°	47.6	0.24	/
S7a	Final sedimentation tank (outlet) (West part of TPSTW)	R1-S7a-A	19 Oct 2020	10:02 - 10:08	28.8	1.4	WSW245°	61.8	0.14	Retake
		R1-S7a-B	19 Oct 2020	10:14 - 10:20	29.5	1.6	WSW253°	59.3	0.12	Retake
		R2-S7a-A	9 Nov 2020	10:34 - 10:40	26.8	2.2	ENE69°	49.4	0.19	/
		R2-S7a-B	9 Nov 2020	10:41 - 10:47	26.2	2.7	ESE113°	49.5	0.17	/
S8	Final sedimentation tank (inlet) (West part of TPSTW)	R1-S8-A	7 Oct 2020	16:46 - 16:52	27.7	1.1	NE50°	68.8	0.41	/
		R1-S8-B	7 Oct 2020	17:07 - 17:13	27.0	0.7	NNE26°	71.7	0.28	/
		R2-S8-A	9 Nov 2020	9:54 - 10:00	28.6	1.5	E82°	42.9	0.15	/
		R2-S8-B	9 Nov 2020	10:01 - 10:07	27.7	0.4	ENE67°	46.7	0.15	/
S8a	Final sedimentation tank (inlet) (West part of TPSTW)	R1-S8a-A	9 Oct 2020	15:24 - 15:30	31.9	1.4	E90°	51.9	0.32	/
		R1-S8a-B	9 Oct 2020	15:31 - 15:37	32.6	0.4	ESE113°	53.9	0.32	/
		R2-S8a-A	9 Nov 2020	10:14 - 10:20	25.9	1.6	E89°	47.6	0.27	/
		R2-S8a-B	9 Nov 2020	10:21 - 10:27	26.9	2.0	NE51°	47.6	0.34	/
S9	Sludge digestion tank (West part of TPSTW)	R1-S9-A	23 Oct 2020	10:09 - 10:15	28.0	2.8	NNW343°	66.5	/	Invalid due to abnormal values obtained.
		R1-S9-B	23 Oct 2020	10:16 - 10:22	28.2	1.6	N11°	69.8	/	
		R2-S9-A	9 Nov 2020	16:13 - 16:19	26.0	2.7	ENE69°	57.9	/	
		R2-S9-B	9 Nov 2020	16:20 - 16:26	26.1	1.6	E91°	64.1	/	
S10	Sludge consolidation tank (West part of TPSTW)	R1-S10-A	23 Oct 2020	9:47 - 9:53	26.2	1.3	NNE30°	51.2	5.46	/
		R1-S10-B	23 Oct 2020	9:55 - 10:01	26.3	1.4	NNW340°	50.9	2.20	/
		R2-S10-A	9 Nov 2020	15:42 - 15:48	27.3	3.1	ENE73°	54.5	14.35	Retake
		R2-S10-B	9 Nov 2020	15:50 - 15:56	28.0	3.1	E89°	55.3	13.70	Retake

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S11	Primary sludge gravity thickener (West part of TPSTW)	R1-S11-A	23 Oct 2020	10:43 - 10:49	27.6	0.4	N355°	70.9	1.00	/
		R1-S11-B	23 Oct 2020	10:50 - 10:56	28.8	1.7	WNW301°	70.6	1.64	/
		R2-S11-A	30 Oct 2020	15:28 - 15:34	30.6	1.5	SE137°	70.2	0.79	/
		R2-S11-B	30 Oct 2020	15:35 - 15:41	30.2	2.3	S184°	71.7	0.78	/
S12	Sludge dewatering house (inlet tank) (West part of TPSTW)	R1-S12-A	23 Oct 2020	14:21 - 14:27	25.9	1.6	ENE59°	53.9	0.20	/
		R1-S12-B	23 Oct 2020	14:28 - 14:34	26.8	0.6	ENE69°	53.1	0.14	/
		R2-S12-A	30 Oct 2020	10:55 - 11:01	27.9	0.8	SSE167°	70.2	0.63	/
		R2-S12-B	30 Oct 2020	11:02 - 11:08	27.4	0.6	W268°	70.9	0.81	/
S12a	Sludge dewatering house (dry sludge) (West part of TPSTW)	R1-S12a-A	23 Oct 2020	11:33 - 11:39	26.4	2.0	WNW303°	48.6	1.25	/
		R1-S12a-B	23 Oct 2020	11:40 - 11:46	25,0	1.5	NW306°	54.1	0.92	/
		R2-S12a-A	30 Oct 2020	10:34 - 10:40	26.9	1.7	SSW192°	74.8	0.98	/
		R2-S12a-B	30 Oct 2020	10:41 - 10:47	27.6	1.7	S190°	71.9	0.85	/
S13	SAS thickening house (West part of TPSTW)	R1-S13-A	23 Oct 2020	14:52 - 14:58	25.3	1.8	NNW332°	55.5	0.22	/
		R1-S13-B	23 Oct 2020	14:59 - 15:05	26.1	0.9	N6°	50.9	0.15	/
		R2-S13-A	30 Oct 2020	11:54 - 12:00	28.5	0.6	SSE148°	68.9	0.59	/
		R2-S13-B	30 Oct 2020	12:01 - 12:07	28.4	0.3	SSE155°	73.4	0.44	/
S14	Sludge pumping station (West part of TPSTW)	R1-S14-A	23 Oct 2020	11:08 - 11:14	27.1	1.7	NNE25°	63.3	0.92	/
		R1-S14-B	23 Oct 2020	11:15 - 11:21	27.0	1.4	WSW245°	63.2	0.73	/
		R2-S14-A	30 Oct 2020	11:20 - 11:26	28.3	1.6	W278°	76.5	1.24	/
		R2-S14-B	30 Oct 2020	11:27 - 11:33	29.0	0.6	NNW333°	73.5	1.96	/
S15	Inlet pumping station (East part of TPSTW)	R1-S15-A	19 Oct 2020	11:34 - 11:40	30.3	1.3	SSE163°	67.0	1.81	/
		R1-S15-B	19 Oct 2020	11:41 - 11:47	29.9	1.1	SSE153°	61.6	1.81	/
		R2-S15-A	2 Nov 2020	10:15 - 10:21	27.6	0.5	NE51°	62.7	3.66	/
		R2-S15-B	2 Nov 2020	10:22 - 10:28	27.9	1.8	ENE65°	64.2	5.02	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S16	Screens house (East part of TPSTW)	R1-S16-A	19 Oct 2020	13:40 - 13:46	28.4	-	-	63.3	1.71	Indoor
		R1-S16-B	19 Oct 2020	13:47 - 13:53	28.3	-	-	64.8	1.09	Indoor
		R2-S16-A	2 Nov 2020	9:49 - 9:55	26.2	-	-	73.0	5.11	Indoor
		R2-S16-B	2 Nov 2020	9:56 - 10:02	26.0	-	-	71.7	3.87	Indoor
S16a	Screens house grit collection tank (East part of TPSTW)	R1-S16a-A	23 Oct 2020	15:26 - 15:32	26.4	1.4	N358°	49.3	0.87	/
		R1-S16a-B	23 Oct 2020	15:33 - 15:39	26.9	0.4	N349°	48.7	0.55	/
		R2-S16a-A	30 Oct 2020	10:06 - 10:12	27.7	1.1	SSW199°	71.4	1.19	/
		R2-S16a-B	30 Oct 2020	10:13 - 10:19	27.3	0.9	S185°	76.5	0.77	/
S17	Primary sedimentation tank (inlet) (East part of TPSTW)	R1-S17-A	9 Oct 2020	10:10 - 10:16	30.1	2.3	N354°	65.6	/	Invalid due to abnormal values obtained.
		R1-S17-B	9 Oct 2020	10:17 - 10:23	32.3	0.6	NNW328°	58.2	/	
		R2-S17-A	3 Nov 2020	16:18 - 16:24	27.0	0.7	NNE30°	64.6	/	
		R2-S17-B	3 Nov 2020	16:25 - 16:31	26.8	0.7	ENE66°	64.0	/	
S17a	Primary sedimentation tank (inlet) (East part of TPSTW)	R1-S17a-A	9 Oct 2020	10:28 - 10:34	31.4	0.6	E91°	60.4	/	
		R1-S17a-B	9 Oct 2020	10:36 - 10:42	30.9	2.3	E79°	59.5	/	
		R2-S17a-A	3 Nov 2020	15:59 - 16:05	27.8	1.2	N8°	65.8	/	
		R2-S17a-B	3 Nov 2020	16:07 - 16:12	27.0	0.5	NW314°	68.0	/	
S18	Primary sedimentation tank (outlet) (East part of TPSTW)	R1-S18-A	9 Oct 2020	10:47 - 10:53	31.6	1.4	WNW283°	63.6	/	
		R1-S18-B	9 Oct 2020	10:53 - 11:00	31.5	1.7	WNW295°	64.8	/	
		R2-S18-A	3 Nov 2020	15:20 - 15:26	28.5	0.8	SSE156°	61.2	/	
		R2-S18-B	3 Nov 2020	15:27 - 15:33	28.0	1.0	E90°	64.1	/	
S18a	Primary sedimentation tank (outlet) (East part of TPSTW)	R1-S18a-A	9 Oct 2020	11:09 - 11:15	32.9	0.7	W280°	55.8	/	
		R1-S18a-B	9 Oct 2020	11:16 - 11:22	33.0	0.8	NW311°	52.3	/	
		R2-S18a-A	3 Nov 2020	15:38 - 15:44	27.6	0.4	E83°	62.5	/	
		R2-S18a-B	3 Nov 2020	15:45 - 15:51	26.8	0.6	E97°	68.8	/	

