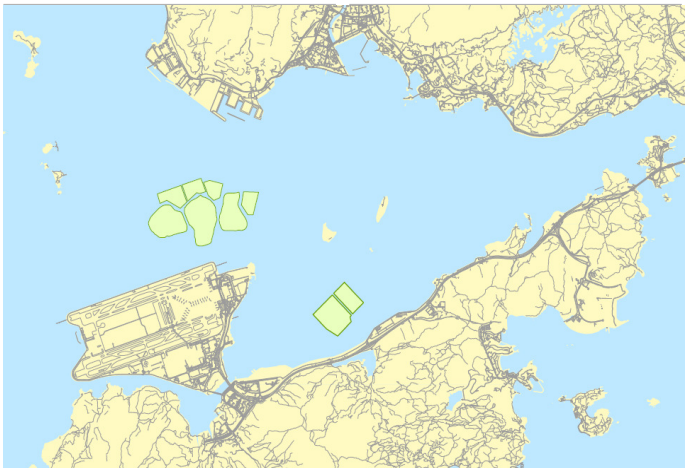


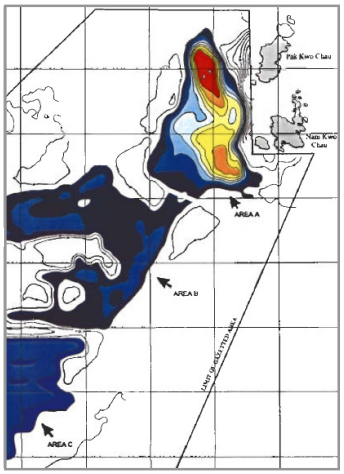



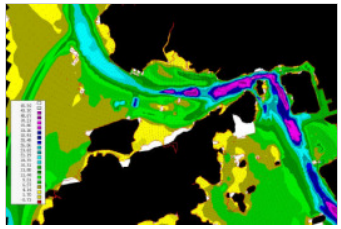

CEDD 土木工程拓展署
Civil Engineering and Development Department

Environmental Monitoring and Audit for Contaminated Mud Pits to the South of The Brothers and at East Sha Chau (2012-2017) – Investigation

Agreement No. CE 23/2012(EP)

Environmental Monitoring and Audit (EM&A) Manual

Final First Review

7 November 2012

Environmental Resources Management
16/F, DCH Commercial Centre
25 Westlands Road
Quarry Bay, Hong Kong
Telephone (852) 2271 3000
Facsimile (852) 2723 5660
www.erm.com

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Environmental Monitoring and Audit for Contaminated Mud Pits to the South of The Brothers and at East Sha Chau (2012-2017) – Investigation

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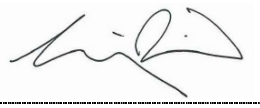
Final First Review

Document Code: 0175086_EM&A Manual_v1.doc

Environmental Resources Management

16/F
DCH Commercial Centre
25 Westlands Road
Quarry Bay
Hong Kong
Telephone: (852) 2271 3000
Facsimile: (852) 2723 5660
E-mail: post.hk@erm.com
http://www.erm.com

Client: Civil Engineering and Development Department (CEDD)	Project No: 0175086
Summary: This document presents the environmental monitoring and audit requirements for Contaminated Mud Pits at the South of The Brothers.	Date: 7 November 2012 Approved by:  Craig A. Reid *Partner*

Revision	Description	By	Checked	Approved	Date
V1	EM&A Manual (Final First Review)	RC	JT	CAR	7/11/12
V0	EM&A Manual (Draft First Review)	RC	CAR	CAR	18/09/12

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Dredging, Management and Capping of Contaminated Sediment Disposal Facility to the South of The Brothers

Environmental Certification Sheet
EP-427/2011/A

Reference Document/Plan

Document/~~Plan~~ to be ~~Certified~~ / Verified:	Environmental Monitoring and Audit (EM&A)
Date of Report:	7 November 2012
Date prepared by ET:	7 November 2012
Date received by IA:	7 November 2012

Reference EP Condition

Environmental Permit Condition: Condition No.: 2.5

The Permit Holder shall no later than one month before commencement of construction of the Project submit to the Director for approval 4 hard copies and 1 electronic copy of an updated EM&A Manual for the Project. Before submission to the Director, the updated EM&A Manual shall be certified by the ET Leader and verified by the Independent Auditor as conforming to the information and recommendations contained in the EIA Review Report attached to the application for Environmental Permit (Application No. AEP-427/2011).

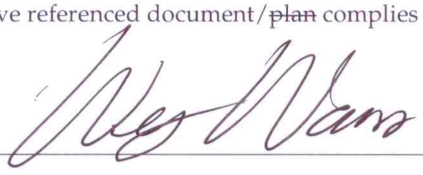
ET Certification

I hereby certify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-427/2011/A

Craig A. Reid,
Environmental Team Leader:  Date: 7/11/2012

IA Verification

I hereby verify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-427/2011/A

Dr Wang Wen Xiong,
Independent Auditor:  Date: Nov. 8, 2012

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

Since early 1990s, contaminated sediment (1) arising from various construction works in Hong Kong has been disposed of at a series of seabed pits at East of Sha Chau (ESC). In late 2008, a review indicated that the existing and planned facilities at ESC would not be able to meet the disposal demand after 2012. In order to meet this demand, the HKSAR Government decided to implement a new contained aquatic disposal (CAD) (2) facility at the South of The Brothers (SB) (hereafter referred to as "the Project") which had been under consideration for a number of years.

The environmental acceptability of the construction and operation of the Project had been confirmed by findings of the associated Environmental Impact Assessment (EIA) study completed in 2005 under *Agreement No. CE 12/2002(EP)* (3). The Director of Environmental Protection (DEP) approved this EIA report under the *Environmental Impact Assessment Ordinance (Cap. 499) (EIAO)* in September 2005 (EIA Register No.: AEIAR-089/2005).

In accordance with the EIA recommendation, prior to commencement of construction works, the Civil Engineering and Development Department (CEDD) undertook a detailed review and update of the EIA findings for the SB site (4) approved, in principle, under *Agreement No. CE 12/2002(EP)* and the *EIAO* to assess for the EIA's relevance. Findings of the EIA review undertaken in 2009/ 2010 confirmed that the construction and operation of the SB site had been predicted to be environmentally acceptable.

An Environmental Permit (EP-427/2011) was issued by the Environmental Protection Department (EPD) to the CEDD, the Permit Holder, on 3 November 2011 and varied on 23 December 2011 (EP-427/2011/A).

Under the requirements of Condition 4 of the EP (EP-427/2011/A), an EM&A programme as set out in the Manual is required to be implemented.

(1) According to the Management Framework of Dredged/ Excavated Sediment of ETWB TC(W) No. 34/2002, contaminated sediment in general shall mean those sediment requiring Type 2 – Confined Marine Disposal as determined according to this TC(W).

(2) CAD options may involve use of excavated borrow pits, or may involve purpose-built excavated pits. CAD sites are those which involve filling a seabed pit with contaminated mud and capping it with uncontaminated material such that the original seabed level is restored and the contaminated material is isolated from the surrounding marine environment.

(3) Detailed Site Selection Study for a Proposed Contaminated Mud Disposal Facility within the Airport East/ East of Sha Chau Area (Agreement No. CE 12/2002(EP))

(4) Under the CEDD study *Contaminated Sediment Disposal Facility to the South of The Brothers (Agreement No. FM 2/2009)*

1.2 PURPOSE OF THE MANUAL

This Environmental Monitoring and Audit (EM&A) Manual ("the Manual") has been prepared by ERM-Hong Kong, Limited (ERM) on behalf of CEDD.

The purpose of the Manual is to provide information, guidance and instruction to personnel charged with environmental duties and those responsible for undertaking EM&A work during the construction and operation of the Project. It provides systematic procedures for monitoring and auditing of potential environmental impacts that may arise from the works.

In preparing this EM&A Manual for the SB Facility, reference has been made to the *Technical Memorandum of the Environmental Impact Assessment Process (EIAO TM)*, the approved EIA Report *(EIAO Register Number: AEIAR-089/2005)* and EM&A Manual for this Project [(1)], the EIA Review Report prepared under the CEDD study *Contaminated Sediment Disposal Facility at South of Brothers (Agreement No. FM 2/2009)*, and the EM&A Manual for the existing contaminated sediment disposal facility at ESC (submitted under the *Environment Permit No. EP-312/2008/A*).

1.3 PROJECT DESCRIPTION

1.3.1 Project Scope

The proposed SB Facility is classified as a Designated Project by virtue of the following items of Item C (Reclamation, Hydraulic and Marine Facilities, Dredging and Dumping), Part I of Schedule 2 under EIAO:

- Item C.10 – A Marine Dumping Area; and
- Item C.12 – A dredging operation exceeding 500,000 m^3.

The Project involves the sequential dredging, disposal of contaminated mud into, and subsequent capping of the two dredged pits. *Figure 1.1* presents the location of the proposed site at SB. The key components of the facility include the following:

- Dredging of two seabed pits (CMP 1 and CMP 2) *sequentially* within the proposed SB Facility Boundary;
- Backfilling each dredged pit *sequentially* with contaminated mud that has been classified as requiring Type 2 disposal in accordance with *ETWB TC(W) No. 34/2002*; and

(1) The EIA Report for *New Contaminated Mud Marine Disposal Facility at Airport East / East Sha Chau Area* was prepared under the CEDD consultancy *Detailed Site Selection Study for a Proposed Contaminated Mud Disposal Facility within the Airport East/ East of Sha Chau Area (Agreement No. CE 12/2002(EP))*

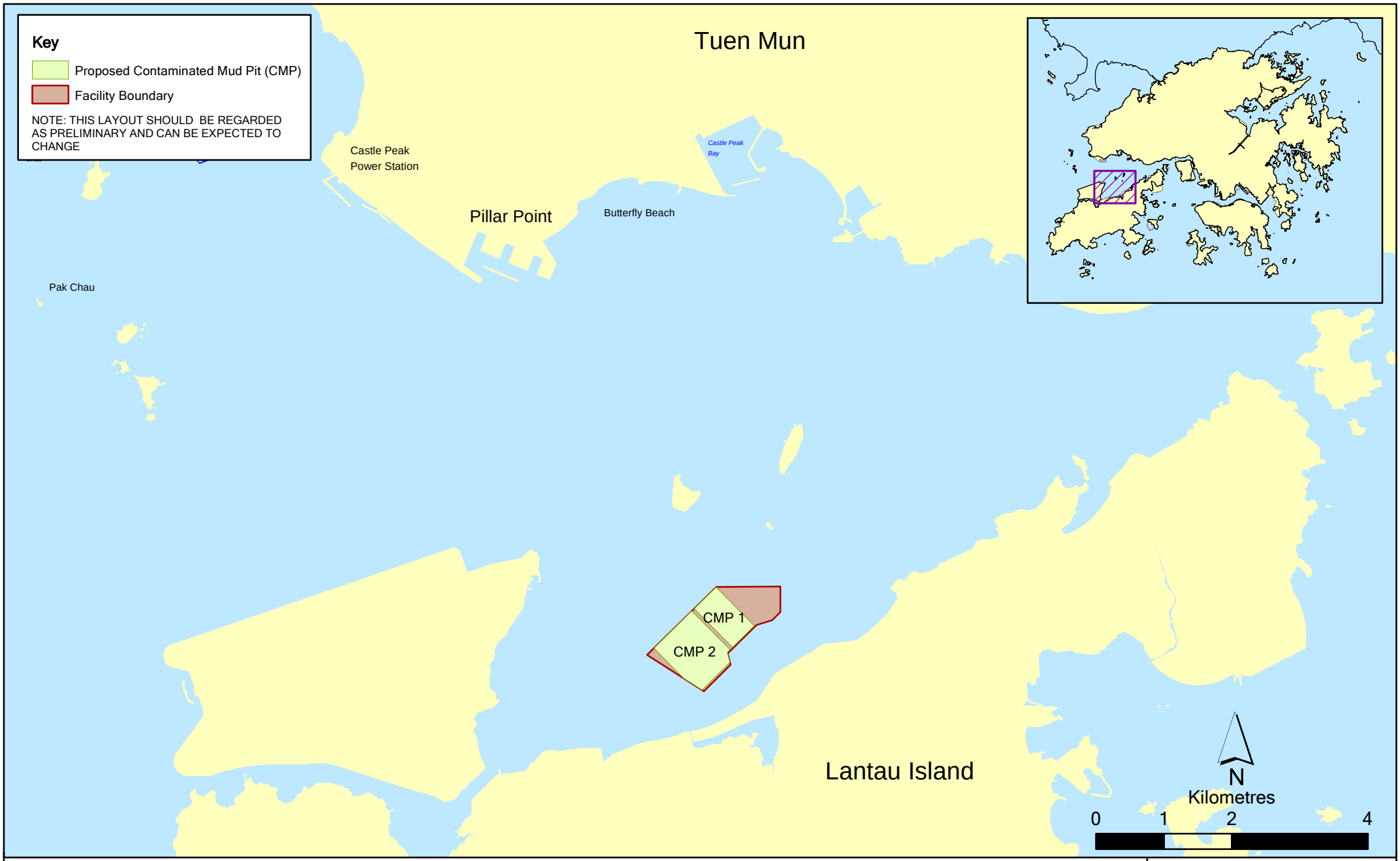


Figure 1.1

Tentative Layout of the Proposed Contaminated Sediment Disposal Facility at South of Brothers

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Date: 14-Sep-12

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- Capping each backfilled pit *sequentially* with uncontaminated material effectively isolating the contaminated mud from the surrounding marine environment.

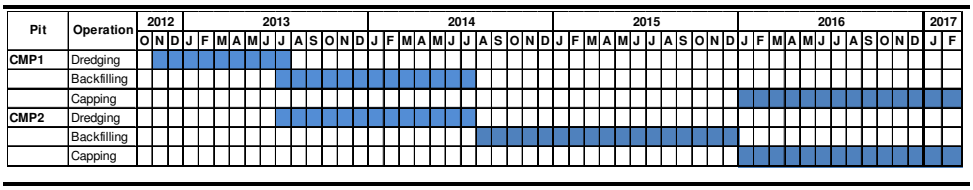
These components constitute the construction and operation phases of the SB CAD facility. They are the subject of the EM&A programme.

1.3.2 Project Programme

Preliminary works programme indicate that the SB Facility will be put into service in phases in 2012. The first pit (CMP 1) is expected to be dredged in November 2012 in order to be ready to receive contaminated mud in mid 2013. According to arisings estimates the second pit (CMP 2) at the SB facility will be backfilled starting in mid 2014. It should be noted that should the rate at which contaminated mud arises change (either increasing or decreasing) then SB CMPs may be capped earlier or later than early 2016.

The tentative project programme is presented in *Figure 1.2*. It should be noted that the timeline presents predicted timeframes for each works component.

Figure 1.2 Indicative Works Programme at the South of The Brothers Facility



1.4 OBJECTIVES OF THE EM&A PROGRAMME

The broad objective of this EM&A Manual is to define the procedures of the EM&A programme for monitoring the environmental performance of the Project during construction and operation. The construction and operational impacts resulting from the implementation of the SB Facility are specified in the EIA Report and the subsequent EIA Review Report. These Reports also specify mitigation measures that need to be implemented to confirm compliance with the required environmental criteria. These mitigation measures and their implementation requirements are presented in the *Implementation Schedule* (*Annex A*).

The EIA recommends that environmental monitoring will be necessary to assess the effectiveness of measures implemented to mitigate potential water quality, marine ecology and fisheries impacts during the construction and operation of the proposed facility. Regular environmental auditing is also recommended to confirm that potential impacts from other sources are adequately addressed through the implementation of the mitigation measures defined in the EIA/ EIA Review Reports.

The objectives of the EM&A programme are as follows:

1) To monitor and report on the environmental impacts of the dredging operations associated with the construction of the disposal pits;

2) To monitor and report on the environmental impacts due to capping operations of the exhausted pits;

3) To monitor and report on the environmental impacts of the disposal of contaminated marine sediments in the active pits and specifically to determine:

    a. changes/trends caused by disposal activities in the concentrations of contaminants in sediments adjacent to the pits;

    b. changes/trends caused by disposal activities in the toxicity of sediment adjacent to the pits;

    c. changes/trends caused by disposal activities in the concentrations of contaminants in tissues of demersal marine life adjacent to and remote from the pits;

    d. impacts on water quality and benthic ecology caused by the disposal activities; and

    e. the risks to human health and dolphin of eating seafood taken in the marine area around the active pits.

4) To monitor and report on the environmental impacts of the disposal operation and specifically to determine whether the methods of disposal are effective in reducing the risks of adverse environmental impacts.

5) To monitor and report on the benthic recolonisation of the capped pits and specifically to determine the difference in infauna between the capped pits and adjacent sites.

6) To assess the impact of a major storm (Typhoon Signal No. 8 or above) on the containment of any uncapped or partially capped pits.

7) To design and continually review the operation and monitoring programme and:

    a. to make recommendations for changes to the operation that will rectify any unacceptable environmental impacts; and

    b. to make recommendations for changes to the monitoring programme that will improve the ability to cost effectively detect environmental changes caused by the disposal activities.

8) To establish numerical decision criteria for defining impacts for each monitoring component.

9) To provide supervision on the field works and laboratory works to be carried out by contractors/laboratories.

The specific objectives of each component are discussed in the relevant sections of this EM&A Manual.

1.5 SCOPE OF THE EM&A PROGRAMME

The scope of this EM&A programme is to:

- Establish baseline water quality levels at specified locations prior to dredging operations for the construction of the SB Facility;
- Implement monitoring and inspection requirements for water quality monitoring programme during dredging, backfilling and capping of the SB Facility;
- Implement monitoring and inspection requirements for sediment quality monitoring programme during backfilling operations at the SB Facility;
- Implement monitoring and inspection requirements for sediment toxicity monitoring programme during backfilling operations at the SB Facility;
- Implement monitoring and inspection requirements for the body burden (marine biota) monitoring programme during backfilling operations at the SB Facility;
- Liaise with, and provide environmental advice (as requested or when otherwise necessary) to site staff on the comprehension and consequences of the environmental monitoring data;
- Identify and resolve environmental issues and other functions as they may arise from the works;
- Check and quantify the Contractor's overall environmental performance, implementation of Event and Action Plans (EAPs), and remedial actions taken to mitigate adverse environmental effects as they may arise from the works;
- Conduct monthly reviews of monitored impact data as the basis for assessing compliance with the defined criteria and to ensure that necessary mitigation measures are identified and implemented, and to undertake additional *ad hoc* monitoring and auditing as required by special circumstances;
- Evaluate and interpret all environmental monitoring data to provide an early indication should any of the environmental control measures or practices fail to achieve the acceptable standards, and to verify the environmental impacts predicted in the EIA;
- Manage and liaise with other individuals or parties concerning other environmental issues deemed to be relevant to the construction and operation process; and

- Conduct regular site inspections of a formal or informal nature to assess:
  - the level of the Contractor's general environmental awareness;
  - the Contractor's implementation of the recommendations in the EIA;
  - the Contractor's performance as measured by the EM&A;
  - the need for specific mitigation measures to be implemented or the continued usage of those previously agreed;
  - to advise the site staff of any identified potential environmental issues; and
  - submit regular EM&A reports which summarise project monitoring and auditing data, with full interpretation illustrating the acceptability or otherwise of any environmental impacts and identification or assessment of the implementation status of agreed mitigation measures.

1.5.1 Environmental Management Plan (EMP)

To ensure effective implementation and reporting on compliance with the stated mitigation measures, as well as the monitoring and auditing requirements and remedial actions defined in the EIA, an appropriate contractual and supervisory framework needs to be established. The basis of the framework within which implementation should be managed overall is through the preparation of EMPs by the Contractor(s).

An EMP is similar in nature to a quality plan and provides details of the means by which the Contractor (and all subcontractors working to the Contractor) will implement the recommended mitigation measures and achieve the environmental performance standards defined in Hong Kong environmental legislation, the contract and in the EIA documentation. The primary reason for adopting the EMP approach is to make the Contractor aware of his environmental responsibilities and to be pro-active about the commitment to achieve the standards specified, rather than relying on the EM&A programme.

The EMP also provides opportunities for the Contractor to draw upon the strength of other institutional processes such as ISO 9000/14000 to ensure that the achievement of the required standards and fulfilment of commitments are documented.

The contractual requirement for an EMP would generally comprise appropriate extracts from (and references to) the EIA Report and EM&A Manual, and include such typical elements as the relevant statutory environmental standards, general environmental control clauses and specific environmental management clauses, as well as an outline of the scope and content of the EMP. In drafting the documentation, due consideration should be given to the predictive nature of the EIA process and the

consequent need to manage and accommodate the actual impacts arising from the construction process. In particular, the Contractor must be placed under a clear obligation to identify and control any implications arising from changes to the working methods assumed in the EIA, or to the progress rates and other estimates made during the preliminary design phase.

1.6 ORGANISATION AND STRUCTURE OF THE EM&A

1.6.1 Project Organisation

The EM&A will require the involvement of CEDD, an Environmental Team (ET), Independent Auditor(s) and the Contractor.

The CEDD will appoint an Environmental Team (ET) to conduct the monitoring and auditing works and to provide specialist advice on the undertaking and implementation of environmental responsibilities.

The ET will have previous relevant experience with managing similarly sized EM&A programmes and the Environmental Team Leader (ET Leader) will be a recognised environmental professional, preferably with a minimum of seven years relevant experience in impact assessments and impact monitoring programmes, particularly with reference to those to the marine environment and where possible related to marine dredging / disposal activities.

To maintain strict control of the EM&A process, the CEDD will also appoint Independent Auditor(s) to verify and validate the environmental performance of the Contractor and the ET.

1.6.2 Roles & Responsibilities

The roles and responsibilities of the various parties involved in the EM&A process are further expanded in the following sections. The ET Leader will be responsible for, and in charge of, the Environmental Team; and will be the person responsible for executing the EM&A requirements.

Contractor

Reporting to the CEDD, the Contractor will:

- Work within the scope of the construction contract and other tender conditions;
- Provide assistance to the ET in conducting the required environmental monitoring;
- Participate in the site inspections undertaken by the ET, as required, and undertake any corrective actions instructed by CEDD;
- Provide information/advice to the ET regarding works activities which may contribute, or be contributing to the generation of adverse environmental conditions;

- Implement measures to reduce impact where Action and Limit levels are exceeded; and

- Take responsibility and strictly adhere to the guidelines of the EM&A programme and complementary protocols developed by their project staff.

Civil Engineering and Development Department (CEDD)

The CEDD will:

- Monitor the Contractor's compliance with contract specifications, including the effective implementation and operation of environmental mitigation measures and other aspects of the EM&A programme;

- Employ Independent Auditor(s) to audit the results of the EM&A works carried out by the ET;

- Comply with the agreed Event and Action Plan in the event of any exceedance; and

- Instruct the Contractor to follow the agreed protocols or those in the Contract Specifications in the event of exceedances or complaints.

