Annex D

Comparative Water Quality Assessment for TKO Section

D1 COMPARATIVE WATER QUALITY ASSESSMENT FOR TKO SECTION

D1.1 Introduction

D1.1_1 It was originally assumed that the WCR would be built on the reclamation formed as part of the Area 131 Study and thus water quality assessment for reclamation activities in the TKO section were excluded. However, following a request by TDD in 20 March 1998 (ref (37) in NTE-JB2/584TH/41 IX) to include the TKO section reclamation, it was considered that a qualitative comparative assessment of the Area 131 based on the *Working Paper on Tidal Flow and Sediment Plume Modelling Report HRHK February 1998* be undertaken to determine the potential impacts generated by the proposed WCR reclamation in the TKO area.

D1.2 Sources of Impact

Disposal of Dredged Material

D1.2_1 The impacts from the generation and disposal of dredged material are a key concern for any proposed reclamation, particularly with regard to dredging of contaminated material. In general, when contaminated sediments are disturbed by dredging, the potential exists for toxic metals previously bound to the sediment particles to be mobilised into the water column. To minimise the potential impacts on water quality, firstly the volumes of marine sediments to be dredged should be reduced to a minimum and then during implementation, seriously contaminated sediments must be dredged with great care and disposed of carefully.

D1.2_2 Other factors that may have a bearing on the significance of the impact may include:

- actual rate of construction activity i.e. volumes of material dredged and dumped per day, and the types of dredging methods employed;
- the phasing of the construction schedule and time required to complete each phase;
- quantity of pollutants discharged into the Study Area from nullahs and stormwater drains;
- dispersion, currents, and flushing characteristics of the receiving water body; and
- the number, nature, and proximity of sensitive receivers.

Fill Activities

D1.2_3 The placement of fill during the construction of the WCR TKO Section reclamation may lead to impacts associated with increase in SS within the water column. However, it is presently envisaged that clean marine sand will be used as fill material and filling will occur behind constructed seawalls to minimize the impacts to nearby sensitive receivers during these activities.

D1.3 Impact Evaluation

D1.3_1 Construction methods proposed for the WCR reclamation in the TKO area would require only a minimal amount of dredging compared to options which remove all soft sediment. Dredging will be confined along the alignment of the seawall. Sediments in the reclamation site will mostly remain undisturbed, with the use of prefabricated vertical band drains and surcharging to improve the strength and residual settlement characteristics of the soft clay.

Area 131 Reclamation

D1.3_2 The total volume of mud to be dredged and fill to be placed for the Area 131 reclamation are summarised in *Table A.1*. A total of 0.38 Mm^3 of contaminated mud and 5.14 Mm^3 of uncontaminated mud will have to be dredged during reclamation. The reclamation was expected to proceed in five stages and take two years.

*Table A.1 **Breakdown of dredged and Fill Volumes for Area 131 Reclamation***

Construction Activities	Dredged Mud Volume (Mm^3)		Fill Volume (Mm^3)		
	Contaminated	Uncontaminated	Sand	Rock	Public
Formation of Southern Seawall	-	1.27	-	1.80	-
Formation of Eastern Seawall	0.161	1.32	1.22	0.38	-
Formation of North Seawall	0.086	0.68	0.68	0.2	-
Formation of Breakwater	0.130	1.87	-	1.1	1.87
Reclamation in WCR and Inshore Areas	-	-	2.78	-	-
Reclamation in Southern MSS	-	-		-	-
Reclamation in Northern Site Area	-	-		-	-
Reclamation in the Two Middle MSS	-	-		-	1.01
TOTAL:	0.377	5.14	4.68	3.48	2.88

WCR Reclamation in TKO Area

D1.3_3 In comparison, the proposed preliminary construction sequence for the WCR TKO Section reclamation (length 940 m, width 80 m and area of 6.9ha) is expected to proceed in one stage and take 39 weeks for seawall construction and 42 weeks for the filling activities. The volume for dredging and filling activities are presented in *Table A.2*.

