6 WATER QUALITY IMPACT ASSESSMENT

6.1 Introduction

6.1.1 This section presents the approach to and the findings of the water quality impact assessment; the aim of which is to identify and examine all beneficial uses and sensitive receivers within the assessment area in order to protect, maintain or rehabilitate the natural environment.

6.1.2 The water quality assessment area is a 1-km radius around the Project site.

6.2 Assessment Approach

6.2.1 The water quality impact assessment has been carried out in accordance with Annexes 6 and 14 of the EIA-TM under the EIAO, and the requirements set out in *Clause 3.4.1* of the EIA Study Brief as follows:

(i) Collect and review relevant background information on the existing and planned water system;

(ii) Characterize water and sediment quality based on existing information collected during the last 5 years or the more recent information collected from appropriate site surveys/tests;

(iii) Identify and analyze existing, planned/committed activities and beneficial uses related to the water system and identify all water sensitive receivers;

(iv) Evaluate the possible impacts arising from the construction, including any possible dredging, filling and/or piling works;

(v) Identify any alteration(s) / change(s) to bathymetry or flow regimes;

(vi) Identify, and analyze all existing, future and other project(s) related water and sediment pollution sources; and analyze these in relation to the provision and adequacy of future facilities to reduce such pollution in terms of capacity and levels of treatment;

(vii) Calculate the impacts on the affected water system and the sensitive receivers due to those alterations and changes identified in (v) above and the pollution sources identified in (vi) above;

(viii) Predicting the cumulative impacts due to other construction activities within a radius of 2 km around the Project area (e.g., Peng Chau Sewage Treatment Works Upgrading);

(ix) Propose water pollution prevention and mitigation measures to be implemented during the construction and operational stages so as to minimize the water / sediment quality impacts;

(x) Evaluate and quantify residual impacts on the water system and sensitive receivers with regard to the appropriate water quality criteria, standards or guidelines; and

(xi) If necessary, identify and quantify all dredging, fill extraction, filling, mud/sediment transportation and disposal activities and requirements as stipulated under *Clauses 3.4.1.4(xii)(a) – (c)* of the EIA Study Brief.

6.3 Regulations, Standards and Guidelines

Water Pollution Control Ordinance (Cap. 358)

6.3.1 The *Water Pollution Control Ordinance* (WPCO) is the principal legislation for the control of water quality in the HKSAR. Under the Ordinance, HKSAR waters are divided into 10 Water Control Zones (WCZs) – each with specific Water Quality Objectives (WQOs).

6.3.2 The water quality study area for the Peng Chau helipad falls entirely within the Southern WCZ. The coastal waters around Peng Chau are designated as a secondary contact recreation sub-zone within Group 4a Southern WCZ under the WPCO. The WQOs for this WCZ are presented in *Table 6.1*.

Table 6.1 Relevant Water Quality Objectives for Southern WCZ

Parameters	WQOs
Dissolved Oxygen (depth average, 90% of sampling occasions during the year)	4 mg/L
Dissolved Oxygen (within 2m of seabed, 90% of sampling occasions during the year)	2 mg/L
Unionized Ammonia (annual average)	0.021 mg/L
Total Inorganic Nitrogen (annual depth average)	0.1 mg/L
Suspended Solids	<30% increase over the ambient level

Technical Memorandum on Environmental Impact Assessment Process

6.3.3 Annexes 6 and 14 of the Technical Memorandum sets out the criteria and guidelines for evaluating and assessing water pollution.

Environmental Transport and Works Branch Technical Circular (Works) No. 34/2002: Management of Dredged/Excavated Sediment

6.3.4 This Technical Circular provides guidelines and procedures for obtaining an approval to dredge/excavate sediment and the management framework for marine disposal of such sediment.

6.4 Baseline Conditions

Beneficial Uses Sensitive to Water Pollution – Water Sensitive Receivers (WSRs)

6.4.1 Beneficial uses sensitive to water pollution with a radius of 1 km from the Project site have been identified in accordance with Annex 14 of the EIA-TM. The coastal waters around Peng Chau are designated as a secondary contact recreation sub-zone for recreation uses.

