1 INTRODUCTION

1.1.1 The VISJET model was used to simulate the near-field plume behaviour of the outfall discharges within a relatively short distance from the effluent discharge location. Hence, the zone of initial dilution (ZID) and vertical structure of the plume could be located. For a surface plume, initial dilution is defined as the dilution obtained at the centre line of the plume when the sewage reaches the surface. For a trapped plume, initial dilution is defined as the dilution obtained at the centre line of the plume where the plume reaches the maximum rise height when the vertical momentum / buoyancy of the plume becomes zero.

1.1.2 The initial dilution model was used to characterize the initial mixing of the effluent discharge, and to feed model results into the far field water quality modules where necessary.

2 MODEL INPUT

2.1.1 Key inputs to the near-field model include:

- Outfall configuration
- Vertical density profile
- Ambient current speed
- Effluent flow rate

2.1.2 Details of the outfall diffuser configuration adopted for near field modelling are given in **Table 2.1**. The graphical illustration of the diffuser configuration is shown in **Figure 2.1.2** on below.

Table 2.1 Diffuser Configuration of Urmston Road Outfall

Description	Value	Remarks
Diffuser Length (m)	600	
Outfall Diameter (m)	2.33	
Riser Separation (m)	20	
No. of Risers	30	
Riser Height (m)	7.87	
Ports per Riser	2	Vertical angle: 90°
Riser Radius (m)	1.73	
Port Diameter (m)	0.25	

