## 5.8 Consideration of Deep Cement Mixing for Seawalls Foundation

5.8.1.1 The site trial on DCM is recommended to carry out in one of the non-critical seawall sections. The constraints to construction timeframe would be less. The possible locations for the trial would include the seawall for Cha Kwo Ling Reclamation, and the seawall for the non-critical portions of Hoi Sham Reclamation work (ie Hoi Sham Reclamation other than that for Central Kowloon Route Construction and other than the bund for gas facilities reprovisioning). The exact locations for the trial, which is likely to have less programme implication, would be selected in the detailed design stage.

5.8.1.2 If the site trial results confirm the feasibility of the method, DCM will be carried out in full scale for that section of seawall, thus obviating the need for dredging for foundation purpose. In the event that DCM is not suitable for applying in the SEKD, minimum dredging for sediment treatment may still be required in accordance with the methodology described in the preceding sections.

## 5.9 Impacts Summary

5.9.1.1 Three reclamation options including the no dredged, dredge for *ex-situ* treatment and minimum dredged reclamation options have been proposed in this section. It has been demonstrated that these reclamation options are technically feasible.

5.9.1.2 The vertical sea wall is usually constructed with large concrete blocks, filled with sand and founded on dredged seabed. The soft materials at the base may have to be removed to ensure the stability of the sea wall. The sloping sea wall, in its simplest form, is usually constructed with quarry-run rockfill core with blocks at the seaward side for erosion protection. The marine deposits are dredged to provide a suitable foundation. In both cases, despite the removal of the soft marine deposits, stability may remain a problem due to trapped marine deposit beneath the reclamation, giving weak planes for slip surfaces; and inadequate shear strength in the alluvial clay.

5.9.1.3 The potential stability problems are increased with the recent Government policy to minimise the amount of dredging and consequent sea disposal of contaminated marine deposits. Ground treatment would be required if the marine deposits were to be left in place. In addition, treatment to the softer alluvium deposits may also be required.

5.9.1.4 Breakwater structures, unlike sea walls, do not require retaining reclamation fill. However, they are heavy structures subject to significant wave loading. Ground treatment may still be required if the structure were to be founded on the soft marine deposits or alluvium deposits.

5.9.1.5 Cross-sections from typical geology at Hoi Sham and KTAC have been chosen and slope stability analyses have been carried out to determine if the marine deposits will pose any stability problems. Although short-term undrained shear strength of the marine and alluvial clays were not provided in the Final Geotechnical Report of the SEKDFS, typical values were adopted using values from the Chap Lap Kok reclamation. The results show that dredging is essential to provide the required stability against slip failure during reclamation and surcharging from an engineering point of view.

5.9.1.6 Based on the above considerations, the use of vertical drains and surcharging is recommended for general reclamation. Full dredging will be carried out in the areas where sea wall, breakwater and tunnel will be constructed. The proposed rock bund at Hoi Sham will also be dredged to provide a stable ground condition for supporting the gas main. Ground investigation will have to be carried out in the dredged zones after reclamation to determine if full dredging has been achieved. Settlement Plates and extensometers will be installed in the reclaimed area to monitor the characteristic of the consolidation. If necessary, the surcharging design would have to be modified to achieve the design criteria.

5.9.1.7 Both the no dredged reclamation option with *in-situ* treatment and the dredge for *ex-situ* treatment reclamation option have been proposed to the KTAC reclamation. Pilot tests would be carried out to determine either *in-situ* or *ex-situ* treatment is more suitable for applying to the KTAC sediments. The no dredged reclamation is preferable and the dredge for *ex-situ* treatment reclamation option would be a fall back option. Recommendations have been made to first carry out the reclamation and the subsequent *in-situ* treatment at the hotspots would be from a land-based operation. Feasibility of this preferred approach needs to be determined through the pilot tests.

5.9.1.8 The minimum dredged reclamation option has been recommended for the KTTS reclamation and the Hoi Sham reclamation. The preferred approach is to first backfill the reclamation and to apply *in-situ* treatment to the potential hotspots with high methane potential after the reclamation. Concurrently, methane gas monitoring would be carried out to cover the treated hotspots and the remaining reclaimed areas without treatment. Provision of protection measures serves as a backup system to deal with the residual impacts that may not be effectively reduced through *in-situ* treatment. *Ex-situ* treatment may also be required to treat the dredged sediments in the sea wall, earth bund, tunnel and breakwater locations.