6.4.2 While no water sports or leisure boating activities were been observed in the immediate vicinity of the Project area during this Study, small sailing boats from Discovery Bay were noted to utilise waters ~100m offshore on several occasions – particularly at weekends. The entrance to the Discovery Bay Marina is located approximately 1 km from the Project area.

6.4.3 There are no bathing beaches or seawater abstraction sites in the assessment area.

Ecology

6.4.4 Live coral communities have been identified around Tai Lei [*Section 7*; *Figure 7.1* refers]. These coral communities are WSRs and have been subject to impact assessment. The impact evaluation is presented in *Section 7*. There are no other sites of ecological conservation importance within the assessment area.

6.4.5 As regards fisheries, there are no recognised fish spawning grounds or fish culture zones in the assessment area, although casual (i.e., apparently not commercial) shellfish harvesting and recreational fishing activities have been observed in the assessment area. There is evidence of shore-based and boat-based fishing activity within the Project boundary, although such activities are on a very limited scale. The fisheries impact assessment is presented in *Section 8*.

Water Quality

6.4.6 Routine water quality monitoring is undertaken by EPD at fixed stations within WCZs. The closest monitoring station in the vicinity of proposed Project site, 'SM10', is located inside the Southern WCZ, approximately 1.7 km to the northwest of the site (coordinate: 22°18.125'N, 114 ° 1.919'E).

6.4.7 The water quality of SM10 for the past 5 years is extracted from Marine Water Quality in Hong Kong (1997-2001) and summarised in *Table 6.2*.

6.4.8 As it can be seen that the baseline water quality complies with the relevant WQOs except for Total Inorganic Nitrogen (TIN). The baseline TIN level exceeds the WQOs and has shown the tendency of increasing over the last 5 years.

Table 6.2 Summary of Water Quality at 'SM10' between 1997 and 2001

	1997	1998	1999	2000	2001
DO mg/L	6.9 (6.3-7.7)	5.9 (3.2-7.2)	6.1 (4.7-7.7)	6.5 (4.9-8.0)	6.0 (4.7-7.4)
DO mg/L (bottom)	6.8 (6.3-8.0)	5.9 (3.9-7.2)	6.3 (4.9-8.0)	6.5 (4.7-8.0)	6.2 (4.8-7.5)
DO % Saturation	94 (86-104)	90 (70-101)	85 (67-97)	90 (72-105)	84 (65-108)
DO % Saturation (bottom)	93 (86-100)	91 (83-98)	87 (69-101)	90 (68-104)	86 (70-106)
Suspended Solids (mg/L)	6.4 (3.3-14.5)	6.9 (4.1-9.9)	12.5 (4.3-45.0)	12.8 (1.7-36.0)	17.9 (6.4-50.5)
Unionised Ammonia (mg/L)	0.003 (0.001-0.008)	0.003 (0.001-0.009)	0.003 (0.001-0.005)	0.004 (0.001-0.014)	0.004 (<0.001-0.010)
Total Inorganic Nitrogen (mg/L)	0.28 (0.16-0.45)	0.27 (0.14-0.43)	0.25 (0.11-0.40)	0.30 (0.09-0.59)	0.33 (0.21-0.44)

Notes:
1. *Unless otherwise specified, data presented are depth-average (A) values calculated by taking the means of three depths: Surface (S), Mid-depth (M) and Bottom (B).*
2. *Data in brackets indicate the ranges.*

Sediment Quality

6.4.9 The closest EPD monitoring station for sediment quality within the Southern WCZ is SS5 which is located to the south of Hei Ling Chau, approximately 4 km from the Project site (coordinate: 22°15.443'N, 114°1.078'E).

6.4.10 The sediment quality of SS5 for the past 5 years as extracted from Marine Water Quality in Hong Kong (1997 - 2000) is summarised in *Appendix 6.1*. It can be seen that the sediment belongs to Category L (i.e., sediment contamination levels do not exceed the Lower Chemical Exceedance Level).

6.4.11 Previous ecology field investigation around the proposed helipad site indicated that the surface is predominantly comprised of sand (51-75% cover), with scattered rocks and boulders (Oceanway, 2001).