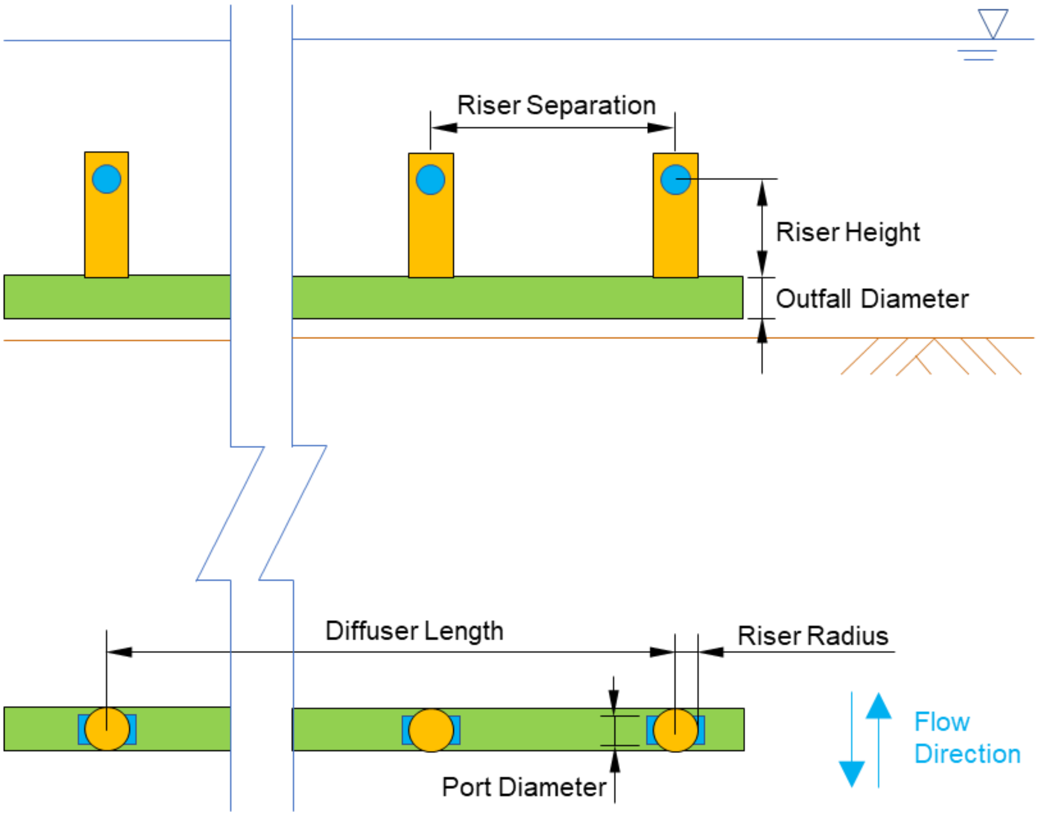

Figure 2.1.2. Graphical illustration of the diffuser configuration

2.1.3 The ambient setup was based on the far field hydrodynamic model output from the Delft3D Yuen Long (YL) Model (details of this far field model refer to **Section 5.5.3.4** of the main text). The far field hydrodynamic model had taken into account the change in coastline configurations as mentioned in **Section 5.5.3.12** and **Table 5.8** of the main text. The modelling scenario covered two 15-day full spring-neap cycles (excluding the spin-up period) for dry and wet seasons respectively. The far field hydrodynamic model is 3 dimensional with a total of 10 vertical water layers. The thickness of each water layer is defined in the model as a percentage of the water depth where the total sum of all the vertical layers must be 100%. All the vertical layers of the hydrodynamic model are assigned to have the same vertical contribution. Thus, each of the vertical layers in the hydrodynamic model contributes 10% of the total water depth. The vertical density profiles extracted from the far field hydrodynamic model are shown in **Table 2.2**. The average model output over the 15-day far field simulation period was adopted for near field model input. The vertical density profiles for dry and wet seasons are assumed to have the same probability of occurrence.

Table 2.2 Density Profile at Urmston Road Outfall

Vertical Water Layer	Depth from Water Surface (m)	Density (kg/m^3)	
		Dry (D1)	**Wet (W1)**
1	0 – 2.2	1.0201	1.0040
2	2.2 – 4.4	1.0204	1.0053
3	4.4 – 6.6	1.0213	1.0086
4	6.6 – 8.8	1.0217	1.0113
5	8.8 – 11.0	1.0220	1.0132
6	11.0 – 13.2	1.0222	1.0146
7	13.2 – 15.4	1.0223	1.0158
8	15.4 – 17.6	1.0224	1.0165
9	17.6 – 19.8	1.0224	1.0168

Vertical Water Layer	Depth from Water Surface (m)	Density (kg/m^3)	
		Dry (D1)	**Wet (W1)**
10	19.8 – 22.0	1.0224	1.0168
	Probability:	**0.5**	**0.5**

2.1.4 The current velocity data were also extracted from the far field hydrodynamic model. The extracted current data have been analyzed and calculated as 10, 50 and 90 percentile values for both dry and wet seasons, namely v10, v50 and v90 respectively as shown in **Table 2.3**. It is assumed that v10 was representative of the current that occurred between the 0 and 20 percentile (20 percent) and the v90 was representative of the current that occurred between the 80 and 100 percentile (20 percent) whereas the v50 was representative of the remaining 60 percent. The outfalls are also assumed to be perpendicular to the orientation of the predominant current direction.

Table 2.3 Ambient Current Velocity at the Existing Seawall Outfall

Vertical Water Layer	Depth from Water Surface (m)	Current Speed (m/s)					
		Dry			**Wet**		
		v10	**v50**	**v90**	**v10**	**v50**	**v90**
1	0 – 2.2	0.195	0.581	0.999	0.194	0.650	1.200
2	2.2 – 4.4	0.192	0.574	0.980	0.174	0.636	1.108
3	4.4 – 6.6	0.189	0.567	0.977	0.173	0.622	1.088
4	6.6 – 8.8	0.155	0.565	0.974	0.172	0.607	1.081
5	8.8 – 11.0	0.129	0.543	0.972	0.171	0.593	1.044
6	11.0 – 13.2	0.129	0.519	0.910	0.170	0.587	1.015
7	13.2 – 15.4	0.128	0.492	0.851	0.165	0.557	0.902
8	15.4 – 17.6	0.128	0.462	0.798	0.130	0.470	0.745
9	17.6 – 19.8	0.124	0.430	0.734	0.134	0.400	0.633
10	19.8 – 22.0	0.108	0.364	0.638	0.112	0.316	0.526
	Probability:	**0.2**	**0.6**	**0.2**	**0.2**	**0.6**	**0.2**

2.1.5 The near field impact was modelled for different combinations of vertical density profile and current velocity for baseline and proposed scenarios (**Section 2.1.6**). For each scenario, a set of three effluent flow rates, Q10, Q50 and Q90 were used, all based on the percentile of occurrence. The Q50 flow rate (the flow rate below which 50 percent of all effluent flow rates occur) was based on the average flow rate. The Q10 flow rate (the flow rate below which 10 percent of all flow rates occur) was calculated using a Q10 to Q50 ratio of 0.90. The Q90 flow rate is calculated using a Q90 to Q50 ratio of 1.16. These ratios were based on the sewage flow record of San Wan STW between September 2015 and August 2017. It is assumed that the Q10 is representative of the flow rates that occurred between the 0 and 20 percentile (20 percent) and the Q90 is representative of the flow rates that occurred between the 80 and 100 percentile (20 percent) whereas the Q50 was representative of the remaining 60 percent. **Table 2.4** below summarises the adopted effluent flows.