Environmental Team

The duties of the Environmental Team (ET) and Environmental Team Leader (ET Leader) are to:

- Monitor the various environmental parameters as required by this or subsequent revisions to the EM&A Manual;

- Assess the EM&A data and review the success of the EM&A programme determining the adequacy of the mitigation measures implemented and the validity of the EIA predictions as well as identify any adverse environmental impacts before they arise;

- Conduct regular site inspections and to investigate and inspect the Contractor's equipment and work methodologies with respect to pollution control and environmental mitigation, monitor compliance with the environmental protection specifications in the Contract, and to anticipate environmental issues that may require mitigation before the problem arises;

- Audit the environmental monitoring data and report the status of the general site environmental conditions and the implementation of mitigation measures resulting from site inspections;

- Review Contractor’s working programme and methodology, and comment as necessary;

- Investigate and evaluate complaints, and identify corrective measures;

- Advice to the Contractor on environmental improvement, awareness, enhancement matters, etc, on site;

- Report on the environmental monitoring and audit results and the wider environmental issues and conditions to the Contractor, CEDD and the EPD; and

- Adhere to the agreed protocols or those in the Contract Specifications in the event of exceedances or complaints.

The ET will be led and managed by the ET leader. The ET leader will have relevant education, training, knowledge, experience and professional qualifications subject to the approval of the Director of Environmental Protection. Suitably qualified staff will be included in the ET, and ET should not be in any way an associated body of the Contractor.

Independent Auditor(s)

- Review and audit the implementation of the EM&A programme and the overall level of environmental performance being achieved;

- Validate and confirm the accuracy of monitoring results, monitoring equipment, monitoring stations, monitoring procedures and locations of sensitive receivers;

- Audit the EIA recommendations and requirements against the status of implementation of environmental protection measures on site;

- Adhere to the procedures for carrying out complaint investigation;

- Review, when required, the effectiveness of environmental mitigation measures and project environmental performance including the proposed corrective measures;

- Report, when required, the findings of audits and other environmental performance reviews to CEDD, ET, EPD and the Contractor.

The independent auditor(s) will have relevant education, training, knowledge, experience and professional qualifications subject to the approval of the Director of Environmental Protection. Independent auditor(s) should not be in any way an associated body of the Contractor or the ET.

1.7 STRUCTURE OF THE EM&A MANUAL

The remainder of the Manual is set out as follows:

- Section 2 sets out the EM&A general requirements;

- Section 3 details the methodologies, parameters to be tested and the requirements for the marine water quality monitoring for the dredging, backfilling and capping operations at the SB Facility;

- Section 4 details the methodologies, parameters to be tested and the requirements for sediment quality monitoring for the backfilling activities at the SB Facility;

- Section 5 details the methodologies, parameters to be tested and the requirements for sediment toxicity quality monitoring for the backfilling activities at the SB Facility;

- Section 6 details the methodologies, parameters to be tested and the requirements for marine biota monitoring for the backfilling activities at the SB Facility;

- Section 7 details the requirements for Human Health and Dolphin Risk Assessment;

- Section 8 details the requirements for benthic re-colonisation assessment;

- Section 9 details the methodologies, parameters to be tested and the requirements for the assessment of impacts due to major storms; and

- Section 10 details the EM&A reporting requirements.

2 EM&A GENERAL REQUIREMENTS

2.1 INTRODUCTION

In this section, the general requirements of the EM&A programme are presented. The scope and content of the programme is developed with reference to the findings and recommendations of the approved EIA Report (*EIA Register No.: AEIAR-089/2005*) and the EIA Review.

Potential environmental impacts associated with the construction and operation of the Project, as identified during the EIA process, will be addressed through monitoring and controls specified in this EM&A Manual and in the construction contracts.

2.2 ENVIRONMENTAL MONITORING

During dredging and capping operations at the SB Facility, water quality will be subject to EM&A, with environmental monitoring being undertaken for water quality as determined in the EIA (see *Section 3* for details).

During backfilling operations at the SB Facility, water and sediment quality, marine ecology and fisheries will be subject to EM&A, with environmental monitoring being undertaken for these aspects (see *Sections 3 to 9* for details).

The environmental monitoring work for this Project will be carried out in accordance with this EM&A Manual and reported by the ET.

2.3 ACTION AND LIMIT LEVELS

Action and Limit (A/L) Levels are defined levels of impact recorded by the environmental monitoring activities which represent levels at which a prescribed response is required. This processes by which these levels should be quantitatively defined are presented in the relevant sections of this Manual and described in principle below:

- *Action Levels*: beyond which there is a clear indication of a deteriorating ambient environment for which appropriate remedial actions are likely to be necessary to prevent environmental quality from falling outside the *Limit Levels*, which would be unacceptable; and

- *Limit Levels*: statutory and/or agreed contract limits stipulated in the relevant pollution control ordinances, HKPSG or Environmental Quality *Objectives* established by the EPD. If these are exceeded, works may not proceed without appropriate remedial action, including a critical review of plant and working methods.

2.4 *EVENT AND ACTION PLAN*

The purpose of Event and Action Plans (EAPs) are to provide, in association with the monitoring and audit activities, procedures for ensuring that if any significant environmental incident (either accidental or through inadequate implementation of mitigation measures on the part of the Contractor) does occur, the cause will be quickly identified and remediated, and the risk of a similar event recurring is reduced. This also applies to the exceedances of A/L criteria to be identified in the EM&A programme.

2.5 *ENQUIRIES, COMPLAINTS, AND REQUESTS FOR INFORMATION*

Enquiries, complaints and requests for information can be expected from a wide range of individuals and organisations including members of the public, Government departments, the press and television media and community groups.

Enquiries, complaints and requests for information concerning the environmental effects of the Project, irrespective of how they are received, will be reported to CEDD and directed to the ET Leader who will set up procedures for handling, investigation and storage of such information. The following steps will then be followed:

1) The ET Leader will notify CEDD of the nature of the enquiry.

2) An investigation will be initiated to determine the validity of the complaint and to identify the source of the problem.

3) The ET Leader will undertake the following steps, as necessary:

    a. investigate and identify source of the problem;

    b. if considered necessary by CEDD undertake additional monitoring to verify the existence and severity of the alleged complaint;

    c. liaise with EPD to identify remedial measures;

    d. liaise with CEDD and the Contractor to identify remedial measures;

    e. implement the agreed mitigation measures;

    f. repeat the monitoring to verify effectiveness of mitigation measures; and

    g. repeat review procedures to identify further possible areas of improvement if the repeat monitoring results continue to substantiate the complaint.

4) The outcome of the investigation and the action taken will be documented on a complaint proforma (*Annex B*). A formal response to each complaint received will be prepared by the ET Leader within a maximum

of five working days and submitted to CEDD, in order to notify the concerned person(s) that action has been taken.

5) All enquiries which trigger this process will be reported in the EM&A reports which will include results of inspections undertaken by the ET Leader, and details of the measures taken, and additional monitoring results (if deemed necessary). It should be noted that the receipt of complaint or enquiry will not be, in itself, a sufficient reason to introduce additional mitigation measures.

In all cases the complainant will be notified of the findings, and audit procedures will be put in place to ensure that the problem does not recur.

2.6 REPORTING

Monthly, Quarterly and Annual reports will be prepared by the ET and submitted to CEDD, EPD and AFCD. The reports will be prepared and submitted within a specified period. Additional details on reporting protocols are presented in *Section 10*.

2.7 CESSATION OF EM&A

The cessation of EM&A programme is subject to the satisfactory completion of the *EM&A Final Review Report*, with approval from EPD.

3 WATER QUALITY

3.1 INTRODUCTION

This Section provides details of the water quality monitoring to be undertaken during the construction and operation of the SB Facility. Water quality modelling carried out for this Project indicates that the potential water quality impacts associated with the dredging, backfilling and capping works will be within acceptable levels and no unacceptable water quality impacts are expected. However, the monitoring programme is designed to verify the predictions of the EIA and confirm compliance with the Water Quality Objectives (WQOs).

3.2 MONITORING ACTIVITIES

Water quality monitoring for the Project can be divided into the following stages:

- Dredging activities to form the pits;
- Backfilling activities at active pits; and
- Capping activities at backfilled pits.

Each of these is discussed in turn below.

3.3 MONITORING FOR DREDGING ACTIVITIES

Water quality monitoring will be conducted during dredging of the two seabed pits at South of The Brothers. Monitoring will consist of the collection of baseline water quality data for the purposes of the development of Action and Limit Levels, as well as impact monitoring during dredging activities.

3.3.1 *Baseline Monitoring Prior to Dredging Activities*

Baseline monitoring will be conducted in the vicinity of the SB Facility and in reference areas (EPD Water Quality Monitoring Stations NM 1, 2, 3, 5 and 6) prior to the commencement of marine dredging works in order to gather representative water quality data for the EM&A. Locations of the baseline monitoring stations are shown in *Figure 3.1* and the coordinates are shown in *Table 3.1*.

The baseline water quality monitoring will be undertaken three days per week at all stations for four consecutive weeks prior to construction works. A sampling survey will include the collection of all water samples and measurement of all *in situ* parameters during both mid-flood and mid-ebb tides at all stations on the same day. Monitoring works will be completed

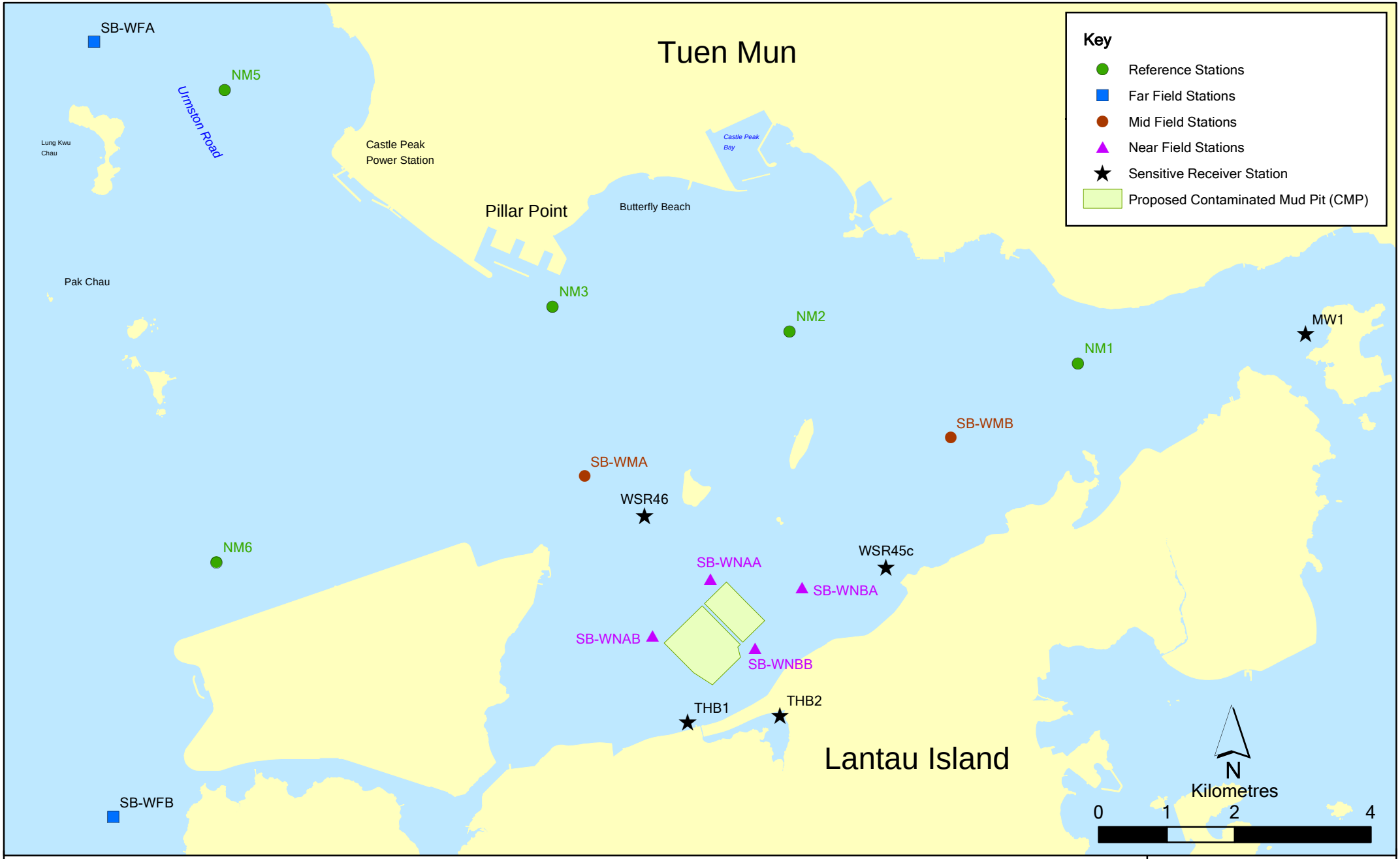


Figure 3.1

Baseline Water Quality Monitoring Stations for Dredging Activities

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Date: 14-Sep-12

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within a 4-hour window of 2 hours before or after mid-flood and mid-ebb tides. The interval between two sampling surveys will not be less than 36 hours.

Table 3.1 ***Coordinates for Water Quality Monitoring Stations for Baseline Water Quality Monitoring for Dredging Activities***

Monitoring Stations	Easting	Northing
Far Field Stations		
SB-WFA	805787	827951
SB-WFB	806066	816537
Mid Field Stations		
SB-WMA	813001	821559
SB-WMB	818386	822120
Near Field Stations		
SB-WNAA	814847	820043
SB-WNAB	816197	819911
SB-WNBA	813999	819207
SB-WNBB	815505	819019
Reference Stations		
NM1	820256	823214
NM2	816015	823686
NM3	812527	824049
NM5	807707	827244
NM6	807584	820286
Sensitive Receiver Stations		
MW1	823604	823654
THB1	814514	817932
THB2	815873	818035
WSR45C	817431	820211
WSR46	813880	820973

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

Each station will be sampled and measurements will be taken at three depths, 1 m below the sea surface, mid depth and 1 m above the seabed. Where the water depth is less than 6 m the mid-depth station may be omitted. If the water depth is less than 3 m, only the mid-depth station will be monitored.

For *in situ* measurements, triplicate readings shall be made at each water depth at each station. Triplicate water samples shall be collected at each water depth at each station for laboratory measurements.

The following suite of parameters should be measured as part of the baseline monitoring:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH (*in situ*);
- Turbidity (NTU) (*in situ);*
- Temperature (°C) (*in situ*);

- Current Velocity and Direction (ms^{-1}) (*in situ*);
- Suspended Solids (mg L^{-1}) (laboratory analysis);
- Ammonia (mg L^{-1}) (laboratory analysis);
- Total Inorganic Nitrogen (TIN mg L^{-1}) (laboratory analysis);
- 5-Day Biochemical Oxygen Demand (BOD5) (mg L^{-1}) (laboratory analysis);
- Cadmium (mg L^{-1}) (laboratory analysis);
- Chromium (mg L^{-1}) (laboratory analysis);
- Copper (mg L^{-1}) (laboratory analysis);
- Lead (mg L^{-1}) (laboratory analysis);
- Mercury (mg L^{-1}) (laboratory analysis);
- Nickel (mg L^{-1}) (laboratory analysis);
- Silver (mg L^{-1}) (laboratory analysis);
- Zinc (mg L^{-1}) (laboratory analysis); and,
- Arsenic (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

Four hard copies and one electronic copy of the *Baseline Monitoring Report* will be submitted to the EPD at least two weeks before commencement of construction of the Project.

3.3.2 Impact Monitoring during Dredging Activities

Impact monitoring for the dredging activities at SB will be conducted at mobile stations around the dredging area. Initially, the impact monitoring will be conducted at both mid-flood and mid-ebb tides for three days per week. The interval between two sets of monitoring shall normally not be less than 36 hours. The frequency of monitoring should be reviewed based on sufficient monitoring results (e.g. from the first three months of monitoring) to determine whether reductions can be made. Subsequent revision(s) of monitoring frequency shall be confirmed upon agreement with the EPD.

The location of the mobile monitoring stations is dependent on the location of the dredging activities. These mobile stations will be located at an

appropriate distance between each other along the up-current and down-current transect for the dredging area. The following methodology will be adopted to determine the precise location of the mobile stations on each sampling occasion:

- Contact the CEDD barge one day before the survey day for every sampling occasion to determine the dredging schedule for that particular survey day and to determine the likely location of dredging at the proposed time of sampling;

- Determine current direction at mid-depth at one station upstream and one station downstream of the SB Facility during both mid-flood and mid-ebb tide;

- Determine a suitable location for the station transect (the first down-current station will be located on the down current edge, and first up-current station will be located on the up-current edge, according to the current direction and the position of dredging at the time of sampling); and

- Collect samples from the stations located on a transect running up-current and down-current of the dredging area.

There will be two stations located up-current and five stations down-current of the monitoring transect. A 500 m separation distance will be adopted between adjacent stations except between adjacent upstream and downstream stations which are located on the pit edge. In addition, water samples will be collected from the Sensitive Receiver stations at Sham Shui Kok, Tai Mo To, Ma Wan and Tai Ho Bay as shown in *Figures 3.2a* and *3.2b*. Locations of upstream and downstream stations are illustrated in *Figures 3.2a* and *3.2b* based on assumed current direction and dredging position during monitoring.

Each station will be sampled and measurements will be taken at three depths, 1 m below the sea surface, mid depth and 1 m above the seabed. Triplicate water samples and measurements will be taken at each depth. Where water depth is less than 6m the mid-depth station may be omitted. If water depth is less than 3m, only the mid-depth station will be monitored.

The following suite of parameters should be measured as part of the impact monitoring for dredging:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);

- Salinity (ppt) (*in situ*);

- pH (*in situ*);

- Turbidity (NTU) (*in situ*);

- Temperature (°C) (*in situ*)

- Current Velocity and Direction (ms^{-1}) (*in situ*); and,

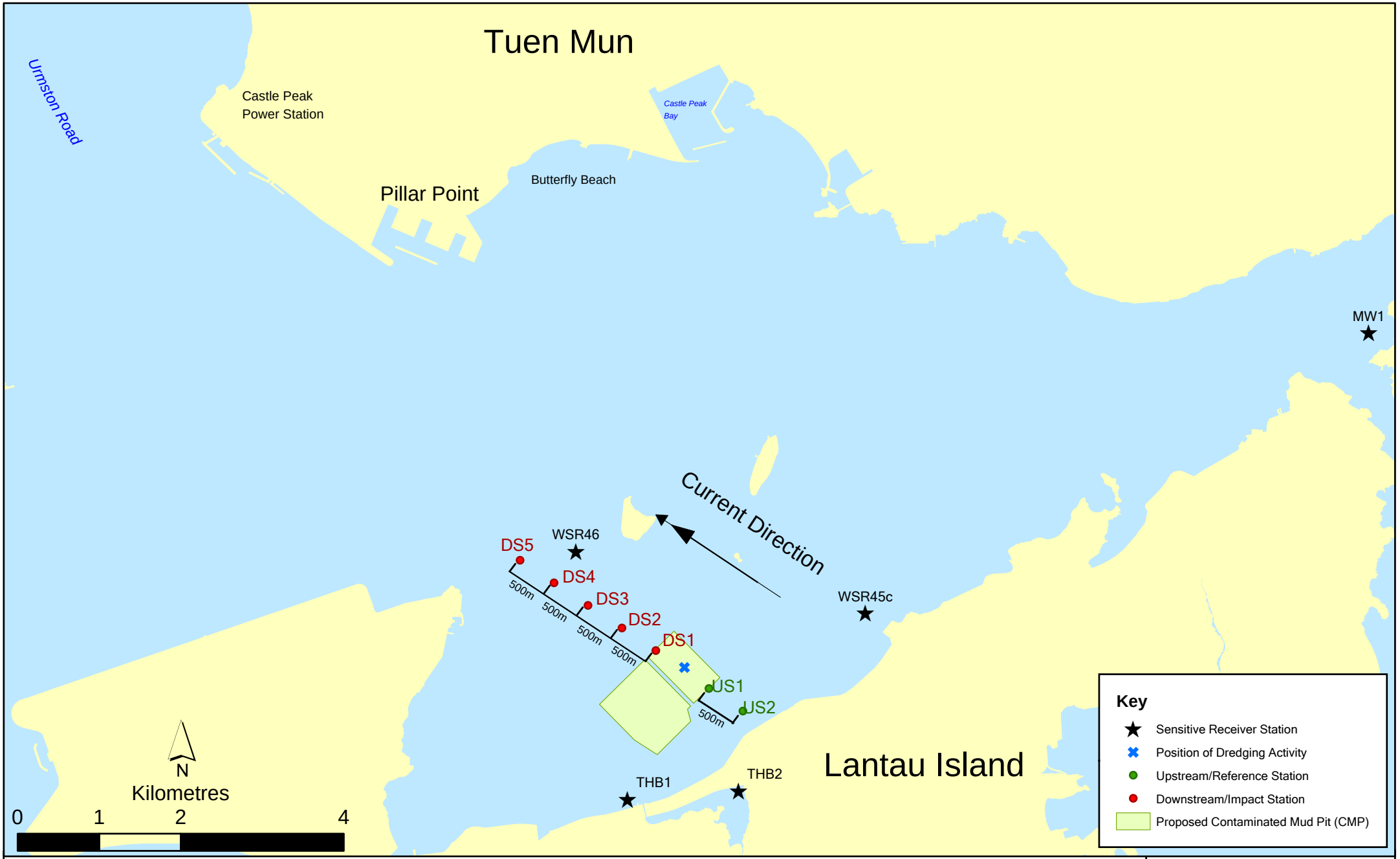

Figure 3.2a

Indicative Dredging Impact Sampling Stations for South Brothers Facility (For Flood Tide)

Note: The locations of sampling stations will be determined on site based on current direction and position of dredging activities

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Date: 14-Sep-12

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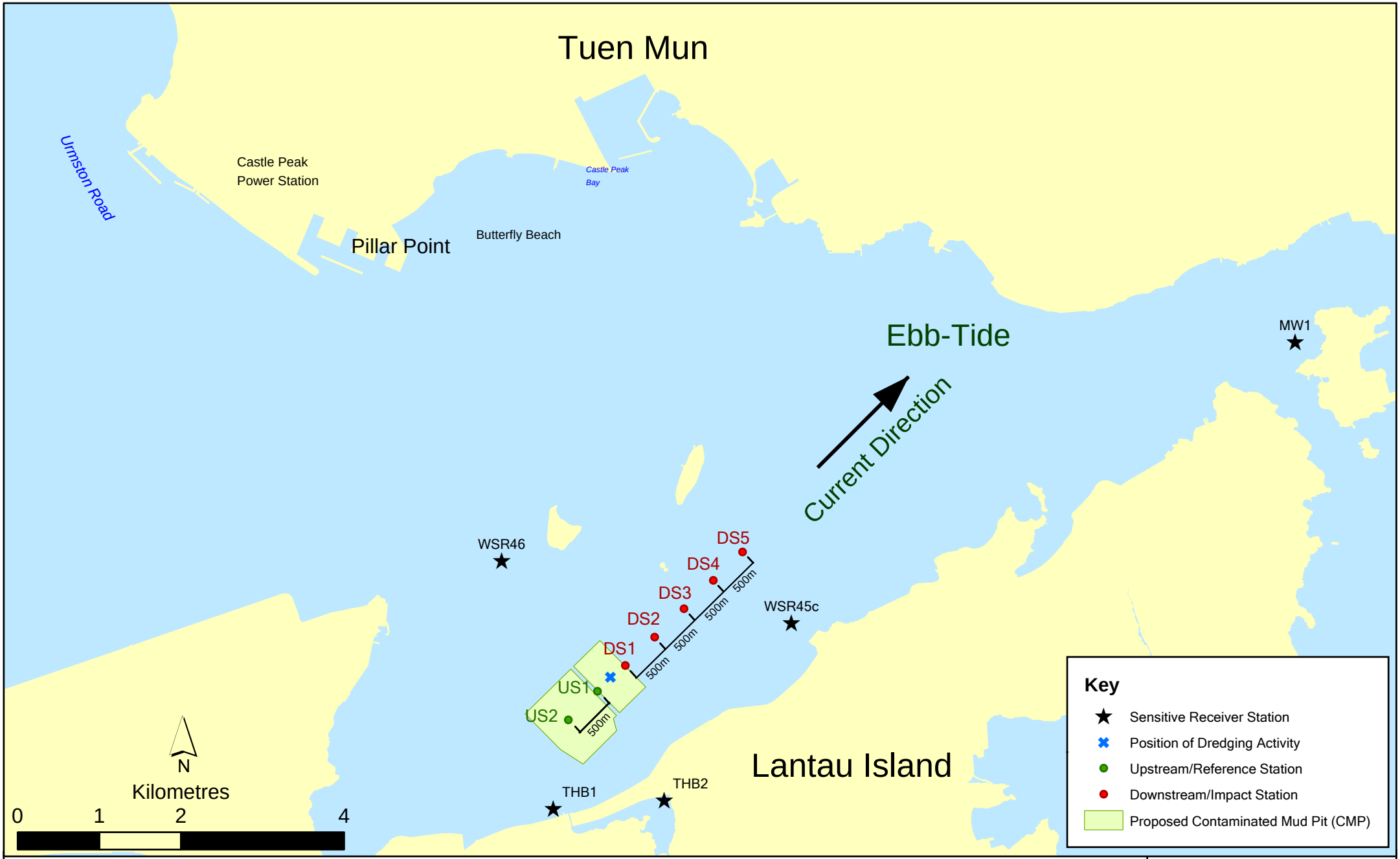

Figure 3.2b

Indicative Dredging Impact Sampling Stations for South Brothers Facility (For Ebb-Tide)

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Date: 14-Sep-12

Note: The locations of sampling stations will be determined on site based on current direction and position of dredging activities.