6.4.12 An approved Sediment Testing Proposal was implemented under this study to determine the chemical characteristics of the marine sediment in the proposed Project area. However, despite several attempts to collect samples from within the footprint of the proposed helipad and EVA link the sampling failed due to the coarse sediment nature, i.e., mainly dead coral and shell fragments on the seabed surface.

6.4.13 From consequent ground investigation works two sediment core samples were collected from within the proposed helipad footprint, from which they were characterised as comprising fine to coarse sand and gravel overlying a bedrock of highly / completely decomposed granite (Bachy, 2003). No evidence of silt or mud was recorded. Accordingly, as potential sediment contamination was considered highly unlikely, a Tier 1 sediment quality proposal for the Project was prepared and accepted by EPD under WBTC 34/2002 and allocation for the disposal of 14,000m^3 marine sediment from the Project has been obtained.

Tidal Hydrodynamics

6.4.14 The tidal currents in the area change periodically. The peak velocity at mid ebb and mid flood tide is approximately 0.4 m/s and 0.6 m/s respectively.

Identification of Impacts

6.4.15 As presented in Section 5, the marine sediment around the Project site has been reasonably assumed to be Category L (i.e. the contaminant level not exceeding the Lower Exceedance Level). Therefore, suspended solid (SS) is the only parameter concerned in this water quality impact assessment.

6.4.16 Impacts from SS may be caused by sediment plumes being transported to WSRs, in this case the corals and the Southern WCZ, leading to the elevation of the SS levels at the WSRs. The level of elevation will determine whether the impact is acceptable. The WQOs in terms of SS for the Southern WCZs are defined as being an allowable maximum elevation of 30% above the background for bathing beaches and sites of ecological interest.

6.4.17 The 90th percentile of SS at SM10 over the last 4 years (1997 – 2000) is 33.5 mg/l, which has been used as the background level. A 30% increase above the background level is thus 10.1 mg/l, giving a total SS limit of 43.6 mg/l. Due to the cumulative impacts from other Projects in 2001, the monitoring data of 2001 was not used in deriving the background SS level.

6.4.18 Silt and clay, also called cohesive sediment, will form large particles by the process of flocculation after being released into the water column, which will then settle back to the seabed, resulting in a smothering effect. This smothering effect can be detrimental to the corals. Given the ecological interest in the area, a limit on the sedimentation rate of 0.1kg/m^2/day was applied to the Project, following the study for Sand Dredging at the West Po Toi Marine Borrow Area (ERM, 2001).

6.4.19 During the operation stage of the Helipads, the helipad footprint may alter the tidal flow regime of the region, thus affecting the water quality, in particular the area between the Helipad and the closest land point 'The Discovery Bay Marina'. Models have been used to predict the alteration to the flow regime, thus the impacts on the water quality identified in *Section 6.6*.

6.4.20 The predicted maximum SS elevation resulting from the dredging has been compared to the SS tolerance value (i.e., 10.1 mg/l) to determine the acceptability of the WQ impacts.

6.5 Assessment Approach & Methodology

Gaussian equation

6.5.1 The following equations, based on the Gaussian theory (CIRIA), were used to estimate the resulting elevation of SS concentration:

$$c_t(x,t) = M_t \exp\{-(x-\xi)^2/(4D_xt)-y^2/(4D_yt)-W_st/h\}/\{4\pi ht\sqrt{(D_xD_y)}\} \quad (1)$$

$$C(x,t_1) = \Sigma\, c_t(x,t) \text{ where } t=0 \text{ to } t_1 \quad (2)$$

Where: c_t – SS concentration from one-off releasing source at time t
C – Cumulative SS concentration (kg/m^3) resulting from the source released from the beginning to time t_1
M – Amount of sediment released (kg)
X – Distance from the releasing point along the flow direction (m)
Y – Distance from the releasing point normal to the flow direction (m)
t – Time after release (s)
W_s – Settling velocity (m/s)
h – Water depth (m)
D_x – Dispersion coefficient in X-direction (m^2/s)
D_y – Dispersion coefficient in Y-direction (m^2/s)
ξ = ut (m) and
u - Flow velocity (m/s)

6.5.2 The critical activity in the helipad construction is the dredging activities associated with the site formation, and thus the impact of this dredging activity on marine water quality has been assessed. The backfill material will have a minimum particle size of 20mm. As such, no fine sediment is expected to be released during the backfilling operation. It is reasonable to consider that the potential impact of other activities such as backfilling will be acceptable as long as the dredging impact is acceptable.