Table 2.4 Effluent Flow Adopted in Near-Field Model

Flow Rates (m^3/d)	Assessment Scenarios	Effluent Flow ID	% of occurrence	Total Flow (m^3/d)	Flow per Riser (m^3/s) (1)	Flow per Port (m^3/s) (1)
246,000	Baseline Scenario	Q10	20	221,346	0.0854	0.0427
		Q50	60	246,000	0.0949	0.0475
		Q90	20	286,028	0.1104	0.0552
270,935	Proposed Scenario	Q10	20	243,782	0.0941	0.0470
		Q50	60	270,935	0.1045	0.0523
		Q90	20	294,624(2)	0.1137	0.0568

Note: (1) Flows are divided equally amongst the risers and ports in the Urmston Road Outfall.

(2) The calculated total flow exceed the design capacity of the Urmston Road Outfall (294,624 m^3/d). The design capacity of the Urmston Road Outfall will be adopted for assessment.

Modelling Scenarios

2.1.6 The near field impact was modelled for different combinations of vertical density profile, current velocity and effluent flow rate for baseline and proposed scenarios. Based on the above information, a total of 18 model runs will be carried out under each scenario as listed in **Table 2.5** and **Table 2.6**.

Table 2.5 Summary of Proposed Model Runs for Baseline Scenario

Run ID	Effluent Flow		Density Profile		Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S1-1	Q10	0.2	D1	0.5	v10	0.2	0.02
S1-2	Q50	0.6	D1	0.5	v10	0.2	0.06
S1-3	Q90	0.2	D1	0.5	v10	0.2	0.02
S1-4	Q10	0.2	D1	0.5	v50	0.6	0.06
S1-5	Q50	0.6	D1	0.5	v50	0.6	0.18
S1-6	Q90	0.2	D1	0.5	v50	0.6	0.06
S1-7	Q10	0.2	D1	0.5	v90	0.2	0.02
S1-8	Q50	0.6	D1	0.5	v90	0.2	0.06
S1-9	Q90	0.2	D1	0.5	v90	0.2	0.02
S1-10	Q10	0.2	W1	0.5	v10	0.2	0.02
S1-11	Q50	0.6	W1	0.5	v10	0.2	0.06
S1-12	Q90	0.2	W1	0.5	v10	0.2	0.02
S1-13	Q10	0.2	W1	0.5	v50	0.6	0.06
S1-14	Q50	0.6	W1	0.5	v50	0.6	0.18
S1-15	Q90	0.2	W1	0.5	v50	0.6	0.06
S1-16	Q10	0.2	W1	0.5	v90	0.2	0.02
S1-17	Q50	0.6	W1	0.5	v90	0.2	0.06
S1-18	Q90	0.2	W1	0.5	v90	0.2	0.02

Table 2.6 Summary of Proposed Model Runs for Proposed Scenario

Run ID	Effluent Flow		Density Profile		Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S2-1	Q10	0.2	D1	0.5	v10	0.2	0.02
S2-2	Q50	0.6	D1	0.5	v10	0.2	0.06
S2-3	Q90	0.2	D1	0.5	v10	0.2	0.02
S2-4	Q10	0.2	D1	0.5	v50	0.6	0.06
S2-5	Q50	0.6	D1	0.5	v50	0.6	0.18
S2-6	Q90	0.2	D1	0.5	v50	0.6	0.06
S2-7	Q10	0.2	D1	0.5	v90	0.2	0.02
S2-8	Q50	0.6	D1	0.5	v90	0.2	0.06
S2-9	Q90	0.2	D1	0.5	v90	0.2	0.02
S2-10	Q10	0.2	W1	0.5	v10	0.2	0.02
S2-11	Q50	0.6	W1	0.5	v10	0.2	0.06
S2-12	Q90	0.2	W1	0.5	v10	0.2	0.02
S2-13	Q10	0.2	W1	0.5	v50	0.6	0.06
S2-14	Q50	0.6	W1	0.5	v50	0.6	0.18
S2-15	Q90	0.2	W1	0.5	v50	0.6	0.06
S2-16	Q10	0.2	W1	0.5	v90	0.2	0.02
S2-17	Q50	0.6	W1	0.5	v90	0.2	0.06
S2-18	Q90	0.2	W1	0.5	v90	0.2	0.02

3 MODEL RESULTS

3.1.1 Key model outputs include initial dilution, plume depth, plume half width, plume thickness and the downstream distance at the edge of the ZID. **Table 3.3** and **Table 3.4** summarize the results from the VISJET simulations. No merging of plumes from adjacent risers was found in all model runs. Merging of plumes from adjacent jets on individual riser was observed in all model runs. The plume merging would reduce the initial dilution. The composite dilution of merged jets was determined by the VISJET model.