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- Suspended Solids (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

3.3.3 Water Quality Compliance and Event & Action Plan

Impact monitoring for dredging activities will be evaluated against Action and Limit Levels. The key assessment parameters are dissolved oxygen (DO) and suspended sediment (SS) and thus Action and Limit Levels based on the assessment criteria are identified for these parameters. However, turbidity can also provide valuable instantaneous information on water quality and thus an Action Limit is measured for this parameter to facilitate quick responsive action in the event of any apparent unacceptable deterioration attributable to the works. Baseline data will be taken into account in setting Action and Limit Levels, however, the rationale are shown in *Table 3.2*.

Action and Limit Levels are used to determine whether operational modifications are necessary to mitigate impacts to water quality (1). In the event that the levels are exceeded, appropriate actions in Event and Action Plans (*Table 3.3*) should be undertaken.

(1) It is proposed that impact monitoring data from individual downstream stations will be compared against the average of data from upstream stations on the same monitoring day.

Table 3.2 Action and Limit Levels of Water Quality for Dredging Activities

Parameter	Action Level	Limit Level
Dissolved Oxygen		
Surface and Middle Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 4 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Bottom	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 2 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Suspended Solids		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations SS (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99%ile of baseline data and 130% or more of the reference stations SS (at the same tide of the same day)
Turbidity		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations turbidity (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99% of baseline data and 130% or more of the reference stations turbidity (at the same tide of the same day)

Table 3.3 Water Quality Event and Action Plan during Dredging Operations

Event	Environmental Team	Contractor
Action level		
Exceedance for one occasion	• Repeat *in-situ* measurement to confirm findings; • Identify the source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD and confirm notification of the non-compliance in writing; • Check monitoring data; • Discuss potential mitigation measures if exceedance is attributed to the works with contractor.	• Discuss potential mitigation measures with ET and agree on mitigation measures to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are implemented; • Assess the effectiveness of the implemented mitigation measures.
Limit Level		
Exceedance for one occasion	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD; • Discuss further mitigation measures if exceedance is attributed to the works with contractor; • Increase the monitoring frequency to daily if exceedance is attributed to the works until no exceedance of the Limit Level.	• Critical review of working methods; • Check plant, equipment and working methods; • Discuss further mitigation measures with ET to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are being implemented; • Assess the effectiveness of the implemented mitigation measures
Limit Level exceeded on two or more occasions	• Identify source(s) of impact; • Inform contractor and contractor informs, CEDD, EPD and AFCD.	• If exceedance is attributed to the works consider and if necessary reduce works until no exceedance of Limit Level
Impacts attributable to works	• Inform contractor and contractor informs, CEDD, EPD and AFCD.	• Comprehensive review of works; • Reduce works; and • Suspension of works.

3.4 MONITORING FOR BACKFILLING ACTIVITIES

3.4.1 Objective

The main objective of this component is to determine the impacts, if any, of backfilling activities at SB Facility on water quality. Two separate components of water quality monitoring are necessary:

- *Routine Water Quality Monitoring* – conducted to examine the impacts of backfilling activities on the level of inorganic metal contaminants in marine waters; and

- *Water Column Profiling* – conducted to examine *in situ* the impacts of backfilling operations on water quality parameters within the water column.

3.4.2 Hypotheses

The impact hypothesis for this work component has been defined based on the predictions from the EIA regarding impacts from the contaminated mud disposal operations and the objectives for the EM&A.

Backfilling (disposal) operations do not result in any exceedances of Northwestern Water Quality Control Zone (NWWCZ) Water Quality Objectives (WQO).

As a consequence of performing two separate tasks for assessing the impacts of backfilling operations on water quality, two null hypotheses will be tested:

Routine Water Quality Monitoring

H_0 There are no differences in the levels of contaminants in water samples in the plume arising from the backfilling works and background levels in the vicinity of the backfilling.

Water Column Profiling

H_0 There is no change in the level of compliance with the NWWCZ WQOs of samples taken from the plume arising from backfilling activities (EIA predicted location).

3.4.3 Sampling Design

Routine Water Quality Monitoring

Routine water quality monitoring will be undertaken during backfilling activities at mid-ebb or mid-flood tide. Water samples will be collected at specific stations at fixed location, which should be located in three areas at increasing distances from the active pit (Reference, Intermediate and Impact stations/areas). Additional Sensitive Receiver stations at Sham Shui Kok, Tai Mo To, Ma Wan and Tai Ho Bay will be sampled. The design for this component of the programme allows impacts, if any, to water quality as a result of the backfilling activities in the vicinity of SB Facility to be assessed.

The number of monitoring stations sampled depends on the state of the tide. During the ebb tide, water samples are collected from five up-current Reference Stations, five down-current Impact Stations and five down-current Intermediate Stations. During the flood tide, water samples are collected from three up-current Reference Stations, three down-current Impact Stations and three down-current Intermediate Stations. The approach will ensure that the impact of temporal changes on the hydrodynamic conditions in the area is considered in the sampling.

The following suite of parameters should be measured as part of routine water quality monitoring operations:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);

- Salinity (ppt) (*in situ*);
- pH (*in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*);
- Suspended Solids ($mg\ L^{-1}$) (laboratory analysis);
- Ammonia ($mg\ L^{-1}$) (laboratory analysis);
- Total Inorganic Nitrogen (TIN $mg\ L^{-1}$) (laboratory analysis);
- 5-Day Biochemical Oxygen Demand (BOD5) ($mg\ L^{-1}$) (laboratory analysis)
- Cadmium ($mg\ L^{-1}$) (laboratory analysis);
- Chromium ($mg\ L^{-1}$) (laboratory analysis);
- Copper ($mg\ L^{-1}$) (laboratory analysis);
- Lead ($mg\ L^{-1}$) (laboratory analysis);
- Mercury ($mg\ L^{-1}$) (laboratory analysis);
- Nickel ($mg\ L^{-1}$) (laboratory analysis);
- Silver ($mg\ L^{-1}$) (laboratory analysis);
- Zinc ($mg\ L^{-1}$) (laboratory analysis); and
- Arsenic ($mg\ L^{-1}$) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

The locations of monitoring stations during ebb and flood tides are shown in *Figures 3.3* and *3.4*, respectively, and the coordinates are shown *Table 3.4*. Additional monitoring stations at Sham Shui Kok, Tai Mo To, Ma Wan and Tai Ho Bay will be sampled. Eight replicate samples will be collected from each monitoring station, for eight times per year, twice in the dry season, twice during the wet season and twice in each of the two transitional

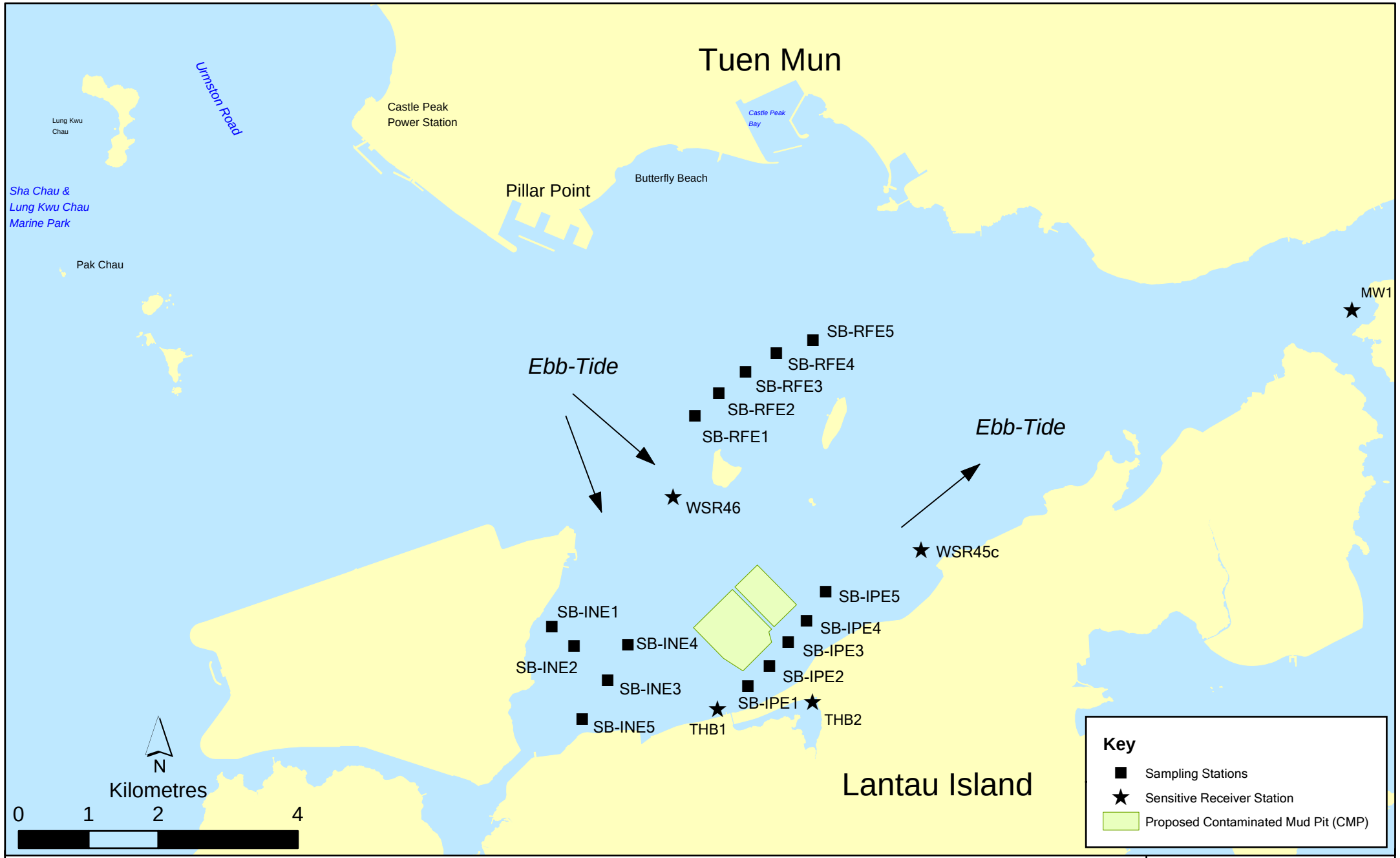

Figure 3.3

Routine & Capping Water Quality Sampling Stations (Ebb-Tide) for South Brothers Facility

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Date: 14-Sep-12

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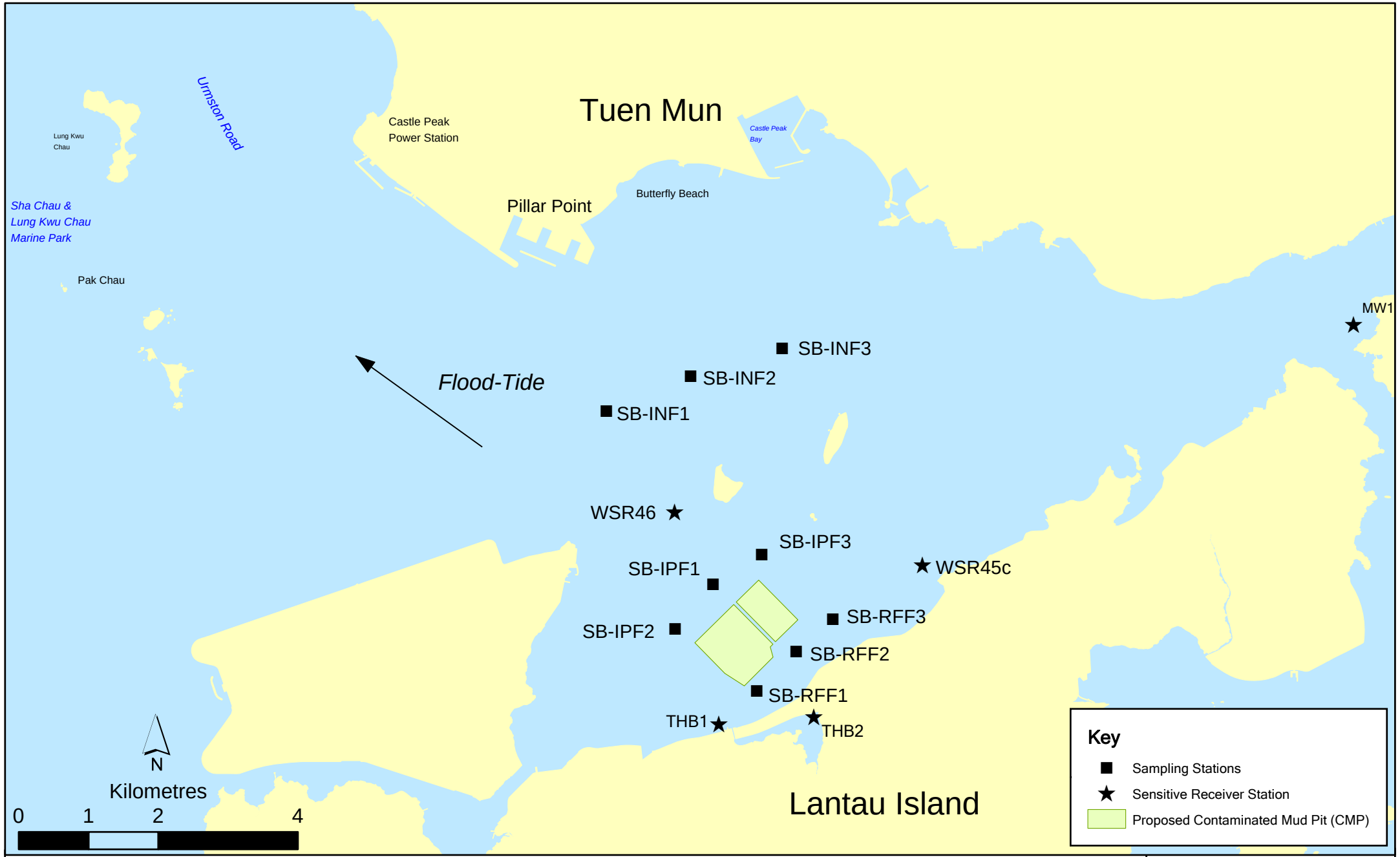

Figure 3.4

Routine & Capping Water Quality Sampling Stations (Flood-Tide) for South Brothers Facility

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Date: 14-Sep-12

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seasons (1). The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach.

For a given sampling event water samples and *in situ* measurements should be taken at mid-depth of all stations during the same tidal state (ie mid-ebb or mid-flood tide), with the exception of Dissolved Oxygen, Suspended Solids and Turbidity for which the sampling/measurements should be taken at both mid-depth and bottom level of all stations during the same tidal state. Sampling frequency and number of replicates for the SB Facility will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

Routine water quality monitoring for SB will be undertaken during its backfilling activities, which is currently predicted to begin in July 2013. Details on the Sampling Programme are shown in *Annex C.*

Table 3.4 Coordinates of Monitoring Stations for Routine Water Quality Monitoring during Backfilling Operations and Water Quality Monitoring during Capping Operations

Monitoring Stations	Easting	Northing
Ebb Tide		
Reference Stations		
SB-RFE1	814191	822133
SB-RFE2	814532	822458
SB-RFE3	814915	822758
SB-RFE4	815356	823032
SB-RFE5	815880	823215
Impact Stations		
SB-IPE1	814949	818257
SB-IPE2	815257	818549
SB-IPE3	815526	818888
SB-IPE4	815790	819189
SB-IPE5	816064	819615
Intermediate Stations		
SB-INE1	812140	819107
SB-INE2	812460	818834
SB-INE3	812941	818337
SB-INE4	813230	818850
SB-INE5	812577	817788
Sensitive Receiver Stations		
MW1	823603	823653
THB1	814514	817932
THB2	815873	818035
WSR45C	817431	820211
WSR46	813880	820973
Flood Tide		
Reference Stations		
SB-RFF1	815058	818400

(1) Initially during the first three months of Routine Water Quality Monitoring for Backfilling Activities, the monitoring will be conducted for three days per week. The frequency of monitoring will be reviewed after this period of monitoring. Dumping activities report during this 3-month review period will also be submitted to EPD.

Monitoring Stations	Easting	Northing
SB-RFF2	815623	818964
SB-RFF3	816147	819427
Impact Stations		
SB-IPF1	814430	819936
SB-IPF2	813887	819291
SB-IPF3	815128	820361
Intermediate Stations		
SB-INF1	812902	822410
SB-INF2	814111	822914
SB-INF3	815421	823317
Sensitive Receiver Stations		
MW1	823603	823653
THB1	814514	817932
THB2	815873	818035
WSR45C	817431	820211
WSR46	813880	820973

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

Water Column Profiling

Water column profiling will be undertaken during backfilling activities. There are two monitoring stations for Water Column Profiling. The two monitoring stations will be mobile, and their locations will be dependent on the position of the disposal barge at the time of monitoring. The two mobile monitoring stations will be approximately 100 m upstream and downstream of the disposal area, respectively.

The following suite of parameters should be measured as part of the water column profiling:

- Salinity (ppt) (*in situ*);
- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (m s^{-1}) (*in situ*)
- pH (in situ); and
- Suspended Solids (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

Water Column Profiling will be conducted monthly. Four replicate samples for SS will be collected at mid-depth from each of the monitoring stations during each sampling event. The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. During each sampling event *in situ* measurements should be taken at 1 m depth intervals through the water column for a period of one hour at each station. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Sampling frequency and the number of replicates for SB will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*. Details on the *Sampling Programme* for the SB Facility are shown in *Annex C*.

3.4.4 Water Quality Compliance and Event & Action Plan

Routine water quality monitoring for backfilling activities will be evaluated against Action and Limit Levels. The key assessment parameters are dissolved oxygen (DO) and suspended sediment (SS) and thus Action and Limit Levels based on the assessment criteria are identified for these parameters. However, turbidity can also provide valuable instantaneous information on water quality and thus an Action Limit is measured for this parameter to facilitate quick responsive action in the event of any apparent unacceptable deterioration attributable to the works. Baseline data will be taken into account in setting Action and Limit levels, however, the rationale are shown in *Table 3.5*.

Action and limit levels are used to determine whether operational modifications are necessary to mitigate impacts to water quality (1) (2). In the event that the levels are exceeded, appropriate actions in Event and Action Plans (*Table 3.6*) should be undertaken.

(1) It is proposed that impact monitoring data from individual downstream stations will be compared against the average of data from upstream stations on the same monitoring day.

(2) Should consistent exceedance of the Action & Limit Levels for the stated parameters are detected at bottom level, such monitoring may be extended to other parameters.

Table 3.5 Action and Limit Levels of Water Quality for Backfilling Activities

Parameter	Action Level	Limit Level
Dissolved Oxygen		
Surface and Middle Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 4 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Bottom	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 2 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Suspended Solids		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations SS (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99%ile of baseline data and 130% or more of the reference stations SS (at the same tide of the same day)
Turbidity		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations turbidity (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99% of baseline data and 130% or more of the reference stations turbidity (at the same tide of the same day)

Table 3.6 Water Quality Event and Action Plan during Backfilling Operations

Event	Environmental Team	Contractor
Action level		
Exceedance for one occasion	• Repeat *in-situ* measurement to confirm findings; • Identify the source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD and confirm notification of the non-compliance in writing; • Check monitoring data; • Discuss potential mitigation measures if exceedance is attributed to the works with contractor.	• Discuss potential mitigation measures with ET and agree on mitigation measures to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are implemented; • Assess the effectiveness of the implemented mitigation measures.
Limit Level		
Exceedance for one occasion	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD; • Discuss further mitigation measures if exceedance is attributed to the works with contractor; • Increase the monitoring frequency to daily if exceedance is attributed to the works until no exceedance of the Limit Level.	• Critical review of working methods; • Check plant, equipment and working methods; • Discuss further mitigation measures with ET to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are being implemented; • Assess the effectiveness of the implemented mitigation measures
Limit Level exceeded on two or more occasions	• Identify source(s) of impact; • Inform contractor and contractor informs, CEDD, EPD and AFCD.	• If exceedance is attributed to the works consider and if necessary reduce works until no exceedance of Limit Level
Impacts attributable to works	• Inform contractor and contractor informs, CEDD, EPD and AFCD.	• Comprehensive review of works; • Reduce works; and • Suspension of works.

3.4.5 Statistical Treatment of Data

Routine Water Quality Monitoring

The hierarchy of sampling design should allow for the application of nested analysis of variance to statistically test any changes or trends in the dataset. Under the nested design, differences will be tested between stations in a particular area and between the three areas (ie Impact, Intermediate and Reference). Once a time series of data has been gathered temporal changes in water quality parameters can be analysed for significant differences. In addition, the data gathered will be examined against the water quality objectives for the NWWCZ to determine if the relevant water quality objectives have been exceeded.

Monitoring results for metals will be compared with the EIA predictions to verify that potential impacts to water quality or contaminant dispersion in the plumes arising from backfilling activities are no worse than as predicted.

Water Column Profiling

The data gathered will be examined graphically against the water quality objectives for the NWWCZ to determine if the relevant water quality objectives have been exceeded for any apparent impacts arising from the backfilling activities.