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S19	Aeration tank (inlet) (East part of TPSTW)	R1-S19-A	19 Oct 2020	15.25 - 15.31	29.9	1.1	NNW339°	57.3	/	Invalid due to abnormal values obtained.
		R1-S19-B	19 Oct 2020	15:32 - 15:38	31.2	0.4	NE40°	59.9	/	
		R2-S19-A	3 Nov 2020	14:13 - 14:19	27.2	0.7	E91°	66.8	/	
		R2-S19-B	3 Nov 2020	14:20 - 14:26	27.6	1.0	E81°	62.8	/	
S19a	Aeration tank (inlet) (East part of TPSTW)	R1-S19a-A	19 Oct 2020	15:03 - 15:09	31.0	0.7	ESE120°	66.8	/	
		R1-S19a-B	19 Oct 2020	15:10 - 15:16	29.5	1.7	ENE61°	65.0	/	
		R2-S19a-A	3 Nov 2020	15:00 - 15:05	29.3	0.0	-	62.0	/	
		R2-S19a-B	3 Nov 2020	15:07 - 15:13	28.3	0.8	SSW206°	61.0	/	
S20	Aeration tank (outlet) (East part of TPSTW)	R1-S20-A	9 Oct 2020	14:29 - 14:35	31.1	1.3	ENE74°	55.2	1.05	/
		R1-S20-B	9 Oct 2020	14:36 - 14:42	30.5	2.1	NE40°	60.0	0.83	/
		R2-S20-A	3 Nov 2020	13:53 - 13:58	25.8	1.0	S190°	68.7	0.42	/
		R2-S20-B	3 Nov 2020	14:00 - 14:06	26.7	1.2	SW217°	64.2	0.62	/
S20a	Aeration tank (outlet) (East part of TPSTW)	R1-S20a-A	9 Oct 2020	11:50 - 11:56	33.5	1.4	SW225°	55.4	1.25	/
		R1-S20a-B	9 Oct 2020	12:02 - 12:08	33.1	0.9	SSW196°	55.4	0.88	/
		R2-S20a-A	3 Nov 2020	14:37 - 14:43	29.8	0.5	NNE25°	59.4	1.08	/
		R2-S20a-B	3 Nov 2020	14:44 - 14:51	29.2	0.6	E85°	58.9	0.71	/
S21	Final sedimentation tank (outlet) (East part of TPSTW)	R1-S21-A	19 Oct 2020	10:42 - 10:48	29.7	1.2	E94°	66.1	0.02	/
		R1-S21-B	19 Oct 2020	10:50 - 10:56	29.3	1.6	E95°	60.8	0.01	/
		R2-S21-A	2 Nov 2020	14:01 - 14:07	32.2	2.2	NW317°	51.6	0.29	/
		R2-S21-B	2 Nov 2020	14:08 - 14:14	33.5	2.2	WNW295°	49.0	0.35	/
S21a	Final sedimentation tank (outlet) (East part of TPSTW)	R1-S21a-A	19 Oct 2020	11:07 - 11:13	28.1	1.5	SW224°	70.3	0.05	/
		R1-S21a-B	19 Oct 2020	11:15 - 11:21	28.9	0.9	SSW201°	65.2	0.03	/
		R2-S21a-A	2 Nov 2020	14:25 - 14:31	33.2	2.3	N352°	50.7	0.58	/
		R2-S21a-B	2 Nov 2020	14:32 - 14:38	32.4	1.9	N355°	55.3	0.35	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S22	Final sedimentation tank (inlet) (East part of TPSTW)	R1-S22-A	19 Oct 2020	14:32 - 14:38	29.1	0.4	SSW202°	65.7	0.30	/
		R1-S22-B	19 Oct 2020	14:39 - 14:45	28.0	1.3	S182°	65.9	0.27	/
		R2-S22-A	2 Nov 2020	15:13 - 15:19	33.5	1.2	NW308°	48.0	0.40	/
		R2-S22-B	2 Nov 2020	15:20 - 15:26	34.2	1.8	NNW327°	46.3	0.46	/
S22a	Final sedimentation tank (inlet) (East part of TPSTW)	R1-S22a-A	19 Oct 2020	14:09 - 14:15	29.7	1.0	NNW341°	64.1	0.21	/
		R1-S22a-B	19 Oct 2020	14:16 - 14:22	33.0	0.5	NNW340°	57.0	0.32	/
		R2-S22a-A	2 Nov 2020	14:48 - 14:54	35.9	2.5	W227°	48.2	0.38	/
		R2-S22a-B	2 Nov 2020	14:55 - 15:01	37.1	2.8	NW316°	25.0	0.41	/
S23	Sludge digestion tank (East part of TPSTW)	R1-S23-A	19 Oct 2020	16:15 - 16:21	30.2	-	-	62.9	1.03	Indoor
		R1-S23-B	19 Oct 2020	16:22 - 16:28	29.3	-	-	68.9	0.60	Indoor
		R2-S23-A	30 Oct 2020	14:55 - 15:01	30.1	-	-	66.9	8.37	Indoor
		R2-S23-B	30 Oct 2020	15:02 - 15:08	30.2	-	-	66.2	7.30	Indoor
S24	Sludge consolidation tank (East part of TPSTW)	R1-S24-A	19 Oct 2020	16:44 - 16:50	27.8	0.9	S177°	61.6	1.45	/
		R1-S24-B	19 Oct 2020	16:51 - 16:57	28.6	1.1	SSW196°	64.0	0.84	/
		R2-S24-A	30 Oct 2020	14:30 - 14:36	28.2	0.5	SSW199°	66.2	1.26	/
		R2-S24-B	30 Oct 2020	14:37 - 14:43	30.7	0.4	SSW207°	65.2	1.03	/
S25	Leachate pre-treatment tank (Sheun Wan leachate pre-treatment works)	R1-S25-A	9 Oct 2020	16:31 - 16:37	30.2	3.0	ENE72°	59.1	0.23	/
		R1-S25-B	9 Oct 2020	16:38 - 16:44	30.6	0.6	ENE66°	57.4	0.21	/
		R2-S25-A	2 Nov 2020	11:40 - 11:46	35.7	1.6	SE129°	45.4	0.63	/
		R2-S25-B	2 Nov 2020	11:47 - 11:53	36.6	0.6	ESE115°	43.7	0.49	/

9 Conclusion

A total of 76 ambient samples (two rounds) at ASRs surrounding the TPSTW were collected during the period of 16th September – 24th September 2020, and a total of 160 source samples (two rounds, retake samples exclusive) from the surface of sewage/sludge/refuse within TPSTW site were collected during the period of 7th October – 9th November 2020. QA/QC samples were obtained for each sampling day. Sampling strategies and actual situations during QA/QC sampling are illustrated in the Appendix. The QA/QC sample concentrations were used for data calibration.