3.1.2 The predicted composite initial dilution was corrected for the background concentration build up due to the tidal effects. The basic assumption of any near field model is that the effluent plume is mixed with clean water. In actuality this is not true, particularly in a tidally mixed environment. The average tracer background build up concentrations were calculated from the far field Delft3D model. The build up was quantified by performing a conservative tracer run on the effluent. A conservative tracer, i.e. without decay or reaction, was used. The initial concentration of the tracer in the effluent of Urmston Road outfall was set to be 1000 mg/L. The average of the far field tracer results were used for the background build up corrections and is on a seasonal (dry season, wet season) timescale. It should be noted that the results from the grid cell into which the tracer is loaded is not representative of the true background build up as this cell will always contain the background build up plus the continuous tracer loading. Therefore, the necessary far field tracer results were taken from a cell located adjacent to the outfall grid cells.

3.1.3 The average tracer results were predicted for both baseline and proposed scenarios in dry and wet seasons. **Table 3.1** shows an example of the background build up correction for the twin submarine outfalls under the 2012 scenario.

Table 3.1 Example of Background Build Up Correction

	Minimum Initial Dilution (1)	**Initial Tracer Concentration in Effluent (2) (mg/L)**	**Average Tracer Concentration (2) (mg/L)**		**Corrected Minimum Initial Dilution (5)**
			Dry (3)	**Wet (4)**	
Run ID	**(A)**	**(B)**	**(C)**	**(D)**	**(E)**
S2-12	150	1000	1.34	0.99	131

Note:
(1) Minimum initial dilution predicted by VISJET model. This dilution occurred in the wet season.
(2) Effluent tracer concentration assumed in the far field modelling.
(3) Average background buildup concentration for dry season predicted by the far field model
(4) Average background buildup concentration for wet season predicted by the far field model.
(5) The average background buildup concentration for wet season was used for the correction in this case as the minimum dilution occurred under the wet season scenario. Corrected Initial Dilution, (E) = (B) ÷ {[1 x (B) + ((A) – 1) x (D)] ÷ (A)}. The formula is obtained from Appendix 6.1 of the approved EIA report “Harbour Area Treatment Scheme (HATS) Stage 2A EIA - Investigation” (AEIAR-121/2008).

Table 3.2 Summary of Near-field Modelling Results for Baseline Scenario

Run ID	**Joint Prob. of Occurrence**	**Initial Dilution [1]**	**Corrected Initial Dilution [2]**	**Average Plume Depth from Surface (m)**	**Average Plume Thickness (m)**	**Average Plume Half-Width (m)**	**Downstream Distance at Edge of ZID (m)**
Dry Season							
S1-1	0.02	329	235	11.7	11.4	6.9	22
S1-2	0.06	330	236	11.4	12.2	7.1	22
S1-3	0.02	322	231	11.1	13.0	7.3	21
S1-4	0.06	727	385	14.5	8.8	6.3	88
S1-5	0.18	670	369	14.4	8.9	6.4	86
S1-6	0.06	594	345	14.2	9.0	6.5	84
S1-7	0.02	865	421	14.9	7.3	5.2	162
S1-8	0.06	799	405	14.8	7.4	5.3	160
S1-9	0.02	727	385	14.7	7.6	5.4	156
Wet Season							
S1-10	0.02	179	155	16.0	8.2	4.6	14
S1-11	0.06	168	146	15.9	8.3	4.7	14
S1-12	0.02	153	**134**	15.8	8.4	4.9	14
S1-13	0.06	334	257	17.4	5.7	4.2	43
S1-14	0.18	310	243	17.3	5.8	4.2	43
S1-15	0.06	275	221	17.2	5.9	4.3	42
S1-16	0.02	428	309	17.6	5.0	3.6	75
S1-17	0.06	398	294	17.5	5.1	3.6	74
S1-18	0.02	363	274	17.5	5.2	3.7	72

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background build up concentration predicted by the far field model at outfall. Bolded and shaded values indicated minimum corrected initial dilution.
3. For baseline scenario, average background buildup concentration predicted by the far field model were 1.22 mg/L and 0.90 mg/L for dry and wet seasons respectively.

