Civil Engineering and Development Department

Agreement No. CE2/2018(CE) Study for Pier Improvement at Lai Chi Wo and Tung Ping Chau - Investigation

Sediment Sampling and Testing Plan for Pier Improvement at Lai Chi Wo

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1 Introduction

1.1 Project Background

1.1.1 Hong Kong is an international metropolis and comprises many natural scenic spots, rare geological features and hiking trails with rich biological diversity. The famous Hong Kong UNESCO Global Geopark, marine parks, old temples, eco-tourism sites and beautiful beaches in coastal areas are some examples. Many attractions are located at remote rural areas without land access and rely on marine transport. In recent years, number of tourists attracted to these remote destinations has been constantly increasing. These remote destinations can be accessed by waterborne transport at public piers.

1.1.2 Although the Government departments carry out regular inspection and maintenance for the remote pubic piers to ensure its structural integrity, some public piers at remote rural areas are in places for many years and cannot cope with the current needs/usages, such as:

(a) Small or primitive piers leading to safety concerns during berthing and unsatisfactory boarding condition especially for kids and elderly;

(b) Inadequate water depth for berthing of vessels, in particular during low tide;

(c) Limited berthing space or narrow accesses which cannot accommodate the fluctuating utilisation during festive times or weekends; and

(d) Aged pied structures with a need for improvement works.

1.1.3 There is a need for pier improvement for improved pier facilities and adequate structural integrity for safe pier usage by local villagers, mariculturists, visitors and tourists.

1.2 EIA Study Brief

1.2.1 The Project Profile (No. PP-561/2017) for the proposed pier improvement at Lai Chi WO was submitted by the Project Proponent – Pier Improvement Unit (PIU), Civil Engineering Office, Civil Engineering and Development Department (CEDD) of the Government of the Hong Kong Special Administrative Region - to the Environmental Protection Department (EPD) for an application for Environmental Impact Assessment (EIA) Study Brief under Section 5(1)(a) of Environmental Impact Assessment Ordinance (EIAO) on 27 December 2017. The public inspection period lasted from 28 December 2017 to 10 January 2018. The EIA Study Brief (EIA Study Brief No.: ESB-305/2017) was formally issued by EPD on 9 February 2018.

1.2.2 The EIA Study Brief sets out the purposes and objectives of the EIA study, the scope of environmental issues which shall be addressed, the requirements that the EIA study to fulfil the necessary procedural and reporting requirements. The Project Proponent shall demonstrate in the EIA report that the criteria in the relevant sections of the Technical Memorandum on Environmental Impact Assessment Process of the EIAO (TM-EIAO) and EIA Study Brief are complied with.

1.3 Objectives of this Document

1.3.1 According to Item 3 in Appendix E of the EIA Study Brief (ESB-305/2017), field investigation, sampling and chemical and biological laboratory tests shall be conducted to characterise and quantify the excavated sediment (approximately 150m^3 to 200m^3 of sediment would be extracted from seabed due to the necessary piling works subject to actual geological conditions and detailed design), and incorporated into the EIA Report for agreement by the Director of Environmental Protection (DEP). This Sediment Sampling and Testing Plan (SSTP) is prepared to seek agreement from EPD on:

- the proposed locations and schedule of marine sediment sampling;
- the specification of chemical test and biological toxicity test of marine sediment samples for the evaluation of waste management under the EIAO process; and
- the specification of elutriate test and pore water test of marine sediment samples for water quality assessment under the EIAO process.

1.3.2 It should be noted that this SSTP only serves the purpose of fulfilling the EIA Study for this Project under the EIAO, and the chemical and biological test results (if any) will be presented in the EIA Report in accordance with Section 3(i), Appendix E of the EIA Study Brief (EIA Study Brief No.: ESB-305/2017). Should there be a need to dredge/ excavate sediment as the Project progresses at the design and construction stage, separate submissions (e.g. Sediment Sampling and Testing Plan (SSTP) and Sediment Quality Report (SQR)) shall be prepared according to the Environment, Transport and Works Bureau Technical Circular (Works) No. 34/2002 “Management of Dredged/Excavated Sediment” (ETWB TC(W) No. 34/2002) for the application for marine dumping permit under the DASO, and submitted to the Director of Environmental Protection (DEP) for approval. The rationale for sediment removal/ disposal shall also be submitted to the Marine Fill Committee (MFC) of CEDD for agreement in accordance with ETWB TC(W) No. 34/2002.

1.4 Nomenclature and Abbreviation

1.4.1 **Table 1.1** lists the abbreviated titles of government bureaux, departments, offices, statutory bodies and public organisations mentioned in this Report

Table 1.1 Abbreviations of bureaux, government departments and organisations

Abbreviations	Full Title
CEDD	Civil Engineering and Development Department
DEP	Director of Environmental Protection
EPD	Environmental Protection Department
HAD	Home Affairs Department
UNESCO	United Nations Educational, Scientific and Cultural Organization
USEPA	United States Environmental Protection Agency

1.4.2 **Table 1.2** lists the abbreviations for expressions adopted in this Report.

Table 1.2 Abbreviations for expressions adopted in this Report

Abbreviations	Full Title
DGIU	Digital Geotechnical Information Unit
EIA	Environmental Impact Assessment
EIAO	Environmental Impact Assessment Ordinance, Cap 499
EM&A	Environmental Monitoring & Audit
EP	Environmental Permit
LCEL	Lower Chemical Exceedance Level
mPD	Metres above Principal Datum
PAH	Polyaromatic Hydrocarbons
SSTP	Sediment Sampling and Testing Plan
TM-EIAO	Technical Memorandum on Environmental Impact Assessment Process
UCEL	Upper Chemical Exceedance Level

2 The Site

2.1.1 Lai Chi Wo Pier is located within Yan Chau Tong Marine Park adjacent to the northeast coast of Plover Cove County Park. Lai Chi Wo was once a prosperous walled village where Hakka people settled about 400 years ago and 500-600 residents were recorded in the most prosperous period.

2.1.2 Lai Chi Wo Pier is a solid concrete finger pier of about 64m long and 2.5m wide, with the pier level at about +3 metres above Principal Datum (mPD). There are 4 pairs of bollards and one light beacon at the head of the pier. It is currently maintained by Home Affairs Department (HAD).

2.1.3 In 2005, repair works at Lai Chi Wo Pier were carried out under Contract No. NC 59 of 2005 commissioned by HAD. The works included removal of shells along the pier, repair of cracks by filling with epoxy mortar, repair and repaint the navigation light tower, installation of 1m high galvanised steel tubular railings and construction of 4 nos. reinforced concrete transverse 400mm (wide) × 400mm (deep) ground beams for fixing bollards. The steps were also repaired by laying 50mm thick no-fines concrete on each step.

2.1.4 However, the existing pier has a relatively narrow access and only one primitive berth. At low tide, there is not adequate water depth for berthing of vessels. Improvement works are considered necessary to improve standards of existing facilities of the pier. The tentative major works items for this pier improvement works at Lai Chi Wo Pier include the following:

- Provision of temporary berthing and mooring facilities using temporary landing pontoon and steel structure supported by piles which serve the public throughout the construction stage (either construct a temporary extension from the existing Lai Chi Wo Public Pier or construct a new temporary pier directly connected to existing footpath subject to further design);
- Modification of the existing pier with pile foundation with a view to extending the pier, widening the catwalk and the pier head;
- Demolition of a portion of the existing pier structure, if necessary; and
- Demolition of temporary berthing and mooring facilities after completion of pier improvement works.