For sampling activities in the same round, two consecutive samples were collected at one sampling location for the evaluation of repeatability of the results. The repeatability of odour sampling and analysis could be affected by the sampling conditions (especially for sampling at water surface with relatively high flowrate/turbulence), as well as the conditions olfactometry analysis (e.g., performance of odour assessors). Due to the nature of olfactometry analysis, especially for high-concentration samples, the difference could be obvious between two consecutive steps (dilution factors). By the end of a single round of sampling activities, the analysis results were reviewed and some abnormal results (large discrepancies between the duplicate samples) were spotted, and resampling was arranged for these samples. Retake of samples at S7a (1st round), S9 (2nd round), S10 (2nd round), S19 (1st round), and S19a (1st round) were conducted. Results of the retake samples were with acceptable differences between duplicated samples, hence, the results of retake samples were adopted as the formal results.

Some high concentrations were identified for both ambient and source samples. Most of the original results of ambient samples were higher than the lower detection limit (LoD, 10 ou/m^3) for our olfactometer, and some of them reached over 100 ou/m^3. It should be noted that the olfactometer has been updated and is different from some previous studies, which is with higher sensitivity for samples with concentrations higher than the LoD. Pre-cleaned zero air was used for dilution of the samples, it is possible for the panels to distinguish nitrogen-only QA/QC samples from the pre-cleaned zero air, hence, the normal concentration range of QA/QC samples is 10~20 ou/m^3. Moreover, it should be noted that other compounds also contribute to the odour of the samples, e.g., vehicle emissions, biogenic emissions, etc. The high odour concentrations therefore were not necessarily attributed to the emissions from TPSTW. Remarks were made during the ambient sampling recording the perception of odour by the sampling team. For those samples with high concentrations over 100 ou/m^3, it should be noted that the repeatability of two consecutive samples is acceptable, indicating the procedures of sampling and analysis should be proper. TPSTW is located in a valley-like region, the dispersion conditions for TPSTW may not be comparable with other STWs located near river or sea. And the meteorological conditions were constantly changed, the recorded data only represent a relatively short period, hence it is possible that the recorded wind direction indicated air flows were toward TPSTW but the odour concentrations were still at high levels.

During review of the data obtained, abnormal values were identified at different locations, including S3, S9, S17, S17a, S18, S18a, S19, and S19a, respectively. These data were discarded in this version of report. Additional sampling and analysis at these locations will be arranged tentatively in May to June 2021 subject to the actual weather conditions.

Appendix

A. Concentration of QA/QC Samples

a) QA/QC Samples for Ambient Sampling

Sample ID	Sampling Date	Odour Concentration (ou/m^3)
QA/QC-R1-D1	16 Sept 2020	15
QA/QC-R1-D2	17 Sept 2020	20
QA/QC-R2-D1	23 Sept 2020	13
QA/QC-R2-D2	24 Sept 2020	15

With the characteristics of ambient sampling considered, the QA/QC samples collected on the days of ambient sampling were collected by directly inject nitrogen into the sample bag.

b) QA/QC Samples for Source Sampling

Sample ID	Sampling Date	Odour Concentration (ou/m^3)
QA/QC-R1-D3	07 Oct 2020	193*
QA/QC-R1-D4	09 Oct 2020	2542*
QA/QC-R1-D5	19 Oct 2020	13
QA/QC-R1-D6	23 Oct 2020	15
QA/QC-R2-D3	30 Oct 2020	19
QA/QC-R2-D4	02 Nov 2020	10
QA/QC-R2-D5	03 Nov 2020	19
QA/QC-R2-D6	09 Nov 2020	15

With the characteristics of source sampling considered, the QA/QC samples collected on the days of source sampling were obtained by injecting nitrogen into the cleaned flux chamber sampler and then collected by CSD30 odour sampler. QA/QC samples collected on 7th and 9th October (highlighted with *) were with abnormally high results, which may due to the residual odourous compounds on the ground or facility surfaces on-site. The sampling strategy of QA/QC sampling for source sampling days was changed to laboratory-based collection immediately after these results were obtained. The abnormal results were excluded for data validation. Average of QA/QC samples for source sampling on other sampling dates were used for data validation for samples collected on 7th and 9th October.

B. Certificates of Qualified Odour Assessors

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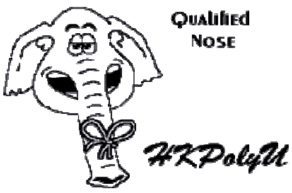

Certificate for Qualified Odour Panel Member

This is to certify that

Miss CHAN Hiu Ting

had demonstrated that her nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, her individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, she is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

Professor S.C. Lee
Lab-in-charge,
Odour Research Laboratory,
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香港理工大學

Date: 15 Sep 2020

Ref.: 20200915QP04

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Qualified Nose
HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr CHAN Ka Ming

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 15 Sep 2020

Ref.: 20200915QP01

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Qualified Nose HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr HUI Yin Fung

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 20 Oct 2020

Ref.: 20201020QP02

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Qualified Nose
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Certificate for Qualified Odour Panel Member

This is to certify that

Mr HUNG Hok To

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 11 Sep 2020

Ref.: 20200911QP02

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HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr LAU Cheuk Fung

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 11 Sep 2020

Ref.: 20200911QP03

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Certificate for Qualified Odour Panel Member

This is to certify that

Miss LI Xinwei

had demonstrated that her nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, her individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, she is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 20 Oct 2020

Ref.: 20201020QP01

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PolyU Technology & Consultancy Company Limited 理大科技及顧問有限公司

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Qualified Nose HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr LIU Ching Hung

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Odour Research Laboratory,
HKPolyU.

Date: 11 Sep 2020

Ref.: 20200911QP04

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Mr LO Wing Yat

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Date: 11 Sep 2020

Ref.: 20200911QP01

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APPENDIX 3.7B

ODOUR SURVEY FOR TAI PO SEWAGE TREATMENT WORKS

PolyU Technology & Consultancy Company Limited 理大科技及顧問有限公司

Technical Report

for

Contract No. SPW 05/2021 – Upgrading of Tai Po Sewage Treatment Works – Investigation – Odour Survey and Analysis

For

Drainage Services Department

Prepared by

Odour Research Laboratory

Department of Civil and Environmental Engineering

The Hong Kong Polytechnic University

Submitted by

PolyU Technology and Consultancy Company Limited

Signed by: ______________________
[Prof. Shun-cheng Lee]

Date: 26/01/2022

1 Introduction

A service to conduct odour sampling and analysis at Tai Po Sewage Treatment Works (TPSTW) including inlet areas, primary sedimentation tanks, aeration tanks and sludge digestion tant has been invited by Ms. Christina KO at Binnies Hong Kong Limited on behalf of Drainage Services Department, HKSAR on 28th June 2021.