Table 3.3 Summary of Near-field Modelling Results for Proposed Scenario

Run ID	Joint Prob. of Occurrence	Initial Dilution [1]	Corrected Initial Dilution [2]	Average Plume Depth from Surface (m)	Average Plume Thickness (m)	Average Plume Half-Width (m)	Downstream Distance at Edge of ZID (m)
Dry Season							
S2-1	0.02	329	229	11.5	12.1	7.0	22
S2-2	0.06	326	227	11.2	12.7	7.2	22
S2-3	0.02	321	225	11.0	13.2	7.4	22
S2-4	0.06	674	354	14.4	8.9	6.4	86
S2-5	0.18	624	339	14.3	9.0	6.4	85
S2-6	0.06	580	326	14.2	9.1	6.5	84
S2-7	0.02	806	387	14.8	7.4	5.3	161
S2-8	0.06	1171	455	14.9	9.4	6.7	168
S2-9	0.02	714	365	14.6	7.6	5.5	155
Wet Season							
S2-10	0.02	169	145	15.9	8.3	4.7	14
S2-11	0.06	158	137	15.8	8.3	4.8	14
S2-12	0.02	150	**131**	15.8	8.4	4.9	14
S2-13	0.06	312	239	17.3	5.9	4.2	43
S2-14	0.18	287	224	17.2	5.9	4.3	43
S2-15	0.06	274	216	17.2	6.0	4.3	43
S2-16	0.02	401	288	17.5	5.1	3.6	74
S2-17	0.06	376	275	17.5	5.2	3.7	73
S2-18	0.02	363	267	17.4	5.3	3.8	73

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background build up concentration predicted by the far field model at outfall. Bolded and shaded values indicated minimum corrected initial dilution.
3. For proposed scenario, average background buildup concentration predicted by the far field model were 1.34 mg/L and 0.99 mg/L for dry and wet seasons respectively.

3.1.4 It is noted that all the predicted minimum dilution rates occurred under the scenario with the largest effluent flow (Q90) and the smallest ambient current (v10). **Table 3.4** summarizes the initial dilution factors.

Table 3.4 Summary of Initial Dilution Factors

	Baseline Scenario	Proposed Scenario
Minimum	134	131
5%ile	144	136
10%ile	152	142

Input to Far Field Model

3.1.5 The near field modelling results were used to determine the appropriate vertical and horizontal grid cell(s) into which the discharge from Urmston Road outfall would be allocated into the far field 3D model. Under each of the assessment scenarios, two weighted averages of the plume depth were calculated for dry and wet seasons respectively based on their joint probabilities of occurrence as shown in **Table 2.5** and **Table 2.6**. Two weighted averages of the plume thicknesses were also calculated for dry and wet seasons respectively. The weighted average plume depths and plume thicknesses for dry and wet seasons were used to determine the appropriate vertical grid cell(s) into which the discharge from Urmston Road outfall would be allocated.

3.1.6 The number of horizontal grid cell(s) of the far field model to be used for loading input was based on the average dimensions of the ZID. Under each of the scenarios, the average of all the downstream distances predicted amongst the 18 model runs was used as the average width of the ZID. The average of all the plume width results predicted amongst the 18 model runs was used for calculating the average length of the ZID. It is assumed that the ZID would be the same in dry and wet seasons for far field modelling. **Table 3.5** illustrates the calculation.

Table 3.5 Summary of Dimensions of ZID

Scenario		Weighted Average Plume Depth (m below Surface)	Weighted Average Plume Thickness (m)	Average Half Plume Width (m)	Average Downstream Distance (m)	Average Dimension of ZID (m)
Baseline	**Dry**	13.9	9.3	5	66	610 (i) x 132 (ii)
	Wet	17.1	6.2			
Proposed	**Dry**	13.8	9.7	5	66	610 (i) x 132 (ii)
	Wet	17.0	6.3			

Note: (i) Length of ZID = diffuser length + average half plume width x 2
(ii) Width of ZID = average downstream distance x 2

3.1.7 Based on the predicted dimension of ZID, pollution loading discharge from Urmston Road outfall would be evenly distributed to 4 grid cells of the water quality model along the alignment of the diffuser for all the modelling scenarios. The vertical allocation of pollution load would be based on the average plume depth and average plume thickness. Given that the far-field model is a 3 dimensional model which consists of 10 evenly distributed vertical layers and the total water depth assumed in the VISJET modelling was 22 m, the pollution loads for dry season were specified in the fifth to ninth layer from the surface whilst for the wet season, the pollution loads were allocated in the seventh to ninth layer from the surface for the baseline and proposed scenarios.