2.1.5 Even though the exact location of the proposed permanent and temporary piers are yet to be determined, they will be within the works area in the vicinity of the existing pier to limit all possible environmental impacts. The locations of the existing pier and the tentative pier improvement works area are shown in **Figure 2.1**.

3 Legislative Requirements

3.1 Legislation and Guidelines

3.1.1 ETWB TC(W) No. 34/2002 sets out the procedure for seeking approval to dredge/ excavate sediment and the management framework for marine disposal of such sediment. It outlines the requirements for sediment quality assessment and provides guidelines for the classification of sediment based on their contaminant levels. It also explains the disposal arrangement for the classified sediment.

3.2 Methodology for Sediment Quality Assessment

3.2.1 The management framework of dredged/excavated sediment in Hong Kong is implemented under a three-tiered approach as illustrated in **Appendix 3.1** in accordance with the ETWB TC(W) No. 34/2002; this also sets out the guidelines for the assessment, sampling, testing and classification of sediment. **Table 3.1** summarises the sediment quality criteria for sediment classification under ETWB TC(W) No. 34/2002.

Table 3.1 Sediment quality criteria for classification of sediment under ETWB TC(W) No. 34/2002

Contaminants	Lower Chemical Exceedance Level (LCEL)	Upper Chemical Exceedance Level (UCEL)
Metals (mg/kg dry wt.)		
Cadmium (Cd)	1.5	4
Chromium (Cr)	80	160
Copper (Cu)	65	110
Mercury (Hg)	0.5	1
Nickel (Ni) [1]	40	40
Lead (Pb)	75	110
Silver (Ag)	1	2
Zinc (Zn)	200	270
Metalloid (mg/kg dry wt.)		
Arsenic (As)	12	42
Organic-PAHs (µg/kg dry wt.)		
Low Molecular Weight PAHs	550	3160
High Molecular Weight PAHs	1700	9600
Organic-non-PAHs (µg/kg dry wt.)		
Total PCBs	23	180
Organometallics (µg TBT/L in Interstitial water)		
Tributyltin [1]	0.15	0.15

Note:
[1] The contaminant level is considered to have exceeded the UCEL if it is greater than the value shown.

3.2.2 The sediment is classified into 3 categories based on its contaminant levels:

Category L — Sediment with all contaminant levels not exceeding the Lower Chemical Exceedance Level (LCEL). The material must be dredged, transported and disposed of in a manner which minimises the loss of contaminants either into solution or by resuspension.

Category M — Sediment with any one or more contaminant levels exceeding the Lower Chemical Exceedance Level (LCEL) and none exceeding the Upper Chemical Exceedance Level (UCEL). The material must be dredged and transported with care, and must be effectively isolated from the environment upon the final disposal unless appropriate biological tests demonstrate that the material will not adversely affect the marine environment.

Category H — Sediment with any one or more contaminant levels exceeding the Upper Chemical Exceedance Level (UCEL). The material must be dredged and transported with great care, and must be effectively isolated from the environment upon the final disposal.

3.2.3 **Tier I Screening** is a desktop screening process to review the available information and determine whether the sediment of concern belonging to Category L material is suitable for open sea disposal. If there is insufficient information to arrive at such conclusion, Tier II chemical screening shall be proceeded accordingly.

3.2.4 **Tier II Screening** is a chemical screening process to categorise sediment based on its chemical contaminant levels and to determine whether the sediment is suitable for open sea disposal without further testing. Upon Tier II screening, the sediment shall be classified as Category L, M or H material. There are three types of disposal options: namely Type 1 for open sea disposal, Type 2 for confined marine disposal and Type 3 for special treatment/disposal respectively. Category L material is suitable for open sea disposal, but Categories M and Category H with one or more contaminant levels exceeding 10 × LCEL will require Tier III screening to further determine the disposal option.

3.2.5 **Tier III Screening** is a biological screening process to identify the most appropriate disposal option for Category M (either Type 1 or 2) and certain Category H sediment (either Type 2 or 3). Sediment classified as Category M shall be subjected to the following three toxicity tests:

- A 10-day burrowing amphipod toxicity test;
- A 20-day burrowing polychaete toxicity test; and
- A 48-96 hours larvae (bivalve or echinoderm) toxicity test.

3.2.6 **Table 3.2** summarises the details of the test endpoints and failure criteria of the three toxicity tests. Sediment classified as Category H and with one or more contaminant levels exceeding 10 times LCEL shall also be subjected to the above three toxicity tests but in a diluted manner (dilution test). In case failure of biological test on Category M material, Type 2 disposal will be required. Similarly, Type 3 disposal will be required for Category H material if biological test is failed.

Table 3.2 Test endpoints and decision criteria for Tier III biological screening under ETWB TC(W) No. 34/2002

Toxicity Test	Endpoints Measured	Test Methods	Failure Criteria
10-day amphipod	Survival	U.S.EPA Standard "Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods", 1994	Mean survival in test sediment is significantly different ($p \leq 0.05$)[1] from mean survival in reference sediment **and** mean survival in test sediment <80% of mean survival in reference sediment.
20-day polychaete worm	Dry Weight[2]	PSEP Standard "Recommended Guidelines for Conducting Laboratory Bioassays on the Puget Sound Sediments – Juvenile Polychaete Sediment Bioassay", 1995	Mean dry weight in test sediment is significantly different ($p \leq 0.05$)[1] from mean dry weight in reference sediment **and** mean dry weight in test sediment <90% of mean dry weight in reference sediment.
48-96 hour larvae (bivalve or echinoderm)	Normality Survival[3]	PSEP Standard Recommended Guidelines for Conducting Laboratory Bioassays on the Puget Sound Sediments – Bivalve Larvae Sediment Bioassay, 1995	Mean normality survival in test sediment is significantly different ($p \leq 0.05$)[1] from mean normality survival in reference sediment **and** mean normality survival in test sediment <80% of mean normality survival in reference sediment.

Notes:
[1] Statistically significant differences should be determined using appropriate two-sample comparisons (e.g., t-tests) at a probability of $p \leq 0.05$.
[2] Dry weight means total dry weight after deducting dead and missing worms.
[3] Normality survival integrates the normality and survival end points, and measures survival of only the normal larvae relative to the starting number.

4 Review of Geological Conditions

4.1.1 The geology of the area around Lai Chi Wo Pier is depicted on the 1:20,000 scale (Sheet No. 4, Kat O Chau, Series HGM20) (Edition I, GEO 1992) and 1: 100,000 scale (Kirk *et al.*, 2000) geological maps published by the Hong Kong Geological Survey, the accompanying geological memoir No. 5 (North Eastern New Territories) (GEO, 1996), as well as the relevant reports and maps prepared for the Geotechnical Area Studies Programme (GASP VIII, GCO, 1988).

4.1.2 As recorded in the 1:20,000 scale geological map (extracted in **Figure 4.1**), the pier is predominantly underlain by coarse ash and crystal tuff of Tai Mo Shan Formation. A sharp interface between this formation and siltstone with sandstone of Sai Lai Kong Formation is noted along an observed fault 20m to the south of the pier, and this might relate to a potentially localised deepened rockhead zone.

4.1.3 The solid geology is predominantly overlain by quaternary marine mud of Hang Hau Formation comprising soft to very soft mud, with estuarine and intertidal deposits in the forms of mud and sand recorded at the central portion of the existing pier.