2 Scope of Works

The scope of the works includes:

- To conduct odour source sampling at designated locations (including primary sedimentation tanks, aeration tanks and sludge digestion tank) using flux chamber or wind tunnel sampler.
- To conduct provisional odour source sampling at designated locations (including inlet pumping stations and screens houses) using flux chamber or wind tunnel sampler.
- To conduct laboratory olfactometry analysis for source samples.
- To submit a report of sampling and analysis results of odour emission rates at sources at different locations.

3 Schedule

Description	Period Covered/Date
First Round of Source Sampling (provisional items included) on-site	27th July 2021 – 28th July 2021
First Round of laboratory olfactometry analysis	28th July 2021 – 29th July 2021
Second Round of Source Sampling (provisional items included) on-site	10th August 2021 – 11th August 2021
Second Round of laboratory olfactometry analysis	11th August 2021 – 12th August 2021
Draft Technical Report Submission	30th August 2021
Final Technical Report Submission	TBC

4 Working Plan

On-site Source sampling work were conducted during the period of 27th July to 11th August 2021. The sampling locations (provisional items included) are illustrated in the following figure 4.1 and figure 4.2.

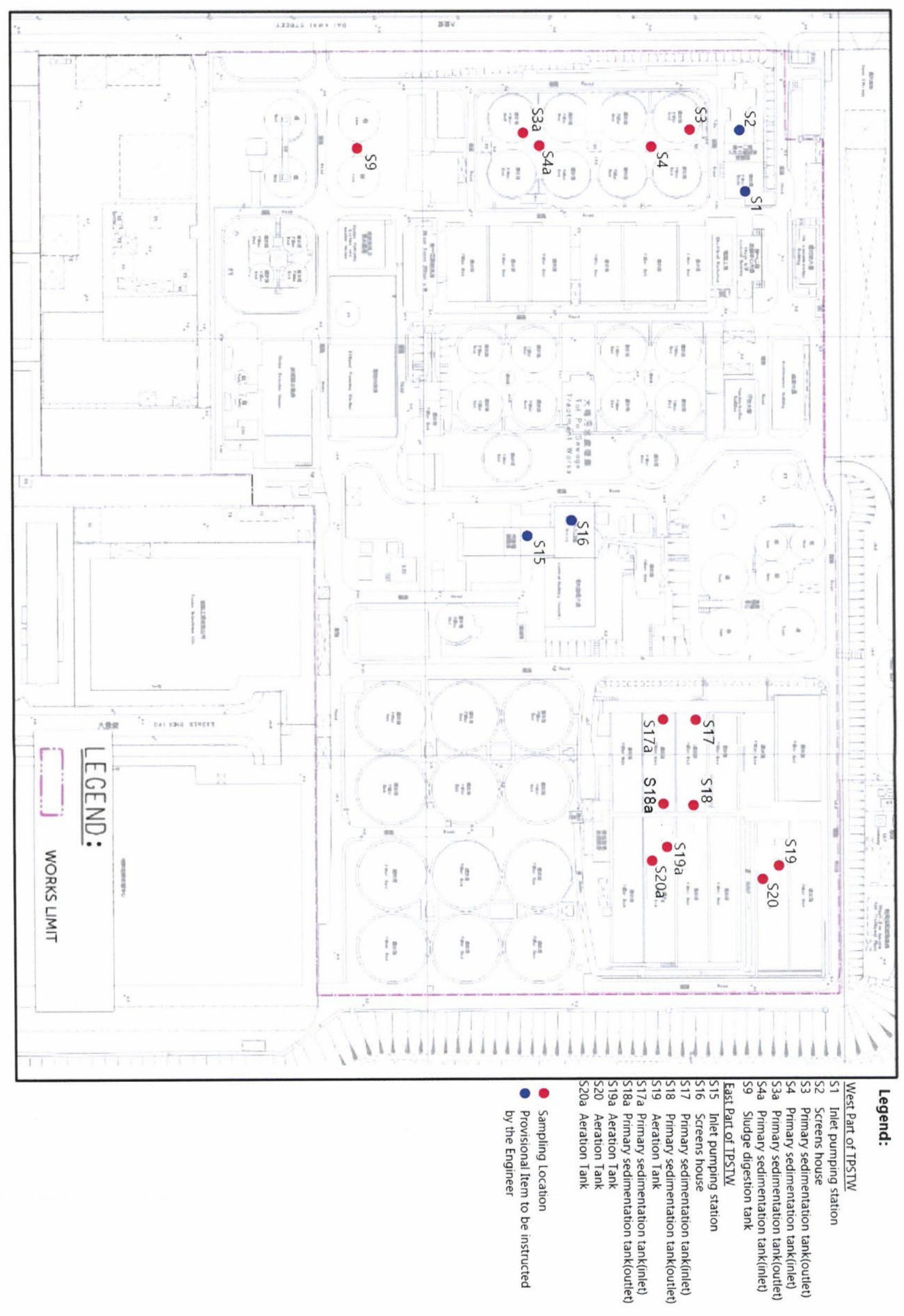


Figure 4.1 Round-1 sampling locations for source odour samples in TPSTW

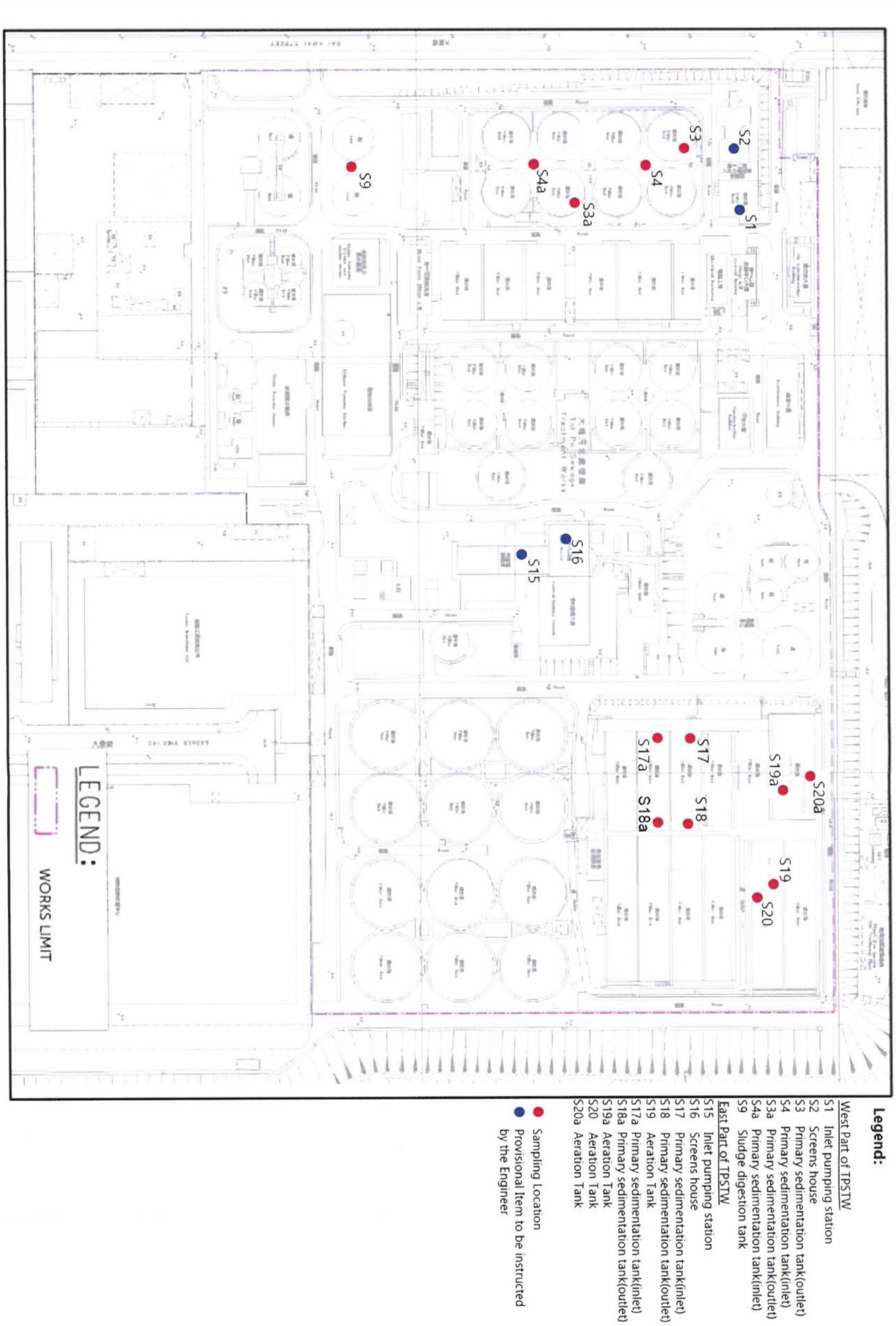


Figure 4.2 Round-2 sampling locations for source odour samples in TPSTW

4.1 Sampling Location

There are 8 primary sedimentation tanks in the west part of TPSTW, 5 primary sedimentation tanks and 7 aeration tanks in the east part of TPSTW in total. During our on-site sampling period, only those tanks under normal operation would be considered to be selected to take odour samples in order to reflect the reasonable odour emission status. Therefore, slight adjustments on the selection of primary sedimentation tanks and aeration tanks were necessary between our two rounds of on-site sampling works. In addition, technical advice on the maintenance and operation status from the engineers and operators of TPSTW would also be helpful and guided for our decision. The final sampling location of each facility was also approved by the engineers of Binnies.

4.2 Daily Detailed Working Plan

Following is the working plan of the source odour sampling.

ID	**Location**	**Odour Sample Quantity**	**1st Round**		**2nd Round**	
			27 Jul	**28 Jul**	**10 Aug**	**11 Aug**
West Part of TPSTW						
S1#	Inlet pumping station	4		2		2
S2#	Screens house	4		2		2
S3	Primary sedimentation tank (outlet)	4		2		2
S3a	Primary sedimentation tank (outlet)	4		2	2	
S4	Primary sedimentation tank (inlet)	4		2		2
S4a	Primary sedimentation tank (inlet)	4		2	2	
S9	Sludge digestion tank	4		2		2
East Part of TPSTW						
S15#	Inlet pumping station	4	2			2
S16#	Screens house	4	2			2

S17	Primary sedimentation tank (inlet)	4	2		2	
S17a	Primary sedimentation tank (inlet)	4	2		2	
S18	Primary sedimentation tank (outlet)	4	2		2	
S18a	Primary sedimentation tank (outlet)	4	2		2	
S19	Aeration tank (inlet)	4	2		2	
S19a	Aeration tank (inlet)	4	2		2	
S20	Aeration tank (outlet)	4	2		2	
S20a	Aeration tank (outlet)	4	2		2	

#: Conducted Provisional Item

5 Methodology

5.1 Odour Sampling

Odour gaseous sample is collected by using a specialized odour sampling system (CSD30, 60L, Olfasence GmbH, Germany). During air sampling, an empty sample bag is placed in the sealed sampler, and the sampler is then evacuated at a controlled rate (by setting total sampling time for 5-minute, 10-minute, 15-minute or 30-minute) by the built-in vacuum pump, sample bag will be filled with sample gas due to negative pressure in the sampler.

CSD30 Odour Sampler

In this technique, all "wetted" parts exposed to the odourous gas are to be composed of stainless steel and Teflon tubing. The sample bags are manufactured from PTFE, Tedlar if the bags are to be reuse, or from nalophane NATM if the bags are to be discarded after use.