Model Input and Assumptions

6.5.3 To ensure that the assessment does not under-estimate potential water quality impacts, a series of worst-case assumptions have been made for input to the model. These relate to 'S-factors' (i.e., the sediment leakage rate from dredging), peak tidal velocity for extreme sediment plume formation and dispersal, and bathymetry (i.e., a shallow water depth scenario was assessed, as this will allow conservative estimation of suspended solids levels).

6.5.4 A single backhoe dredger with a grab capacity of 6 – 8 m^3 per grab will be engaged for the dredging. The maximum volume of 8m^3 per grab has been adopted to represent the worst-case scenario in the calculation on the assumption that the sediment leakage rate for either a 6m^3 or an 8m^3 grab would be the same, and assuming that the number of grab 'events' per unit time would be the same for these two different grab volumes.

6.5.5 The total dredging volume is 14,000 m^3 over a period of 30 days with 8 working hours per day, giving a mean dredging rate of 58 m^3/hr or 0.0162 m^3/s. For the purpose of this impact assessment, a daily maximum dredging rate of 465 m^3 has been assumed. The dredging shall be monitored and a daily

record shall be kept to ensure the dredging rate would not exceed the assumed maximum daily rate of of 465 cubic metres as recommended in the EIA.

6.5.6 The typical sediment leakage rate (or S-factor) for a grab dredger is 12 to 25 kg/m^3 (i.e. there will be 25 kg sediment leakage for every cubic metre of volume dredged). Using the S-factor of 25 kg/m^3 as the worst-case scenario, the calculated leakage rate is 0.405 kg/s.

6.5.7 Based on borehole sampling data, on average 85% of the marine sediment is consisted of sand or coarser material (i.e., gravels), with 15% comprising finer sediment. As such, there will be 0.344 kg/s sand or coarser material and 0.061 kg/s silt or clay released into the water column during the dredging period.

6.5.8 The model was run separately to assess the SS elevation resulting from the sand and the fine sediments. The SS elevation resulting from the sand release is then superimposed to that from releasing the fine sediments. The total SS elevation is then compared to the tolerance value to determine the acceptability of the water quality impact. A typical particle size for sand, 200μm is conservatively adopted for assessing the impact of sand release. The settling velocity of the sand is estimated to be 0.02 m/s.

6.5.9 The water depth at the offshore end of the proposed works area is approximately 1 mCD, and reaches 5 mCD some 50m from the shoreline. For the purpose of this assessment, a constant total water depth of 2 m has been used for estimating the mixing zone (i.e., within which SS elevation is in excess of 30% above the baseline SS level). A constant total water depth of 5.8m has been used for estimating the SS elevation at the coral site around Tai Lei Island, based on the information from the site survey and the navigation chart.

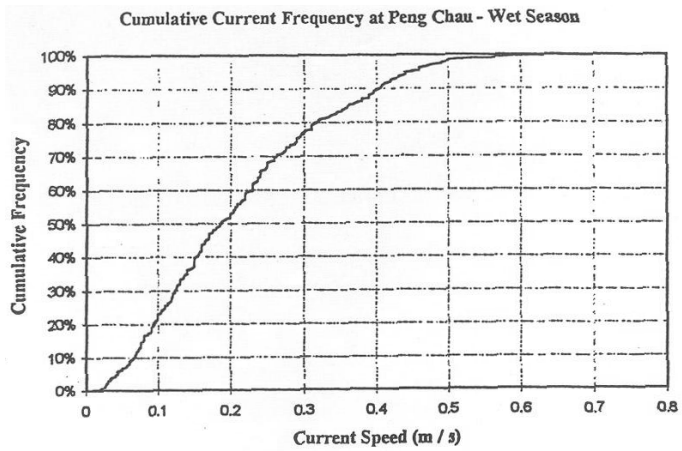
6.5.10 The tidal currents in the area change periodically. The peak velocity at mid ebb and mid flood tide is approximately 0.4 m/s and 0.6 m/s respectively. The frequency distribution of current velocity at Peng Chau for the wet and dry seasons is displayed in Figure 6.1. As the coral sites are to the west of the dredging area, there will be no dredging impact on the coral communities during the flood tide as the dredging plume will be travelling eastwards, in the opposite direction.