Table A.2 Estimated volumes of dredging and fill materials for TKO Section Reclamation

Activity	Volume of Dredging (m^3)(1)	Volume of Fill Materials (m^3)(2)
Sloping Seawall	299,150	594,440
General Reclamation	0	536,145
Total	299,150	1,130,585

Note : (1) Assumed seabed level at -10.0 mPD with the bottom of Marine Deposit at -15.0 mPD
(2) General fill to replace dredged material. Top of reclamation level to be at +4.5 mPD

D1.4 Methodology for the Area 131 Study

D1.4_1 A 50 m grid WAHMO 2-D two-layered model was used to simulate the tidal flow in the TKO area for different tidal conditions (dry and wet seasons, spring and neap tides) in the Area 131 Study.

D1.4_2 To study construction phase impacts due to dredging, filling or dumping activities for the reclamation works, sediment plume modelling was undertaken in the Area 131 Study. Sediment plume transport based on a provisional dredging and filling programme was carried out for different tidal situations (dry and wet seasons, spring and neap tides).

D1.4_3 Details of modelling approach and results were presented in the *"Working Paper on Tidal Flow and Sediment Plume Modelling Report HRHK" February 1998.*

D1.4_4 A worst case scenario for the Area 131 reclamation was modelled for sediment plume, assuming four reclamation activities being undertaken concurrently:

- Dredging contaminated marine mud at seawall trench at total rate 2,747 m^3 per day;
- Dredging clean marine mud at seawall trench at total rate 2,753 m^3 per day;
- Seabed improvement by deep cement mixing with total rate 3,437 m^3 per day; and
- Sandfilling at seawall trench with total rate 5,056 m^3 per day.

For each of the above activities, the assumed losses of fine sediments are as follows:

- Dredged contaminated mud: 0.78 kgs^{-1}
- Dredged clean mud: 0.78 kgs^{-1}
- Seabed improvement by deep cement mixing: 19.42 kgs^{-1}

- Sandfilling: 4.13 kgs^{-1}

D1.4_5 The worst cast scenario was simulated for both the wet and dry season spring and neap tides using flow data from the 50 m grid WAHMO 2-D two-layered model which had been set up as part of the Area 131 Study.

Results of Area 131 Study

D1.4_6 Contours of the predicted suspended solids concentration during peak flood and peak ebb for spring and neap tides in the dry season and for spring and neap tides in the wet season were presented in *Figures 5.3b-c*, *5.4b-c*, *5.5b-c* and *5.6b-c* of the *Working Paper on Tidal Flow and Sediment Plume Modelling Report HRHK February 1998*. Maximum spreading of the sediment plume occurred in the dry season for both spring and neap tides during peak flood. The sediment plumes were predicted to extend beyond the South East Kowloon reclamation along the northern side of Victoria Harbour. During the wet season for flood tides, sediment plumes were predicted to be much smaller and did not extend far beyond Lei Yue Mun. This was due to the influence of the freshwater outflows from the Pearl Estuary in the wet season which enhanced the ebb but inhibits the flood flows.

D1.4_7 Time series of the predicted elevation of suspended solids (SS) at three seawater intakes (Yau Tong, Tsuen Kwan O, Siu Sai Wan) were plotted in *Figures 5.3a*, *5.4a*, *5.5a* and *5.6a* of the *Working Paper on Tidal Flow and Sediment Plume Modelling Report HRHK February 1998*. Locations of these sensitive receivers are shown in *Figure 6.1*.

D1.4_8 Modelling results for the Area 131 Study indicated that only the Yau Tong intake would be affected by suspended sediments. Predicted results for the Yau Tong intake are summarised in *Table A.3*.

Table A.3 Sediment Plume Modelling Results (Yau Tong Seawater Intake)

Scenario	Predicted Maximum Increase in SS (mg L^{-1})	
	Surface Layer	Bottom Layer
Dry Season Spring Tide	3	7
Dry Season Neap Tide	5	6
Wet Season Spring Tide	0.5	1
Wet Season Neap Tide	negligible	negligible

D1.4_9 Maximum increase in suspended solids were presented for both the surface and the bottom layer. According to the Area 131 Study, an increase of SS not greater than 6 mg L^{-1} at the sensitive receivers was be deemed to be acceptable. However, the current study has determined that the ambient depth average 90th percentile at the Yau Tong seawater intake is 15.9 mg L^{-1} (Section 5.5.39 of the main text). This gives an allowable increase of 4.1 mg L^{-1} (the maximum total concentration) at the Yau Tong Seawater Intake. For the purpose of evaluating

the impacts of the WCR, by referring to the WQOs, the value of 4.8 mg L^{-1} will be used.