Dynamic sampling system, which includes an odour-free gas source from a gas cylinder or gas cleaning device, a dynamic flux chamber or wind tunnel sampler, and sample collection system, is suitable for measuring emission rates. The flux chamber or wind tunnel will be placed on the emission surface of selected locations and a stream of odour-free gas from a certified gas cylinder or a gas cleaning device will be supplied to the chamber to simulate a parallel wind blowing above the emission surface. The flow rate of the gas will be measured by a flow meter attached on the gas supply tubing. Odour emission rate is then determined by the air flow through the chamber and the odour concentration of the collected gas sample, according to the following equation:

$$\mathrm{SOER\ (ou/m^2/s)} = \frac{\mathrm{Odour\ Conc.\ (ou/m^3) \times Air\ Flow\ Inside\ Flux\ Chamber\ (m^3/s)}}{\mathrm{Covered\ Surface\ Area\ (m^2)}}$$

The required flowrate of odour-less nitrogen injected into flux chamber is 5 L/min, hence the dynamic flux chamber will be used for the sampling of source emission. In general, the wind tunnel sampler is capable to obtain average emission rate from low-emission heterogeneous sources (e.g., nullah, seawater surface, etc.) by covering a larger surface area. In this specific project, the odour emission rates from wastewater and sludge surfaces are to be collected, which are with obviously higher emission rates (compared to the natural water bodies) and with more uniform emission rate for each specific sampling location. Also there is are safety considerations on utilizing the bulky wind tunnel sampling on wastewater or sludge surface sampling. Hence, the flux chamber sampler is considered capable for source sampling for this specific project. The effective covering area of the dynamic flux chamber is about 0.13 m^2. In consideration of the sample size, the sampling period of each sample shall be within 10 minutes. Specifically for our CSD30 sampler, the flowrate to sample bag is identical for 5-min and 10-min setting, while the 10-min setting is at intermittent sampling mode. For sample representativeness, the difference between 5-min and 10-min is not significant. Hence, 5-min sampling duration was proposed for the source sampling in this specific project. For supporting a sampling period of 5-min, the lowest flowrate of injected nitrogen gas is suggested to be adjusted to at least 12 L/min, and for the consideration of redundance, a 15 L/min flowrate of nitrogen was adopted for source sampling.

Dynamic Flux Chamber

For the purpose of Quality Assurance & Quality Control (QA/QC), during each sampling day, a control sample with odour-less nitrogen purged into sample back will be collected for olfactometry analysis. During the date of ambient sampling, nitrogen gas was directly injected to sample bags by connecting CSD30 sampler with the gas cylinder. While during the date of source sampling, nitrogen gas was injected to the cleaned flux chamber sampler first, and QA/QC samples were collected by CSD30 sampler from the cleaned flux chamber with nitrogen gas cylinder connected. Odour concentrations of ambient samples and source samples were validated by the QA/QC sample results obtained on the same day.

5.2 Olfactometry Analysis

The odour concentration of a gaseous sample is determined by presentation to a panel of observers, with known acuity to odour, in varying dilutions. The odour concentration is then expressed in multiples of dilution. Odour concentration is determined by a forced-choice dynamic olfactometer (Odournet TO Evolution) in full accordance with the European Standard Method (EN13725). This European Standard is applicable to the measurement of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The range of measurement including pre-dilution prior to the olfactometry analysis is typically from 10^1 ou/m^3 to 10^7 ou/m^3. This analysis technique provides directly comparable data for different odour types, and used for input into dispersion models to determine odour impact in terms of annoyance and abatement efficiency assessments.

Odournet TO Evolution Olfactometer

The TO Evolution Olfactometer at Odour Research Laboratory, The Hong Kong Polytechnic University has undergone regularly factory calibration. Calibration certificate could be provided upon request.