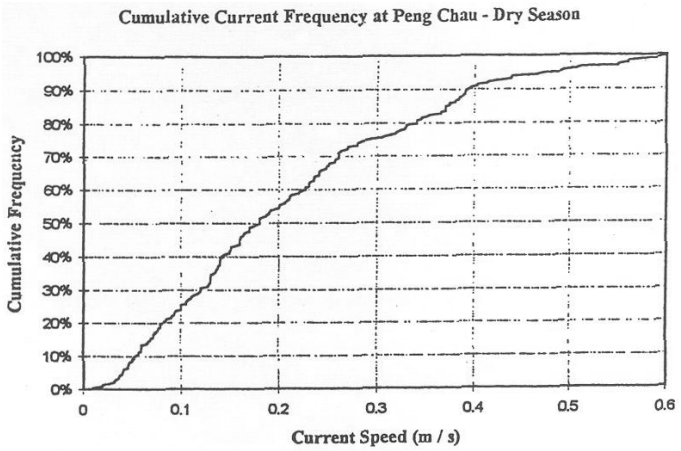
6.5.11 The constant peak velocity at the ebb tide has been adopted for calculating the impact on the coral communities during the ebb tide. It is conservatively assumed that this peak constant velocity is for a continuous 6.5 hours during the entire ebb tide. The flood tide peak velocity, as it is bigger than the ebb tide velocity, is however conservatively adopted for estimating the extent of the mixing zone.

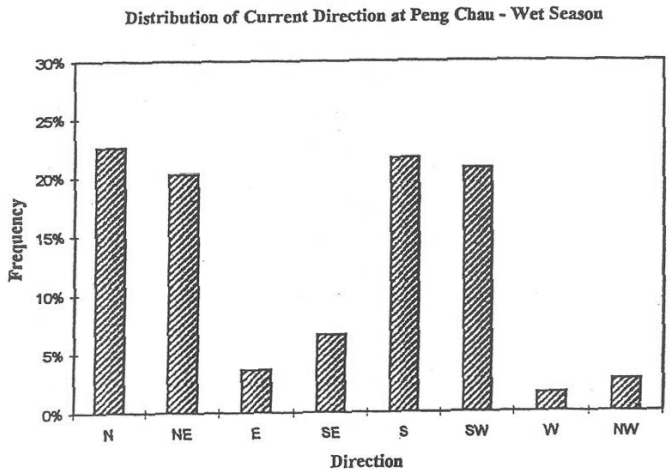
6.5.12 As the sediment will be released continuously during the dredging period, the resulting sediment concentration from the dredging within each time element as calculated using the Gaussian Equation (1) is superimposed to obtain the resultant sediment concentration of the continuous release.

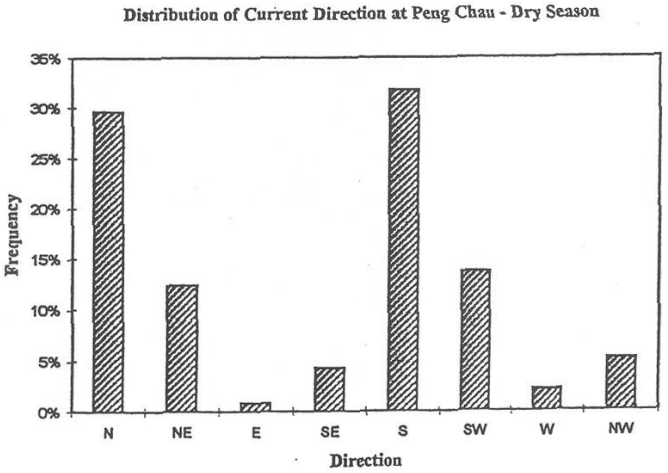
6.5.13 A typical dispersion coefficient of 1 m^2/s is used for both D_x and D_y.