3.4.6 Use of Data

Should increases be detected in the level of contaminants or exceedances of the NWWCZ WQOs be detected, a review of the other monitoring parameters will be undertaken. This will focus on sampling stations in the vicinity of the water quality stations where increases are detected to see if these can be attributed to contaminant spread from the active pits. If so, consideration will be given to revise the facility operations plan and backfilling activities to reduce the spread of contaminants in the plume and achieve compliance with WQOs.

3.5 MONITORING FOR CAPPING ACTIVITIES

The design for this component of the programme allows impacts to water quality as a result of the overall capping activities of the SB Facility to be assessed. Replicate water samples will be collected at specific stations, which should be located in three discrete areas: Impact, Intermediate and Reference. The number of monitoring stations sampled depends on the state of the tide. During the ebb tide, water samples will be collected from five up-current Reference Stations, five down-current Impact Stations and five down-current Intermediate Stations. During the flood tide, water samples will be collected at three up-current Reference Stations, three down-current Impact Stations and three down-current Intermediate Stations.

The following suite of parameters should be measured as part of the impact monitoring for capping operations:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH (*in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*);

- Suspended Solids (mg L^{-1}) (laboratory analysis);
- Ammonia (mg L^{-1}) (laboratory analysis);
- Total Inorganic Nitrogen (TIN mg L^{-1}) (laboratory analysis); and
- 5-Day Biochemical Oxygen Demand (BOD5) (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

The locations of stations during ebb and flood tides for SB are the same as those proposed for Routine Water Quality Monitoring during backfilling activities (*Figures 3.3* and *3.4*; *Table 3.4*). Additional Sensitive Receiver stations at Sham Shui Kok, Tai Mo To, Ma Wan and Tai Ho Bay will be sampled for both ebb and flood tides. Samples should be collected eight times per year, twice in the dry season, twice during the wet season and twice in each of the two transitional seasons (1). Three replicate water samples will be collected from mid-depth at each monitoring station during each sampling event, with the exception of Suspended Solids for which the sampling should be taken at both mid-depth and bottom level at each monitoring station during each sampling event. In addition, *in situ* measurements should be taken at mid-depth and bottom level of all stations during the same tidal state (ie mid-ebb or mid-flood tide) during a sampling event. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Sampling will be undertaken during capping activities for SB as detailed in the *Sampling Programme* shown in *Annex C*.

The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. These will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

3.5.1 Water Quality Compliance and Event & Action Plan

Routine water quality monitoring for capping activities will be evaluated against Action and Limit Levels. The key assessment parameters are dissolved oxygen (DO) and suspended sediment (SS) and thus Action and Limit Levels based on the assessment criteria are identified for these parameters. However, turbidity can also provide valuable instantaneous

(1) Initially during the first three months of Water Quality Monitoring for Capping Activities, the monitoring will be conducted for three days per week. The frequency of monitoring will be reviewed after this period of monitoring.

information on water quality and thus Action and Limit Levels are measured for this parameter to facilitate quick responsive action in the event of any apparent unacceptable deterioration attributable to the works. Baseline data will be taken into account in setting Action and Limit levels, however, the rationale are shown in *Table 3.7*.

Action and Limit Levels are used to determine whether operational modifications are necessary to mitigate impacts to water quality (1). In the event that the levels are exceeded, appropriate actions in Event and Action Plans (*Table 3.8*) should be undertaken.

Table 3.7 Action and Limit Levels of Water Quality for Capping Activities

Parameter	Action Level	Limit Level
Dissolved Oxygen		
Surface and Middle Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 4 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Bottom	The average of the impact, WSR 45C and WSR 46 station readings are < 5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are < 2 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Suspended Solids		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations SS (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99%ile of baseline data and 130% or more of the reference stations SS (at the same tide of the same day)

(1) It is proposed that impact monitoring data from individual downstream stations will be compared against the average of data from upstream stations on the same monitoring day.

Parameter	Action Level	Limit Level
Turbidity		
Depth Averaged	The average of the impact, WSR 45C and WSR 46 station readings are > 95%ile of baseline data and 120% or more of the reference stations turbidity (at the same tide of the same day)	The average of the impact, WSR 45C and WSR 46 station readings are > 99% of baseline data and 130% or more of the reference stations turbidity (at the same tide of the same day)

Table 3.8 Water Quality Event and Action Plan during Capping Operations

Event	Environmental Team	Contractor
Action level		
Exceedance for one occasion	• Repeat *in-situ* measurement to confirm findings; • Identify the source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD and confirm notification of the non-compliance in writing; • Check monitoring data; • Discuss potential mitigation measures if exceedance is attributed to the works with contractor.	• Discuss potential mitigation measures with ET and agree on mitigation measures to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are implemented; • Assess the effectiveness of the implemented mitigation measures.
Limit Level		
Exceedance for one occasion	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD; • Discuss further mitigation measures if exceedance is attributed to the works with contractor; • Increase the monitoring frequency to daily if exceedance is attributed to the works until no exceedance of the Limit Level.	• Critical review of working methods; • Check plant, equipment and working methods; • Discuss further mitigation measures with ET to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are being implemented; • Assess the effectiveness of the implemented mitigation measures
Limit Level exceeded on two or more occasions	• Identify source(s) of impact; • Inform contractor and contractor informs, CEDD, EPD and AFCD.	• If exceedance is attributed to the works consider and if necessary reduce works until no exceedance of Limit Level
Impacts attributable to works	• Inform contractor and contractor informs, CEDD, EPD and AFCD.	• Comprehensive review of works; • Reduce works; and • Suspension of works.

3.6 SAMPLING PROCEDURE FOR WATER QUALITY MONITORING

In situ water quality monitoring (salinity, temperature, current velocity and direction) will be conducted using the equipment listed in *Section 3.6.1* and

following the testing protocols detailed in *Section 3.6.2*. In order to ensure the reliability and quality of the data, the measuring instrument will be calibrated prior to each sampling cruise and the probe of the measuring instrument will be maintained at a suitable distance from the seabed to avoid re-suspension of bottom sediments from skewing the results.

Water quality profiling will be conducted continuously for a one-hour period from a fixed point. After deployment, the probe of the measuring equipment will be allowed to equilibrate with the surrounding seawater for approximately 30 seconds. Subsequently, average readings will be taken every few seconds to minimise sampling noise arising from the sensitivity of the equipment.

In addition to *in situ* water quality monitoring, water samples will be collected in a water sampler. Samples will be stored in sealed sampling bottles and chilled, and on completion of the survey will be transported to the laboratory for immediate analysis. Samples not for immediate analysis will be stored at 4 ± 2°C.

3.6.1 Equipment

The following equipment will be supplied and used by the contractor for the water quality monitoring:

- *Positioning Device* - Horizontal positioning will be used and determined by a differential Global Positioning System (dGPS) with the differential signal being provided by a UHF differential transmitter. The UHF system should provide an accuracy of better than 3m at the 95% confidence level to ensure the survey vessel is in the correct location before taking measurements. The dGPS will be calibrated daily before each survey period or results reported. And all data will be printed and logged on disc.

- *Electronic data logging device* - A data logging device capable of storing measurement data will be used. The device will be able to read and store the output from all electronic meters used for this project and will record time and location as measured by the GPS.

- *Dissolved Oxygen and Temperature Measuring Equipment* – The instrument will be a portable, weatherproof dissolved oxygen measuring instrument complete with cable, sensor, comprehensive operation manuals, and will be operable from a DC power source. It will be capable of measuring: dissolved oxygen levels in the range of 0 - 20 mg L^{-1} and 0 - 200% saturation; and a temperature of 0 - 45 degrees Celsius. It will have a membrane electrode with automatic temperature compensation complete with a cable of not less than 20 m in length. Sufficient stocks of spare electrodes and cables will be available for replacement where necessary (for example, YSI model 59 metre, YSI 5739 probe, YSI 5795A submersible stirrer with reel and cable or an approved similar instrument).

- *Turbidity Measurement Equipment* - Turbidity within the water will be measured in situ by the nephelometric method. The instrument will be a portable, weatherproof turbidity-measuring unit complete with cable, sensor and comprehensive operation manuals. The equipment will be operated from a DC power source, it will have a photoelectric sensor capable of measuring turbidity between 0 - 1000 NTU and will be complete with a cable with at least 20 m in length (Hach 2100P or an approved similar instrument).

- *Salinity Measurement Instrument* - A portable salinometer capable of measuring salinity in the range of 0 - 40 ppt will be provided for measuring salinity of the water at each monitoring location.

- *pH meter* – A portable pH meter capable of measuring a range between 0.0 and 14.0 will be provided to measure pH in marine waters.

- *Suspended Solid Measurement Equipment* - A water sampler (eg Kahlsic Water Sampler), which is a PVC cylinder (capacity not less than 2 litres) which can be effectively sealed with latex cups at both ends, will be used for sampling. The sampler will have a positive latching system to keep it open and prevent premature closure until released by a messenger when the sampler is at the selected water depth. Water samples for suspended solids measurement will be collected in high density polythene bottles, packed in ice (cooled to 4^{o}C without being frozen), and delivered to the laboratory in the same day as the samples were collected.

- *Water Depth Gauge* - A portable, battery-operated echo sounder (Seafarer 700 or a similar approved instrument) will be used for the determination of water depth at each designated monitoring station. This unit will either be hand-held or affixed to the bottom of the work boat if the same vessel is to be used throughout the monitoring programme.

- *Water Sampling Equipment* - A water sampler, consisting of a transparent PVC or glass cylinder of not less than two litres which can be effectively sealed with cups at both ends, will be used (Kahlsico Water Sampler 13SWB203 or an approved similar instrument). The water sampler will have a positive latching system to keep it open and prevent premature closure until released by a messenger when the sampler is at the selected water depth.

- *Current Velocity Measuring Equipment* – An NE Sensortec A/S UCM-60 current meter or Valeport 108 MKIII current meter or a similar approved instrument will be used for measuring current direction. Current velocity is measured by ADCP. Calibration of ADCP is not likely to be necessary for these instruments as they are calibrated for the life of the instrument.

3.6.2 Sampling/Testing Protocol

The position of the survey vessel will be positioned to within 3 m of the designated coordinates at each monitoring station using a differential Global Positional System (dGPS).

All *in situ* monitoring instruments will be checked, calibrated and certified by laboratory accredited under HOKLAS or any other international accreditation scheme before use, and subsequently re-calibrated at three month intervals throughout the stages of the water quality monitoring. Responses of sensors and electrodes will be checked with certified standard solutions before each use.

On-site calibration of field equipment will follow the "*Guide to Field and On-Site Test Methods for the Analysis of Waters*", BS 1427: 2009. Sufficient stocks of spare parts will be maintained for replacements when necessary. Backup monitoring equipment will also be made available so that monitoring can proceed uninterrupted even when equipment is under maintenance, calibration etc.

Water samples for SS measurements will be collected in high density polythene bottles, packed in ice (cooled to 4° C without being frozen), and delivered to a HOKLAS laboratory as soon as possible after collection.

At least two replicate samples should be collected from each of the monitoring events for *in situ* measurement and lab analysis.

3.6.3 Laboratory Procedures

Using chain of custody forms, collected water samples will be transferred directly to laboratory for immediate processing of suspended solids, ammonia, nutrients and BOD_5. Water samples will be analysed for pH and BOD within 4 hours of their arrival at the laboratory. All other parameters will be analysed within 48 hours of arrival. During this period samples will be held at 4 ± 2ºC. Prior to subjecting the sample to metals analysis, samples will be filtered to remove solids and colloidal matter. Filtration will be accomplished using acid washed, single-use 0.45 micron membrane filters within a maximum of 8 hours from sample collection. Where necessary, samples will undergo further preparation involving preconcentration which allows lower method detection limits to be achieved and removes some of the possible sources of interference.

3.7 QA/QC

3.7.1 Field Logs

Field logs will be maintained for all survey work, noting the date of the survey, equipment used, survey manager and a record of all activities and observations. Field logs will be retained for the duration of the Project and archived on completion.

In situ measured data will be digitally recorded from the instruments and converted into Microsoft Excel format, or manually noted. Both disc copy and hard copy will be retained for the file records. Any deviation from the standard procedure will be noted in the log and the reason for the deviation recorded. In addition, field logs will contain notes of events or activities in the vicinity of the monitoring location which might give rise to anomalous data being recorded.

3.7.2 Sampling

The sampling, collection, storage and identification procedures are described in *Section 3.6* of this Manual and the monitoring team will record all data from *in situ* testing and from any analysis carried out on the boat in a Field Log. All samples will be identified with a unique date/ time/ location/ depth/ sample type code which will be attached to the sample container or written in indelible ink directly on the container. In order to avoid contamination of the samples, all containers will be new and unused and of analytical grade quality. Sources of contamination will be isolated from the working area (for example, vessel fuel and exhaust fames) and any sample contaminated by local material (such as printed circuit boards) will be discarded and the sampling repeated. Low level metal analysis in seawater is easily contaminated through inappropriate handling and sampling techniques. Site staff involved in seawater sample collection intended for dissolved metal analysis will ensure that they wear non-contaminating disposable gloves if they have previously been operating or have handled metallic equipment.

3.7.3 Measurement Procedures

All *in situ* monitoring instruments will be checked, calibrated and certified and subsequently re-calibrated at three monthly intervals throughout all stages of the water quality monitoring, or as required by the manufactures specification. Certificate(s) of Calibration specifying the instrument will be attached to the monitoring reports.

3.7.4 Transport of Samples

All samples transferred from one sub-contractor to another will be accompanied by Chain of Custody (COC) forms. Any missing or damaged samples require notification to ET Leader following logging in the laboratory QA system. The number of samples, the parameters to be tested and the time of delivery should be clearly stated on the COC forms to ensure that samples are analysed for the correct parameters and suitable time is provided to the analytical laboratory for provision of resources required in the analyses.

3.7.5 Laboratory Procedures

For details of the contaminants to be tested, the methods to be used, the accreditation status of laboratory analytical methods, instruments and procedures to be used, sample preparation information, method detection limits (MDLs), QA/QC protocols and turnaround times, the monitoring team

will refer to the previous monitoring programme for the ESC CMPIV and CMPV. The analytical techniques to be adopted for this Project must conform to HOKLAS (or similar overseas) accreditation.

3.8 *DATA QUALITY OBJECTIVES*

Data Quality Objectives (DQOs) have been developed in the previous monitoring programme for ESC CMPIV and CMPV [(1)] [(2)] to address precision, accuracy and analyte recovery. The monitoring team is recommended to follow the DQOs developed for data analysis.

3.8.1 *In-situ data*

As the QA/QC procedures for the *in-situ* measurement of DO and Turbidity, where the difference in value between the first and subsequent measurements at a certain depth is more than 25% of the value of the first measurement, the measurements should be discarded and further measurements should be taken to confirm the values.

3.8.2 *Inorganic Analyses*

Details of quality control specifications for inorganic testing should be included in the updated EM&A Manual prior to commencement of disposal activities.

Precision

Duplicates (1 in every 20 samples) will be used to monitoring the precision of the analysis. Results should be flagged for reference when:

- In water samples, for metals with a concentration >4x MDL, the duplicate results have more than a 15% RPD
- For all analytes with concentration <4x MDL, the duplicate results will be reported as analysed and no bounds should be quoted

Accuracy

Standard and certified reference material (CRM) will be used to monitor accuracy and precision within and between batches: Results should be flagged for reference if:

- The variation of the standard from its true value is more than ± 15% (for mercury: ± 20%)

(1) ERM (2001) Op cit.

(2) Mouchel (2001) Op cit.

Recovery

Post digest spikes will be used to determine the recovery of determinants in complex sample matrices. Results should be rejected if:

- Spike recoveries are more than ± 25% from the theoretical recovery for water samples. An exceptional case would be if the sample concentration is greater than four times the spike value, the spike may be disregarded.

4 SEDIMENT QUALITY

4.1 INTRODUCTION

In accordance with the recommendations of the EIA for this Project, a monitoring programme examining sediment quality will be instituted to verify the EIA predictions and confirm that there is no build-up in contamination adjacent to the pits. Sediment chemistry has long been an important component of monitoring programmes at the East of Sha Chau mud disposal complex. A comprehensive list of Contaminants of Concern (COCs) has been used since 1997, comprising eight heavy metals and one metalloid, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (eg DDT) and Tributyltin (TBT). These contaminants (which correspond to the list of COCs in ETWB TC(W) 34/2002 in sediments should be measured in the present monitoring programme and changes over time and distance should also be examined.

4.2 OBJECTIVE

The main objective of this task is to determine if there are any changes and/or trends in the concentrations of contaminants in sediments adjacent to the pits caused by disposal activities at the SB Facility. This objective is most appropriately addressed through two separate but intrinsically linked sub-tasks:

- *Pit Specific Monitoring of Sediment Quality* - conducted to examine near field impacts of backfilling operations at SB on the spread of contaminants from the pits and to allow for rapid detection of any unacceptable environmental impacts and, if necessary, changes to the operations plan.

- *Cumulative Impact Monitoring of Sediment Quality* - conducted to analyse the ambient conditions in the North Lantau region and to investigate whether any impacts to marine sediments are occurring due to the dispersion of contaminants from the active pits at SB.

4.3 HYPOTHESES

The impact hypothesis for this task is as follows:

There is no increase in sediment contaminant concentrations over time at individual stations or a trend of increasing concentrations with proximity to the active pit.

As a result of the separation of this programme into two sub-tasks, two sets of null hypotheses should be tested:

Pit Specific Monitoring of Sediment Quality

H_0 There is no increase in sediment contaminant concentration in the area adjacent to the pits during contaminated mud disposal works.

Cumulative Impact Monitoring of Sediment Quality

H_0 There is no increase in sediment contaminant concentration over time in the area of contaminated mud disposal activity.

H_0 There is no increase in sediment contaminant concentration with proximity to the active pits.

4.4 SAMPLING DESIGN

The designs for assessing the impacts of disposal of contaminated sediment in the active pits at SB on the sediment chemistry of remote and adjacent areas take into account the following factors:

- The null hypotheses being tested;
- Background levels of contaminants in the region;
- Predictions on sediment plume locations;
- Spatial variability in sediment chemistry;
- Temporal variability in sediment chemistry; and,
- Expected statistical treatment of the data.

This EM&A Manual is an evolving document that should be updated to maintain its relevance as the Project progresses. This includes the relocation of monitoring stations, if considered appropriate, to best suit the requirements of the monitoring programme and to take into account other work that is occurring in the direct vicinity of the active facility.

4.4.1 Data Collection Parameters

The parameters that should be measured in sediments collected during the two sub-tasks and the rationale for each are given below. Some of the contaminants listed are the "Contaminants of Concern" for which Lower and Upper Chemical Exceedance Limits (LCEL/UCEL) exist.

a) **Total Organic Carbon (TOC)** - an indicator of organic load and the impact on bottom layer dissolved oxygen. TOC is an important factor influencing the chemical partitioning and toxicity of hydrophobic organic compounds such as PAHs, PCBs and pesticides. High TOC often infers that hydrophobic contaminants are less bioavailable;

b) **Inorganic Contaminants** - metals and metalloids present in the disposed sediments which may be bioaccumulated;

c) **Polycyclic Aromatic Hydrocarbons (PAH)** - a class of organic compounds some of which are persistent and carcinogenic. These compounds may be bioaccumulated and stored in the fatty body tissues of marine mammals;

d) **Total Polychlorinated Biphenyls (PCB**) - a class of persistent man-made chemicals which tend to bioaccumulate through the food chain and can cause reproductive failure and cancer;

e) **Organochlorine Pesticides (DDE & DDT)** - contaminants which are persistent, highly lipophilic (can be accumulated and stored in fat), have high bioaccumulation and biomagnification potential, and high toxicity to aquatic organisms;

f) **Tributyltin (TBT) (in sediment and interstitial water)** – moderately persistent toxic compound found in marine sediments which may be bioaccumulated and cause growth abnormalities and reproductive failure; and

g) **Percentage of Silt/Clay (% < 63µm)** – measured in Cumulative Impacts Monitoring only. Organic contaminants and metals bind more readily to finer particles than coarser particles due to their larger surface area and consequent larger number of binding sites.

4.4.2 Pit Specific Monitoring of Sediment Quality

Pit specific monitoring of sediment quality will be undertaken during backfilling activities. Sediment samples will be collected from two stations in the active pit, two stations on the edge of the active pit and two stations in close proximity to the pit. For pit specific monitoring, parameters (a) to (f) in *Section 4.4.1* will be analysed.

Sediment samples will be collected on a monthly basis from any of the six stations shown in *Figure 4.1* and *Table 4.1*. Locations of the six sampling stations will be dependent on the location of the active pit and will be adjusted accordingly. For example, when SB CMP 1 is active, stations SB-NNAA-B, SB –NEAA-B and SB -NPAA-B will be monitored. Twelve replicates of composite samples (i.e. 5 grab samples obtained using a cluster grab) will be collected from each of the stations. The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. These will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

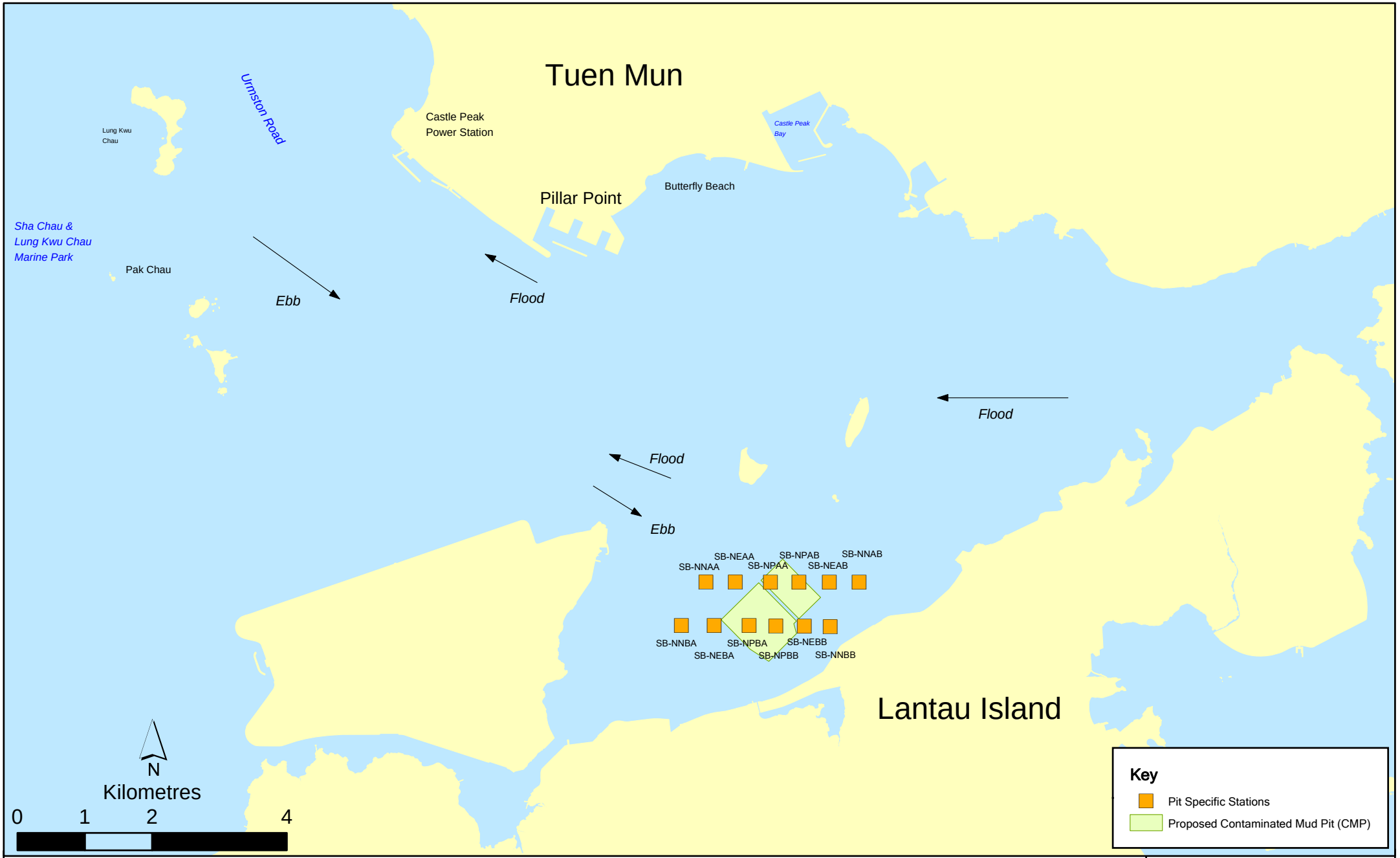

Figure 4.1

Pit Specific Sediment Quality Monitoring Stations for South Brothers Facility

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Date: 14-Sep-12

Environmental Resources Management

ERM

Table 4.1 Coordinates of Pit Specific Sediment Monitoring Stations

Monitoring Stations	Easting	Northing
SB CMP 1 Active		
Near-Pit		
SB-NNAA	813945	819657
SB-NNAB	816218	819650
Pit-Edge		
SB-NEAA	814380	819657
SB-NEAB	815775	819650
Active-Pit		
SB-NPAA	814901	819650
SB-NPAB	815324	819650
SB CMP 2 Active		
Near-Pit		
SB-NNBA	813580	819005
SB-NNBB	815790	818990
Pit-Edge		
SB-NEBA	814067	819005
SB-NEBB	815404	818997
Active-Pit		
SB-NPBA	814587	819005
SB-NPBB	814982	819001

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

4.4.3 Cumulative Impact Monitoring of Sediment Quality

Sediment samples should be collected from stations located in four discrete areas, with two stations in each area. The areas should be located at increasing distances from the disposal operations (ie. Near Field, Mid Field, Capped Pits and Far Field). Sediment samples should also be collected from the Ma Wan and Tai Ho Bay monitoring stations. For cumulative impacts monitoring parameters (a) to (g) in *Section 4.4.1* will be analysed.