6 On-site Sampling

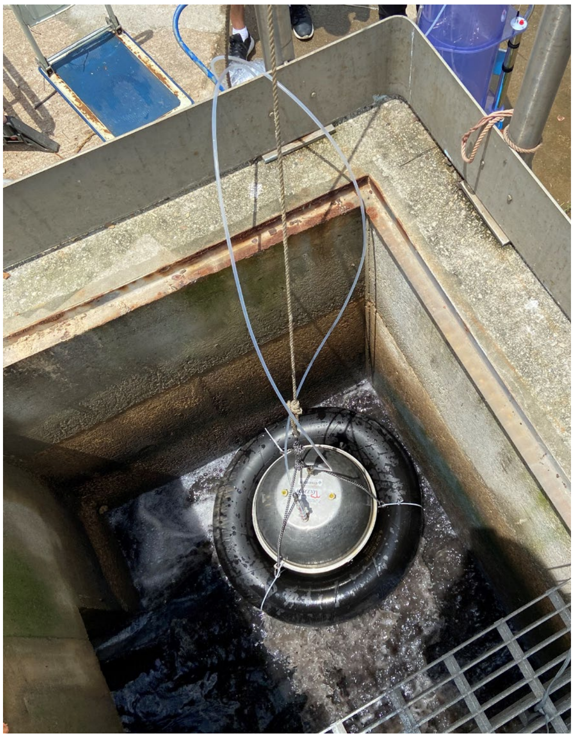
Photos illustrating sampling activities for source samples.


Sampling at S1

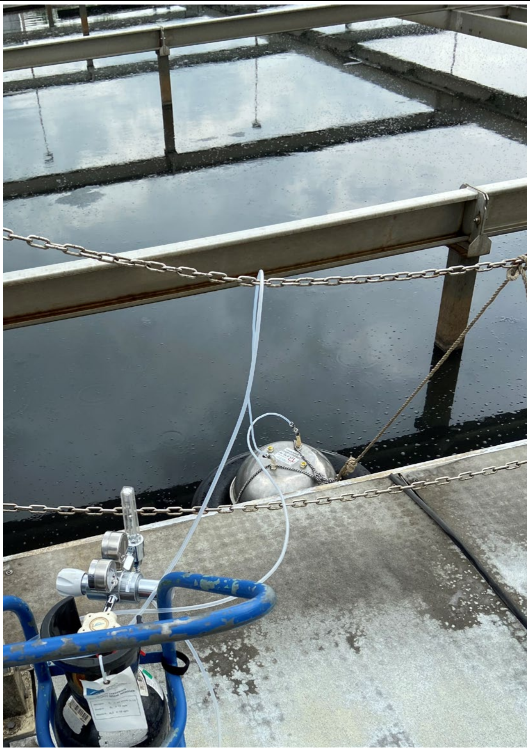

Sampling at S2


Sampling at S3

Sampling at S3a

	
Sampling at S4	Sampling at S4a
	
Sampling at S9	Sampling at S15

	
Sampling at S16	Sampling at S17
	
Sampling at S17a	Sampling at S18

	
Sampling at S18a	Sampling at S19
	
Sampling at S19a	Sampling at S20

	
Sampling at S20a	

7 Laboratory Analysis

Specific odour emission rates (SOER, OU/m^2/s) can be calculated by the following equation:

$$\text{SOER (ou/m}^2\text{/s)} = \frac{\text{Odour Conc. (ou/m}^3\text{)} \times \text{Air Flow Inside Flux Chamber (m}^3\text{/s)}}{\text{Covered Surface Area (m}^2\text{)}}$$

For the current setting of sampling, the air flowrate inside flux chamber is 15 L/min, i.e., 0.00025 m^3/s, for all source sampling. The covered surface area by the flux chamber is 0.132 m^2. Odour concentration from the samples are determined by the olfactometry analysis.

8 Analytical Results

Analytical Results for Source Sampling (Calibrated with Odour Concentration of QA/QC Samples Deducted)

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER ($ou/m^2/s$)	Remarks
S1#	Inlet pumping station (West part of TPSTW)	R1-S1-A	28 Jul 2021	09:42 - 09:48	30.5	0.9	NW321°	79.5	115.66	Covered
		R1-S1-B	28 Jul 2021	09:50 - 09:56	31.1	2.2	N356°	84.2	105.88	Covered
		R2-S1-A	11 Aug 2021	10:52 - 10:58	33.4	1.7	WNW297°	78.2	120.95	Covered
		R2-S1-B	11 Aug 2021	11:00 - 11:06	34.5	0.8	WNW292°	77.6	120.95	Covered
S2#	Screens house (West part of TPSTW)	R1-S2-A	28 Jul 2021	10:18 - 10:24	35.7	1.1	SW227°	67.4	96.89	House covered
		R1-S2-B	28 Jul 2021	10:25 - 10:31	36	0.7	WSW239°	69.9	71.05	House covered
		R2-S2-A	11 Aug 2021	10:26 - 10:32	32.2	0.1	NNW348°	83.2	88.70	House covered
		R2-S2-B	11 Aug 2021	10:33 - 10:39	33.7	0.1	NNW338°	82	71.09	House covered
S3	Primary sedimentation tank (outlet) (West part of TPSTW)	R1-S3-A	28 Jul 2021	15:31 - 15:37	32	0.7	ESE111°	77.5	12.06	/
		R1-S3-B	28 Jul 2021	15:40 - 15:46	32.4	1	E99°	81.2	9.48	/
		R2-S3-A	11 Aug 2021	11:16 - 11:22	34.3	0.7	NW307°	79.9	12.10	/
		R2-S3-B	11 Aug 2021	11:25 - 11:31	34.7	0.8	NW313°	82.9	11.51	/
S3a	Primary sedimentation tank (outlet) (West part of TPSTW)	R1-S3a-A	28 Jul 2021	14:15 - 14:21	32.7	0.9	ENE75°	76.1	126.38	/
		R1-S3a-B	28 Jul 2021	14:23 - 14:29	33.3	1.8	E86°	79	120.91	/
		R2-S3a-A	10 Aug 2021	10:57 - 11:03	29.9	0.4	SW224°	88.9	3.30	/
		R2-S3a-B	10 Aug 2021	11:05 - 11:11	29.8	0.5	S191°	93.8	2.39	/
S4	Primary sedimentation tank (inlet) (West part of TPSTW)	R1-S4-A	28 Jul 2021	15:06 - 15:12	31.2	1.1	E087°	77.3	110.67	/
		R1-S4-B	28 Jul 2021	15:16 - 15:22	30.6	2	NE53°	81.9	120.91	/
		R2-S4-A	11 Aug 2021	11:38 - 11:44	35.5	0.5	WNW285°	75.5	120.95	/
		R2-S4-B	11 Aug 2021	11:46 - 11:52	36	0.4	WNW284°	74.3	115.71	/