5.9.1.9 The proposed reclamation options would minimize dredging. Sediment plume dispersion could be easily controlled in the KTAC reclamation if dredging for *ex-situ* treatment is to be carried out. Odour emission could be minimized through the in-pipe chemical oxidation as part of the *ex-situ* treatment process. *In-situ* treatment would minimize the disturbance to the sediments. Therefore, odour emission is unlikely to be a critical issue. The application of *in-situ* or *ex-situ* treatment in the proposed reclamation options would not cause any significant environmental impacts to pose a constraint to the SEKD. It is anticipated that there would be no insurmountable impacts as a result of the development.

5.9.1.10 A summary of the potential impacts associated with the contaminated sediments is presented in **Table 5.34**.

**Table 5.34 Impact Summary for Contaminated Sediments**

| Issue | Impact |
|---|---|
| Assessment Locations | SEKD Study Area |
| Relevant Criteria | Dumping at Sea Ordinance (Cap. 466);<br>Technical Circular No. (TC) No.1-1-92, Classification of Dredged Sediments for Marine Disposal;<br>Works Branch Technical Circular No. 22/92, (WBTC No. 22/92) Marine Disposal of Dredged Mud;<br>Works Bureau Technical Circular No. 3/2000, (WBTC No. 3/2000) Management of Dredged/Excavated Sediment; and<br>Works Bureau Technical Circular No. 12/2000, (WBTC No. 12/2000) Fill Management.<br>Suggested maximum safe rate of gas emission for biogas assessment: 10 L/m$^2$/d based on the Green Island Development Study. |
| Potential Impacts | High contaminant levels of sediments at KTAC, KTTS and Hoi Sham. Almost all the samples collected in these areas fell into the Category H material. The contaminants included heavy metals and organic pollutants.<br><br><u>KTAC</u><br>The contamination in the KTAC sediments was dominated by copper, silver, chromium, nickel, zinc and to a lesser extent by lead, mercury and cadmium. The sediments at sampling points AC1 to AC5 located near the entrance of Kai Tak Nullah showed higher contamination levels. The contamination levels at sampling points AC6 and AC7 located farther away from the entrance of Kai Tak Nullah were comparatively lower. The organic micro-pollutants (PCBs, PAHs and TBT) were generally high in concentrations especially the PCB levels at AC2 and AC5. The TBT levels at AC6 and AC7 were found to be higher than that of the other sampling points in the KTAC. |

