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 The effluent would be discharged via a 1800 mm diameter sewage outfall at the existing seawall of the YLSTW, with an invert level of 0.87 mPD. The seawall outfall location is indicated in Figure 5.1 of the main text.

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 5.6.3 of the main text). The far field hydrodynamic model had taken into account the change of coastline configurations as mentioned in Section 5.6.3.8 and Table 5.13 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 2.1**. 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 2.1 Density Profile for the Existing Seawall Outfall

Vertical Water Layer	Depth from Water Surface (m)	Density (kg/m^3)	
		Dry (D)	Wet (W)
1	0 - 0.33	1.0125	0.9971
2	0.33 - 0.66	1.0125	0.9971
3	0.66 - 0.99	1.0129	0.9972
4	0.99 - 1.32	1.0134	0.9972
5	1.32 - 1.65	1.0138	0.9972
6	1.65 - 1.98	1.0142	0.9972
7	1.98 - 2.31	1.0144	0.9972
8	2.31 - 2.64	1.0145	0.9972
9	2.64 - 2.97	1.0146	0.9972
10	2.97 - 3.30	1.0146	0.9972
	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 2.2**. 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 2.2 Ambient Current Velocity at the Existing Seawall Outfall

Vertical Water Layer	Depth from Water Surface (m)	Current Speed (m/s)					
		Dry			Wet		
		dv10	dv50	dv90	wv10	wv50	wv90
1	0 - 0.33	0.017	0.060	0.109	0.017	0.062	0.106
2	0.33 - 0.66	0.014	0.062	0.115	0.018	0.058	0.107
3	0.66 - 0.99	0.013	0.067	0.115	0.018	0.055	0.102
4	0.99 - 1.32	0.013	0.067	0.115	0.016	0.051	0.096
5	1.32 - 1.65	0.012	0.062	0.106	0.014	0.048	0.082
6	1.65 - 1.98	0.010	0.052	0.087	0.013	0.044	0.075
7	1.98 - 2.31	0.009	0.042	0.073	0.011	0.041	0.071
8	2.31 - 2.64	0.008	0.033	0.069	0.008	0.038	0.068
9	2.64 - 2.97	0.003	0.026	0.064	0.007	0.034	0.062
10	2.97 - 3.30	0.003	0.021	0.054	0.007	0.030	0.052
	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 the three normal operation scenarios of YLSTW/YLEPP (Section 5.6.3.11 of the main text). **Table 2.3** below summarises the adopted effluent flows.

Table 2.3 Effluent Flow Adopted in Near Field Model

Scenario	ID	Effluent Flow	
		(m^3/d)	(m^3/s)
Scenario 1: Base Case (YLSTW)	S1	70,000	0.8102
Scenario 2: YLEPP Phase 1	S2	100,000	1.1574
Scenario 3: YLEPP Phase 2	S3	180,000	2.0833

2.1.6 The near field impact was modelled for different combinations of vertical density profile, ambient current velocity and effluent flow rate for normal operation scenarios of YLSTW/YLEPP. Based on the above information, a total of 18 model runs were carried out as listed in **Table 2.4**.

Table 2.4 Summary of Proposed Model Runs for Near Field Model

Run ID	Effluent Flow (ID)	Density Profile		Current Velocity		Joint Probability of occurrence
		ID	Probability of occurrence	ID	Probability of occurrence	
S1-1	S1	D	0.5	dv10	0.2	0.1
S1-2	S1	D	0.5	dv50	0.6	0.3
S1-3	S1	D	0.5	dv90	0.2	0.1
S1-4	S1	W	0.5	wv10	0.2	0.1
S1-5	S1	W	0.5	wv50	0.6	0.3
S1-6	S1	W	0.5	wv90	0.2	0.1
S2-1	S2	D	0.5	dv10	0.2	0.1
S2-2	S2	D	0.5	dv50	0.6	0.3

Run ID	Effluent Flow (ID)	Density Profile		Current Velocity		Joint Probability of occurrence
		ID	Probability of occurrence	ID	Probability of occurrence	
S2-3	S2	D	0.5	dv90	0.2	0.1
S2-4	S2	W	0.5	wv10	0.2	0.1
S2-5	S2	W	0.5	wv50	0.6	0.3
S2-6	S2	W	0.5	wv90	0.2	0.1
S3-1	S3	D	0.5	dv10	0.2	0.1
S3-2	S3	D	0.5	dv50	0.6	0.3
S3-3	S3	D	0.5	dv90	0.2	0.1
S3-4	S3	W	0.5	wv10	0.2	0.1
S3-5	S3	W	0.5	wv50	0.6	0.3
S3-6	S3	W	0.5	wv90	0.2	0.1

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 3.2** summarize the results from the VISJET simulations.