4.1.4 As revealed by a detailed search from the Digital Geotechnical Information Unit (DGIU), no existing ground investigation or environmental sampling records could be retrieved at the area around Lai Chi Wo Pier. Since there is a lack of available sediment information for estimation of sediment quality and quantity, sediment sampling and testing to be conducted making reference with ETWB TC(W) No. 34/2002 is required for the satisfaction of requirement in the EIA Study Brief.

5 Proposed Marine Sediment Sampling & Testing

5.1 Sediment Sampling

5.1.1 As mentioned in **Section 2**, pile foundation will be required to extend the pier, and to widen the catwalk and the pier head, and sediment might need to be excavated for this pier improvement work. The tentative pier improvement works area as illustrated in **Figure 2.1** is approximately 150m long and 90m wide. No dredging operation will be deployed for the future pier improvement work. Since there is a lack of available sediment quality and quantity data within the vicinity, a 100m × 100m sampling grid is proposed to determine the number of environmental sampling locations required. A total number of 2 sampling locations are proposed based upon tentative pier improvement works area. The proposed sampling locations are shown in **Figure 5.1** and their coordinates are given in **Table 5.1**. The sediment sampling and testing is targeted to commence in mid-2019, upon the agreement of this SSTP.

Table 5.1 Proposed marine sediment sampling locations at Lai Chi Wo

Sampling Locations	Sampling Method	Sampling Depth	Coordinates	
			Easting	Northing
LCW/VC1	Vibrocore Sample	Vibrocore samples collected at Seabed Level, 0.9m, 1.9m, 2.9m, thereafter 3m to the bottom of marine sediment	845235	843313
LCW/VC2			845196	843321

5.1.2 Vibrocore samples will be collected at 0m, 0.9m, 1.9m, 2.9m depths, and thereafter every 3m to the bottom of the marine deposit. The aforesaid sediment quantities to be collected by vibrocores have been confirmed with the testing laboratory.

5.1.3 All collected vibrocore samples will be subjected to Tier II chemical screening. Based on the chemical contaminant levels, sediment will be classified into either Category L, M or H sediment according to the criteria stated in ETWB TC(W) No. 34/2002. Tier III biological screening test will only be implemented for Category M sediment. Sediment classified as Category H and with one or more contaminant levels exceeding 10 × LCEL will also undergo the biological screening test but in a diluted manner (dilution test).

5.1.4 Composite sample shall be prepared for biological screening test (if required) and it shall be mixed from 5 samples of same Category (M or H) in continuous vertical/ horizontal profile. The number of biological screening tests proposed to be undertaken, arrangement for preparing the composite samples and the test species and conditions shall be made reference to ETWB TC(W) No. 34/2002.

5.1.5 In addition, elutriate testing will be performed on all the vibrocore subsamples (refer to **Section 5.3** for details) and pore water testing will be performed on the grab samples (refer to **Section 5.4** for details). If the outcome of this feasibility study ascertains the need for generation of dredged/ excavated sediment, another round of sediment sampling and testing exercise will be conducted at a later stage of the Project under the DASO application process in accordance with ETWB TC(W) No. 34/2002.

5.2 Chemical and Biological Test

5.2.1 Sediment quality will be assessed through laboratory analyses of sediment samples for the chemical and/or biological parameters. The reference sediment (clean sample) (see **Section 5.6** for details) will also be tested for comparison. Based on the chemical contaminant levels, sediment will be classified into either Category L, M or H sediment according to the criteria stated in ETWB TC(W) No. 34/2002. Tier III biological screening test will only be implemented for Category M sediment. Sediment classified as Category H and with one or more contaminant levels exceeding 10 × LCEL will also undergo the biological screening test but in a diluted manner (dilution test). The chemical and biological screening parameters are summarised in **Table 5.2** and **Table 5.3** respectively, and the preparation method for the dilution test is presented in **Table 5.4.**

Table 5.2 Chemical screening parameters for sediment quality assessment

Parameters	Preparation Method *US EPA Method* (i)	Determination Method *US EPA Method* (i)	Reporting Limit (ii)
Metals (mg/kg dry wt.)			
Cadmium (Cd)	3050B	6020A or 7000A or 7131A	0.2
Chromium (Cr)	3050B	6010C or 7000A or 7190	8
Copper (Cu)	3050B	6010C or 7000A or 7210	7
Mercury (Hg)	7471A	7471A	0.05
Nickel (Ni)	3050B	6010C or 7000A or 7520	4
Lead (Pb)	3050B	6010C or 7000A or 7420	8
Silver (Ag)	3050B	6020A or 7000A or 7761	0.1
Zinc (Zn)	3050B	6010C or 7000A or 7950	20
Metalloids (mg/kg dry wt.)			
Arsenic (As)	3050B	6020A or 7000A or 7061A	1
Organic-PAHs (µg/kg dry wt.)			
Low Molecular Weight PAHs+	3550B or 3540C and 3630C	8260B or 8270C	55
High Molecular Weight PAHs++	3550B or 3540C and 3630C	8260B or 8270C	170
Organic-non- PAHs (µg/kg dry wt.)			
Total PCBs+++	3550B or 3540C and 3665A	8082	3
Organometallics (µg TBT/L in interstitial water)			
Tributyltin	Krone *et al.* (1989)* - GC/MS UNEP/IOC/IAEA**	Krone *et al.* (1989)* - GC/MS UNEP/IOC/IAEA**	0.015

Notes:
(i) The preparation and determination methods shown in this table are practicable as confirmed by the testing laboratory.
(ii) The reporting limits shown in this table are the most stringent limits and are practicable as confirmed by the testing laboratory.
(iii) Any methodology for which the laboratory is accredited that will produce equivalent or better results/reporting limits as required may be used subject to approval by DEP.
\+ Low molecular weight PAHs include acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene
++ High molecular weight PAHs include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k] fluoranthen, indeno[1,2,3-c,d]pyrene and benzo[g,h,i]perylene

+++ The reporting limit is for individual PCB congeners. Total PCBs include 2,4' diCB, 2,2',5 triCB, 2,4,4' triCB, 2,2',3,5' tetraCB, 2,2',5,5' tetraCB, 2,3',4,4' tetraCB, 3,3',4,4' tetraCB, 2,2',4,5,5' pentaCB, 2,3,3',4,4' pentaCB, 2,3',4,4',5 pentaCB, 3,3',4,4',5 pentaCB, 2,2',3,3',4,4' hexaCB, 2,2',3,4,4',5' hexaCB, 2,2',4,4',5,5' hexaCB, 3,3',4,4',5,5' hexaCB, 2,2',3,3',4,4',5 heptaCB, 2,2',3,4,4',5,5' heptaCB, 2,2',3,4',5,5',6 heptaCB (ref: the "summation" column of Table 9.3 of Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (The Inland Testing Manual) published by U.S.EPA).
* Krone *et al.* (1989), A method for analysis of butyltin species and measurement of butyltins in sediment and English Sole livers from Puget Sound, Marine Environmental Research 27 (1989) 1-18. Interstitial water to be obtained by centrifuging the sediment and collecting the overlying water.
** UNEP/ICO/IAEA refers to IAEA's Marine Environment Laboratory reference methods. These methods are available free of charge from UNEP/Water or Marine Environmental Studies Laboratory at IAEA's Marine Environment Laboratory. Interstitial water to be obtained by centrifuging the sediment and collecting the overlying water.

