Contract No. NL/2017/03

Tung Chung New Town Extension – Reclamation and Advance Works

Eco-shoreline Implementation Plan

September 2020

土木工程拓展署
Civil Engineering and Development Department

Tung Chung New Town Extension

Environmental Certification Sheet for Environmental Permit No. EP-519/2016

Reference Document/Plan

Document/Plan to be Certified:	Eco-shoreline Implementation Plan
Date of Report:	September 2020

Reference EP Condition

Environmental Permit Condition: Condition 2.14

The Permit Holder shall, no later than 3 months before the commencement of construction of the eco-shoreline at Tung Chung East, submit 3 hard copies and 1 electronic copy of a detailed Eco-shoreline Implementation Plan (The Plan) to the Director for approval. The Plan shall include at least the following information:

(i) the form of eco-shoreline to be adopted for the artificial seawall along the reclamation boundary at Tung Chung East;

(ii) a robust and innovative eco-shoreline design with clear objectives of enhancing its ecological, landscape, visual and other functions;

(iii) an implementation programme;

(iv) detailed management arrangements; and

(v) a monitoring programme with indicators for success.

ET Certification

I hereby certify that the above referenced document/plan complies with the above referenced condition of EP-519/2016

Jovy Tam
Environmental Team Leader
ERM-Hong Kong, Limited

Date: 9 September 2020

土木工程拓展署
Civil Engineering and Development Department

Qualified Ecologist Certification

I hereby confirm that the Qualified Ecologist of the ET has been consulted in preparing ecological aspects of the above referenced document/plan.

Raymond Chow
Qualified Ecologist
ERM-Hong Kong, Limited

Date: 9 September 2020

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OUR REF 198377-0268

YOUR REF

DATE 9 September 2020

Sustainable Lantau Office
Civil Engineering and Development Department
13/F, North Point Government Offices
333 Java Road, North Point
Hong Kong

For the attention of Mr. S.K. LO / Mr. K.T. WO

Dear Sirs,

Agreement No. CE 59/2017 (EP)
Independent Environmental Checker for Tung Chung New Town Extension – Investigation

Eco-shoreline Implementation Plan (EP condition 2.14)

We refer to the Eco-shoreline Implementation Plan dated September 2020 and certified by the Environmental Team Leader on 9 September 2020. Please note we have no adverse comments on the captioned submission. The captioned submission is hereby verified in accordance with the requirement stipulated in Condition 2.14 of EP-519/2016.

Should you have any query, please feel free to contact the undersigned at 2608 7314 (chuawo@bv.com) or our Ivan Ting at 9222 9490 (iec.tcnte@gmail.com).

Yours faithfully,
for and on behalf of
BLACK & VEATCH HONG KONG LIMITED

MANUEL CHUA
INDEPENDENT ENVIRONMENTAL CHECKER

cc: ET Leader – ERM (Attn: Mr. Jovy TAM) [by Email: jovy.tam@erm.com]
PM/TCE – AECOM (Attn: Mr. Chris CHEUNG) [by Email: sreg1@tce-aecom.com]

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Appendix A – Implementation Programme for Eco-shoreline
Appendix B – Implementation Schedule for Eco-shoreline

1. INTRODUCTION

1.1. The Project

1.1.1 AECOM Asia Co Ltd has been commissioned by the Civil Engineering and Development Department (CEDD) to undertake Agreement No. CE 69/2015 (CE) – Tung Chung New Town Extension (East) – Design and Construction. The Agreement commenced on 16 June 2016 and is scheduled to be completed in June 2027.

1.1.2 The reclamation, site formation, engineering infrastructure and associated works to support developments of both Tung Chung East (TCE) and Tung Chung West (TCW) are funded by PWP Item "7786CL - Tung Chung New Town Extension". The Technical Feasibility Statement for 7786CL was approved in September 2014. 7786CL is to be delivered by two consultancy agreements namely, Tung Chung New Town Extension (East) - Design and Construction (this Assignment) and Tung Chung New Town Extension (West) - Design and Construction (Agreement No. CE 70/2015(CE)).