Sediment samples will be collected four times per year, twice during the dry season and twice during the wet season at stations indicated on *Figure 4.2* and the coordinates are shown in *Table 4.2*. Twelve replicates of composite samples (i.e. 5 grab samples obtained using a cluster grab) will be collected from each station. The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. These will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

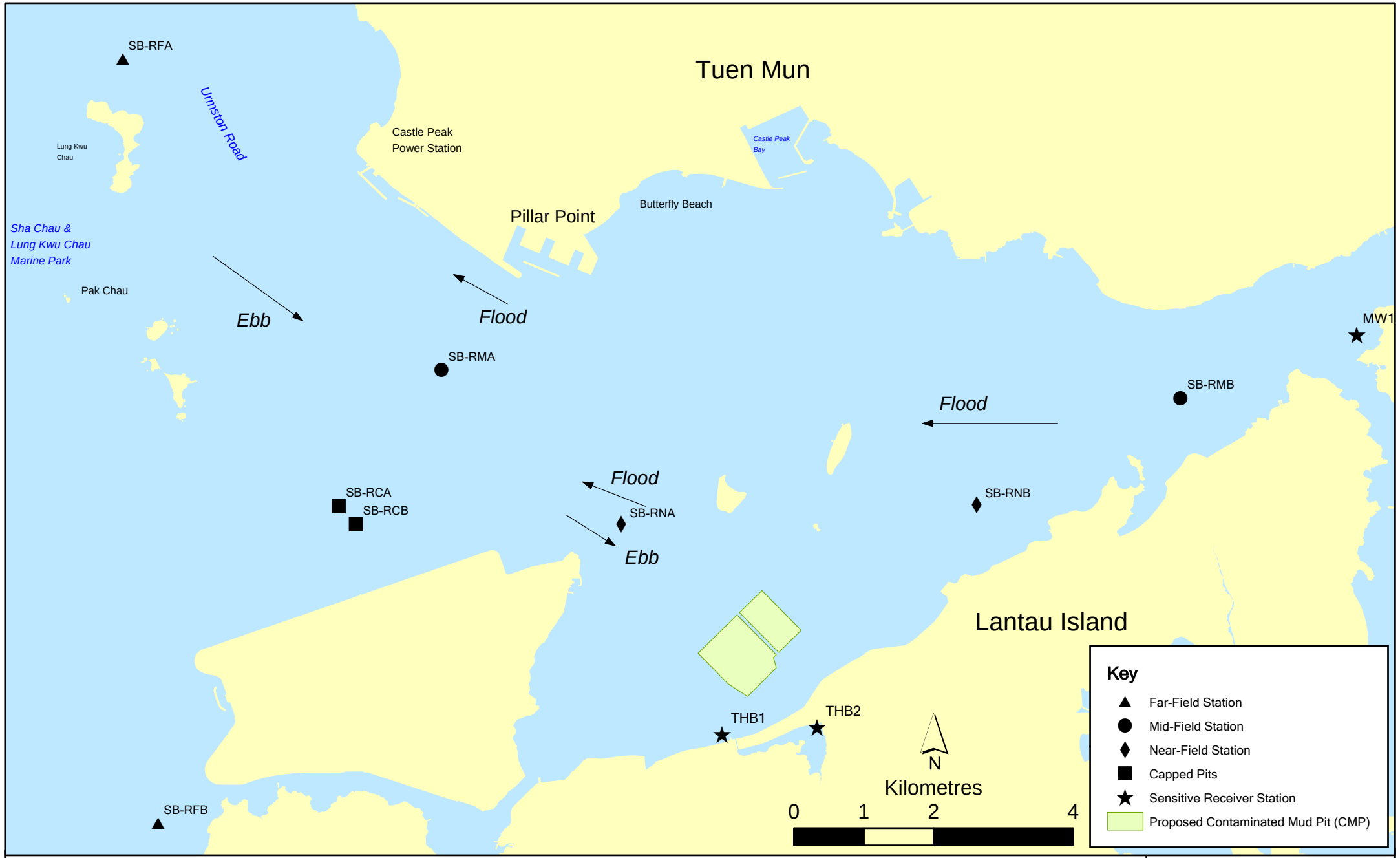

Figure 4.2

Cumulative Impacts Sediment Quality Monitoring Stations for South Brothers Facility

File: T:\GIS\CONTRACT\0175086\Mxd\0175086_4.2_SQMS_cum impact.mxd
Date: 14-Sep-12

Environmental Resources Management

ERM

Table 4.2 Coordinates of Cumulative Impact Sediment Monitoring Stations

Monitoring Stations	Easting	Northing
Near-field		
SB-RNA	813067	820942
SB-RNB	818158	821226
Mid-field		
SB-RMA	810491	823152
SB-RMB	821078	822747
Far-field		
SB-RFA	805928	827614
SB-RFB	806435	816662
Capped Pits		
SB-RCA	809024	821205
SB-RCB	809268	820942
Sensitive Receiver Stations		
MW1	823603	823653
THB1	814514	817932
THB2	815873	818035

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

4.5 STATISTICAL TREATMENT OF DATA

4.5.1 Pit Specific Monitoring of Sediment Quality

Observed differences in the levels of contaminants will be tested using analysis of variance (ANOVA) with factors area and station, followed by Student Newman Keuls (SNK) multiple comparison procedures to isolate which levels within the factor(s) differ from others.

For all of the ANOVA techniques performed during the monitoring programme, initial analyses should be performed to ensure that the data complies with the specific assumptions of ANOVA. These assumptions state:

- the data within and among samples must be independent of each other;
- the variance within samples must be equal (tested through the use of tests such as Levene's median test); and,
- the data among the samples must be normally distributed (tested through the use of tests such as the Kolgomorov-Smirnov test).

Should the data not comply with these assumptions then appropriate transformation should be applied to the data (eg, arc-sin for percentage data, log (x+1) for abundance data, or rank transformation if necessary). If, after transformation, the data are still non-compliant then non-parametric tests equivalent to ANOVA such as Kruskal-Wallis tests should be used.

4.5.2 *Cumulative Impacts of Sediment Quality*

The design of the monitoring programme should allow nested ANOVA techniques to be employed. These techniques will be used to analyse the data at different spatial and temporal scales of replication. Statistical differences should be tested at the following factors: between areas and between sampling times. An advantage of this sampling design is that it removes the possibility of detecting differences simply due to inherent variation over spatial scales in the active area and thus facilitates clearer attribution to disposal operations. By replicating within each area, ie by sampling two stations in one area, any statistically significant differences detected between areas are more likely to be due to factors other than spatial variation (eg locations of disposal operations). This approach is now an internationally recommended technique for use in monitoring programmes (1). Multidimensional scaling ordination techniques will also be applied to the data, if deemed necessary.

4.6 *USE OF DATA*

Should significant increases be detected in the level of contaminants in sediment samples over time or proximity to the active pits, a review of the other monitoring parameters should be undertaken. This review will focus on sampling stations in the vicinity of the sediment quality monitoring stations where increases are detected to see if these can be attributed to contaminant migration from the active pits. Assessment of the statistical significance of the data, confidence in the data and the presence of supporting data from other components of the monitoring programme should be jointly assessed. If appropriate, changes to the operations plan should be considered.

4.7 *SAMPLING PROCEDURE AND EQUIPMENT*

All samples should be collected by an experienced sampling team, deployed on a survey boat equipped with fully calibrated sampling equipment and precision navigational instruments. All vessel positioning should be accomplished with a calibrated Differential Global Positioning System (dGPS), ensuring station location accuracy to < ± 1 m (95% confidence), with sample position automatically logged and mapped by the navigation computer. Where sample stations are located in close proximity to the pit area, positioning should be further validated by use of an echo sounder to detect whether the vessel is within the boundaries of the pit.

At each sampling station the top 5 cm of seabed sediment should be collected using a 5-component cluster grab sampler which collects surface sediments with a minimal disruption to the surface layer and is designed to work effectively in soft sediment such as those found in the area. The cluster grab

(1) AJ Underwood (1997) Experiments in Ecology: their logical design and interpretation using analysis of variance.

should be deployed once at each of the stations located within each sampling area (eg Pit-Edge). The grabs can be customised and a fine mesh lid added, which ensures that the fine fluid sediments on the surface of the seabed are retained in the sample. Utilisation of this cluster sampler allows a large volume of sediment to be collected in a single deployment. Other similar samplers (eg Petit-ponar) collect less sediment in each deployment may have difficulty in collecting adequate samples in soft sediments, such as those within the study area, thereby reducing efficiency and increasing collection time. The five-cluster grab should be collected and combined, and the sample, labelled, double-bagged and stored in an ice chest cooled to a temperature of 4°C with ice packs. The sediment sampler and all other utensils should be rinsed with seawater after each sample has been collected to avoid cross contamination between samples. On completion of the survey, all samples should be promptly transported, in chilled containers, to the testing laboratory for analysis.

4.8 QA/QC

A broad range of contaminants should be analysed in sediment samples including metals, metalloids, PAHs, PCBs, pesticides and Tributyltin in both sediment and interstitial water. The method detection limits should be consistent with previous monitoring programmes at East of Sha Chau. Other QA/QC procedures to be implemented for marine sediment analyses include:

- *Laboratory blanks* - an analyte free matrix to which all reagents will be added in the same volumes or proportions as used in the standard sample preparation to monitor contamination introduced in the laboratory (organics and inorganics);
- *Batch duplicates* - an intralaboratory split sample randomly selected from the sample batch to monitor method precision (intrabatch) in a given sample matrix (inorganics only);
- *Certified Reference Materials* - analysis of a material with a known concentration of contamination to determine the accuracy of results in a given matrix (inorganics only);
- *Single Control Samples* - a known, interference-free matrix spiked with target analytes used to monitor laboratory preparation techniques (organics only);
- *Duplicate Control Samples* - multiple single control samples designed to monitor preparation technique reproducibility (organics).

4.9 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) have been developed to address precision, accuracy and analyte recovery.

4.9.1 Inorganic Analyses

Precision

Duplicates (1 in every 20 samples) should be used to monitoring the precision of the analysis. Results should be flagged for reference when:

- For all analytes, except metals, with concentration >4x Method Detection Limit (MDL), the duplicate results have more than a 20% Relative Percentage Deviation (RPD)
- In water samples, for metals with a concentration >4x MDL, the duplicate results have more than a 15% RPD
- In sediment and biota samples, for metals with a concentration >4x MDL, the duplicate results have more than a 25% RPD
- For all analytes with concentration <4x MDL, the duplicate results should be reported as analysed and no bounds should be quoted

Accuracy

Standard and certified reference material (CRM) will be used to monitor accuracy and precision within and between batches: Results should be flagged for reference if:

- The variation of the standard from its true value is more than ± 15% (for mercury: ± 20%).

Recovery

Post digest spikes should be used to determine the recovery of determinants in complex sample matrices. Results should be rejected if:

- Spike recoveries are more than ± 25% from the theoretical recovery for waters, sediment and marine biota. An exceptional case would be if the sample concentration is greater than four times the spike value, the spike may be disregarded.

4.9.2 Organic Analyses

Samples should be analysed in lots of less than 20. In order to measure the laboratory performance within each batch of samples, a single control sample (SCS), a duplicate control sample (DCS) and a method blank (MB) should be processed concurrently with the samples. A SCS or DCS consists of an interference free control matrix that is spiked with a group of target compounds representative of the method analytes.

Method blanks, also known as reagent, analytical, or preparation blanks, should be analysed to assess the level of contamination that exist in the analytical system and which might lead to the reporting of elevated concentration levels or false positive data. For organic analyses, the

concentration of target analytes in the blank must be below the reporting limit for that analyte in order for the blank to be considered acceptable.

Accuracy is expressed as the average percent recovery for the SCS and precision is expressed as the relative percent difference (RPD) for the DCS pair. For control limits that are not established due to insufficient data sets, the QC Acceptance Criteria of US EPA Method 8080 and 8270A should be used as a supplement. Once enough data are collected, the in-house control limits should then be calculated.

The accuracy and precision data for SCS and DCS should be evaluated against laboratory established control limits. QC results falling outside the control limits should be automatically flagged. The acceptance criterion is that 100 percent of the precision and accuracy values must fall within the control limits. If this criterion is not met, corrective action must be taken. This may include repeat sample analysis.

The average percent recovery of the SCS should be compared to the limit set for each compound being monitored (*Table 4.3*). For DCS, an RPD of less than 20% is deemed to be acceptable in normal instances.

For multianalyte organic tests, if greater than 20% of the accuracy or precision results for the SCS/DCS are outside of the control limits, the data are considered suspect and the samples associated with the unacceptable DCS are reprepared and/or reanalysed.

Table 4.3 Quality Control Acceptance Criteria for Organics Analyses

Target Analytes	Percent Recovery Measured
Naphthalene	74 - 126
Acenaphthalene	69 - 125
Acenaphthene	73 - 119
Fluorene	81 - 129
Phenanthrene	74 - 131
Anthracene	63 - 116
Fluoranthene	73 - 134
Pyrene	59 - 129
Benzo(a)anthracene	77 - 136
Chrysene	53 - 130
Benzo(a)pyrene	51 - 103
Dibenzo(a,h)anthracene	78 - 126
DDE	73 - 121
DDT	87 - 120
Total PCBs	79 - 127
Tributyltin	80 - 115

Results must be greater than zero

5 SEDIMENT TOXICITY

5.1 INTRODUCTION

The ecotoxicological testing programme will feature a suite of tests that include three phylogenetically distinct species that interact with bedded sediments in different ways. Unacceptable impacts may have occurred if the levels of contaminants in the sediments collected in the adjacent area of the active pits are shown to have caused toxicity to marine fauna. The findings of the sediment toxicity tests will be compared to the results of the sediments chemistry.

5.2 OBJECTIVE

The objective of this task is to determine if there are any changes and/or trends caused by backfilling activities in the toxicity of sediments adjacent to the pits as a result of backfilling activities.

5.3 HYPOTHESIS

In accordance with the objectives of this EM&A programme, the impact hypothesis for this task will be as follows:

There is no increase in sediment toxicity over time at individual stations or a trend of increasing toxicity with proximity to the pit.

The null hypothesis which should be statistically tested is as follows:

H_0 There are no differences in the toxicity of sediments collected at stations adjacent to the active pits when compared with reference sediments.

5.4 SAMPLING DESIGN

In order to determine whether contaminated sediment placed in the active pit represents an ecological risk to biota in areas adjacent to the mud pit, ecotoxicological evaluations will be performed on sediment collected from these surrounding areas.

The toxicological testing programme should feature a suite of tests that includes phylogenetically distinct species which interact with sediments in different ways. The testing programme will include whole-sediment, or solid-phase toxicity tests. The following three international species should be tested:

- Burrowing amphipod (*Leptocheirus plumulosus*, *Ampelisca abdita*, *Eohaustorius estuarius* or other equivalent species);

- Burrowing polychaete (*Neanthes arenaceodentata* or other equivalent species); and,

- Free swimming larvae of bivalves (*Crassostrea gigas*, *Mytilus* spp. or other equivalent species).

In addition, two of the following local species should also be tested:

- Amphipod *Melita longidactyla*;

- Polychaete *Capitella capitata*;

- Juvenile shrimp *Metapenaeus ensis* or *Penaeus (Litopenaeus) vannamei*; and,

- Barnacle larvae *Balanus amphitrite*.

The experimental designs for assessing the impacts of disposal of contaminated sediment at SB on the toxicity of sediments in remote and adjacent areas take into account the following factors:

- The null hypotheses being tested;

- Location of other potential sources of contaminants in the North Lantau region, eg, Pearl River;

- Predictions taken from the EIA on sediment plume locations; and,

- Expected statistical treatment of the data.

Once the pit is active (ie receiving contaminated sediment), sediment toxicity testing will be performed only when the level(s) of sediment contaminant(s) in the Near-field station(s) exceed the LCELs as measured by the *Cumulative Impact Monitoring of Sediment Quality*. Monitoring stations will be sampled not more than twice per year (once in each of the wet and dry seasons).

Sediment samples will be collected from two treatment areas as well as at the Ma Wan and Tai Ho Bay stations. The first treatment area is represented by samples taken from two stations in an area close to the active pits (Near-Field) and the second treatment area is represented by samples collected from stations in a reference area (Far-Field). The locations of stations are shown in *Figure 5.1* and the coordinates are presented in *Table 5.1*. Five replicates of composite samples will be collected from each of the stations and used for the sediment toxicity tests. The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. These will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*. In addition, locations of sampling stations will be amended based on location of the active pit.

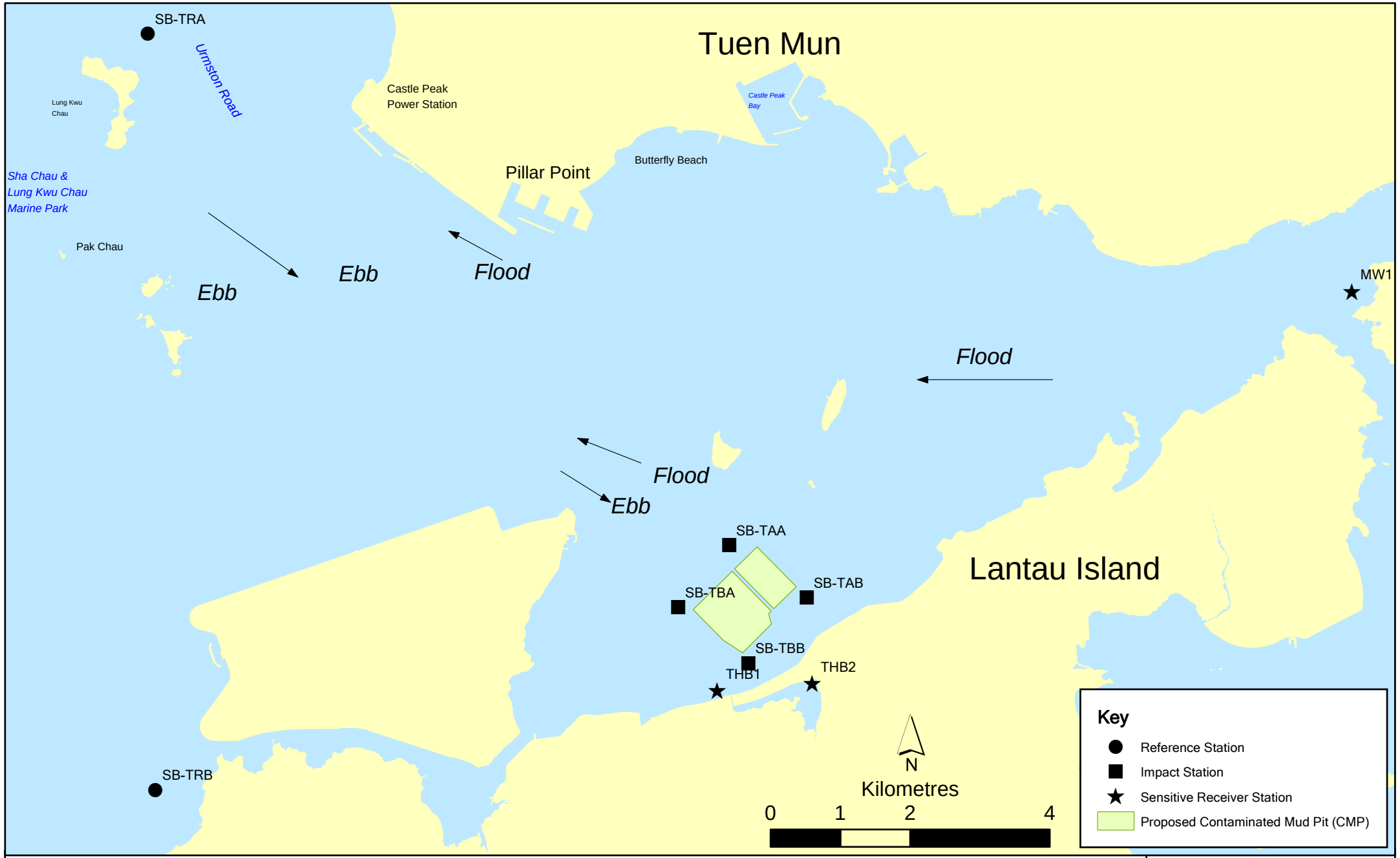

Figure 5.1

Sediment Toxicity Monitoring Stations for South Brothers Facility

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Table 5.1 Sediment Toxicity Testing Sampling Stations

Station	Easting	Northing
SB CMP 1 Active		
Reference		
SB-TRA	806358	827343
SB-TRB	806465	816513
Near-Field		
SB-TAA	814685	820017
SB-TAB	815797	819269
Sensitive Receiver Stations		
MW1	823603	823653
THB1	814514	817932
THB2	815873	818035
SB CMP 2 Active		
Reference		
SB-TRA	806358	827343
SB-TRB	806465	816513
Near-Field		
SB-TBA	813954	819131
SB-TBB	814960	818327
Sensitive Receiver Stations		
MW1	823603	823653
THB1	814514	817932
THB2	815873	818035

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

5.5 STATISTICAL TREATMENT OF DATA

Each of the toxicological tests will be evaluated for statistically significant increases in toxicity. Statistically significant toxicity will be determined by performing an analysis of variance (ANOVA) test that compares the responses observed in the test treatments with those of the reference treatments. At the end of the monitoring programme changes in the toxicity of the sediments over time will be evaluated through the use of ANOVA incorporating both spatial and temporal scales of variation.