D1.4_10 For the Yau Tong intake, exceedance of 6 mg L^{-1} was only predicted for the bottom layer during the Dry Season Spring Tide. At the surface layer, predicted elevation in SS is less than 6 mg L^{-1}. In view of the fact that this intake is situated at the top layer, the Area 131 Study concluded that it would be unlikely that the sediment plume generated by the Area 131 reclamation would cause an impact on this intake in Yau Tong. However, the results predict that the allowable increase in SS for the current study would be exceeded for both the spring and neap tides in the dry season.

D1.4_11 It should be pointed out that a worst case scenario for the Area 131 reclamation was assumed for the modelling works. Loss rate for fine particles were based on open grabs without silt curtain. It was thus recommended that both closed grabs and silt curtains be are used. It was considered that the use of these mitigation measures would substantially reduce the sediment loss rate and thus the water quality impacts at the Yau Tong WSD intake would be acceptable.

D1.4_12 In terms of the sensitive receiver of Tung Lung Chau mariculture zone, it was predicted that the dredging and reclamation works for Area 131 would not have any impact. Modelling works indicated that the sediment plume during dredging and reclamation activities for Area 131 would not be transported to Tung Lung Chau as shown in *Figures 5.3a*, *5.4a*, *5.5a* and *5.6a*.

D1.4_13 The plume dispersion modelling results for the Area 131 Study showed that apart from the actual sediment sources, the maximum SS concentration in the Victoria Harbour would be less than 25 mg L^{-1}. Even with the maximum metal concentrations measured in the contaminated sediment samples collected within the proposed dredged area and the worst case assumption that all the metals in the sediment could be released into the water column, the resultant metal concentrations in the Victoria Harbour would be in the order of 0.0025 mg L^{-1} or less. In fact, only a small fraction of the metals contained in the sediment would be released in the water column. As the suspended sediment plume was not predicted to reach Tung Lung Chau, it was therefore expected that there would not be any impacts generated at Tung Lung Chau Fish Culture Zone.

D1.4_14 For the WCR TKO reclamation, a worst case scenario was assumed during dredging of seawall and filling stage, prior to the construction of seawalls.

D1.4_15 A qualitative comparative assessment has been undertaken to comparatively assess the difference in dredging and filling rates and loss rates between the Area 131 reclamation and the WCR TKO Section reclamation. The comparative assessment has been based on the assumptions for dry density and loss rates used in the Area 131 Study.

Table A.4 Comparison of Area 131 and WCR Worst Case Scenario

Activity	Rate (m^3 per day)	Loss Rate of dredged/fill material (%)	Loss Rate of dredged/fill material (kg s^{-1})
Area 131			
Dredging contaminated marine mud at seawall trench (1)	2,747	5%	0.78
Dredging clean mud at seawall trench(1)	2,753	5%	0.78
Deep cement mixing	3,437	100%	19.42
Sandfill at seawall trench(2)	5,056	4.15%	4.13
Total	13,993		25.11
WCR TKO Section			
Dredging at seawall trench(1)	1,644	5%	0.46
Sandfill at seawall trench(2)	2,177	4.15%	1.93
Total	3,821		2.39
Comparison (%)	27.3%		9.5%

Note: (1) Dry density of 488 kg/m^3 for marine sediment
(2) Dry density of 1700 kg/m^3 for sandfill material

D1.4_16 As shown in *Table A.3*, the generation rate of suspended solids of the WCR TKO Section reclamation is well within the range (only 27.3% of the total rate of Area 131 and 9.5% of the total loss rate of Area 131) adopted for the worst case scenario in Area 131.

D1.4_17 As the SS loss rate of the WCR TKO section reclamation is expected to be only approximately 9.5% of the total generated by the Area 131 reclamation. The increases in suspended sediment concentrations from WCR TKO will be 9.5 % of those for the WCR dredging. This means that the maximum SS concentrations at the Yau Tong Seawater Intake will be 0.5 mg L^{-1} in the surface layer and 0.7 mg L^{-1} in the bed layer, which is well within the allowable increase at the intake. The intrusion of suspended sediments into Victoria Harbour will be reduced to be 2.4 mg L^{-1} from the 25 mg L^{-1} predicted in the Area 131 modelling. An increase in suspended sediment concentrations in Victoria Harbour of 2.4 mg L^{-1} will be acceptable. Furthermore the release points of dredging and filling activities for the WCR reclamation will only be around 80 m from the TKO coastline (approximately 300 m closer than the Area 131 reclamation). This will further reduce the transport of sediment, as the current flows are lower closer to the coastline.