| Issue | Impact |
|---|---|
| | The analytical results for the KTAC show that there was a decreasing trend of TOC concentrations from AC1 to AC7. The inner part of KTAC contained higher concentrations of organic matter. The range of TOC results varied from 0.45 to 13.2% (dry weight). The overall depth-averaged TOC in the KTAC sediments was 4.4 % (dry weight). The SOD levels in the sediments collected at AC1 to AC5 were higher than those at AC6 and AC7. This was consistent with the TOC measurements. The overall depth-averaged SOD in the KTAC sediments was 9376 mg/kg (dry weight).<br><br><u>KTTS</u><br><br>The copper concentrations in the KTTS sediments were the highest. The contamination was dominated to a lesser extent by lead, chromium, zinc, cadmium and nickel. Some of the silver and mercury contents were several times higher than their LCELs. The arsenic levels at all the sampling points were below the LCEL except the lower sediment layer (1.49–2.05m) at KT2. The measured organic micro-pollutant concentrations (PCBs, PAHs and TBT) were high at KT1 and KT2. The contamination levels were found to be higher mostly in the upper and middle layers of the sediments. The sediments collected at sampling points KT3 and KT4 located near the exit of Tsui Ping Nullah were found to be less contaminated.<br><br>The TOC and SOD results in the sediments collected at sampling points KT1 and KT2 were found to be high. The pollutants discharged from the nearby box culvert may contribute to the high concentrations of TOC and SOD at KT1 and KT2. The overall depth-averaged TOC and SOD results are 2.9% (dry weight) and 6017 mg/kg (dry weight) respectively.<br><br><u>Hoi Sham</u><br>The analytical results of the sediments collected in Hoi Sham showed that the copper concentrations were the highest amongst the other tested heavy metals, in particular at KB6 and KB7. The concentrations of other heavy metals were also found to be high and mostly exceeded the LCEL. Elevated levels of lead, chromium and zinc were recorded in most of the sampling points. The arsenic concentrations were in general below the LCEL except in the lower sediment layer at KB5. Some of the PCB and PAH levels in the sediments collected from Hoi Sham were exceptionally high. The highest PCB and PAH levels were found at KB6. The analytical results indicated that the entire depth at KB6 (0-1.9m) was seriously contaminated. Not only high PAH and PCB levels were observed at KB6, the concentrations of other tested parameters were also high at the same location. The TBT levels in the Hoi Sham area were comparatively higher than that recorded in the KTAC and KTTS.<br><br>The sediments collected in Hoi Sham contained lower SOD and TOC levels when compared to the other two reclamation areas. The SOD results ranged between 570 and 9750 mg/kg (dry weight) whilst the TOC results ranged between 0.49 and 5.27 % (dry weight). The overall depth-averaged SOD and TOC levels were 2744 mg/kg (dry weight) and 2.2 % (dry weight) respectively.<br><br><u>Biogas Potential</u><br>Total methane potential based on TOC:<br>KTAC – $1.95 \times 10^7$ kg or $2.74 \times 10^7$ $m^3$<br>KTTS – $8.61 \times 10^6$ kg or $1.21 \times 10^7$ $m^3$<br>Hoi Sham – $1.15 \times 10^7$ kg or $1.62 \times 10^7$ $m^3$<br><br>Estimated methane fluxes based on TOC (2-year after sediment becomes anaerobic):<br>KTAC – 68.8 $L/m^2/d$ (half-life cycle = 2 years); 24.95 $L/m^2/d$ (half-life cycle = 5 years)<br>KTTS – 25.59 $L/m^2/d$ (half-life cycle = 2 years); 9.28 $L/m^2/d$ (half-life cycle = 5 years)<br>Hoi Sham – 20.56 $L/m^2/d$ (half-life cycle = 2 years); 7.46 $L/m^2/d$ (half-life cycle = 5 years)<br><br>Total methane potential based on SOD:<br>KTAC – $2.17 \times 10^6$ $m^3$<br>KTTS – $9.33 \times 10^5$ $m^3$<br>Hoi Sham – $7.51 \times 10^5$ $m^3$<br><br>Estimated methane fluxes based on SOD (2-year after sediment becomes anaerobic):<br>KTAC – 5.46 $L/m^2/d$ (half-life cycle = 2 years); 1.98 $L/m^2/d$ (half-life cycle = 5 years)<br>KTTS – 1.98 $L/m^2/d$ (half-life cycle = 2 years); 0.72 $L/m^2/d$ (half-life cycle = 5 years)<br>Hoi Sham – 0.95 $L/m^2/d$ (half-life cycle = 2 years); 0.35 $L/m^2/d$ (half-life cycle = 5 years) |

| Issue | Impact |
|---|---|
| Reclamation Options | Three possible reclamation options:<br>• No dredged reclamation<br>• Dredge for *ex-situ* Treatment reclamation<br>• Minimum dredged reclamation<br><br>No Dredged Reclamation<br>No dredging with application of in-situ treatment and/or no dredging with monitoring and provision of protection measures.<br><br>*In-situ treatment*<br>• Fenton's Reagent<br>• Oxygen Release Compound<br>• Seditreat™ method<br><br>*Monitoring and Protection Measures*<br>Implementation of protection measures would be based on the monitoring results and the following criteria:<br><br>(1) Measured Methane Emission Rates higher than the Maximum Safe Rate of Gas Emission<br><br>In case where the methane gas emission rates measured from any boreholes in a particular area are higher than the maximum safe rate of gas emission (10 L/m$^2$/d) or safe flow rate of 200 L/d, protection measures should be provided to protect the buildings to be constructed in that area.<br><br>(2) Measured Methane Emission Rates below the Maximum Safe Rate of Gas Emission<br><br>When the measured flow rate of methane in a particular area is consistently lower than the safe flow rate of 200 L/d, protection measures may not be required. However, the monitoring data should cover the flow rate of methane measured during the low atmospheric conditions to confirm whether there is any exceedance of the safe flow rate under unusual conditions. In addition, the trend of the monitoring results should be analyzed. Continuous monitoring would be required if an increasing trend of the flow rate in a particular area were found. To be conservative, provision of protection measures could be considered for this situation.<br><br>(3) Measured Methane Emission Rates occasionally exceed the Maximum Safe Rate of Gas Emission<br><br>If monitoring results show significant variations in the methane flow rate emitted from the boreholes and exceedances of the safe flow rate (> 200 L/d), continuous monitoring should be undertaken to confirm whether there would be an increasing trend or a decreasing trend of the methane flow rate. When there is a clear indication of the measured methane flow rate consistently below the safe flow rate, protection measures may not be required. Otherwise, suitable protection measures should be provided to prevent methane hazards to the individual developments or buildings in the area of concern.<br><br>Dredge for *Ex-situ* Treatment Reclamation<br>Dredging of sediments would be required. Off-site disposal would be considered for sediments with low contaminant levels. *Ex-situ* treatment has been recommended to reduce the contaminant levels of the highly contaminated sediments. The treated material could be off-site disposal or reused as fill material if appropriate. The proposed *ex-situ* treatment techniques would include:<br><br>• BioGenesis Sediment Washing; and<br>• Daramend Bioremediation.<br><br>Minimum Dredged Reclamation<br><br>Minimum dredged reclamation option would be applied to the areas where major marine structures are to be constructed. *In-situ* and *ex-situ* treatment would be adopted, wherever appropriate, to minimise the biogas potential in the undredged areas and the contaminant levels of the dredged sediments. |
| Impacts due to Dredging | Potential impacts due to dredging of sediments include:<br>• Generation of sediment plumes |