#: Conducted Provisional Item

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S4a	Primary sedimentation tank (inlet) (West part of TPSTW)	R1-S4a-A	28 Jul 2021	14:41 - 14:47	31.7	1.9	ESE109°	80.8	56.82	/
		R1-S4a-B	28 Jul 2021	14:50 - 14:56	30.9	3.6	ENE063°	85.8	47.60	/
		R2-S4a-A	10 Aug 2021	10:01 - 10:07	31.4	0.9	SSW199°	90.1	15.95	/
		R2-S4a-B	10 Aug 2021	10:10 - 10:16	31.7	1.3	WSW247°	86.6	17.58	/
S9	Sludge digestion tank (West part of TPSTW)	R1-S9-A	28 Jul 2021	10:55 - 11:01	33.9	0.6	WNW290°	71.8	110.66	Covered
		R1-S9-B	28 Jul 2021	11:02 - 11:08	34.3	1.1	WSW250°	70.5	96.88	Covered
		R2-S9-A	11 Aug 2021	12:10 - 12:16	35.1	0.5	NNW339°	72	19.26	Covered
		R2-S9-B	11 Aug 2021	12:18 - 12:24	35.4	0.7	NNW343°	68	10.53	Covered
S15#	Inlet pumping station (East part of TPSTW)	R1-S15-A	27 Jul 2021	10:03 - 10:09	33.1	1.9	W275°	74.9	3.27	/
		R1-S15-B	27 Jul 2021	10:09 - 10:15	34.2	2.9	W266°	73.8	3.00	/
		R2-S15-A	11 Aug 2021	09:55 - 10:01	32.1	0.4	NNW333°	86.9	3.26	/
		R2-S15-B	11 Aug 2021	10:03 - 10:09	33	0.1	NW325°	88	3.13	/
S16#	Screens house (East part of TPSTW)	R1-S16-A	27 Jul 2021	10:22 - 10:28	33.6	/	/	73.5	3.82	Indoor
		R1-S16-B	27 Jul 2021	10:28 - 10:34	33	/	/	76.1	3.43	Indoor
		R2-S16-A	11 Aug 2021	09:26 - 09:32	30	/	/	96.7	3.95	Indoor
		R2-S16-B	11 Aug 2021	09:34 - 09:40	29.9	/	/	94.8	5.40	Indoor
S17	Primary sedimentation tank (inlet) (East part of TPSTW)	R1-S17-A	27 Jul 2021	11:16 - 11:22	35.3	1.9	W277°	63.6	105.91	/
		R1-S17-B	27 Jul 2021	11:25 - 11:31	36.4	0.9	WNW294°	69.1	101.34	/
		R2-S17-A	10 Aug 2021	13:45 - 13:51	30.1	0.9	S185°	89.4	88.75	/
		R2-S17-B	10 Aug 2021	13:53 - 13:59	30.3	0.7	SE145°	90.3	74.32	/
S17a	Primary sedimentation tank (inlet) (East part of TPSTW)	R1-S17a-A	27 Jul 2021	10:57 - 11:03	35.7	1.1	W264°	71	101.33	/
		R1-S17a-B	27 Jul 2021	11:03 - 11:09	36	2.8	WNW282°	66	81.21	/
		R2-S17a-A	10 Aug 2021	13:22 - 13:28	30	0.8	S169°	95.2	56.63	/
		R2-S17a-B	10 Aug 2021	13:31 - 13:37	29.9	0.8	E96°	94.2	64.85	/

ID	Location	Sample ID	Date	Time	Temperature, °C	W-Speed, m/s	W-D	RH, %	SOER (ou/m²/s)	Remarks
S18	Primary sedimentation tank (outlet) (East part of TPSTW)	R1-S18-A	27 Jul 2021	14:30 - 14:36	36.2	1.4	WSW251°	59.7	74.32	/
		R1-S18-B	27 Jul 2021	14:40 - 14:46	36.4	1.7	W269°	59.6	59.52	/
		R2-S18-A	10 Aug 2021	14:26 - 14:32	31	0.4	WSW253°	87.6	62.14	/
		R2-S18-B	10 Aug 2021	14:35 - 14:41	30.8	0.5	WSW254°	89.4	71.14	/
S18a	Primary sedimentation tank (outlet) (East part of TPSTW)	R1-S18a-A	27 Jul 2021	14:15 - 14:21	36.3	1.8	WSW258°	69.6	52.14	/
		R1-S18a-B	27 Jul 2021	14:21 - 14:27	36.5	1.3	WSW256°	60.3	67.98	/
		R2-S18a-A	10 Aug 2021	14:06 - 14:12	31	1.2	NE48°	87.9	67.93	/
		R2-S18a-B	10 Aug 2021	14:14 - 14:20	30.4	1	W270°	90.7	54.49	/
S19	Aeration tank (inlet) (East part of TPSTW)	R1-S19-A	27 Jul 2021	15:53 - 15:59	30.8	0.8	N3°	85.5	5.80	/
		R1-S19-B	27 Jul 2021	16:01 - 16:07	30.4	0.4	NNE33°	82.9	8.72	/
		R2-S19-A	10 Aug 2021	15:20 - 15:26	32.1	0.3	WNW294°	86.3	1.97	/
		R2-S19-B	10 Aug 2021	15:28 - 15:34	31.5	0.6	WNW291°	89.3	2.48	/
S19a	Aeration tank (inlet) (East part of TPSTW)	R1-S19a-A	27 Jul 2021	14:54 - 15:00	35.3	1.9	NNE13°	65.2	8.34	/
		R1-S19a-B	27 Jul 2021	15:01 - 15:07	33.3	4	NW312°	69.9	6.33	/
		R2-S19a-A	10 Aug 2021	14:55 - 15:01	31	0.9	NW325°	85.3	6.06	/
		R2-S19a-B	10 Aug 2021	15:03 - 15:09	30.7	0.7	NNW337°	87.8	10.50	/
S20	Aeration tank (outlet) (East part of TPSTW)	R1-S20-A	27 Jul 2021	16:12 - 16:18	30.4	0.5	NNE20°	88.8	0.35	/
		R1-S20-B	27 Jul 2021	16:20 - 16:26	29.6	0.6	NNE27°	91	0.45	/
		R2-S20-A	10 Aug 2021	15:41 - 15:47	32	0.6	N353°	83.4	0.62	/
		R2-S20-B	10 Aug 2021	15:50 - 15:56	31.6	0.4	WNW297°	86	0.47	/
S20a	Aeration tank (outlet) (East part of TPSTW)	R1-S20a-A	27 Jul 2021	15:13 - 15:19	33.7	1.1	NNW337°	67.8	2.45	/
		R1-S20a-B	27 Jul 2021	15:28 - 15:34	33	0.9	NW306°	72.5	1.62	/
		R2-S20a-A	10 Aug 2021	16:02 - 16:08	32.8	0.5	WNW295°	82.1	0.86	/
		R2-S20a-B	10 Aug 2021	16:10 - 16:16	32.1	0.7	WNW286°	83.4	0.86	/

9 Conclusions and Observations

A total of 68 source samples (two rounds, provisional items included) from the surface of sewage/sludge within TPSTW site were collected during the period of 27th July – 11th August 2021. QA/QC samples were obtained for each sampling day. Sampling strategies and actual situations during QA/QC sampling are illustrated in the Appendix. The QA/QC sample concentrations were used for data calibration.

For sampling activities in the same round, two consecutive samples were collected at one sampling location for the evaluation of repeatability of the results. The repeatability of odour sampling and analysis could be affected by the sampling conditions (especially for sampling at water surface with relatively high flowrate/turbulence), as well as the conditions olfactometry analysis (e.g., performance of odour assessors). Due to the nature of olfactometry analysis, especially for high-concentration samples, the difference could be obvious between two consecutive steps (dilution factors). By reviewing the emission rates, all these analytical results for the obtained samples kept consistence for the two consecutive samples for each location in the same round.

Some high concentrations were identified for the source samples. All the original results of ambient samples were higher than the lower detection limit (LoD, 10 ou/m^3) for our olfactometer. It should be noted that the olfactometer has been updated and is different from some previous studies, which is with higher sensitivity for samples with concentrations higher than the LoD. Pre-cleaned zero air was used for dilution of the samples, it is possible for the panels to distinguish nitrogen-only QA/QC samples from the pre-cleaned zero air, hence, the normal concentration range of QA/QC samples is 10~20 ou/m^3. For those samples with high concentrations, it should be noted that the repeatability of two consecutive samples is acceptable, indicating the procedures of sampling and analysis should be proper.