1.1.3 The Project of this Assignment (the Project) includes reclamation, site formation and engineering infrastructure works (including construction of Road P1) for the developments of TCE, provision of salt water supply to TCNT and SHW topside and infrastructure works in Tung Chung Area 58 in the existing TCNT. The scope of the Project comprises the following principal works components:

a) Works in TCE

(i) Reclamation of about 120 hectares of seabed abutting the coastal area between Tung Chung Phase 3A and Tai Ho Bay Inlet and associated site formation works for the proposed developments;
(ii) Engineering infrastructure works including roads, drainage, sewerage including sewage pumping stations, and waterworks to support the proposed developments;
(iii) Provision of a marina;
(iv) Construction of a salt water pumping station for flushing use in TCNT, TCE, TCW and SHW topside;
(v) Landscaping, streetscaping and ancillary works; and
(vi) Provision of environmental mitigation measures for the works mentioned in (i) to (vi) above;

b) Works in the existing TCNT or SHW

(i) Construction of a Fresh Water Service Reservoir (FWSR) near Chek Lap Kok New Village or at Siu Ho Wan for TCE and TCW;
(ii) Construction of a Salt Water Service Reservoir (SWSR) near Chek Lap Kok New Village for flushing use in TCNT, TCE, TCW and SHW topside;
(iii) Site formation works including natural terrain hazards mitigation measures for the works mentioned in (i) and (ii) above;
(iv) Waterworks for salt water supply for toilet flushing in SHW topside; and
(v) Engineering infrastructure works including roads, drainage, sewerage and waterworks to support the land allocation at Area 58 of the existing TCNT.

c) Works related to Road P1

(i) Reclamation of about 9 hectares of seabed for Road P1 (section between TCE and Tai Ho);
(ii) Construction of Road P1 with cycle track (section between TCE and Tai Ho) and associated engineering infrastructure works including drainage, sewerage and waterworks;
(iii) Site formation works for a cycle park of about 2 hectares near Tai Ho Interchange;
(iv) Improvement works to existing Tung Chung Waterfront Road and Ying Hei Road, including construction of noise barriers and footbridges, resurfacing of road pavement, etc., for upgrading them to a primary distributor as part of Road P1;
(v) Construction of an elevated interchange near Tai Ho connecting Road P1 to NLH and Cheung Tung Road (Tai Ho Interchange);
(vi) Landscaping, streetscaping works and ancillary works; and
(vii) Provision of environmental mitigation measures for the works mentioned in (i) to (vi) above.

1.1.4 Recognising the limited ecological value of standard artificial seawall design, the Project Environmental Impact Assessment (EIA) Report (CEDD, 2015) recommended that ecological enhancement measures are considered in the seawall design for the TCE Potential Development Area (PDA) and Road P1 (Tung Chung - Tai Ho Section) Extension reclamation. This would provide mitigation for marine ecological impacts resulting from the Project, which include the permanent loss of 145 ha of marine waters/seabed (considered a minor to moderate scale impact, **Diagram 1.1**). Ecologically enhanced seawalls could partially compensate this impact by providing habitat for intertidal and subtidal marine communities.