| Issue | Impact |
|---|---|
| | • Release of contaminants from the contaminated sediments into the water column;<br>• Increase in SS and turbidity in the water column; and<br>• Odour emission. |
| Protection Measures to Prevent Biogas Hazards | Protection measures during construction:<br>• Special precautions and safety measures to be undertaken for works to be carried out in confined space;<br>• Monitoring of the methane, carbon dioxide and oxygen levels in excavated areas and areas below ground to ensure a safe working environment;<br>• Provision of sufficient ventilation in temporary structures including site huts and unventilated enclosures;<br>• Smoking and open fire should be prohibited in the region where drilling activities are carried out;<br>• Provision of vent pipes to vent off the accumulated methane gas in areas with high concentrations of methane gas.<br><br>Protection measures for individual developments or buildings to minimise biogas risks:<br>• Use of a porous fill material to allow the generated methane gas to migrate from underground to the surface of the fill material;<br>• Installation of a gas collection layer for methane gas collection;<br>• Provision of low gas permeability sealant and low permeability physical barriers to prevent methane gas from entering the buildings in the future developments;<br>• Installation of a membrane with low gas permeability in the floor slab of buildings including underground car parks and rooms to prevent ingress of methane gas;<br>• Sealing of openings in the floor;<br>• Installation of vent pipes to vent off the collected methane gas;<br>• Provision of passive barriers and passive ventilation systems; and<br>• Providing sufficient ventilation within buildings to avoid accumulation of methane gas. |
| Ground Improvement | Ground improvements methods may include:<br>• Pre-loading and installation of vertical drains;<br>• Soil mixing such as Deep Cement Mixing;<br>• Vibroreplacement / vibrodisplacement; and<br>• Lime columns.<br><br>Site trials may be required to determine the suitability of the selected method. |
| Protection Measures to Minimise Dredging Impacts | • Provision of silt curtains<br>• Carrying out water quality monitoring near the dredging areas<br>• Controlling the loading of the dredged sediments to the barge to avoid splashing and overflowing of the sediment slurry to the surrounding water<br>• Minimising exposure to the contaminated sediments<br>• The workers should wear protective gloves when carrying out the dredging work<br>• Adequate washing and cleaning facilities should be provided on site<br>• The dredged sediments should be transferred from the barge to the sediment washing unit immediately after dredging when ex-situ treatment is undertaken<br>• Storage of the dredged sediments should be avoided<br>• The dredged sediments should be segregated from other wastes |
| Mitigation measures to minimise odour impacts | *Ex-situ* Treatment is adopted:<br>• In-pipe injection of strong oxidant, i.e. Fentons' Reagent, to reduce much of the AVS<br>• Use of suction dredging to remove the sediments under water<br>• Provision of suitable enclosures in the *ex-situ* treatment plants to minimise odour emission<br>*In-situ* Treatment is adopted:<br>• Carrying out reclamation first then implementing *in-situ* treatment when required. |