Table 5.3 Biological screening* parameters for sediment quality assessment

Toxicity Test	Test Method	Endpoints Measured	Failure Criteria
10-day amphipod	U.S.EPA 600/R-94/025 June 1994 Test Method 100.4	Survival	Mean survival in test sediment is significantly different ($p \leq 0.05$)** from mean survival in reference sediment **and** mean survival in test sediment < 80% of mean survival in reference sediment.
20-day polychaete worm	Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments, PSEP, July 1995	Dry weight***	Mean dry weight in test sediment is significantly different ($p \leq 0.05$)** from mean dry weight in reference sediment **and** mean dry weight in test sediment <90% of mean dry weight in reference sediment.
48-96 hour larvae (bivalve or echinoderm)	Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments, PSEP, July 1995	Normality survival****	Mean normality survival in test sediment is significantly different ($p \leq 0.05$)** from mean normality survival in reference sediment **and** mean normality survival in test sediment <80% of mean normality survival in reference sediment.

Notes:
* Ancillary testing parameters to be analysed for all sediment samples include Moisture Content, Grain Size (<63 µm), Total Organic Carbon, Ammonia (as mg N/L), and Salinity in pore water.
** Statistically significantly differences should be determined using appropriate two-sample comparisons (e.g. t-tests) at a probability of $p \leq 0.05$.
*** Dry weight means total dry weight after deducting dead and missing worms.
**** Normality survival integrates the normality and survival end points, and measures survival of only the normal larvae relative to the starting number.

Table 5.4 Preparation method of dilution test

Sediment Characteristics	Preparation Method
Category H sediment (> 10 × LCEL)	Sample to be mixed with 9 portions of reference sediment

Sediment Characteristics	Preparation Method
Category M sediment or Category H sediment (> 10 × LCEL) suspected of ammonia contamination	Additional set of sample (after dilution for Category H sediment) to be purged# for ammonia removal (for amphipod test only).

Note:
If the ammonia concentration in the overlaying water of the test system is ≥20mg/L, purging of sediment is required. This is performed by replacing the overlying water at a rate of 6 volume replacement / 24 h for 24 hours, and repeated once only if the ammonia level still exceeds 20mg/L.

5.2.2 Only ecologically relevant species should be used for carrying out the biological screening tests. The species to be used for each type of test are summarised in **Table 5.5**.

Table 5.5 Species to be used for biological screening test

Test Type	Species	Reference Test Conditions*
10-day burrowing amphipod toxicity test	*Ampelisca abdita* *Leptocheirus plumulosus* *Eohaustorius estuarius*	U.S.EPA(1994)/PSEP(1995) U.S.EPA(1994) U.S.EPA(1994)/PSEP(1995)
20-day burrowing polychaete toxicity test	*Neanthes arenaceodentata*	PSEP(1995)
48-96 hour larvae (bivalve or echinoderm) toxicity test	Bivalve: *Mytilus* spp. *Crassostrea gigas*	 PSEP(1995) PSEP(1995)
	Echinoderm: *Dendraster excentricus* *Strongylocentrotus* spp.	 PSEP(1995) PSEP(1995)

Note:
* U.S.EPA (U.S. Environmental Protection Agency) 1994. Methods for assessing the toxicity of sediment-associated contaminants with estuarine and marine amphipods. Office of Research and Development. U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/R94/025. PSEP (Puget Sound Estuary Program) 1995. Recommended guidelines for conducting laboratory bioassays on Puget Sound Sediments.

5.3 Elutriate Test

5.3.1 Preparation of elutriate will be conducted in accordance with the Evaluation of Dredged Material proposed for Discharge in Waters of the US – Testing Manual (Inland Testing Manual), USEPA and USACE, 1998. The reference sediment and marine water samples will also be tested for comparison. Analytical methods and reporting limits are given in **Table 5.6**.

5.3.2 For the samples which are subject to elutriate testing, 6L of marine water sample will be required for each sample for the elutriate test as well as the blank test. The water samples will be collected from 1m below the surface, mid-depth and 1m above the seabed at each environmental sampling location.

5.3.3 Elutriate samples will be prepared by sub-sampling approximately 1L of sediment sample combined with unfiltered marine water collected on-site in a sediment-to-water ratio of 1:4 by volume in a pre-cleaned container in the laboratory. The mixture will be stirred for 30 minutes on a platform shaker. After the 30 minutes, the mixture will be allowed to settle for 1 hour and the supernatant will then be siphoned off without disturbing the settled material. The decanted solution will be

centrifuged to remove particulates prior to chemical analysis (approximately 2000 rpm for 30 min, until visually clear).

5.4 Pore Water Test

5.4.1 Preparation of pore water from all grab sediment samples will be conducted in accordance with "Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual, USEPA 2001" (or equivalent). The reference sediment will also be tested for comparison.

5.4.2 All seawater being trapped inside the grab during sampling should be drained out carefully before any further process. After draining out all the seawater, individual grabs will be composited on-site and split into portions for packing for laboratory pore water testing.

5.4.3 Pore water samples will be prepared by sub-sampling approximately 1L of sediment in a pre-cleaned container in the laboratory and centrifuged at rotation speed at 3,000 rpm for 10 minutes. After that, the supernatant will be decanted without disturbing the sediment material. The pore water testing parameters and assessment criteria will be the same as those for elutriate samples. Analytical methods and reporting limits are given in **Table 5.6.**

Table 5.6 Chemical Parameters for Sediment Elutriate and Pore Water Testing

Contaminant of Concern	Instrumentation	Determination Method	Reporting Limit
Cadmium (Cd)	ICP-MS	USEPA 6020A	0.2 µg/L
Chromium (Cr)	ICP-MS	USEPA 6020A	1 µg/L
Copper (Cu)	ICP-MS	USEPA 6020A	1 µg/L
Mercury (Hg)	ICP-AES / CVAAS	USEPA 6010B /APHA3112B	0.05 µg/L
Nickel (Ni)	ICP-MS	USEPA 6020A	1 µg/L
Lead (Pb)	ICP-MS	USEPA 6020A	1 µg/L
Silver (Ag)	ICP-MS	USEPA 6020A	1 µg/L
Zine (Zn)	ICP-MS	USEPA 6020A	10 µg/L
Arsenic (As)	ICP-MS	USEPA 6020A	10 µg/L
Ammonia	FIA	APHA 4500-NH3 H	0.01 mg/L
Nitrite as N	FIA	APHA 4500-NO2 I	0.01 mg-N/L
Nitrate as N	FIA	APHA 4500-NO3 I	0.01 mg-N/L
TKN as N	Kjeldahl	APHA 4500-Norg + NH3 C	0.1 mg-N/L
Total P	Colorimetric	APHA 4500-P B&E	0.1 mg-P/L
Reactive P	FIA	APHA 4500-P G	10 µg-P/L
PAHs (1)	GC-MSD	USEPA 3510C USEPA 3630C USEPA 8270C	0.2 µg/L (individually)
Total PCBs	GC-ECD/GCMSD	USEPA 3510C USEPA 3620B USEPA 8082/8270	0.01 µg/L (for each PCB congener)
Tributyltin (TBT)	GC-MSD	UNEP/IOC/IAEA (2)	0.015 µg/L
Chlorinated Pesticides: Alpha-BHC	GC-MSD/GCECD	USEPA 3510C USEPA 3620B USEPA 8270C	0.2 µg/L (individually)

Contaminant of Concern	Instrumentation	Determination Method	Reporting Limit
Beta- BHC Gamma-BHC Delta-BHC Heptachlor Aldrin (individually) Heptachlor epoxide Endosulfan 1 p,p'-DDE p,p'-DDD p,p'-DDT Endosulfan sulfate		USEPA 8081A	

Notes:
(1) Low Molecular Weight PAHs shall include acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene and phenanthrene. High Molecular Weight PAHs shall include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-c,d]pyrene and benzo[g,h,i]perylene.
(2) UNEP/ICO/IAEA refers to IAEA's Marine Environment Laboratory reference methods.

