CONTENTS

1 MODEL SETUP

1.1 PROPOSED EFFLUENT CHARACTERISTICS

The characteristics of the proposed effluent for TKO Desalination Plant are presented below.

Table 1.1 Effluent Characteristics of the Proposed TKO Desalination Plant

Determinand	Designed Effluent Standards
Normal Effluent Discharge	
Flow Rate (m^3/day)	464,000
Salinity (mg/L)	65,000

It should be highlighted that the purpose of this near field dispersion modelling is to determine the vertical profile of the saline effluent discharged from the proposed submarine outfall. The effect of near field dispersion would not be considered in the far field Delft3D modelling for conservative reason. Therefore, other chemical constituents, such as iron and anti-scalant, would not be taken into account in this exercise.

The ambient condition used in the first iteration of the near field CORMIX modelling is extracted from the baseline scenario (i.e. without saline discharge) of the Delft3D FLOW simulation. The predicted vertical profile of effluent plume would be adopted into the Delft3D FLOW module to generate a new set of ambient salinity and flow conditions which take into account the discharge of saline. Such iterations were repeated under this modelling exercise to establish a stable hydrodynamic which takes into account the saline discharge and its associated change in ambient conditions. The repeated iteration conducted under Study is illustrated below:

- Far Field Delft FLOW Modelling to provide ambient condition (Far field baseline – no saline discharge)
- Near Field CORMIX Modelling to determine effluent vertical profile (Near field iteration 1)
- Far Field Delft FLOW Modelling to provide ambient condition (Far field iteration 1 – saline discharge at vertical layer predicted in Near field iteration 1)
- Near Field CORMIX Modelling to determine effluent vertical profile (Near field iteration 2)
- Far Field Delft FLOW Modelling to provide ambient condition (Far field iteration 2 – saline discharge at vertical layer predicted in Near field iteration 2)
- Etc… (if required)

1.2 *DESIGN OF SUBMARINE OUTFALL*

The design specifications of the proposed outfall are shown below in *Table 1.2*.

Table 1.2 Design of the Proposed Outfall and the Existing Outfall

Parameter	Information
No. of discharge ports in the diffuser	36
Diameter of discharge port	150 mm
Configuration of discharge port	Ports are alternating and to be inclined at 60 degree to horizontal. Port spacing is 4.2 m.
Location of diffuser from the nearest coastline	The first diffuser is designed to be 200 m away from the nearest coastline
Discharge Depth	10 m

1.3 *INPUT VALUES FOR NEAR FIELD MODELLING*

The input parameters for near field modelling are summarized below. All the hydrodynamic conditions adopted were derived from the Delft3D FLOW simulation of the TKO Refined Model. A total of 2 iterations were conducted for both seasons.

Table 1.3 Discharge Parameters Inputs for CORMIX Modelling

Parameter	Scenarios
Discharge Type	Submerged discharge (60 degree to horizontal) at sea bottom with 1500 m diameter diffuser
Total discharge flow rate	464,000 m^3/day
Upper limit Concentration of Effluent	Salinity = 65,000 mg/L

Table 1.4 Ambient Condition Inputs for CORMIX Modelling for the First Iteration

Parameter		Scenarios	
		D10/D50/D90	**W10/W50/W90**
		Dry season	**Wet season**
Ambient Conditions	Ambient Velocity (1)	D10: 0.048 m/s; D50: 0.122 m/s; D90: 0.188 m/s.	W10: 0.071 m/s; W50: 0.103 m/s; W90: 0.156 m/s.
	Water Depth at discharge outfall	10 m	
	Average Surface (1) Water Density	1023.71 kg/m^3	1022.49 kg/m^3
	Average Bottom (1) Water Density	1023.72 kg/m^3	1024.40 kg/m^3
	Ambient Wind Speed	2 m/s (CORMIX's recommended value for conservative design condition)	

Parameter	Scenarios

Note:

(1) The water density is derived from simulated temperature and salinity from the baseline scenario of the Delft3D FLOW modelling of TKO Refined Model at proposed submarine outfall. Ambient velocity and current direction is also derived from simulation results of Delft3D Flow modelling.

(2) Based on the results of far-field hydrodynamic simulation, the ambient current is close to orthogonal to the outfall alignment. As such, all CORMIX simulations are carried out in cross-flow configuration.