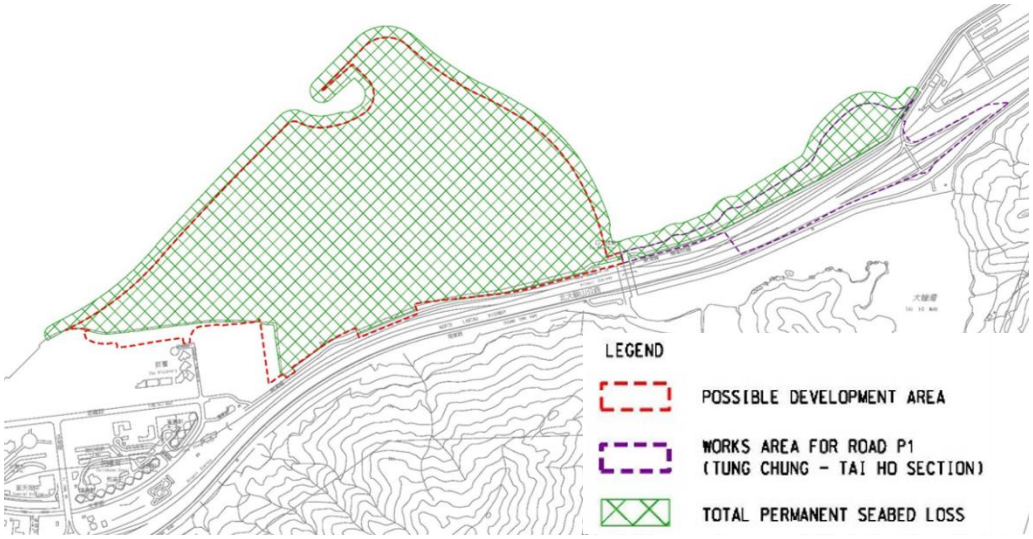


Diagram 1.1 – Extent of Permanent Seabed Habitat Loss (CEDD, 2015)

1.2. Scope of this Document

1.2.1. Pursuant to the Project Environmental Permit (Permit No. EP-519/2016) Condition 2.14, the Permit Holder shall, no later than 3 months before the commencement of construction of the eco-shoreline at Tung Chung East, submit 3 hard copies and 1 electronic copy of a detailed Eco-shoreline Implementation Plan (The Plan) to the Director of Environmental Protection for approval. The Plan shall include at least the following information:

(i) the form of eco-shoreline to be adopted for the artificial seawall along the reclamation boundary at Tung Chung East;

(ii) a robust and innovative eco-shoreline design with clear objectives of enhancing its ecological, landscape, visual and other functions;

(iii) an implementation programme;

(iv) detailed management arrangements; and

(v) a monitoring programme with indicators for success.

1.2.2. The eco-shoreline design for TCE comprises three typologies (rocky, mangrove and vertical). Construction of these typologies will commence as follows:

- Vertical Eco-shoreline: June 2020
- Rocky Eco-shoreline: August 2021
- Mangrove Eco-shoreline: end May 2021

2. FORM OF ECO-SHORELINE

2.1. General

2.1.1. Section 9.8.4.3 of the EIA Report defines an eco-shoreline as ‘any shoreline which provides beneficial functions to the local ecosystems through a range of active or passive solutions, whilst providing coastal protection’. Section 9.8.4.4 of the EIA Report recommends that three basic options for eco-shoreline design, namely mangrove eco-shoreline, rocky eco-shoreline and vertical eco-shoreline, are explored for the TCE Potential Development Area (PDA) and Road P1 (Tung Chung - Tai Ho Section) Extension reclamation. The distribution of eco-shoreline is as shown in **Diagram 2.1**.

2.1.2 Eco-shoreline is to provide ecological functions to mitigate the loss of general marine habitat, while the function of coastal and shoreline protection should be provided by seawall structure. Elements of eco-shoreline such as mangroves, mudflat, oyster basket and bio-blocks will be installed/planted on top of seawall structure. The seawall structure was designed in accordance with Port Works Design Manual.