5.6 USE OF DATA

Once the data have been evaluated for significance, it is important to identify potential causes of toxicity and the biological significance of the observed effects. The cause of the observed effects needs to be distinguished between 1) non-persistent contaminants, 2) persistent contaminants, and 3) physical factors. It is most important to determine if the cause of the toxicity is due to persistent contaminants that are derived from the contaminated sediment placed in the pits (eg metals, pesticides, PAHs, TBT), to non-persistent contaminants (eg sulfides, ammonia, salinity) or to physical factors (eg grain size).

If the toxicity is due to persistent contaminants that are associated with disposal operations, the operations plan for the active pits may not be effective

enough at managing the containment of contaminated sediment to acceptable levels and thus should be modified. If the observed toxicity is due to non-persistent contaminants, the effects may be due to the pit but they are transient. The toxicity of these types of contaminants can be assimilated by the environment in relatively short time periods, and are thus less harmful. If the effects are related to physical factors, they are again of less concern and would not likely require changes in the facility operations plan.

As non-contaminant factors and physical factors can confound toxicity test interpretation, the ET will monitor ammonia, sulfides, interstitial salinity, and sediment-grain size. Each of these factors has been observed to elicit a toxic response in test organisms, however, they are not factors related to persistent contaminants of concern. This information will be used to investigate any observed toxicity responses and determine whether the response is due to persistent contaminants or to more transient factors.

5.7 *DATA COLLECTION PARAMETERS*

The amphipod toxicity test with burrowing amphipod (*Leptocheirus plumulosus, Ampelisca abdita, Eohaustorius estuarius* or other equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate survival following a 10-day exposure to test sediment. Procedures will follow those outlined in PSEP (1995) (1) and/or USEPA (1994) (2), depending on the species used for the test, and CEDD's Environmental Laboratory Guidance Document (1996) (3). The amphipod test will be conducted as a static test and will be performed with 175 ml of sediment and 800 ml of overlying seawater placed in a 1-L glass jar. At test initiation, each of five replicate test chambers will be seeded with 20 amphipods. Test chambers will be maintained at 20°C and will be checked daily throughout the test to establish trends in sediment avoidance. After the 10-day exposure, the benthic tests will be terminated by sieving the sediments and enumerating the live and dead amphipods.

The test on *Neanthes arenaceodentata* (or an equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate polychaete survival and growth following a 20-day exposure to test sediment. Test methods will follow those outlined in PSEP (1995) (4). The test will be conducted as a static test, performed in 175 ml of sediment and 800 ml of overlying seawater in 1-L glass jars. At test initiation, each of five replicate test chambers will be seeded with five polychaetes. Test chambers will be maintained at 20°C and will be checked daily to record mortality and

(1) Puget Sound Estuary Program (PSEP) (1995). Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Prepared for the US EPA.

(2) 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.

(3) EVS (1996). Testing of Dredged material for Marine Disposal: Environmental Laboratory Guidance Document. Prepared for CED.

(4) EVS (1996). Testing of Dredged material for Marine Disposal: Environmental Laboratory Guidance Document. Prepared for CED.

sediment avoidance. To promote growth, worms will be fed TetraMarin every third day throughout the test. After 20 days, the *N. arenaceodentata* test will be terminated by sieving each test chamber and enumerating both live and dead organisms. Surviving polychaetes will be dried and weighed for each test chamber. Average dry weight will be compared to initial biomass to determine mean growth for each test chamber.

The larval-development toxicity test will be performed with fertilized bivalve embryos (*Crassostrea gigas, Mytilus* spp. or a equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate larval survival and development following a 48 to 96-hour exposure to test sediments. This procedure will follow those outlined in PSEP (1995) (1). This test will be conducted in 20 mg of test sediment with 800 ml of seawater in 1-L glass jars. At test initiation, test jars will be seeded with 20 to 40 embryos per ml. Test chambers will be maintained at 16°C. At termination, overlying water will be decanted and subsamples drawn from the supernatant. Survival and normal larval development will then be determined under an inverted compound microscope.

In each of the sediment tests, a sediment/seawater control (consisting of clean sediment for amphipod and polychaete or clean seawater for the bivalve larval test) will be tested concurrently with the test sediments. The control treatment should be included to determine the health of the test organisms. Sediments collected from the reference stations will also be tested concurrently with test sediments to provide a basis for statistical comparison. For the larval tests, grain-size controls will be tested concurrently with the test sediments to discern any effects related to sediment grain size. Additionally, a water-only reference toxicant test using cadmium (from $CdCl_2$) or copper (from $CuNO_3$) will be conducted with each batch of test organisms. This reference-toxicant test provides a measure of relative sensitivity for each group of test organisms. All toxicity tests will be completed and reported within four months from collection of the samples.

5.8 SAMPLING PROCEDURE AND EQUIPMENT

Procedures for sampling will be as for the sediment chemistry for Sediment Quality Monitoring as detailed in *Section 4.7* of this Manual. Shipments of the sediments will be packaged in ice-boxes in order to maintain the sediments at a constant temperature of 4°C and dispatched by express courier for immediate testing.

5.9 QA/QC

To ensure the quality and integrity of the ecotoxicological data and subsequent analyses, a QA/QC control program will be followed that meets or exceeds the QA/QC program outlined in Chapter 4 of CEDD's

(1) PSEP (1995) *op cit*.

Environmental Laboratory Guidance Document (1996). The QA/QC program for the facility ecotoxicological program is described below.

5.9.1 Sediment Handling and Chain-of-Custody

Upon sample receipt, samples will be held at 4° ± 2° C in the dark until required for testing. Sediment holding times for biological testing begin the day of sample collection and will be kept at a minimum. The holding time for sediment intended for biological testing will be eight weeks. Chain-of custody forms will accompany each batch of samples to track samples and to provide temperature data before and after shipping.

5.9.2 Bioassay Seawater

Clean seawater for holding test organisms will be sand-filtered seawater piped directly into the testing laboratory. Seawater used for test water and control water should be additionally gravity-feed filtered through a 0.45 micron filter before use for all test species. Bioassay seawater should be continually monitored for water quality and the presence of algal blooms.

5.9.3 Instrument Maintenance and Calibration

Procedures for calibration and maintenance of water quality equipment will follow Measurement Standards Laboratory (MSL) protocols. All measuring and testing equipment used on this Project should be traceable to the data collected and should be calibrated before use.

The pH meters used for obtaining water quality data must be calibrated daily before use according to MSL-M-045, Calibration and Use of pH Meters. The calibration will be documented on the pH Meter Calibration Record sheet. Maintenance on pH meters will be performed monthly. Maintenance should include visual inspection, cleaning probes in 0.1 M HCl, and cleaning any corroded contacts.

Refractometers used for obtaining water quality data will be calibrated monthly using IAPO Standard Seawater according to MSL-M-048, Calibration and Use of Refractometers. The calibration should be documented on the Refractometer Calibration Record sheet. Refractometers should be inspected visually and cleaned monthly.

Digital thermometer calibrations will be performed monthly by comparison to a certified mercury thermometer as specified in MSL-M-047, Calibration and Use of Thermometers. The calibration will be documented on a Thermometer Calibration Record. Maintenance should include visual inspection and cleaning of salt and corrosion from connectors and contacts.

Dissolved oxygen meters should be calibrated daily before use according to MSL-M-046, Calibration and Use of Dissolved Oxygen Meters. The calibration should be documented on the Dissolved Oxygen Meter Calibration Record. Maintenance should be performed once monthly and should include visual inspection, cleaning the probe, and replacing of probe membrane.

The Fisher Accumet 1003 pH/selective ion electrode meter with ammonia electrode should be maintained according to manufacturer's instructions. The meter should be calibrated on each day of use with three concentrations of NH_4Cl standards bracketing the expected test concentrations of ammonia. The ammonia probe should be stored in 0.02 M NH_4Cl when not in use.

5.9.4 Data Review and Validation

In addition to QA/QC mentioned above, a series of reviews by qualified laboratory personnel should be implemented to ensure that the data generated for this Project meets the data quality objectives. These reviews should include the following:

- Data should be reviewed periodically by laboratory personnel to ensure that sample testing activities are completely and adequately documented.

- Sample holding times, sample integrity, test animal handling and acclimation, equipment calibration, water quality measurements, reference toxicity results, observations, and control survival will be reviewed by qualified laboratory personnel. The results of QC measurements will be compared to pre-established criteria as a measure of data acceptability.

- A final data audit by the Quality Assurance Officer will be performed prior to submission of the data and report. This audit will ensure that the data are accurate, traceable, defensible, and complete, as compared to the Manual. The audit procedure (MSL-Q-005, Quality Assurance Data Audits) is a statistical, randomized check which involves comparing selected reported values to the original data. This procedure is designed to ensure a 95 percent chance of detecting whether one percent or more reported values disagree with the original data.

The overall quality assurance objective for this Project is to implement procedures that will ensure the collection of representative data that is of acceptable and defensible quality. The data quality objectives for the ecotoxicological tests will be devised with reference to the previous data quality objectives established for the previous monitoring programmes for the East of Sha Chau CMPs.

A negative control provides a measure of test organism health. Negative control treatment will be running concurrent to each toxicity test as a measure of the test organism's health. For the amphipod (eg *Ampelisca sp*.) and polychaete (eg *Neanthes* sp.) toxicity tests, the negative control should consist of clean, native sediment that is to be collected from the test organism's natural habitat. For the bivalve larval test, the negative control should consist of clean seawater. Acceptable limits for the negative controls will be defined with reference to the limits established for the East of Sha Chau CMP monitoring programmes. If survival or normal development do not meet the acceptability criteria, all data should be evaluated and the test may need to be repeated.

Water quality measurements provide documentation of environmental conditions within the test chambers during the exposure. Temperature, dissolved oxygen, pH, and salinity will be measured daily throughout the test. Conditions that are acceptable to maintain the health of the test organisms will be defined with reference to the acceptable conditions defined for the East of Sha Chau CMP monitoring programmes. If test conditions are outside the acceptability criteria, the data will need to be qualified.

The positive control provides a relative measure of test organism sensitivity. For each of the bioassays for the active pits, a separate reference-toxicant test should be performed with each batch of test organisms. The results of the reference-toxicant tests will be compared with control charts generated by the testing laboratory for that species and toxicant. Those results within two standard deviations of the cumulative mean are considered to be similar in sensitivity to previous test populations. For amphipods (eg *A. abdita*) the reference-toxicant test will be performed with cadmium in the form of cadmium chloride ($CdCl_2$); for polychaetes (eg *N. arenaceodentata*) and bivalve larvae reference-toxicant tests will be performed with copper as copper nitrate ($CuNO_3$). If the test results are outside the control limits, the data will need to be qualified.

6 MARINE BIOTA

6.1 INTRODUCTION

The bioaccumulation of contaminants by prey organisms and consequent biomagnification of contaminants up the food chain has long been an issue of concern for the disposal of contaminated sediment at East of Sha Chau. Although the public at large may not appreciate the technical details of a biomonitoring programme, especially concerning mobile populations, they are well aware of the potential for contaminated sediment disposal to taint seafood products. In recognition of these issues, a comprehensive biomonitoring programme which will address public concerns about contamination of seafood in the area through use of the data in a risk assessment framework should be undertaken for the backfilling activities at the active pits.

6.2 OBJECTIVE

As well as examining the influence of contaminated sediment disposal on contaminant levels in demersal fisheries resources, the impact of disposal on the abundance and structure of demersal fisheries should also be assessed. Consequently, there are two objectives for this task:

- *Biomonitoring of Contaminants* - To identify any increases in the concentrations of contaminants in tissues and whole body burdens of demersal marine life adjacent to and remote from the active pits.
- *Trawling, Sorting & Analysis* - To assess the impact of contaminated sediment disposal at the active pits on the fisheries resources of the North Lantau area.

6.3 HYPOTHESIS

In accordance with the predictions of the EIA and the objectives for this EM&A programme, the impact hypothesis for this task is as follows:

There is no increase in tissue or whole body contaminant concentration over time in selected target species.

In order to reflect the dual workstreams under this task, two sets of null hypotheses should be tested:

Biomonitoring of Contaminants

H_0 The concentrations of contaminants in tissue and whole body samples of demersal marine life adjacent to the active pits are not greater than

contaminant concentrations from samples collected at stations remote from the active pits.

H_0 The concentrations of contaminants in tissue and whole body samples of demersal marine life do not increase over time.

Trawling, Sorting & Analysis

H_0 There are no differences in the composition or abundance of demersal fisheries resources near to and remote from the active pits.

H_0 There are no differences in the composition or abundance of demersal fisheries resources over time.

6.4 SAMPLING DESIGN

6.4.1 Biomonitoring of Contaminants

Samples for biomonitoring of contaminants will be selected from trawl samples described in *Section 6.4.2*. Samples of the target species should be collected twice per year (July/August in the wet season and January/February in the dry seasons) specifically from six stations. The reference stations will comprise of two stations located near Lung Kwu Chau and two stations to the south west of the airport (*Figure 6.1*). These reference stations are the same as those sampled in the ongoing monitoring programme (*Agreements No. CE 64/99*, *CE 19/2004* and *CE 4/2009(EP)*). The other two stations will be impact stations, located on the edge of active pits. However, in order to obtain sufficient tissue and whole body samples from impact and reference stations, samples collected at different impact and reference stations will be combined where necessary.

Due to concerns regarding the collection of sufficient quantities of target species, catch from the first trawl survey of each season (trawl for catch characterisation) should be retained in a frozen state for joint processing with the biomonitoring samples in the following month.

Five replicate tows (each with six nets) should be conducted at each station and composite samples prepared from all nets and tows at each station during each of the sampling events. Replicate data points should be obtained whenever the abundance of target species allows laboratory analysis of more than one tissue/whole body sample for each target species at each station. The design to be developed should address the following key issues:

- Rigour of the dataset to allow for statistical testing of observed differences;
- Data required for the risk assessment;
- Composite samples to minimise the variance between fish and improve the reliability of detecting any significant trends; and,

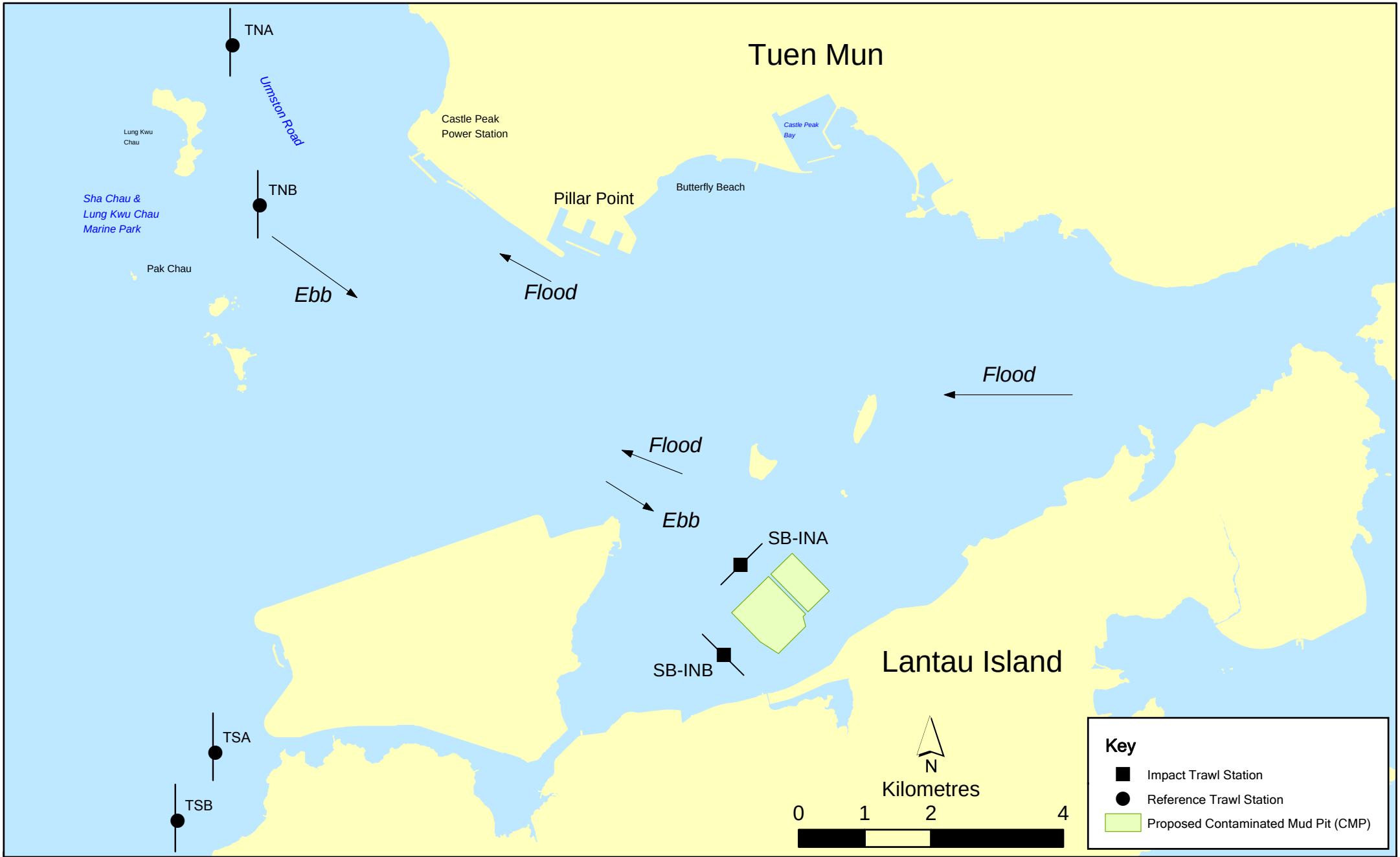

Figure 6.1

Marine Biota Monitoring Stations for South Brothers Facility

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- Analysing replicate samples, whenever possible, to provide cost effective statistical rigour.

The locations of biota monitoring stations are shown in *Figure 6.1* and the coordinates are shown *Table 6.1*. Details on the *Sampling Programme* are shown in *Annex C*. The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach.

Table 6.1 Demersal Trawl Sampling Station Coordinates (Center of the transect)

Station	Easting	Northing
Impact		
SB-INA	814304	819813
SB-INB	814052	818459
Reference North		
TNA	806627	827674
TNB	807040	825248
Reference South		
TSA	806366	816977
TSB	805796	815951

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

6.4.2 Trawling Sorting & Analysis

The design of the sampling programme should encompass the following key issues:

- Temporal variation in fisheries assemblages; and,
- Spatial variation of mobile assemblages of demersal fisheries resources.

Samples should be collected for analysis four times each year (twice in the dry season and twice in the wet season) to account for temporal variation in the fisheries assemblages. The samples should be collected from 5 replicate trawls (each with 6 nets) undertaken along a transect at each of the six stations, in which two stations are located at the impact area while four stations are located at the two reference areas (*Figure 6.1*). The sampling frequency and number of replicates are the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. Samples for biomonitoring of contaminants will be selected from the trawl samples.

6.5 STATISTICAL TREATMENT OF DATA

6.5.1 Biomonitoring of Contaminants

The data should be analysed using analysis of variance (ANOVA) techniques to test for differences between the two sampling sites (Impact and Reference). Once a time series of data (sequential sampling events) has been gathered, differences should be tested between sites and between the different sampling

events to examine any temporal trends in contaminant levels in the target species.

6.5.2 *Trawling, Sorting and Analysis*

Catch composition should be analysed using analysis of variance (ANOVA) techniques to account for changes in catches between and within sites in the North Lantau region and between different sampling times.

6.6 *USE OF DATA*

If significant increases are detected in the levels of contaminants in fisheries resources in this programme it will indicate that bioaccumulation is occurring. However, as demersal fisheries resources are generally mobile (except burrowing species such as the gobies *Trypauchen* and *Oxyurichthys*), increases may not necessarily be due to backfilling at the SB Facility. Other contaminant sources such as discharges from the Pearl River, local sewage outfalls or non-point source pollution may cause such increases. To account for these confounding effects, the results from this Project's sediment and water quality monitoring programmes along with the most recent sediment toxicity test results will be examined so that the sources of any increases can be identified. Should there be evidence that effects are due to the active facility, the monitoring and disposal programmes will be reviewed and revised where necessary as agreed with CEDD and the EPD.

6.7 *DATA COLLECTION PARAMETERS*

6.7.1 *Biomonitoring of Contaminants*

The contaminants of concern for this Project should be measured separately, firstly in tissue samples (soft tissue) and secondly in whole body samples obtained from the species list established for this project. The species to be examined should be chosen based on two criteria:

- The degree to which the organisms are exposed to contaminants in the sediments; and
- The position of the organisms in the food chain and the trophic level of their predators (ie, humans or Indo-Pacific Humpback Dolphin).

The species list (*Table 6.3*) has been devised with reference to the previous biomonitoring programmes for the East of Sha Chau CMP's. Comparing to the monitoring programme from February 2006 to April 2009, the analysis of whole body samples of Cephalopods is suggested to be removed from the present monitoring programme as according to Jefferson and Hung (2004) (1), there is little evidence that Indo-Pacific Humpback Dolphin consumed Cephalopods as a major prey item. Therefore, it is considered unnecessary to

(1) Jefferson TA and Hung SK (2004) Op cit.

analyse Cephalopods for the risk assessment of Indo-Pacific Humpback Dolphin (please refer to *Section 7* for details of risk assessment).

Table 6.2 List of Target Species for Tissue and Whole Body Analysis

Type	Tissue Analysis Target Taxon	Alternative Taxon	Whole Body Analysis Target Taxon	Alternative Taxon
Prawn	*Metapenaeus ensis* *Metapenaeus Affinis*	*Metapenaeus joyneri* *Metapenaeopsis* spp.	*Metapenaeus* spp.	*Metapenaeopsis* spp.
Mantis Shrimp	*Oratosquilla oratoria*	*Oratosquillina interrupta* *Miyakea nepa*	*Oratosquilla* spp.	*Oratosquillina* spp.
Swimming Crab	*Charybdis cruciata*	*Portunus sanguinolentus* *Scylla serrata* *Portunus pelagicus* *Portunus Trituberculatus*		
Flat Fish	*Cynoglossus macrolepidotus*	*Cynoglossus trigrammus* and *Solea ovate*		
Burrowing Fish	*Trypauchen vagina*	*Oxyurichthys Tentacularis*		
Demersal/Pelagic Fish	*Leiognathus brevirostris*	*Collichthys lucida*	*Leiognathus* spp. *Collichthys lucida*	 *Johnius belengeri* Other Sciaenidae
Gastropod	*Turritella terbra*			
Non-Commercial Crab			*Charybdis* spp.	

Note:

- In case sufficient samples of the target species cannot be obtained, analysis of the alternative species should be carried out.
- The alternative species are listed in order of priority.