5.5 Sample Handling and Storage

5.5.1 All sediment samples will be stored at 4ºC during transportation and at the laboratory prior to testing. The sampling bottles and pre-treatment methods will follow the recommendation stipulated in Section 2 (b)(i) of Appendix B of ETWB TC(W) No. 34/2002. All sampling bottles will be labelled with the station number, sample length, diameter and depth, sampling date and time, together with a full description of the sample. The recommended types of sampling bottle and pre-treatment methods are summarized below.

Table 5.7 Recommended Types of Sampling Bottle and Pre-treatment Methods

Parameters to be tested	Sampling Bottle	Pre-treatment Procedure#
Metals and metalloid	High density polyethylene bottles*	USEPA SW-846+ Chapter 3
Organic	Wide mouth Borosilicate glass bottles with Teflon lined lid	USEPA SW-846 Chapter 4
Biological response	Wide mouth Borosilicate glass bottles with Teflon lined lid or high density polyethylene bottles *	USEPA SW-846 Chapter 3 or Chapter 4 as appropriate.

Notes:
* Heavy duty plastic bags may be used for the storage of sediment sample for testing metals, metalloid and biological response.
# Other equivalent methods may be used subject to the approval of DEP.
+ Test methods for evaluating solid waste: physical/chemical methods, SW-846, 3rd edition, United States Environmental Protection Agency.

5.5.2 Sediment samples will be extracted in the laboratory and placed in the appropriate containers directly after the sampling. All samples will be double-bagged and labelled internally and externally with indelible ink. Samples for biological testing

(if any) will be stored in the same manner as described above (including for ancillary parameters).

5.5.3 Samples for chemical testing will be extracted and analysed within 2 weeks to ensure a Tier III Biological Testing Programme (where required) can be developed and commenced within 8 weeks from the date of sampling.

5.6 Reference Samples

5.6.1 Based on the data from EPD's Annual Marine Water Quality Report - *Marine Water Quality in Hong Kong in 2017*, one of the EPD reference marine sampling points at Outer Port Shelter (PS6, E850234, N820057) is proposed to be used as the reference station for the Project. The most recent available test results from EPD on the recovered sediments at sampling point PS6 indicated that the sediments are with all contaminant levels not exceeding the Lower Chemical Exceedance Level (LCEL), as defined in ETWB TC(W) No. 34/2002, which means the sediment could be classified as Category L. The location of reference sample and excerpts of the published marine sediment testing results at PS6 are given in **Appendix 5.1**.

5.6.2 Modified Van Veen grab (or equivalent) of capacity ~2L will be deployed from vessel and reference sediment (surface grab) of ~30L will be collected at Port Shelter. The samples will be stored at 4ºC during transportation and at the laboratory prior to testing.

5.7 QA/QC Requirements

5.7.1 Field logs and site diary will be maintained for all on-site sampling works with date, equipment used, site activities and observations, undertaken as far as possible. Any deviation from the standard procedures with reasons will be recorded in the logs.

5.7.2 Laboratory QA/QC requirements, including analyses by HOKLAS accredited laboratory, certified reference materials, spike recovery, blank samples, duplicate samples (for every 20 samples), negative/positive control for biological test, etc. will be strictly complied.

6 Conclusion

6.1.1 This SSTP summarises the ranges of parameters to be analysed; the number, type and methods of sampling; sample preservation; chemical and biological laboratory test methods to be used for the categorization of possible dredged/ excavated sediment. The subsequent chemical and biological test results (if any) will be presented in the EIA Report in accordance with Section 3(i), Appendix E of the EIA Study Brief (EIA Study Brief No.: ESB-305/2017).

6.1.2 Nevertheless, should there be a need to dredge/ excavate sediment as the Project progresses at the design and construction stage, separate submissions (e.g. SSTP and Sediment Quality Report (SQR)) shall be prepared according to the ETWB TC(W) No. 34/2002 for the application for marine dumping permit under the DASO, and submitted to the DEP for approval. The rationale for sediment removal/ disposal shall also be submitted to the MFC of CEDD for agreement in accordance with ETWB TC(W) No. 34/2002.

References

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[5] Geotechnical Control Office (GCO) (1996). Geology of the North Eastern New Territories. Hong Kong Geological Survey Memoir No. 5, Geotechnical Engineering Office, Hong Kong, 144 p.

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[7] Kirk, P.A., Sewell, R.J., Campbell, S.G., Fletcher, C.N., Lai, K.W. & Li, X.C. (2000). Geological Map of Hong Kong. Series HGM100, Scale 1:100,000. Hong Kong Geological Survey, Geotechnical Engineering Office, Hong Kong.

[8] Krone et al. (1989). A Method for Analysis of Butyltin Species and Measurement of Butyltins in Sediment and English Sole livers from Puget Sound. Marine Environmental Research 27 (1989) 1-18.

[9] Puget Sound Estuary Program (PSEP) (1995). Recommended guidelines for conducting laboratory bioassays on Puget Sound Sediments

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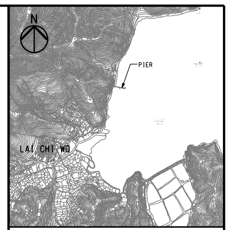
Figures



KEY PLAN N.T.S.