Figure 6.1 Frequency and Direction of Current Velocity at Peng Chau









Source: Outlying Islands Sewerage Stage 1 Phase 1 EIA Study (CES (Asia), 1997) [in EIA Study Report for Peng Chau Sewage Treatment Works Upgrade (CDM, 2004)].

6.6 Impact Assessment & Evaluation

6.6.1 As discussed above, the background SS level based on the 90th percentile over the 4-year period from 1997 to 2000 is 33.5 mg/l, and the tolerance of SS elevation is 10.1 mg/l.

6.6.2 *Table 6.3* summarises the calculated SS elevation. It can be seen that the SS elevation will not exceed the tolerance level even in the very vicinity of the dredging location for the average water depth of 5.8m in the study area. However, the mixing zone where the SS elevation exceeds the tolerance level will be about 16m (along the flow direction) by 5m (normal to the flow direction) for a water depth of 3m.* The mixing zone will increase to 25m (along the flow direction) by 8m (normal to the flow direction) if the water depth is reduced to 2m. *Figure 6.2* displays the cumulative spatial extent of the mixing zone in relation to the works area.

Table 6.3 Predicted SS Elevation

X (m)	Y (m)	C_{sand} (mg/l)	C_{silt} (mg/l)	C= C_{sand}+ C_{silt} (mg/l)
Depth = 5.8m				
20	0	4.17	0.84	5.01
15	0	4.92	0.96	5.88
10	0	6.44	1.22	7.66
9	0	6.71	1.26	7.97
8	0	6.85	1.29	8.14
7	0	6.82	1.27	8.09
6	0	6.59	1.23	7.82
5	0	6.14	1.15	7.29
2	0	3.92	0.72	4.64
8	1	6.72	1.26	7.98
8	2	6.34	1.19	7.53
Depth = 3.0m				
18	0	7.69	1.70	9.39
16	0	8.30	1.80	10.10
15	0	8.69	1.86	10.55
10	0	11.72	2.36	14.08
9	0	12.26	2.44	14.70
8	0	12.56	2.49	15.05
7	0	12.54	2.47	15.01
8	2	11.62	2.30	13.92
8	5	7.83	1.57	9.40
Depth = 2.0m				
26	0	7.63	2.14	9.77
25	0	7.92	2.19	10.11
8	8	5.62	1.23	6.85
8	6	9.08	1.94	11.02

* The mixing zone is the region of a water body where initial dilution of a pollution input takes place and where water quality criteria can be exceeded (EIA-TM, Annex 6).

6.6.3 Only one dredger will be in operation during the dredging works. As such, the spatial extent of exceedance of the WQO for SS will be localised, and no significant adverse impacts are expected in the secondary contact recreation sub-zone.

6.6.4 The dredging at the helipad and the associated EVA will lead to some SS elevation at the coral sites identified. However, the maximum SS elevation at the identified coral sites around Tai Lei Island is at a negligible level of 0.002mg/l and the sedimentation rate is estimated to be considerably less than 0.1kg/m^2/d.

6.6.5 As such, given the small scale of dredging, no adverse water quality-induced impacts are anticipated either at the coral community at east Tai Lei [*Section 7* refers] or on fisheries resources within the Project boundary [*Section 8* refers]. There will be no adverse water quality impacts on the WSRs at the Discovery Bay Marina.

6.6.6 During the operation stage, the flow cross-section to be affected by the helipad footprint is in the shallow water near the coast and is less than 50m in length. In view of a total cross-section length of ~ 1km between the proposed Project and the closest land point on Lantau (i.e., the Discovery Bay Marina), no significant impact on the tidal regime and therefore water quality around the Project area is anticipated during the operational phase.

6.6.7 Given the nature of the Project, there will be no waste / materials generated during the operational phase, and therefore no water quality impacts are anticipated that could potentially translate into impacts on the marine environment.