In the laboratory, each trawl sample should be sorted for target species and target species selection should be based on the abundance and potential sample mass available for each species captured. In preparing composite samples for analysis, different species will not be mixed. Each composite sample for laboratory analysis should consist of three or more organisms, with priority given to larger individuals with no more than 2 fold difference in length. Length and weight of all individual organisms represented by the composite sample will be recorded and individuals for tissue sample analysis dissected with a sterilised (with hexane) titanium knife and a composite sample prepared. Care should be taken not to cross contaminate any tissue samples with gut contents. For fish, the axial muscle should be extracted for

analysis. For prawn/shrimp and crab, abdominal and claw/leg muscle should be used, respectively. For gastropods, tissue samples should be taken from the soft body tissue.

The analytical parameters for tissue and whole body testing are given below:

- Inorganic Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury
- Nickel;
- Silver;
- Zinc;
- Total Polychlorinated Biphenyls (PCBs);
- Organochlorine Pesticides (DDE & DDT);
- Tributyltin (TBT);
- Polycyclic Aromatic Hydrocarbons (PAHs); and,
- Moisture content.

For each of the target taxon a total of five replicates (i.e. composite samples) from each station should be analysed for each analytical parameter for tissue and whole body analysis, respectively. The number of replicates is the same as those currently proposed for the CMP V EM&A programme and will initially be used for SB monitoring as a consistent and conservative approach. It will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

Tissue Pooling and Preparation

In the event when insufficient biota are collected in the trawl samples for chemical analysis of contaminants. Samples may be pooled using the procedures shown in *Table 6.3* and in the text below. It may be noted that inter-seasonal pooling is not permitted.

Table 6.3 Methodology for Pooling Samples to Obtain Sufficient Tissue/Whole Body

#	Step Stations to Be Combined	Decision Criteria
1	Impact (INA) + Impact (INB) = Impact Reference (TNA) + Reference (TNB) = Reference	Proceed to step 2 unless tissue and whole body samples are adequate for analysis
2	Above + previous months Impact (INA) = Impact Above + Reference (TSA) + Reference (TSB) = Reference	Proceed to step 3 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
3	Above + previous months Impact (INB) = Impact Above + previous months Reference (TNA) = Reference	Proceed to step 4 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
4	Above + previous months Reference (TSB) = Reference	Proceed to step 5 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
5	Above + Reference (TSA) and Reference (TSB) = Reference	N/A

(1) Note that inter-seasonal pooling is not permitted

The pooling of Reference and Impact biota is not permitted. Pooling biota from station in the same area should only be done as a last measure.

Wherever possible, samples from the same station and of the same species should be pooled together ie pooling together Species X from TNA Trawl 1 January 2012 with TNA Trawl 2 January 2012 would be preferable to pooling samples from TNA and TNB, this can sometimes be unavoidable due to low catch rates. Pooling of totally different taxa is not permitted, however, similar taxa can sometimes be pooled when using 'Alternative Species'.

If insufficient material is obtained following pooling then, material should be kept and used in 'Alternative Species' pooling if they are of a similar group (e.g. if not enough *Charybdis cruciata* are available after the pooling of stations it is possible to pool with other *Charybdis* sp.). Contaminant uptake is dependent on the salinity of the water, which is seasonal. Typically greater uptake occurs during the wet season when salinity is lower than in the dry season [1]. For this reason, the pooling of samples between different seasons should not be conducted.

6.7.2 Trawling, Sorting & Analysis

Catches from the trawl vessel should be processed to record the abundance and biomass of individuals of commercial fisheries resources as well as the number of species (or to the lowest possible taxonomic level) present.

[1] Mouchel (2003). Op cit.

6.8 SAMPLING PROCEDURE AND EQUIPMENT

Trawl sampling should be conducted during daytime (0600 – 1800 hours) by a shrimp trawler equipped with a GPS system to ensure accurate positioning of each trawl. Five replicate trawls, with six nets deployed in each, should be conducted for 10 minutes at a trawl speed of about 5 km/hr at each station. If more than one of the six nets are retrieved in a damaged condition, the samples should be rejected and the trawl repeated. To ensure the quality of the benthic trawl samples, several control measures have been incorporated into the sampling programme, including:

- no more than three consecutive trawls should be conducted at a station and resampling should only occur after a minimum of two hours has elapsed;
- subsequent trawls at each station should be shifted (e.g. by ~ 500 m) to avoid repetitive sampling over the same area of seabed; and,
- the first station sampled in each survey should be selected at random to minimise the diurnal influences on catches.

Catches from all six nets in each trawl should be combined to form one sample. Each sample should be immediately washed and stored in sterilised (with hexane) glass jars. All samples should be chilled to 4 °C and transported to the laboratory for further sorting and analysis.

7.1 INTRODUCTION

The waters north of Lantau have historically been important fishing grounds. These fishermen's catches comprise mainly shrimps and crabs, as well as fish species of relatively low commercial value such as pony fish, puffer fish and gobies (1). The North of Lantau area also is recognized as the primary habitat of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) within Hong Kong waters. This species, which is listed as Near Threatened on International Trade in Endangered Species (CITES), has a limited distribution in Hong Kong waters due to its preference for shallow, coastal estuarine habitat and is thought to be threatened by continuing development in the Pearl River Delta.

Backfilling operations at the SB Facility will be designed to minimize the dispersion of contaminated sediments during disposal and to prevent the long-term migration of contaminants through placement of a clean sand and mud cap. However, as losses of contaminated sediment will nevertheless occur during placement, and as the area serves as habitat for marine species which may be consumed by humans and/or the Indo-Pacific Humpback Dolphin, the risk of adverse impacts must be addressed by the monitoring programme. Pathways of contaminant release to sensitive receivers (ie humans and dolphins) include ingestion of contaminated sediment, ingestion of dissolved and suspended contaminants in water, and ingestion of organisms with contaminant residues.

Consequently, a risk assessment will be performed on an annual basis to verify that no unacceptable risk are occurring to either human health or marine mammals as a result of consuming prey species from the waters in the vicinity of the pits of North Lantau. The details of the EM&A programme for assessing hazard to health of humans and marine mammals are presented below.

7.2 OBJECTIVE

The objective of the risk assessment component of the monitoring programme is to determine whether backfilling operations at the active pits are posing an unacceptable risk to humans and dolphins through consumption of seafood/marine prey species from the North Lantau area. This objective should be addressed through a standardized risk assessment methodology which cost effectively builds on existing risk assessment methodologies and databases and overcomes some of the previous studies' limitations.

(1) ERM (1997) Fisheries Resources and Fishing Operations in Hong Kong Waters. Draft Final Report prepared AFD.

7.3 HYPOTHESIS

Given the above discussion of objectives, the impact hypotheses for this component of the monitoring programme are defined as follows:

For Human Health

IH_1: *Risks to human health from consumption of commercial species captured adjacent to the active pits are no greater than risks associated with consumption of species remote from the active pits;*

AND

IH_2: Risks to human health from consumption of commercial species captured adjacent to the active pits are below the screening risk criterion (see *Section 7.5*).

For Dolphins

IH_1: Risks to dolphins from consumption of prey species captured adjacent to the active pits are no greater than risks associated with consumption of prey species remote from the active pits;

AND

IH_2: Risks to dolphins from consumption of prey species captured adjacent to the active pits are below the screening risk criterion (see *Section 7.5*).

7.4 SAMPLING DESIGN

Data required for the risk assessment should consist of:

- contaminant concentrations in commercial/prey species collected from stations adjacent to and remote from the active pits;
- toxicology data for humans and dolphins;
- literature-derived human consumption rates and patterns for seafood;
- literature-derived data on exposure of humans from other food groups;
- literature-derived data on contaminant levels in marine mammals;
- data collected by AFCD on contaminant levels in stranded *Sousa chinensis* carcasses; and,
- existing natural history information for the Indo-Pacific Humpback Dolphin and related species (eg diet composition and feeding range).

The primary data input to the risk assessment should derive from the biannual trawl (ie tissue samples for human populations and whole body

samples for dolphins) monitoring events (*Section 6*). The risk assessment will be performed on an annual basis.

7.5 USE OF DATA

The risk assessment will follow the guidelines of the US Environmental Protection Agency [1] [2] and will incorporate a four-step approach involving problem formulation, estimation of exposure, characterization of ecological or human health effects (injury), and risk characterization. Each of these steps is described below with reference to how each applies to both human health and ecological risk assessment.

Problem Formulation: Also known as hazard definition [3], the problem formulation will describe the sensitive populations (eg the general Hong Kong population, subsistence fishermen, the Indo-Pacific Humpback Dolphin) and identify biological effects of concern potentially associated with the backfilling operations at the active facility. Identification of these effects should include a discussion of contaminants of concern, measurement endpoints and a conceptual model embodying the mechanisms of contaminant migration.

Estimation of Exposure: The purpose of the exposure estimation is to determine the intake of each contaminant of concern by potentially exposed individuals. This step will consider the various routes of contaminant release and their migration from the site to sensitive receivers. Factors such as fate and transport processes, the concentrations in the ambient environment, and the maximum short-term or average lifetime doses should be assessed.

For human populations exposure factors presented in previous reports [1] [2] will be critically evaluated to determine if further modification is necessary. These factors, which include amounts of seafood consumed, origin of seafood products, and methods of preparation (eg raw versus cooked, whole body vs tissue only) will be evaluated for the general population and any sensitive sub-populations (eg subsistence fishermen fishing in the SB area).

Characterization of Effects: The effects assessment is designed to quantify the relationship between the degree of exposure to a substance and the extent of toxic injury or disease. This step in the assessment will use data derived from dose response studies on laboratory animals or, less frequently, on exposed human populations and clinical trials. For non-carcinogenic substances, once the relationship between doses and responses is established, a threshold which represents the highest contaminant concentration that is not expected to result in an adverse effect, ie the reference dose (RfD) or a No Observed Adverse Effect Level (NOAEL) can be established. This threshold

(1) U.S. Environmental Protection Agency. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001. Risk Assessment Forum, U.S. EPA, Washington, DC.

(2) U.S. Environmental Protection Agency. 1996. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Draft). U.S. EPA.

(3) Suter, G W II. (1993). Ecological Risk Assessment. Lewis Press, Boca Raton, FL, 538 pp.

will then compare to the dose derived from the exposure assessment above to produce the risk characterization.

For humans, dose-response relationships must be considered separately for carcinogens and non-carcinogens. When dealing with carcinogens, a cancer potency factor (CPF) or Slope Factor (SF) for each contaminant of concern will be used. For non-carcinogens, the NOAEL or LOAEL (lowest observed adverse effect level) will be used as the threshold value. Data on CPFs and NOAEL/LOAEL values are available through the U.S. EPA's IRIS (Integrated Risk Information System) and HEAST (Health Effects Assessment Summary Tables) databases. The relationship between contaminant concentrations in toothed cetacean tissues and the concentrations in their prey items will be assessed in this programme.

Risk Characterization: The risk characterization will integrate the results of the exposure and effects assessments to estimate the risks and consequences of contaminant exposures. In this step, the estimated exposure should be divided by the threshold value to obtain a Hazard Quotient (HQ). Generally HQ values below 1 are considered to represent a very low risk of adverse effects, whereas HQ values above 10 indicate a moderate to high level of risk.

For human populations, the general approach to evaluating HQs can be applied to this Project. However, the human health risk characterization produced for this Project should be updated through the use of continually collected tissue and other environmental monitoring data to reflect current conditions. This Study's human health risk assessment will improve the robustness of previous studies through a careful reconsideration of all exposure and effects parameters, with particular focus on background doses and seafood consumption patterns.

8 BENTHIC RECOLONISATION

8.1 INTRODUCTION

The EIA conducted for the SB Facility has indicated that benthic fauna are expected to recolonise the pits following capping with uncontaminated mud. It is expected that recolonisation of the natural benthic assemblage will occur and eventually the benthic assemblage will resemble that of the surrounding areas. Recolonisation may be achieved by larval recruitment, influx of juveniles or adults carried in water currents, or through the active swimming or crawling of individuals. However, other natural (eg storm events, hypoxia, salinity fluctuations) or anthropogenic (eg pollution, dredging activities and fisheries operations) activities may hinder recolonisation of capped pits. As a result, the factors contributing to the composition of the benthic assemblage may be difficult to determine. It is also important for any recolonisation studies to be aware of any cap maintenance (or "topping up") activities which may also impact the resident benthic assemblages.

In order to verify the recolonisation of marine biota on the capped pits, a benthic recolonisation programme is recommended. The full details of the EM&A programme for benthic recolonisation are presented in the following sections.

8.2 OBJECTIVE

The objective for this component of the EM&A is to monitor and report on the benthic recolonisation of the capped pits including the previous ones and specifically to determine the difference in infauna between the capped pits and adjacent sites.

8.3 HYPOTHESIS

The impact hypothesis for this task is as follows:

Recolonisation is occurring at the capped pits such that assemblages at the capped pits become more similar to reference assemblages as time since capping increases.

The null hypothesis to be tested for this work component is as follows:

H_0 There is no difference in the structure of benthic infaunal assemblages found at the capped pits at the active facility and adjacent reference areas.

H_0 Similarity of assemblage structures between impact and reference stations does not change over time.

8.4 SAMPLING DESIGN

The sampling design of this task involves two treatments: capped pits and reference areas. The capped pit treatment will involve collection of samples from the capped mud pits at the active facility. The second treatment will involve sampling at different reference sites, which are chosen to improve the balanced nature of the design. Using multiple controls is an effective way of ensuring that the extremely variable nature of Hong Kong's marine benthos from one site to another does not overly influence or alter the results. Current ecological theory suggests that the use of multiple control sites in sampling designs are statistically more robust and hence the conclusions more reliable [(1) (2)].

The benthic sediment samples collected during this task will be analysed for the following parameters:

- Percentage of silt/clay in the sediments;
- Faunal Abundance;
- Faunal Biomass;
- Species Composition; and,
- Trophic Structure

The locations of impact and reference stations for the SB facility are shown in *Figure 8.1* and the coordinates are shown *Table 8.1*. For standardisation purposes, the reference stations are at the same locations as existing monitoring programmes for ESC facilities. Samples will be collected twice per year, once in the dry season, once during the wet season. Twelve replicate samples will be collected from each of the monitoring stations. Sampling will commence once capping of all pits is completed, as detailed in the *Sampling Programme* in *Annex C*.

The sampling frequency and number of replicates are the same as those currently proposed for the CMP IV/ V EM&A programmes and will initially be used for SB monitoring as a consistent and conservative approach. These will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

(1) RJ Schmitt & CW Osenberg(1996) Detecting Ecological Impacts: concepts and applications in coastal habitats. Academic Press.

(2) AJ Underwood (1997) op cit.

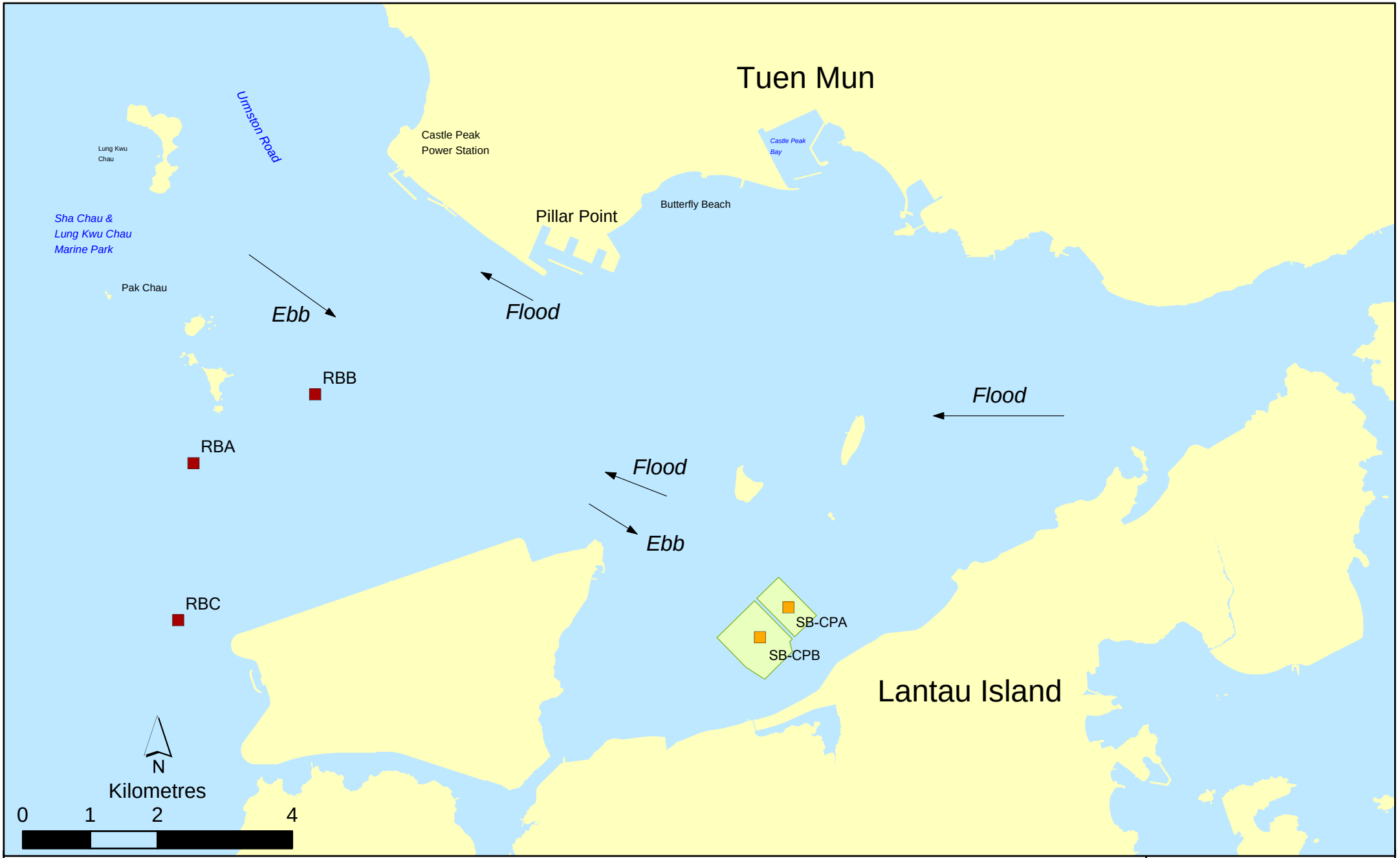

Figure 8.1

Benthic Monitoring Stations for South Brothers Facility

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Date: 14-Sep-12

Environmental Resources Management

ERM

Table 8.1 Coordinates of Benthic Monitoring Stations at South Brothers Facility

Station	Easting	Northing
Reference		
RBA	806399	821682
RBB	808206	822708
RBC	806171	819354
Capped Pit		
SB-CPA	815231	819548
SB-CPB	814808	819098

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

8.5 STATISTICAL TREATMENT OF DATA

The data collected during the monitoring programme will be analysed using two different but complementary approaches as detailed below.

8.6 USE OF DATA

ANOVA & MANOVA: Simple, univariate measures will be tested using an Analysis of Variance (ANOVA), and multivariate measures of community structure will be tested using the Multiple Analysis of Variance (MANOVA). Both ANOVA and MANOVA test the same null hypothesis using similar methods. The method is essentially a comparison of the variability within a site to the variability between sites. If the ratio of these two variances (that is, the between-group-variance over the within-group-variance) is large enough, then any differences observed are due to true differences that exist between the groups and not just to random variation. ANOVA and MANOVA tests are based on several assumptions related to the underlying distribution of the data being analysed (ie normality, homogeneity of variances). If the data deviate significantly from these assumptions, then these tests are considered to be inappropriate. If this situation arises, alternative procedures (ie parametric tests with rank transformed data or non-parametric analogues such as Kruskal Wallis) which address similar hypotheses but do not require such stringent assumptions will be adopted. Observed differences between the sites and/or areas will be tested using multiple comparison procedures such as the Student Newman Keuls (SNK) or Tukey test.

8.6.1 Multivariate Analyses

Non-metric Multi-dimensional Scaling (MDS): Multi-dimensional Scaling (MDS) will also be used to depict the similarities between stations based on their benthic assemblages. MDS is a method for creating a low dimensional picture of the relationships between stations in a complex, multi-dimensional problem. The Bray-Curtis distance matrices will be used for both the clustering techniques and the MDS. The dendrogram from the cluster analysis and the MDS ordination plot will provide complementary views of

the same similarity information. The data for MDS and cluster analyses should be standardised prior to analysis, to ensure that bias resulting from including data in different forms (eg percent data for silt clay composition, numerical data for abundances and biomass data in mg) does not occur.

8.7 USE OF DATA

The detailed statistical analyses described above will be used to comprehensively explore the benthic assemblage patterns in the area of the active pits. This exploration should lead to conclusions regarding the effectiveness of the cap material in promoting post-dredging benthic assemblages.

8.7.1 *Sampling Procedure and Equipment*

The sampling team and vessel will be deployed and accurate positioning attained as described in *Section 4*. The vessel will be equipped with adequate fixed sieve stations to facilitate rapid processing of samples and ensure the required number of samples are collected in each survey. At each of the designated benthic sampling stations, seabed sampling will be carried out with a modified Van Veen grab sampler (dimensions 30 cm H 30 cm H 15 cm D) or similar instrument approved by EPD/AFCD. One subsample of approximately 1 kg sediment will be collected from each sample for analysis of particle size. The remaining sediment from each sample will be used for sorting. Samples will be labelled and sieved through a 1 mm and 0.5 mm sieve and all residues and organisms retained, double-bagged and preserved in 4% buffered formalin in seawater. A vital stain (eg Rose bengal) will be added to distinguish organic materials and organisms from other non-living residues. The grab and utensils will be washed thoroughly with seawater after each deployment to avoid cross-contamination between samples. On completion of the survey all samples will be transferred to the laboratory for sorting and identification. All sediment sieving will be conducted by qualified marine scientists who will oversee and coordinate all field operations.

8.7.2 *Laboratory Procedures*

Upon arrival at the laboratory, all benthic samples should be re-inventoried and checked against chain-of-custody forms. Sample rescreening should be performed after the samples have been held in formalin for a minimum of 24 hours to ensure adequate fixation of the organisms. Individual samples from the 500 µm and 1 mm^2 mesh sieves will be gently rinsed with fresh water into a 250 µm sieve to remove the formalin from the sediments. Sieves will be partially filled while rinsing a specific sample to maximize washing efficiency and prevent loss of material. All material retained on the 250 µm sieve is placed in small fractions into a labelled petri dish and preserved with 70% ethanol. The material is lightly agitated to ensure complete mixing of the alcohol with the sediments. The sediment is then sorted to remove all

animals and fragments. Original labels will remain with the rescreened sample material.

Standard and accepted techniques will be used for sorting organisms from the sediments [1]. Small fractions of a sample will be placed in a petri dish under a 10-power magnification dissecting microscope. The petri dish will be scanned systematically and all animals and fragments removed using forceps. Each petri dish will be sorted at least twice to ensure removal of all animals. Organisms representing major taxonomic groups including Polychaeta, Arthropoda, Mollusca, and miscellaneous taxa will be sorted into separate, labelled vials containing 70 percent ethanol. All sorted samples will be systematically checked to ensure compliance with QA/QC program requirements before proceeding to the taxonomic identification, enumeration, and biomass determination phases of the analysis.