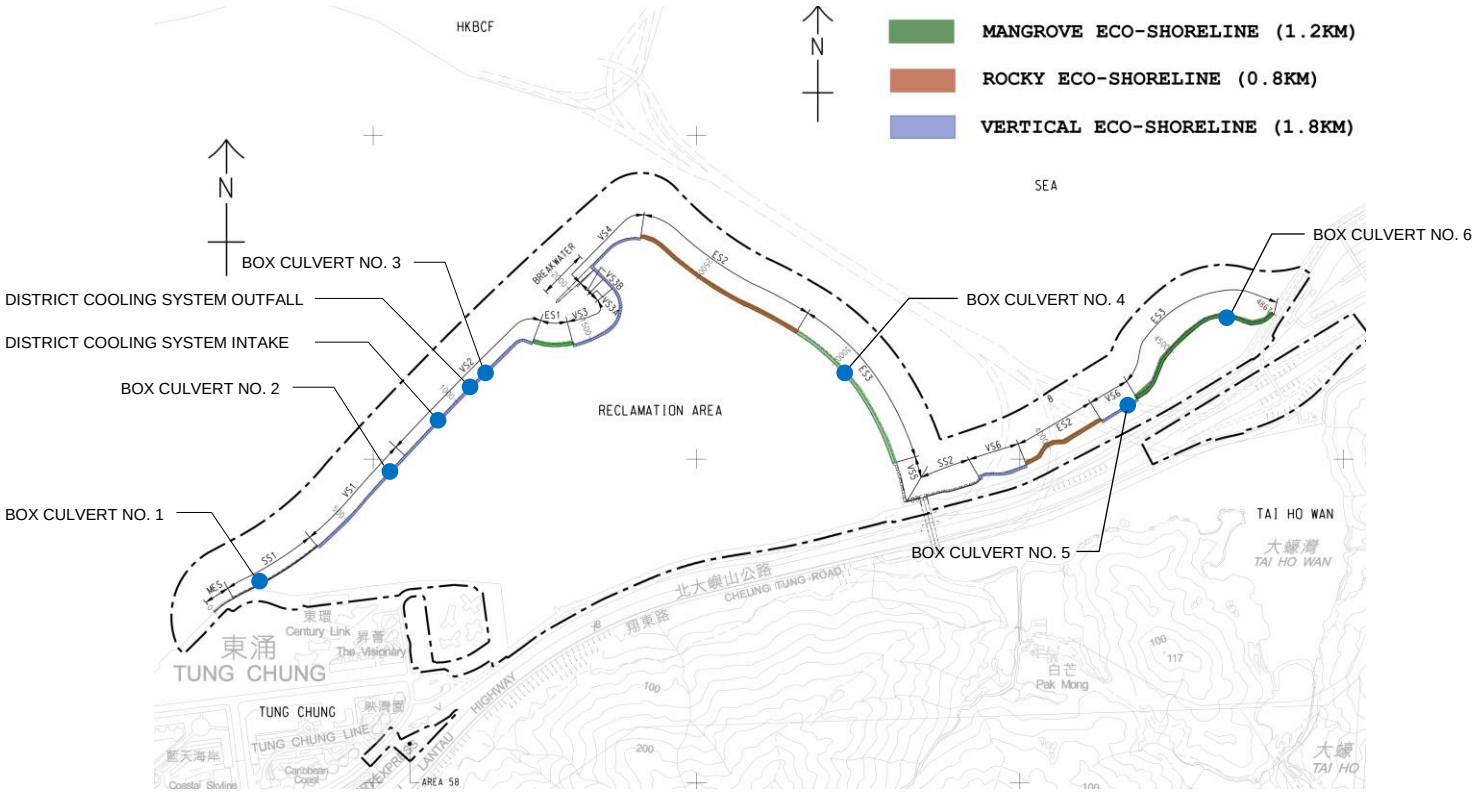


Diagram 2.1 – Layout Plan for Eco-shoreline

Note: Location of box culverts, District Cooling System outfall and intake are indicative.

2.2. Mangrove Eco-shoreline

2.2.1. The mangrove eco-shoreline comprises of mudflats, mangroves and oyster baskets which highlighted in green shown in the **Diagrams 2.2**.

2.2.2. The sediment and nutrient rich, low salinity waters of Tung Chung support extensive soft-shore communities such as mangrove, mudflats and sandy beaches, where suitably sheltered shorelines occur. These communities tend to be more productive and diverse than hard shorelines in the area. Mudflats would be sourced locally within the Pearl River Estuary region and would be agreed by the *Project Manager*, ET and IEC before submitting to EPD.

2.2.3. The mangrove eco-shoreline design is proposed for the Road P1 (Tung Chung – Tai Ho Section), and the majority of the eastern coast of the TCE PDA, as well as an area on the western side of the marina. The typical arrangement of the proposed design is shown in **Diagram 2.2,** which incorporates mangrove and mudflat habitat into the shoreline.