Table 1.5 Ambient Condition Inputs for CORMIX Modelling for the Second Iteration

Parameter		Scenarios	
		D10 / D50 / D90	**W10 / W50 / W90**
		Dry season	**Wet season**
Ambient Conditions	Ambient Velocity (1)	D10: 0.075 m/s;	W10: 0.088 m/s;
	Water Depth at discharge outfall	10 m	
	Average Surface (1) Water Density	1024.04 kg/m^3	1022.65 kg/m^3
	Average Bottom (1) Water Density	1026.04 kg/m^3	1026.34 kg/m^3
	Ambient Wind Speed	2 m/s (CORMIX's recommended value for conservative design condition)	

Note:

(1) The water density is derived from simulated temperature and salinity from the first iteration of the Delft3D FLOW modelling of TKO Refined Model at proposed submarine outfall. Ambient velocity and current direction is also derived from simulation results of Delft3D Flow modelling.

(2) Based on the results of far-field hydrodynamic simulation, the ambient current is close to orthogonal to the outfall alignment. As such, all CORMIX simulations are carried out in cross-flow configuration.

1.4 MODELLING SCENARIOS

The near field impact was modelled for combinations of different vertical density profile and ambient current velocity. Based on the input information above, total of three (3) model runs were carried out for each season in the first iteration as listed below. In the second iteration, only the lowest flow scenarios are modelled for conservative assessment.

Table 1.5 Summary of Near-field Preliminary Model Scenarios

Scenario ID	Iteration No.	Seasons	Percentile of Current Velocity
D10-1	1	Dry Season	10th
D50-1		Dry Season	50th
D90-1		Dry Season	90th
W10-1		Wet Season	10th
W50-1		Wet Season	50th
W90-1		Wet Season	90th

Scenario ID	Iteration No.	Seasons	Percentile of Current Velocity
D10-2	2	Dry Season	10th
W10-2		Wet Season	10th

2 *MODELLING PREDICTIONS*

The predicted levels of effluent plume at the zone of initial dilution by the near field modelling under various scenarios are presented below in *Table 2.1*.

As shown in the results of the first iteration of near field modelling, the effluent plume predicted under the low ambient current scenarios is in general very thin layer near the seabed. In contrast, the plume thickness predicted under the high ambient current scenarios is much thicker and takes up a greater portion of the water column. Since the predicted vertical profile of the effluent plume would be adopted in the Delft3D far field modelling, conservative interpretation of the near field modelling would results in conservative prediction of the Delft3D far field modelling. As such, the predicted vertical profile of the effluent plume under the 10^{th} percentile current velocity is adopted in both the first iteration of the far field modelling (i.e. bottom discharge of saline in the Delft3D FLOW model). The ambient conditions provided by the first iteration of the far field modelling are then adopted in the second iteration of the near filed modelling.

The results of the 10^{th} percentile flow scenario in the second iteration of the near field indicates that the presence of saline discharge in the far field flow model would slightly increase the buoyancy experienced by the effluent plume itself in the near field model and results in slight lift in the predicted plume thickness in both season. Yet the change in plume thickness is only 1% to 2% of the water column and the predicted effluent plume would still be within the bottom 10% of the water column (i.e. the bottom layer of the Delft3D model). Since the input to the Delft3D FLOW simulation would be the same as that of the first iteration (saline discharge at bottom level) for both seasons, second iteration is deemed not necessary. The predicted vertical profile of saline discharge (bottom discharge) would be adopted in the Delft3D far field modelling. As discussed in the previous sections, the horizontal dispersion predicted by the near field modelling exercise would not be taken into account in far field modelling and the dispersion of constituent chemicals in the saline would be based only on the far field modelling taking into account the predicted vertical distribution of the effluent plume.

Table 2.1 Vertical and Horizontal Extent of Effluent Plume at the Edge of Zone of Initial Mixing

Iteration	Scenarios	Distance from Discharge Port to the Edge of Zone of Initial Mixing (m)	Top Level of Effluent Plume at the Edge of Zone of Initial Mixing (m below water surface)	Bottom Level of Effluent Plume at the Edge of Zone of Initial Mixing (m below water surface)	Effluent Plume Thickness at the Edge of Zone of Initial Mixing (m)
1	D10-1	116.53	-9.90	-10.00	0.10
1	D50-1	49.09	-9.43	-10.00	0.57
1	D90-1	53.64	-3.77	-10.00	6.23
1	W10-1	61.55	-9.79	-10.00	0.21
1	W50-1	54.80	-9.56	-10.00	0.44
1	W90-1	54.00	-4.90	-10.00	5.10
2	D10-2	57.46	-9.76	-10.00	0.24
2	W10-2	53.7	-9.69	-10.00	0.31