LEGEND
TENTATIVE PIER IMPROVEMENT WORKS AREA

Rev	Description	By	Date
B	SECOND ISSUE	GL	04/19
A	FIRST ISSUE	GL	09/18

Consultant
ARUP

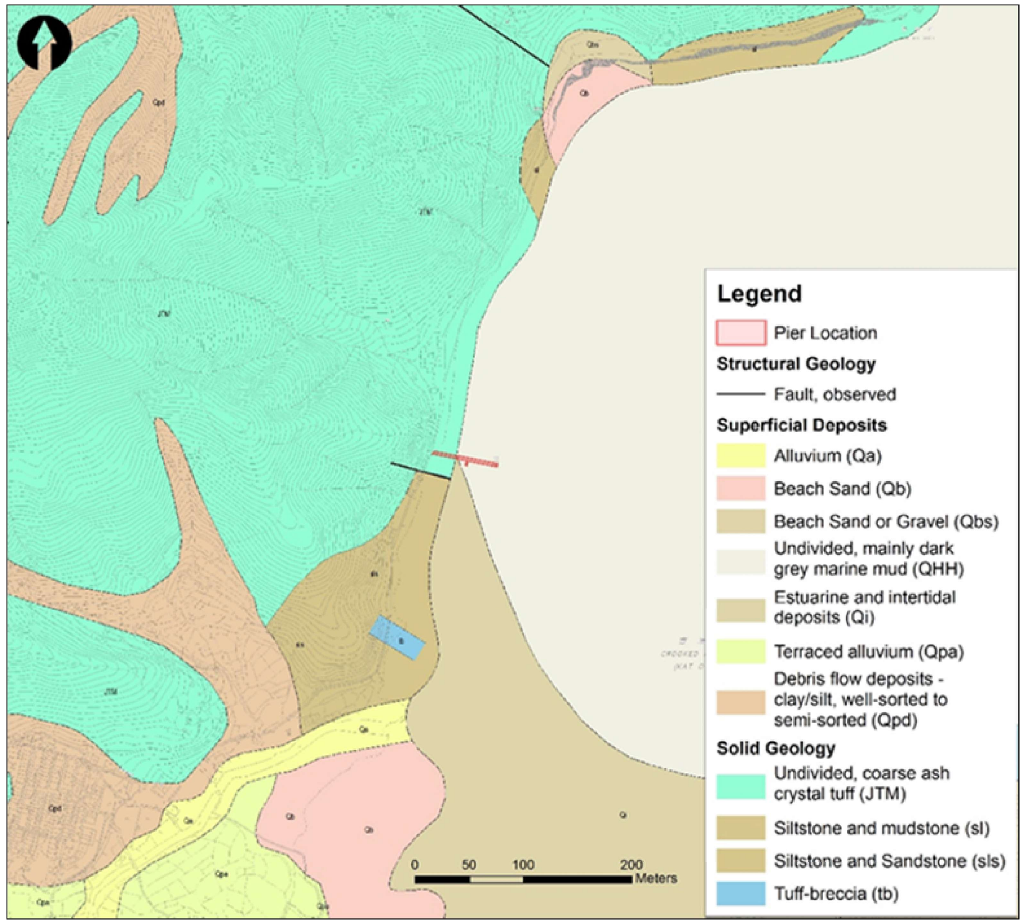
Project title
Agreement No. CE 2/2018 (CE)
Study for Pier Improvement at Lai Chi Wo and Tung Ping Chau - Investigation

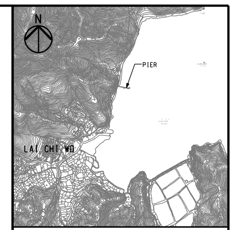
Drawing title
LOCATION OF PROJECT

Drawing no.		Rev.	
FIGURE 2.1		B	
Drawn: GL	Date: 04/19	Checked: LK	Approved: FC
Scale: 1:1000 @ A3		Status: PRELIMINARY	

土木工程拓展署
Civil Engineering and Development Department

Printed by: HKGTRAD14 4/3/2019
Filename: \\HKGNTS21\EnV\env\project\262945\03 Drawing Deliverables\Reports\03 SSTP\Figure 2.1 - Location of Project_v1.dgn





KEY PLAN N.T.S.

Rev	Description	By	Date
A	FIRST ISSUE	GL	09/18

Consultant
ARUP

Project title
Agreement No. CE 2/2018 (CE)
Study for Pier Improvement at Lai Chi Wo and Tung Ping Chau - Investigation

Drawing title
EXTRACT OF 1:20000 SCALE GEOLOGICAL MAP OF LAI CHI WO PIER

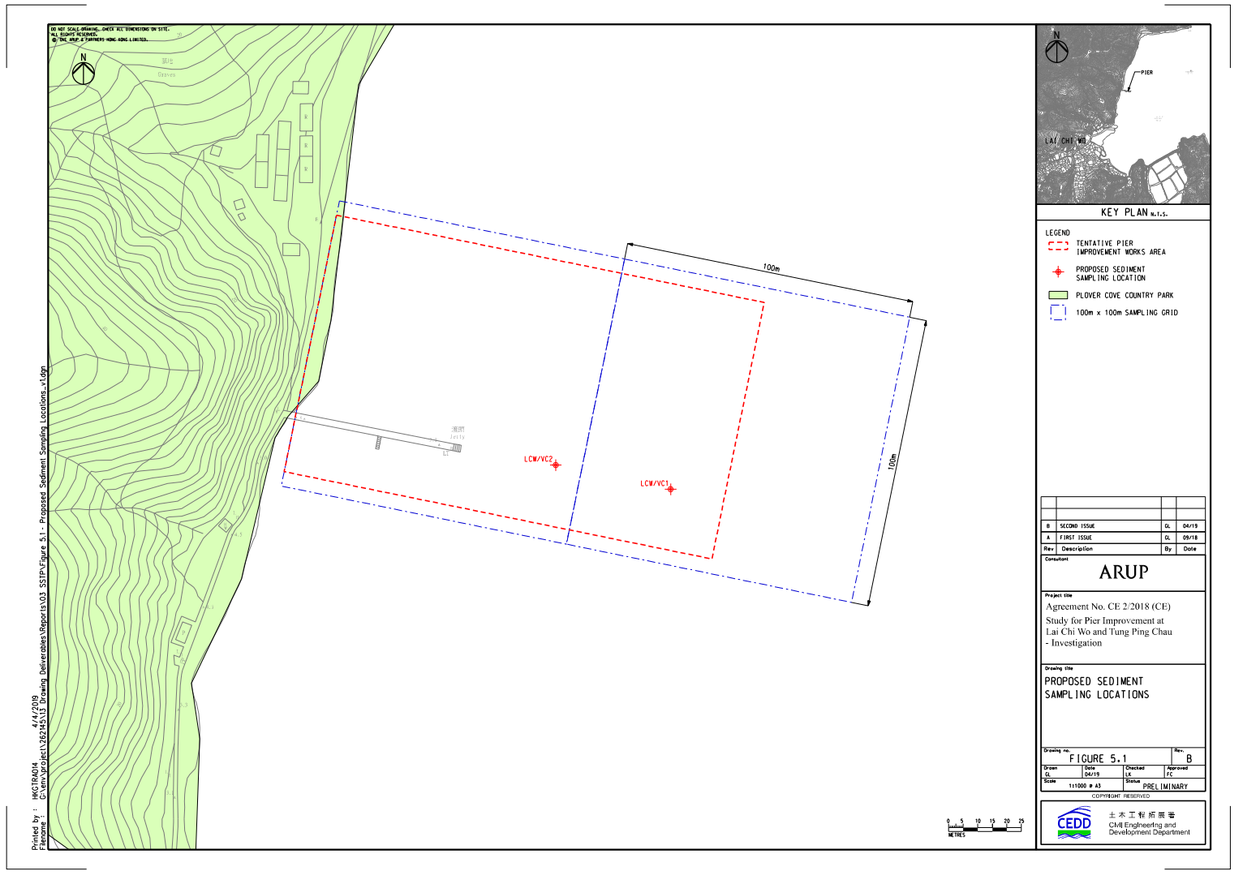
Drawing no.		Rev.	
FIGURE 4.1		A	
Drawn: GL	Date: 09/18	Checked: LK	Approved: FC
Scale: N.T.S.		Status: PRELIMINARY	