Taxonomic identifications will be performed by regional taxonomic experts using stereo dissecting and high-power compound microscopes, to the family level except for dominants, which will be identified, where possible, to species. The careful sampling procedure employed in the Study will minimise fragmentation of organisms, however should breakage of soft-bodied organisms occur, only anterior portions of organism fragments will be counted. All fragments will be retained and weighed during biomass determinations, described below. Rare or questionable taxa will be compared against reference collection specimens for confirmation and consistency of identification. The nomenclature used in all reference collections referred to in this study should be cross checked and differences or discrepancies should be noted. Biomass determinations will be made by taking the blotted wet mass of each taxonomic fraction.

8.8 BENTHIC MICRO-INFAUNA AND TAXONOMIC IDENTIFICATION

Sorting QA/QC will be performed using 25-power magnification by someone other than the original sorter. Twenty percent of each sorted sample should be resorted to ensure 95 percent sorting efficiency. A sample passes QA/QC if the number of organisms found during the QA/QC check does not represent more than 5 percent of the total number of organisms found in the entire sample. If the number of organisms found is greater than 5 percent of the total number, the entire sample will be resorted. Any samples where the identification of taxa is questionable will be sent out for independent re-identification by a qualified regional expert. Reference collections developed during previous seabed and benthic studies in Hong Kong should be consulted as necessary.

[1] Holme, N.A. and A.D. McIntyre (eds) (1984) Methods for the study of marine benthos. Blackwell Scientific Publications, Oxford (UK).

9 IMPACTS OF MAJOR STORMS

9.1 INTRODUCTION

Based on the previous experience with the development and approval for CMPs at East of Sha Chau for use as a contained aquatic disposal for contaminated sediment, monitoring of the dispersion of uncapped sediments during major storm events, such as typhoons of signal 8 or higher, is an important objective of this EM&A programme. It is therefore considered necessary to include this post-storm monitoring as part of the EM&A programme when the SB Facility is active for backfilling operations.

9.2 SAMPLING DESIGN

The post-storm monitoring programme will mobilise within one week of a major storm event (Typhoon Signal Number 8 or above) in order to determine whether the pits retain disposed sediments during storms and whether there are any detectable changes in sediment quality adjacent to the pits. Sediment samples will be collected within one week of a major storm at stations of the *Cumulative Impact Monitoring of Sediment Quality* programme (*Figure 4.2*; *Section 4.4.3*). Only inorganic contaminants and particle size distribution (organic contaminants are not measured as inorganics can provide a more cost-effective indicator of any sediment quality change) will be analysed in the storm assessment.

The field, laboratory and QA/QC procedures for sediment sample collection after major storm events will be identical to those used for the *Cumulative Impact Monitoring of Sediment Quality* Programme (*Section 4*).

10 REPORTING

10.1 GENERAL

Reports will be provided in both hard copy and electronic version upon agreeing the format with EPD. This would enable a transition from a paper/historic and reactive approach to an electronic/real time proactive approach.

10.2 REPORTS

The following documents will be submitted as part of the EM&A programme:

- Environmental Monitoring and Audit Manual;
- Reports on Dredging and Capping Operations;
- Monthly EM&A Reports;
- Quarterly EM&A Reports;
- Annual Review Report;
- Annual Risk Assessment Report;
- Draft Final EM&A Report;
- Executive Summary Report; and
- Final EM&A Report.

Monthly EM&A Reports will be required for the duration of the programme period and will be submitted to CEDD by the 10th working day of each month. Each report will typically contain:

- a list of the activities, tests, analyses and assessments performed in the month according to that detailed in the Environmental Monitoring and Audit Manual for the purpose of reporting any significant findings resulting from monitoring and audit activities;
- a list of outstanding activities, tests, analyses and assessments as well as the schedule for completing these outstanding items; and,
- a list of previously outstanding activities, tests, analyses and assessments that are completed in the month.

Quarterly EM&A Reports will be required for the duration of the programme period and will be submitted within 30 days from the end of every quarterly monitoring period. Each report will:

- confirm that all activities, tests, analyses, assessments etc. have been carried out as stated in this EM&A Manual;

- report on the auditor's findings on the field events and laboratory tests and analysis;

- report on any trends resulting from disposal, dredging and capping activities at the active facility.

An **Annual Review Report** will be submitted within 60 days from the end of every yearly monitoring period. Each report will:

- make a clear statement on the acceptability of environmental impacts by reference to the impact hypotheses;

- state how successful the monitoring programme has been in addressing the objectives of the Assignment;

- make recommendations for revisions to the monitoring programme and disposal operation, as necessary, to ensure that the objectives are fully met in a cost effective manner; and

- summarise the monitoring results to illustrate whether any change or trend resulting from the disposal, dredging and capping activities is detected or not.

A Risk Assessment Report will be prepared within 60 days from the end of every yearly monitoring period. Each report will address the risk to the human health and dolphin of eating seafood taken in the marine area around North Lantau area due to disposal of contaminated marine sediments in the active pits.

A Draft Final EM&A Report will be prepared within 90 days from the end of the monitoring period for this EM&A programme. It will address how each objective of the EM&A programme has been met and should will include a final version of the EM&A Manual as an appendix.

A Final EM&A Report will be prepared within 3 weeks after the agreed revisions on the Draft Final Report.

An English and Chinese **Executive Summary Report** will be prepared within 3 weeks of receipt of comments on the Draft Final Report. It should highlight any issues of concern and the acceptability of the operations at the SB facility.

Annex A

Implementation Schedule

A1 IMPLEMENTATION SCHEDULE

This *Annex* provides a consolidation of the mitigation measures recommended for the Project. The *Implementation Schedule* has the following column headings:

EIA Ref

This denotes the section number or reference from the EIA Report (*EIA Register Number: AEIAR-089/2005*) Main text.

EM&A Log Ref

This denotes the sequential number of each of the recommended mitigation measures specified in the *Implementation Schedule*.

Environmental Protection Measures

This denotes the recommended mitigation measures, courses of action or subsequent deliverables that are to be adopted, undertaken or delivered to avoid, minimise or ameliorate predicted environmental impacts.

Objectives

This denotes the objectives of the recommended mitigation measures and main concerns to address.

Location/Duration of Measures/Timing of Completion of Measures

This indicates the spatial area in which the recommended mitigation measures are to be implemented together with details of the programming or timing of their implementation.

Implementation Agent

This denotes where the responsibility lies for the implementation of the recommended mitigation measures.

Implementation Stage

This denotes the stage at which the recommended mitigation measures are to be implemented either during the Design, Construction, Operation or Decommissioning.

Relevant Legislation

This section defines the controlling legislation that is required to be compiled with.

Table 1.1 Implementation Schedule for the South Brothers Contaminated Sediment Disposal Facility

EIA Ref	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/ Duration of Measures/ Timing of Completion of Measures	Implementation Agents	Implementation Stage				Relevant Legislation & Guidelines
						Des	C	O	Dec	
		WATER QUALITY								
S 4.6		Although there is no requirement for constraints on timing or sequencing apparent from the assessment, as all scenarios have been demonstrated to be acceptable with the required mitigation measures in place. The following operational constraints shall be implemented to ensure no unacceptable water quality impacts.								
	1	• CMP 1 (the upper pit) of the proposed Facility should be constructed and operated first for backfilling of contaminated sediment.	To avoid Potential interface issues with the proposed Brothers Island Marine Park	During project planning and design	CEDD	✓	✓	✓		
S 4.6	2	• Dredging operation within the SB facility should not exceed 100,000 m^3 $week^{-1}$	To avoid unacceptable water quality impacts during dredging	At the work site, throughout the whole duration of the dredging works	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	3	• Backfilling operations within the Facility do not exceed a disposal rate of 26,700 m^3day^{-1}.	To avoid unacceptable water quality impacts during backfilling	At the work site, throughout the whole duration of backfilling	CEDD			✓		*Water Pollution Control Ordinance*
S 4.6	4	• Capping operations within the Facility do not exceed a capping rate of 26,700 m^3day^{-1}.	To avoid unacceptable water quality impacts during capping	At the work site, throughout the whole duration of capping	Contractor			✓		*Water Pollution Control Ordinance*

EIA Ref	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/ Duration of Measures/ Timing of Completion of Measures	Implementation Agents	Implementation Stage				Relevant Legislation & Guidelines
						Des	C	O	Dec	
S 4.6	5	To verify the calculated prediction in the EIA Review water quality impact assessment taking into account latest programmes of construction and operation of the SB facility with the presence of other latest concurrent projects as well as coastline changes due to these projects, a water quality remodelling exercise will be carried out prior to project construction works commencing.	To avoid Unacceptable water quality impacts during dredging	During project planning and design	CEDD	✓				*Water Pollution Control Ordinance*
S 4.6	6	Dredged marine mud shall be disposed of in a gazetted marine disposal area in accordance with the *Dumping at Sea Ordinance (DASO)* permit conditions.	To avoid Unacceptable water quality impacts during dredging	At the work site, throughout the whole duration of the construction period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	7	All disposal vessels should be fitted with tight bottom seals in order to prevent leakage of material during transport.	To prevent leakage of material during transport	At the work site, throughout the whole duration of the construction and operation period	Contractor			✓		*Water Pollution Control Ordinance*
S 4.6	8	All barges should be filled to a level which ensures that material does not spill over during transport to the disposal site and that adequate freeboard is maintained to ensure that the decks are not washed by wave action.	To ensure that material does not spill over during transport and the decks are not washed by wave action	At the work site, throughout the whole duration of the construction and operation period	Contractor		✓	✓		*Water Pollution Control Ordinance*
S 4.6	9	After dredging, any excess materials should be cleaned from decks and exposed fittings before the vessel is moved from the dredging area.	To avoid potential adverse water quality impacts associated with dredging	At the dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	10	The contractor(s) should ensure that the works cause no visible foam, oil, grease, litter, or other objectionable matter to be present in the water within and adjacent to the dredging site	To avoid potential adverse water quality impacts associated with dredging	At the dredging site through the dredging period	Contractor		✓			*Water Pollution Control Ordinance*

EIA Ref	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/ Duration of Measures/ Timing of Completion of Measures	Implementation Agents	Implementation Stage				Relevant Legislation & Guidelines
						Des	C	O	Dec	
S 4.6	11	If installed degassing systems should be used to avoid irregular cavitations within the pump	To avoid adverse water quality impacts due to irregular cavitation within the pump	At the work site, throughout the whole duration of the construction and operation period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	12	Monitoring and automation systems should be used to improve the crews information regarding the various dredging parameters to improve dredging accuracy and efficiency	To improve dredging accuracy and efficiency	At the dredging site, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	13	Control and monitoring systems should be used to alert the crew to leaks or any other potential risks.	To alert the crew to leaks or any other potential risks	At the work site, throughout the whole duration of the construction and operation period	Contractor		✓	✓		*Water Pollution Control Ordinance*
S 4.6	14	When the dredging material has been unloaded at the disposal area, any material that has accumulated on the deck on other exposed parts of the vessel should be removed and placed in the hold of a hopper. Under no circumstance should the decks be washed in a way that permits material to be released overboard	To prevent release of dredged material overboard	At the dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.6	15	All dredgers should be maintained adequate clearance between vessels and the seabed at all states of the tide and reduced operations speed to ensue that excessive turbidity is not generated by turbulence from vessel movement or propeller wash	To ensure that undervessel turbidity is not generated by turbulence from vessel movement or propeller wash	At the dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*

EIA Ref	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/ Duration of Measures/ Timing of Completion of Measures	Implementation Agents	Implementation Stage				Relevant Legislation & Guidelines
						Des	C	O	Dec	
S 4.8	16	Water quality monitoring will be required for the following activities at: - Dredging of each pit; - Backfilling of each pit with contaminated mud; and - Capping of each pit.	To avoid impacts to water quality during dredging, backfilling and capping	At the work sites, throughout the dredging, backfilling and capping period	Contractor		✓			*Water Pollution Control Ordinance*
S 4.8	17	Sediment quality monitoring will be required for the backfilling activities	To avoid impacts to water quality during backfilling	At the work sites, throughout the backfilling period	Contractor		✓			Water Pollution Control Ordinance
		MARINE ECOLOGY & FISHERIES								
S 5.6	18	In accordance with the guidelines in the EIAO-TM, the general policy for mitigating impacts to marine ecological resources shall be applied in order of the following priority: - **Avoidance**: Potential impacts should be avoided to the maximum extent practicable by adopting suitable alternatives; - **Minimisation**: Unavoidable impacts should be minimised by taking appropriate and practicable measures such as constraints on the intensity of works operations (eg dredging rates, timing of works operations); and - **Compensation**: The loss of important species and habitats may be provided for elsewhere as compensation. Enhancement and other conservation measures should always be considered whenever possible.	To avoid potential impacts to marine ecology	During project planning and design	Design Team	✓				EIAO-TM
S 5.6	19	Sediment toxicity monitoring will be conducted to assess the potential toxicity impacts to marine life due to backfilling activities.	To avoid impacts to marine life due to backfilling activities	At SB throughout the backfilling period	Contractor			✓		
S 5.6	20	Marine biota monitoring will be conducted to assess the potential impacts to fisheries resources due to backfilling activities.	To avoid impacts to fisheries due to backfilling activities	At SB throughout the backfilling period	Contractor			✓		

EIA Ref	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/ Duration of Measures/ Timing of Completion of Measures	Implementation Agents	Implementation Stage				Relevant Legislation & Guidelines
						Des	C	O	Dec	
	21	Benthic recolonisation monitoring will be required to assess the recolonisation status of benthic fauna on capped pits.	To assess the recolonisation status of benthic fauna on capped pits	At SB, after capping of mud pits	Contractor			✓		
		HAZARD TO HEALTH								
S 7	22	A risk assessment to verify that no unacceptable risk are occurring to either human health or marine mammals as a result of consuming prey species from the waters in the vicinity of the pits will be required.	To assess hazard to health of humans and marine mammals	In the vicinity of SB, throughout the disposal period	Contractor			✓		

Annex B

Complaints Proforma

COMPLAINTS PROFORMA

REPORT FORM FOR COMPLAINTS `	SHEET ____ OF ____ UNIT REFERENCE _____

RECIPIENT

NAME: LOCATION: TEL.:

COMPLAINANT

NAME: TEL.: FAX:

ADDRESS:

COMPLAINT

TYPE: Water Quality/Other

DATE: TIME: Location:

DESCRIPTION:

COPY FAX TO: DATE:	ORIGINAL TO: DATE:

REVIEW RESULTS

SIGNED: DATE:

RECOMMENDATIONS

SIGNED: DATE:

ATTACHMENTS

COPY TO: DATE/TIME:

CED: DATE: TIME:

INDEPENDENT ENVIRONMENTAL CHECKER DATE: TIME.:

Annex C

Sampling Programme

Annex C - Environmental Monitoring and Audit Sampling Schedule for South of The Brothers (September 2012 - December 2017)

			2012												2013												2014												2015												2016												2017											
Baseline Monitoring Prior to Dredging	**Code**	**Frequency**	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Far Field Stations																																																																											
	SB-WFA	3 days per week for 4 weeks							*	*																																																																
	SB-WFB	3 days per week for 4 weeks							*	*																																																															
Mid Field Stations																																																																											
	SB-WMA	3 days per week for 4 weeks							*	*																																																																
	SB-WMB	3 days per week for 4 weeks							*	*																																																																
Near Field Stations																																																																											
	SB-WNAA	3 days per week for 4 weeks							*	*																																																																
	SB-WNAB	3 days per week for 4 weeks							*	*																																																																
	SB-WNBA	3 days per week for 4 weeks							*	*																																																																
	SB-WNBB	3 days per week for 4 weeks							*	*																																																															
Reference Stations																																																																											
	NM1	3 days per week for 4 weeks							*	*																																																																
	NM2	3 days per week for 4 weeks							*	*																																																															
	NM3	3 days per week for 4 weeks							*	*																																																															
	NM5	3 days per week for 4 weeks							*	*																																																															
	NM6	3 days per week for 4 weeks							*	*																																																															
Sensitive Receiver Stations																																																																											
	MW1	3 days per week for 4 weeks							*	*																																																															
	THB1	3 days per week for 4 weeks							*	*																																																															
	THB2	3 days per week for 4 weeks							*	*																																																															
	WSR45C	3 days per week for 4 weeks							*	*																																																															
	WSR46	3 days per week for 4 weeks							*	*																																																															

Impact Monitoring for Dredging			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Upstream Stations																																																																											
	US1	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	US2	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
Downstream Stations																																																																											
	DS1	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	DS2	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	DS3	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	DS4	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	DS5	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
Sensitive Receiver Stations																																																																												
	MW1	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	THB1	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	THB2	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	WSR45C	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									
	WSR46	3 days per week										*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																																									

Pit Specific Sediment Chemistry			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SB CMP 1 Active																																																																											
Near-Pit																																																																											
	SB-NNAA	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
	SB-NNAB	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
Pit-Edge																																																																											
	SB-NEAA	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
	SB-NEAB	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
Active-Pit																																																																											
	SB-NPAA	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
	SB-NPAB	Monthly																			12	12	12	12	12	12	12	12	12	12	12	12	12																																									
SB CMP 2 Active																																																																											
Near-Pit																																																																											
	SB-NNBA	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								
	SB-NNBB	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								
Pit-Edge																																																																											
	SB-NEBA	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								
	SB-NEBB	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								
Active-Pit																																																																											
	SB-NPBA	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								
	SB-NPBB	Monthly																																12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12																								

		2012												2013												2014												2015												2016												2017											
Cumulative Impact Sediment Chemistry		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Near-field Stations																																																																									
SB-RNA	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
SB-RNB	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
Mid-field Stations																																																																									
SB-RMA	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
SB-RMB	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
Far-Field Stations																																																																								
SB-RFA	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
SB-RFB	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
Capped Pit Stations																																																																								
SB-RCA	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
SB-RCB	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
Sensitive Receiver Stations																																																																								
MW1	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
THB1	4 times per year																				12				12		12				12		12				12		12				12		12				12																								
THB2	4 times per year																				12				12		12				12		12				12		12				12		12				12																								

Sediment Toxicity Tests		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SB CMP 1 Active																																																																									
Reference																																																																									
SB-TRA	2 times per year																				5						5																																														
SB-TRB	2 times per year																				5						5																																														
Near-Field																																																																									
SB-TAA	2 times per year																				5						5																																														
SB-TAB	2 times per year																				5						5																																														
Sensitive Receiver Stations																																																																									
MW1	2 times per year																				5						5																																														
THB1	2 times per year																				5						5																																														
THB2	2 times per year																				5						5																																														
SB CMP 2 Active																																																																									
Reference																																																																									
SB-TRA	2 times per year																																5						5						5																											
SB-TRB	2 times per year																																5						5						5																											
Near-Field																																																																									
SB-TBA	2 times per year																																5						5						5																											
SB-TBB	2 times per year																																5						5						5																											
Sensitive Receiver Stations																																																																									
MW1	2 times per year																																5						5						5																											
THB1	2 times per year																																5						5						5																											
THB2	2 times per year																																5						5						5																											

Tissue/ Whole Body Sampling		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Near-Pit Stations																																																																									
SB-INA	2 times per year																				*						*						*						*						*																											
SB-INB	2 times per year																				*						*						*						*						*																											
Reference North																																																																									
TNA	2 times per year																				*						*						*						*						*																											
TNB	2 times per year																				*						*						*						*						*																											
Reference South																																																																									
TSA	2 times per year																				*						*						*						*						*																											
TSB	2 times per year																				*						*						*						*						*																											

Demersal Trawling		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Impact																																																																									
SB-INA 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											
SB-INB 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											
Reference North																																																																									
TNA 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											
TNB 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											
Reference South																																																																									
TSA 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											
TSB 1-5	4 times per year																			5	5					5	5					5	5					5	5					5	5																											

			2012												2013												2014												2015												2016												2017											
Routine Water Quality Monitoring			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Ebb Tide																																																																												
Impact Stations Downcurrent																																																																											
	SB-IPE1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPE2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPE3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPE4	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPE5	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Intermediate Stations Downcurrent																																																																											
	SB-INE1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INE2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INE3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INE4	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INE5	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Reference Stations Upcurrent																																																																											
	SB-RFE1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFE2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFE3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFE4	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFE5	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Sensitive Receiver Stations																																																																											
	MW1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	THB1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	THB2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	WSR45C	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	WSR46	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Flood Tide																																																																											
Impact Stations Downcurrent																																																																											
	SB-IPF1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPF2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-IPF3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Intermediate Stations Downcurrent																																																																											
	SB-INF1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INF2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-INF3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Reference Stations Upcurrent																																																																											
	SB-RFF1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFF2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	SB-RFF3	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
Sensitive Receiver Stations																																																																											
	MW1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	THB1	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	THB2	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	WSR45C	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									
	WSR46	8 times per year																			8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8																									

Water Column Profiling			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Plume Stations	WCP1	Monthly																			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4																								
	WCP2	Monthly																			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4																								

		2012												2013												2014												2015												2016												2017											
Capping Water Quality Monitoring		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Ebb Tide																																																																									
Impact Stations Downcurrent																																																																										
SB-IPE1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPE2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPE3	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPE4	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPE5	8 times per year																																																	3	3		3	3		3	3		3	3													
Intermediate Stations Downcurrent																																																																										
SB-INE1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INE2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INE3	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INE4	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INE5	8 times per year																																																	3	3		3	3		3	3		3	3													
Reference Stations Upcurrent																																																																										
SB-RFE1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFE2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFE3	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFE4	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFE5	8 times per year																																																	3	3		3	3		3	3		3	3													
Sensitive Receiver Stations																																																																										
MW1	8 times per year																																																	3	3		3	3		3	3		3	3													
THB1	8 times per year																																																																									
THB2	8 times per year																																																																									
WSR45C	8 times per year																																																	3	3		3	3		3	3		3	3													
WSR46	8 times per year																																																	3	3		3	3		3	3		3	3													
Flood Tide																																																																										
Impact Stations Downcurrent																																																																										
SB-IPF1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPF2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-IPF3	8 times per year																																																	3	3		3	3		3	3		3	3													
Intermediate Stations Downcurrent																																																																										
SB-INF1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INF2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-INF3	8 times per year																																																	3	3		3	3		3	3		3	3													
Reference Stations Upcurrent																																																																										
SB-RFF1	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFF2	8 times per year																																																	3	3		3	3		3	3		3	3													
SB-RFF3	8 times per year																																																	3	3		3	3		3	3		3	3													
Sensitive Receiver Stations																																																																										
MW1	8 times per year																																																	3	3		3	3		3	3		3	3													
THB1	8 times per year																																																																									
THB2	8 times per year																																																																										
WSR45C	8 times per year																																																	3	3		3	3		3	3		3	3													
WSR46	8 times per year																																																	3	3		3	3		3	3		3	3													

Benthic Recolonisation Studies		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Capped Contaminated Mud Pits																																																																										
SB-CPA	2 times per year																																																								12				12								12				12
SB-CPB	2 times per year																																																								12				12								12				12
																																																										12				12								12				12
Reference Stations																																																																										
RBA	2 times per year																																																								12				12								12				12
RBB	2 times per year																																																								12				12								12				12
RBC	2 times per year																																																								12				12								12				12

Notes:
"*" = Number of replicates depends on parameters
Naming of stations are tentative only and will be subjected to changes