Cumulative Impacts

6.6.8 The marine works for the Peng Chau STW submarine outfall shall be developed by the open trench method from August 2005 for completion around April 2006. Marine works for the Peng Chau Helipad are scheduled between February and July 2006. Although the latest information from DSD indicates there may be around 2 months of concurrent works, the impact assessment using a standard calculation based on the Gaussian theory has indicated no overlap in the affected area. As such, no cumulative water quality impacts are anticipated.

6.7 Impact Mitigation & Residual Impact Assessment

6.7.1 An increase in the dredging rate without additional mitigation measures would lead to an increase in the sediment leakage rate and an increase in water quality impact, and should be avoided. If an increase in the dredging rate is unavoidable, the potential water quality impact on the WSRs should be re-assessed.

6.7.2 While no significant adverse water quality impacts are predicted, it is as a precautionary good practice measure recommended that a silt curtain(s) be placed in an arc on three sides (east, north and west) around the dredger to prevent sediment dispersal to open marine waters. This shall ensure the area of the mixing zone is minimised, and the silt curtain(s) should be installed prior to the commencement of dredging. The silt curtain(s) shall enclose the dredger while not interfering with its operation. The silt curtain(s) shall be progressively moved as the dredger moves through the dredging area, and shall be weighed down against the seabed prior to commencing dredging.

6.7.3 The following good site practices are recommended to further minimize potential water quality impacts:

- The daily dredging volume should be spread as evenly as possible over the working hours whenever practical to avoid sudden surge of pollution elevation during short spells;
- Special care should be taken during lowering and lifting grabs to minimize unnecessary disturbance to the seabed;
- To ensure vessels used have adequate clearance of the seabed in order to reduce undue turbidity

generated by turbulence from vessel movement or propeller wash;

- Barges should be fitted with tight fitting seals to their bottom openings to prevent leakage of material;
- The contractor should ensure that grabs are tightly closed and the hoist speed is suitably low;
- Barges should not be filled to a level which will cause overflow of materials during loading and transportation; and
- Large objects should be removed from the grab to avoid losses from partially closed grabs.

6.8 Environmental Monitoring & Audit

As no significant adverse water quality impacts are anticipated, no water quality monitoring is required for the Project.

6.9 Conclusions and Recommendations

6.9.1 There is some potential for water quality impacts associated with proposed construction phase dredging activities.

6.9.2 As only one dredger will be in operation during the dredging works, calculations predict that elevations in suspended solids at the identified sensitive receivers are negligible and well within the tolerance level. It is also predicted that the SS elevation will not exceed the tolerance level of 10.1 mg/l even in the very vicinity of the dredger, based on an average water depth of 5.8m in the study area. The mixing zone where the SS elevation will exceed the tolerance level is only 16m (along the main flow direction) by 5m (normal to the flow direction) at a water depth of 3m and 25m by 8m at a water depth of 2m, and will not affect water sensitive receivers.

6.9.3 The use of silt curtains will further limit the extent of the mixing zone, and will ensure compliance with the water quality criteria at the WSRs. As such, no significant adverse water quality impacts are anticipated during the construction phase and, accordingly, no adverse residual impacts are expected.

6.9.4 As regards cumulative effects, the construction method for the Peng Chau STW submarine outfall will involve the open trench method. These works will be commenced in August 2005 for tentative completion around April 2006. As there will be no overlap in the affected area, no cumulative impacts are anticipated.

6.9.5 Hydrodynamic effects of the constructed Project will be negligible, while there will be no operational discharges that could potentially translate into impacts on the marine environment.

6.9.6 As the backfilling material will be rock armour and granular material with a minimum particle size of 20mm, no fine sediment is expected to be released into water column during the backfilling stage and this activity will have much less water quality impacts than the dredging activities.

6.9.7 It is concluded that the potential adverse water quality impacts of the proposed helipad are insignificant during both the construction and operation stages. The proposed good practice measures will further safeguard the compliance of the water quality with the water quality criteria during construction works.