土木工程拓展署
Civil Engineering and Development Department

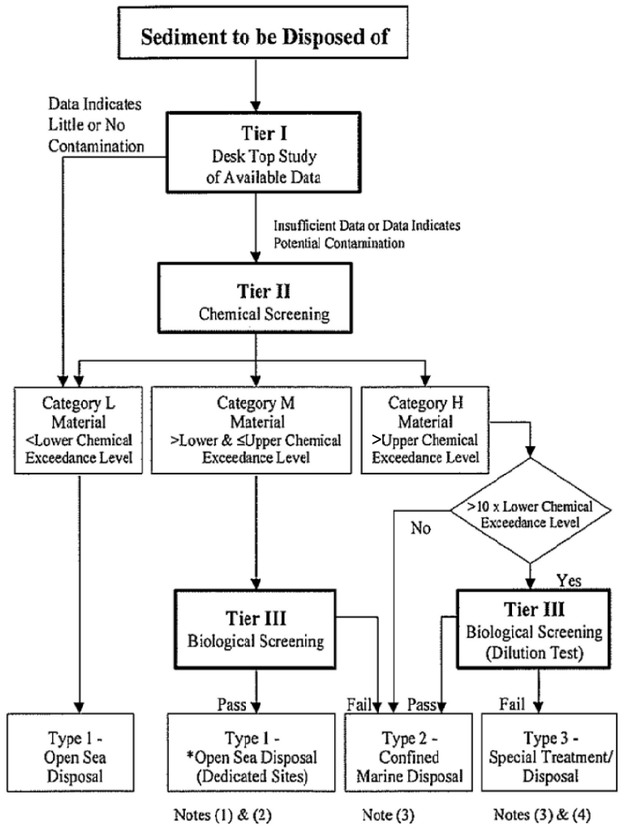
Printed by: HKGTRAD14 9/4/2018
Filename: \\HKGNTS21\EnV\env\project\262945\03 Drawing Deliverables\Reports\03 SSTP\Figure 4.1 - Extract of 1 to 20,000 scale geological map of Lai Chi Wo Pier.dgn

Appendix 3.1

Management Framework for Dredged/Excavated Sediment



Management Framework for Dredged/Excavated Sediment



Notes

(1) Most open sea disposal sites are multi-user facilities and as a consequence their management involves a flexibility to accommodate varying and unpredictable circumstances. Contract documents should include provisions to allow the same degree of flexibility should it be necessary to divert from one disposal site to another during the construction period of a contract.

(2) Dedicated Sites will be monitored to confirm that there is no adverse impact.

(3) For sediment requiring Type 2 or Type 3 disposal, contract documents shall state the allocation conditions of MFC and Director of Environmental Protection (DEP). At present, East Sha Chau mud pits are designated for confined marine disposal.

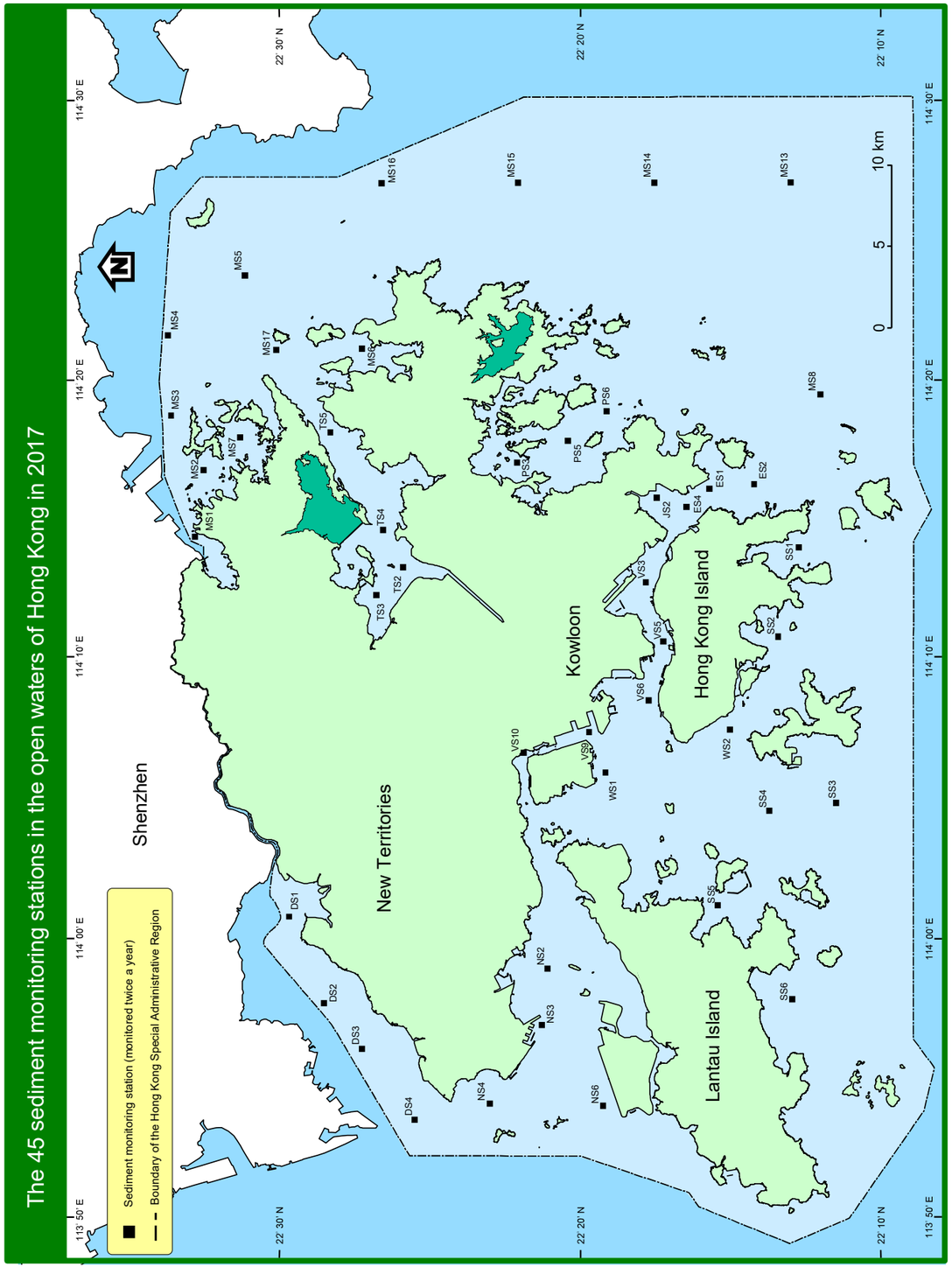
(4) If any sediment suitable for Type 3 disposal (Category H sediment failing the biological dilution test) is identified, it is the responsibility of the project proponent, in consultation with DEP, to identify and agree with him/her, the most appropriate treatment and/or disposal arrangement. Such a proposal is likely to be very site and project specific and therefore cannot be prescribed. This will not preclude treatment of this sediment to render it suitable for confined marine disposal.

(5) The allocation of disposal space may carry a requirement for the project proponent to arrange for chemical analysis of the sediment sampled from 5% of the vessels en-route to the disposal site. For Category M and certain Category H sediment, the chemical tests will be augmented by biological tests. Vessel sampling will normally entail mixing five samples to form a composite sample from the vessel and undertaking laboratory tests on this composite sample. All marine disposal sites will be monitored under the general direction of the Civil Engineering Department. However, exceptionally large allocations might require some additional disposal site monitoring. These will be stipulated at the time of allocation.

(6) Trailer suction hopper dredgers disposing of sediment at East Sha Chau mustuse a down-a-pipe disposal method, the design of which must be approved in advance by DCE. The dredging contractor must provide equipment for such disposal.