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 seawall outfall was set to be 100 mg/L. The average of the far field tracer results were used for the background build up corrections. 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 all normal operation scenarios of YLSTW/YLEPP in dry and wet seasons. **Table 3.1** shows an example of the background build up correction for model run ID S3-1.

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)
S3-1	1.37	100	39.3	53.8	1.20

Note: (1) Minimum initial dilution predicted by VISJET model. This dilution occurred in the dry 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 dry season was used for the correction in this case as the minimum dilution occurred under the dry season scenario. Corrected Initial Dilution, (E) = (B) ÷ {[1 x (B) + ((A) – 1) x (C)] ÷ (A)}.

Table 3.2 Summary of Near Field Modelling Results

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	0.1	1.34	1.25	0.9	0.6	1.1	0.9
S1-2	0.3	1.37	1.27	1.0	0.6	1.1	0.9
S1-3	0.1	1.46	1.33	1.0	0.9	1.0	0.8
S2-1	0.1	1.34	1.23	1.1	1.3	0.9	1.2
S2-2	0.3	1.35	1.23	1.1	1.3	0.9	1.2
S2-3	0.1	1.42	1.28	1.1	1.3	0.8	1.1
S3-1	0.1	1.37	**1.20**	1.2	1.7	0.7	1.8
S3-2	0.3	1.36	1.21	1.2	1.7	0.7	1.7
S3-3	0.1	1.40	1.21	1.2	1.7	0.7	1.7
Wet Season							
S1-4	0.1	2.04	1.60	3.3	1.6	1.5	3.3
S1-5	0.3	2.12	1.63	3.3	1.6	1.5	3.2
S1-6	0.1	2.52	1.79	3.3	1.7	1.7	3.0
S2-4	0.1	2.18	1.53	3.3	1.4	1.7	4.5
S2-5	0.3	2.21	1.54	3.3	1.5	1.7	4.4
S2-6	0.1	2.62	1.66	3.3	1.7	2.0	4.3
S3-4	0.1	2.59	1.40	3.3	1.7	2.2	7.6
S3-5	0.3	2.53	1.39	3.3	1.6	2.1	7.6
S3-6	0.1	2.85	1.43	3.3	1.8	2.4	7.5

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 seawall outfall. Bolded and shaded values indicated minimum corrected initial dilution.

3.1.4 It is noted that the predicted minimum dilution rate occurred under the scenario with the largest effluent flow (S3) and the smallest ambient current (dv10).

Input to Far Field Model

3.1.5 The purpose of near field modelling results were used to determine the appropriate vertical and horizontal grid cell(s) into which the discharge from YLSTW/YLEPP outfall would be allocated into the far field 3D model. Under each of the normal operation scenarios, two weighted averages of the plume depth were calculated for dry and wet seasons respectively based on their joint probabilities of occurrence. 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 YLSTW/YLEPP 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 6 model runs was used as the average width of the ZID. The average of all the plume width results predicted amongst the 6 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 3.3** illustrates the calculated dimension of ZID.

Table 3.3 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)
Scenario 1: Base Case (YLSTW)	Dry	1.0	0.6	1.3	2.0	4.4 x 2.0
	Wet	3.3	1.6			
Scenario 2: YLEPP Phase 1	Dry	1.1	1.3	1.3	2.8	4.4 x 2.8
	Wet	3.3	1.5			
Scenario 3: YLEPP Phase 2	Dry	1.2	1.7	1.4	4.4	4.6 x 4.4
	Wet	3.3	1.7			

Note: 1. Length of ZID = Diameter of outfall + average half plume width x 2
2. Width of ZID = average downstream distance