9.1 Observations at the inlet of west part of TPSTW (Location ID: S1, S2, S4)

A relatively high odour concentration is observed at the inlet area of the west part of TPSTW including the location of S1 – inlet pumping station, S2 – screens house and S4 – primary sedimentation tank (inlet). For the location of S1(inlet pumping station), a coarse screening was built inside the sampling well and some suspended matters and rubbish were observed inside the well (shown in Figure 9.1), which may increase the odour concentration to certain extend. While some coloured wastewater was also observed on one of the sampling days at the inlet area. For the location of S2, suspended foams and scums were observed during the sampling period (shown in Figure 9.2) which could lead to the increase of odour concentration. No particular status was observed at location S4.

Figure 9.1 Photos of the S1 sampling location and status

Figure 9.2 Photos of the S2 sampling location and status

The consistent high odour emission rates at S1, S2 and S4, which were 115.86 ou/m^2/s, 81.93 ou/m^2/s and 117.06 ou/m^2/s in average, respectively, affirming the high odour concentration at the inlet area during our sampling periods. However, both the sampling locations of S1 and S2 are fully covered with constructed chambers and access doors, and only little odour in nearby ambient could be perceived when doors were closed.

9.2 Observations at the primary sedimentation tanks of TPSTW (West and East, Location ID: S3, S3a, S17, S17a, S18, S18a)

A common situation of suspended matters/foams/scums was observed at the primary sedimentation tanks in both west and east part of TPSTW (shown in Figure 9.3). The said situation may impact the odour concentration and emission rate at the water surface of primary sedimentation tanks, which will further explain the variance of the olfactometry results between different sedimentation tanks and the two-round of sampling works.

Figure 9.3 Photos of the west and east sedimentation tanks at TPSTW

Appendix

A. Concentration of QA/QC Samples

QA/QC Samples for Source Sampling

Sample ID	Sampling Date	Odour Concentration (ou/m^3)	Averaged Concentration for Correction (ou/m^3)
R1-QA/QC-D1	27 Jul 2021	26	**26**
R1-QA/QC-D2-A	28 Jul 2021	40	**53**
R1-QA/QC-D2-B		66	
R2-QA/QC-D1-A	10 Aug 2021	16	**17**
R2-QA/QC-D1-B		18	
R2-QA/QC-D2-A	11 Aug 2021	38	**31**
R2-QA/QC-D2-B		24	

The sampling strategy of all QA/QC samples were laboratory-based nitrogen injection sampling. There was only one sample taken for the first day of sampling. To ensure a valid and repeatable QA/QC sample, the sampling quantity change to two from the second day on. All these QA/QC samples were in a normal range and were then averaged for each day for the correction of the odour concentration of practical source samples.

B. Certificates of Qualified Odour Assessors

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Qualified Nose
HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr HUNG Hok To

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 14 July 2021

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Qualified Nose
HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Mr LAM Yuet Hang

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Qualified Nose
HKPolyU

Certificate for Qualified Odour Panel Member

This is to certify that

Miss LI Xinwei

had demonstrated that her nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, her individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, she is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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This is to certify that

Mr LO Wing Yat

had demonstrated that his nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, his individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, he is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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This is to certify that

Miss TAN Yan

had demonstrated that her nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, her individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, she is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Date: 14 July 2021

Ref.: 20210714QP07

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This is to certify that

Miss WANG Meng

had demonstrated that her nose has a normal sensitivity to comply with the requirements of European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725). In a set of screening tests carried out by Odour Research Laboratory of the HKPolyU, her individual threshold (n-butanol) was determined to be in the range of 20 to 80 ppb/v with a standard deviation of R < 2.3. According to the requirement of the EN13725, she is qualified to participate in olfactometry analysis. This certificate will be valid for a period of 3 months from the day of issue.

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Appendix 3.7c Summary of Odour Survey for Tai Po Sewage Treatment Works

		Odour Survey at TPSTW (2020)	Odour Survey at TPSTW (2021)	Max. SOER from the Equivalent Sampling Points
Sampling Point	Description	SOER from the Equivalent Sampling Points (ou/m2.s)	SOER from the Equivalent Sampling Points (ou/m2.s)	
S1	Inlet pumping station (West part of TPSTW)	8.27	120.95	120.95
S2	Screens house (West part of TPSTW)	20.46	96.89	96.89
S2a	Screens house grit collection tank (West part of TPSTW)	4.65	-	4.65
S3	Primary sedimentation tank (outlet) (West part of TPSTW)*	9.89	12.1	12.10
S3a	Primary sedimentation tank (outlet)(West part of TPSTW)*	4.65	126.38	126.38
S4	Primary sedimentation tank (inlet) (West part of TPSTW)*	1.83	120.95	120.95
S4a	Primary sedimentation tank (inlet) (West part of TPSTW)*	3.72	56.82	56.82
S5	Aeration tank (inlet)(West part of TPSTW)*	9.03	-	9.03
S5a	Aeration tank (inlet) (West part of TPSTW)*	5.78	-	5.78
S6	Aeration tank (outlet)(West part of TPSTW)*	0.3	-	0.30
S6a	Aeration tank (outlet) (West part of TPSTW)*	0.2	-	0.20
S7	Final sedimentation tank (outlet) (West part of TPSTW)*	0.34	-	0.34
S7a	Final sedimentation tank (outlet) (West part of TPSTW)*	0.19	-	0.19
S8	Final sedimentation tank (outlet) (West part of TPSTW)*	0.41	-	0.41
S8a	Final sedimentation tank (inlet) (West part of TPSTW)*	0.34	-	0.34
S9	Sludge digestion tank (West part of TPSTW)	31.16	110.66	110.66
S10	Sludge consolidation tank (West part of TPSTW)	5.46	-	5.46
S11	Primary sludge gravity thickener (West part of TPSTW)	1.64	-	1.64
S12	Sludge dewatering house (inlet tank) (West part of TPSTW)	0.81	-	0.81
S12a	Sludge dewatering house (dry sludge) (West part of TPSTW)	1.25	-	1.25
S13	SAS thickening house (West part of TPSTW)	0.59	-	0.59
S14	Sludge pumping station (West part of TPSTW)	1.96	-	1.96
S15	Inlet pumping station (East part of TPSTW)	5.02	3.27	5.02
S16	Screens house (East part of TPSTW)	5.11	5.4	5.40
S16a	Screens house grit collection tank (East part of TPSTW)	1.19	-	1.19
S17	Primary sedimentation tank (inlet) (East part of TPSTW)*	-	105.91	105.91
S17a	Primary sedimentation tank (inlet) (East part of TPSTW)*	-	101.33	101.33
S18	Primary sedimentation tank (inlet) (East part of TPSTW)*	-	74.32	74.32
S18a	Primary sedimentation tank (outlet) (East part of TPSTW)*	-	67.98	67.98
S19	Aeration tank (inlet) (East part of TPSTW)*	-	8.72	8.72
S19a	Aeration tank (inlet) (East part of TPSTW)*	-	10.5	10.50
S20	Aeration tank (outlet) (East part of TPSTW)*	-	1.05	1.05
S20a	Aeration tank (outlet) (East part of TPSTW)*	-	2.45	2.45
S21	Final sedimentation tank (outlet) (East part of TPSTW)*	0.35	-	0.35
S21a	Final sedimentation tank (outlet) (East part of TPSTW)*	0.58	-	0.58
S22	Final sedimentation tank (inlet) (East part of TPSTW)*	0.46	-	0.46
S22a	Final sedimentation tank (inlet) (East part of TPSTW)*	0.41	-	0.41
S23	Sludge digestion tank (East part of TPSTW)	8.37	-	8.37
S24	Sludge consolidation tank (East part of TPSTW)	1.45	-	1.45
S25	Leachate pre-treatment tank (Sheun Wan leachate pre-treatment works)	0.63	-	0.63

Remarks:

* Due to abnormal operation, the sampling results (underlined) were considered not representative for assessment.