Appendix 5.1

Relevant EPD's Sediment Monitoring Results



Summary statistics for bottom sediment quality in the Port Shelter and Mirs Bay WCZs, 2013 - 2017

	Inner Port Shelter	Outer Port Shelter		Starling Inlet	Crooked Island		Port Island	Mirs Bay (North)
Parameter	PS3	PS5	PS6	MS1	MS2	MS7	MS17	MS3
Number of samples	10	10	10	10	10	10	10	10
Particle Size Fractionation <63µm (%w/w)	85 (12 - 97)	63 (39 - 85)	77 (56 - 90)	90 (60 - 99)	96 (88 - 99)	93 (86 - 99)	93 (85 - 98)	81 (67 - 94)
Electrochemical Potential (mV)	-302 (-399 - -96)	-278 (-407 - -86)	-276 (-400 - -86)	-274 (-395 - -143)	-330 (-401 - -155)	-349 (-415 - -235)	-272 (-388 - -131)	-274 (-395 - -104)
Total Solids (%w/w)	36 (32 - 39)	50 (40 - 61)	50 (45 - 54)	39 (37 - 43)	33 (30 - 38)	31 (26 - 36)	34 (30 - 38)	43 (36 - 49)
Total Volatile Soilds (%TS)	12.1 (11.0 - 13.0)	8.9 (6.6 - 12.0)	8.8 (7.6 - 10.0)	7.6 (6.7 - 8.4)	9.3 (8.6 - 10.0)	11.3 (9.9 - 15.0)	9.8 (8.8 - 11.0)	8.0 (6.4 - 8.9)
Chemical Oxygen Demand (mg/kg)	14900 (10000 - 18000)	11850 (7400 - 17000)	11760 (9600 - 14000)	14100 (11000 - 17000)	16100 (13000 - 21000)	16900 (13000 - 21000)	13940 (8400 - 17000)	13230 (8300 - 20000)
Total Carbon (%w/w)	1.1 (1.0 - 1.3)	1.6 (1.1 - 2.4)	1.4 (1.1 - 1.7)	0.5 (<0.1 - 0.8)	0.7 (0.5 - 0.8)	0.8 (0.6 - 1.0)	0.8 (0.5 - 1.1)	0.8 (0.4 - 1.3)
Ammonical Nitrogen (mg/kg)	7.82 (1.90 - 12.00)	5.52 (3.50 - 9.50)	6.03 (3.30 - 8.90)	7.55 (4.00 - 8.80)	10.53 (8.10 - 17.00)	10.56 (7.20 - 13.00)	8.70 (7.10 - 11.00)	8.69 (2.60 - 18.00)
Total Kjeldahl Nitrogen (mg/kg)	720 (310 - 1000)	610 (510 - 730)	670 (570 - 770)	530 (390 - 620)	660 (570 - 770)	690 (520 - 800)	700 (590 - 880)	510 (400 - 610)
Total Phosphorus (mg/kg)	210 (190 - 240)	220 (190 - 280)	250 (210 - 280)	190 (170 - 200)	190 (180 - 220)	200 (170 - 240)	220 (190 - 280)	200 (150 - 220)
Total Sulphide (mg/kg)	43.2 (22.0 - 69.0)	16.3 (2.1 - 33.0)	36.2 (24.0 - 54.0)	31.4 (2.7 - 88.0)	72.2 (34.0 - 150.0)	69.0 (1.3 - 180.0)	32.0 (5.7 - 67.0)	51.5 (1.3 - 170.0)
Total Cyanide (mg/kg)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.3)	0.2 (<0.1 - 0.2)	0.2 (<0.1 - 0.2)	0.1 (<0.1 - 0.3)	0.1 (<0.1 - 0.3)
Arsenic (mg/kg)	5.7 (3.6 - 7.8)	4.9 (3.2 - 6.1)	6.0 (5.2 - 7.2)	8.6 (7.1 - 9.7)	7.8 (6.0 - 10.0)	7.0 (5.8 - 7.8)	6.6 (5.1 - 8.2)	6.2 (4.5 - 8.4)
Cadmium (mg/kg)	<0.1 (<0.1 - 0.1)	<0.1 (<0.1 - <0.1)	<0.1 (<0.1 - <0.1)	0.2 (<0.1 - 0.3)	0.3 (0.3 - 0.4)	0.4 (0.2 - 0.5)	<0.1 (<0.1 - <0.1)	<0.1 (<0.1 - 0.1)
Chromium (mg/kg)	24 (16 - 29)	20 (14 - 31)	24 (21 - 28)	31 (26 - 36)	34 (30 - 39)	31 (25 - 34)	32 (26 - 37)	25 (21 - 33)
Copper (mg/kg)	20 (10 - 23)	10 (6 - 16)	11 (9 - 13)	22 (14 - 27)	23 (19 - 27)	21 (13 - 26)	16 (12 - 18)	11 (8 - 15)
Lead (mg/kg)	36 (21 - 44)	26 (18 - 38)	31 (24 - 40)	44 (31 - 54)	46 (34 - 51)	41 (27 - 50)	42 (34 - 46)	28 (20 - 34)
Mercury (mg/kg)	0.09 (0.06 - 0.11)	0.05 (<0.05 - 0.06)	0.05 (<0.05 - 0.07)	0.06 (<0.05 - 0.07)	0.06 (<0.05 - 0.09)	0.07 (<0.05 - 0.11)	0.05 (<0.05 - 0.07)	0.05 (<0.05 - 0.06)
Nickel (mg/kg)	16 (11 - 19)	14 (10 - 21)	17 (15 - 20)	18 (15 - 20)	22 (18 - 25)	21 (17 - 25)	22 (18 - 26)	16 (13 - 20)
Silver (mg/kg)	<0.2 (<0.2 - 0.2)	<0.2 (<0.2 - 0.2)	<0.2 (<0.2 - <0.2)	0.4 (<0.2 - 0.8)	0.3 (0.2 - 0.3)	0.2 (<0.2 - 0.3)	0.2 (<0.2 - 0.3)	<0.2 (<0.2 - <0.2)
Zinc (mg/kg)	100 (55 - 130)	73 (43 - 110)	77 (61 - 100)	100 (82 - 130)	110 (89 - 130)	98 (82 - 110)	97 (75 - 110)	69 (56 - 89)
Total Polychlorinated Biphenyls (PCBs) (µg/kg) [3]	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg) [4][6]	140 (90 - 230)	110 (90 - 150)	140 (90 - 330)	140 (90 - 210)	170 (90 - 360)	160 (90 - 320)	110 (90 - 180)	130 (90 - 340)
High Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg) [5][6]	75 (32 - 160)	39 (18 - 78)	47 (18 - 91)	50 (24 - 90)	58 (26 - 88)	89 (31 - 270)	55 (31 - 140)	41 (20 - 66)

Note:
1. Data presented are arithmetic means ; data in brackets indicate ranges.
2. All data are based on the analyses of bulk (unsieved) sediment and are reported on a dry weight basis unless stated otherwise.
3. Total PCBs results are derived from the summation of 18 congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.
4. Low molecular weight polyaromatic hydrocarbons (PAHs) include 6 congeners of molecular weight below 200, namely : Acenaphthene, Acenaphthylene, Anthracene, Flourene, Naphthalene and Phenanthrene.
5. High molecular weight polyaromatic hydrocarbons (PAHs) include 10 congeners of molecular weight above 200, namely : Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene.
6. Low and high molecular weight PAHs results are derived from the summation of the corresponding congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.