6.10 References

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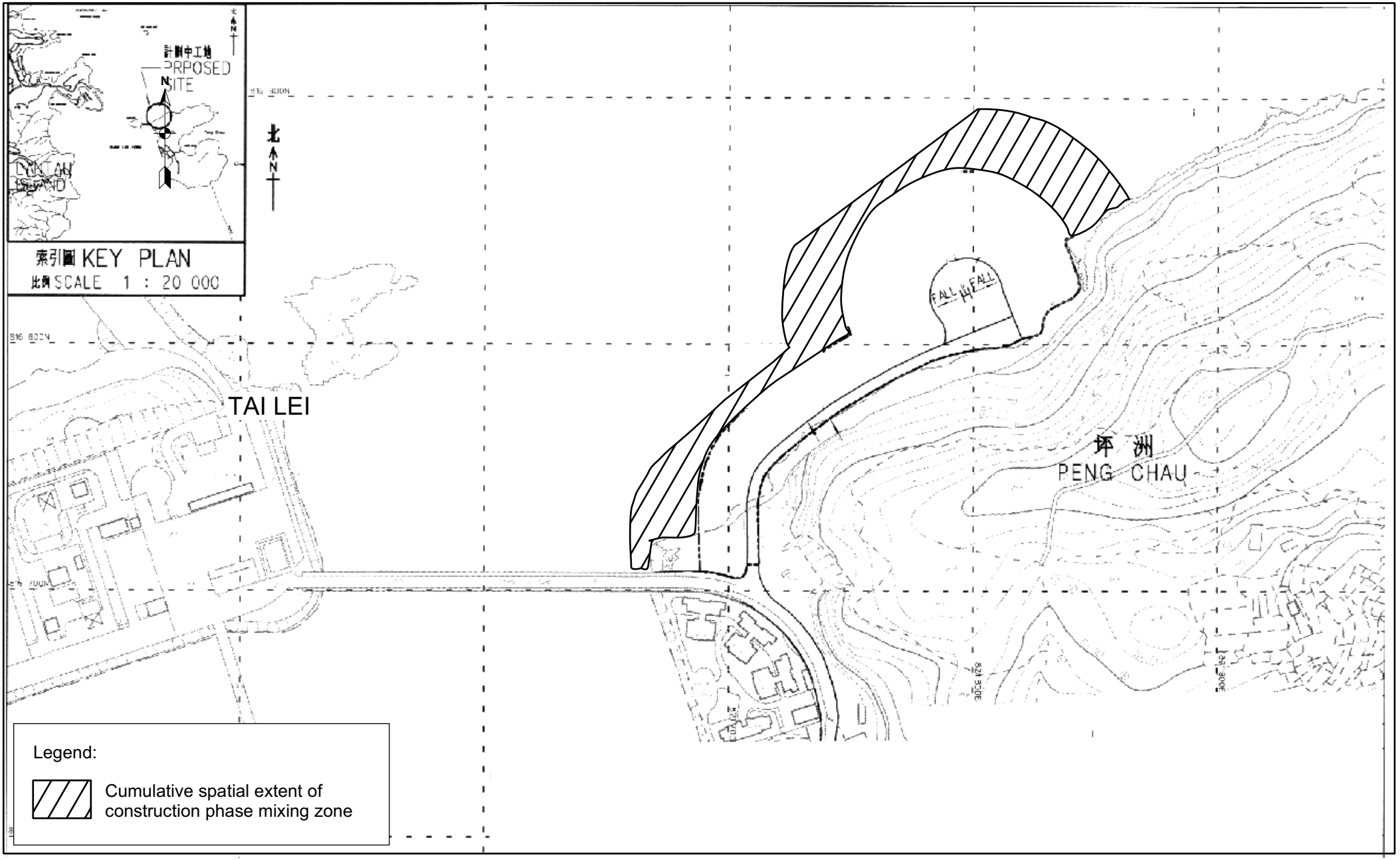

EIA Study for Peng Chau Helipad

CUMULATIVE SPATIAL EXTENT OF CONSTRUCTION PHASE MIXING ZONE

Figure 6.2

Drawn	FEW	Checked	RBR
Scale	1 : 2000	Date	June 2005