D1.4_18 As the SS loss rate of the WCR TKO section reclamation is expected to only a fraction of the total generated by the Area 131 reclamation. It is therefore unlikely that there will be any impacts generated at Tung Lung Chau Fish Culture Zone by the WCR TKO section reclamation.

D1.5 Operation Phase

D1.5_1 The major concern of the water quality assessment of the operational phase for the Area 131 Study was the effect of the Area 131 reclamation on the main tidal flow stream through Lei Yue Mun. As the Area 131 reclamation site lies close to Lei Yue Mun, which is the narrowest part of the main flow channel of Victoria Harbour, the Area 131 reclamation could effectively increase the friction and reduce flow through Victoria Harbour. However the eventual Area 131 layout was designed to minimise this impact. This may have an overall implication on distribution of flow in Hong Kong waters. The Area 131 reclamation layout comprises a total area of 45 ha and was approximately 1,100 m in length and 410 m in width and is shown in *Figure A1.5a*.

D1.5_2 Changes in tidal flow was studied in the Area 131 Study by applying the 50 m grid WAHMO 2-D two-layered model. The flow model was used to simulate flows in and near Tseung Kwan O for spring and neap tides in the dry season and for spring and neap tides in the wet season. The model results showed that maximum current speeds in most of Tseung Kwan O would be reduced by the Area 131 reclamation by less than 0.1 m s^{-1}. This would result in slight increases in the areas of near-slack water areas in the North and North East of Tsueng Kwan O. The water quality impact due to the creation of these areas of slack water would also be slight as there were not expected to be any significant pollution loadings entering in the TKO area.

D1.5_3 The proposed WCR TKO Section reclamation is shown in *Figure A1.5b* and has a total area of 6.9 ha. A comparison of the two the reclamation sizes is presented in *Table A.5* below.

D1.5_4 A comparative assessment has been undertaken to comparatively assess the difference in reclamation size (and hence impacts to tidal flow) between the Area 131 reclamation and the WCR TKO Section reclamation.

Table A.5 Comparison of Area 131 and WCR Reclamation Size

	Length (m)	Width (m)	Area (ha)
Area 131 Reclamation	1100 m length	410 m width	45 ha
Area 131 Breakwater	1,040 m length	-	-
WCR TKO Section Reclamation	940 m length	80 m width	6.9 ha
Comparison	85.5%	19.5%	15.3%

D1.5_5 By comparison the proposed WCR reclamation in the TKO area is only 19.5 % of the total width of the Area 131 reclamation and should therefore not affect the tidal flow in the TKO area.

D1.5_6 More importantly the WCR reclamation does not impinge on the Lei Yue Mun Headland as the reclamation is located away from the Lei Yue Mun Headland.

D1.5_7 The findings of the Area 131 Study have shown that the Area 131 reclamation is acceptable in terms of tidal flow. As the WCR reclamation in the TKO section is substantially smaller in terms of size and shape, it is therefore considered that there is unlikely to be any adverse impacts by the WCR TKO Section reclamation on tidal flow in the TKO area.

D1.6 Conclusions

Construction Phase

D1.6_1 A comparative assessment of the suspended sediment generated by the WCR reclamation based on the Area 131 Study results show that the impacts should be minimal. The estimated loss rates of the WCR are only expected to be 9.5% of the total of the Area 131 reclamation. Furthermore the release points of dredging and filling activities for the WCR reclamation will only be around 80 m from the TKO coastline (approximately 300 m closer to the coastline than the Area 131 reclamation). This will further reduce the transport of sediment, as the current flows are lower closer to the coastline.

Operation Phase

D1.6_2 The findings of the Area 131 Study have shown that the Area 131 reclamation is acceptable in terms of tidal flow. As the WCR reclamation in the TKO section is substantially smaller in terms of size (only 15.3% of the Area 131 total) and shape, it is therefore considered that there is unlikely to be any adverse impacts by the WCR TKO Section reclamation on tidal flow in the TKO area.