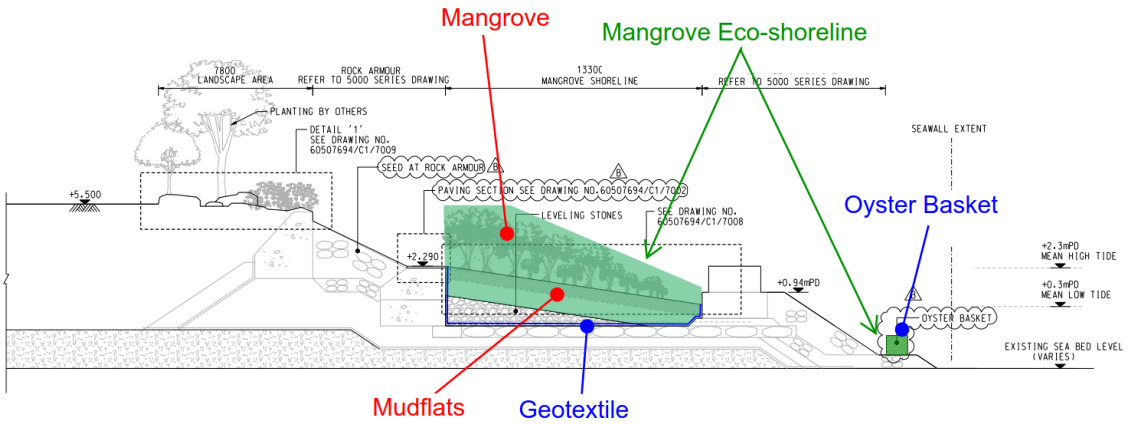


Diagram 2.2 – Typical Section of Mangrove Eco-shoreline

2.3. Rocky Eco-shoreline

2.3.1. Rocky eco-shoreline comprises of bio-blocks and oyster basket which highlighted in blue shown in the **Diagram 2.3**.

2.3.2. Although hard-shoreline habitats are likely to support a lower abundance and diversity of intertidal fauna and flora than soft-shoreline habitats, they provide habitats that support different community types not associated with the mangrove and mudflats, particularly epifaunal species such as rock oysters (*Saccostrea cucullata*), limpets (e.g. *Cellana* sp.), barnacles (e.g. *Balanus* sp.), whelks (e.g. *Thais* sp.) mussels (e.g. *Perna viridis*), nerites (*Nerita* spp.) and littorinid gastropods (e.g. *Littoraria* sp. and *Echinolittorina* sp.). Furthermore, they can also add visual interest to the shoreline design. For these reasons, rocky eco-shoreline has been included in the eco-shoreline plan for the Project.

2.3.3. The rocky eco-shoreline design is proposed for the north-eastern coast of the TCE PDA. This location has been selected as it is the most exposed section of coastline to be constructed under the project, therefore environmental conditions would naturally favour hard shoreline in this area. A typical section of the proposed design is shown in **Diagram 2.3,** which incorporates a band of rocky habitat into the shoreline.

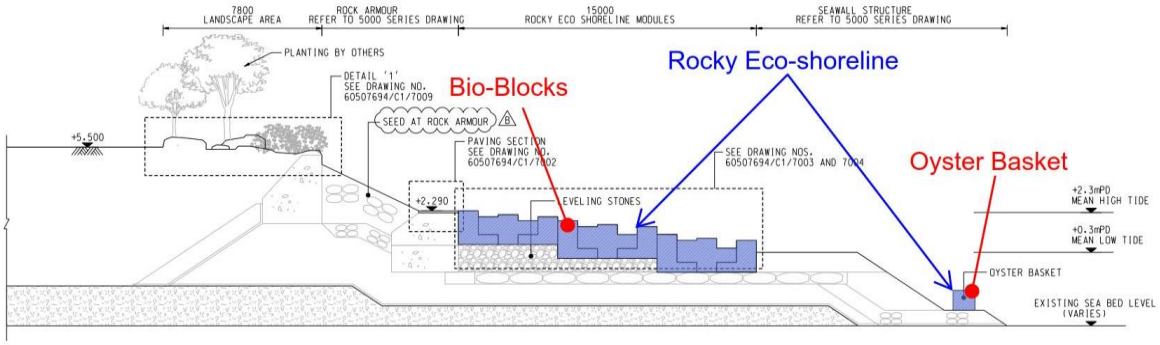


Diagram 2.3 – Typical Section of Rocky Eco-shoreline

2.4. Vertical Eco-shoreline

2.4.1. Vertical eco-shoreline comprises of eco-pattern, eco-drillhole, eco-pot and bird resting area which highlighted in orange shown in the **Diagram 2.4**.

2.4.2. Standard vertical seawalls have a structurally simple, narrow intertidal zone of very limited ecological value. However, even these habitats can be enhanced to some degree by increasing surface complexity.

2.4.3. The vertical eco-shoreline design will be implemented on the western coast of the TCE PDA, as well as the vertical seawall on the eastern coast of the TCE PDA. A typical section of the design is shown in **Diagram 2.4**.

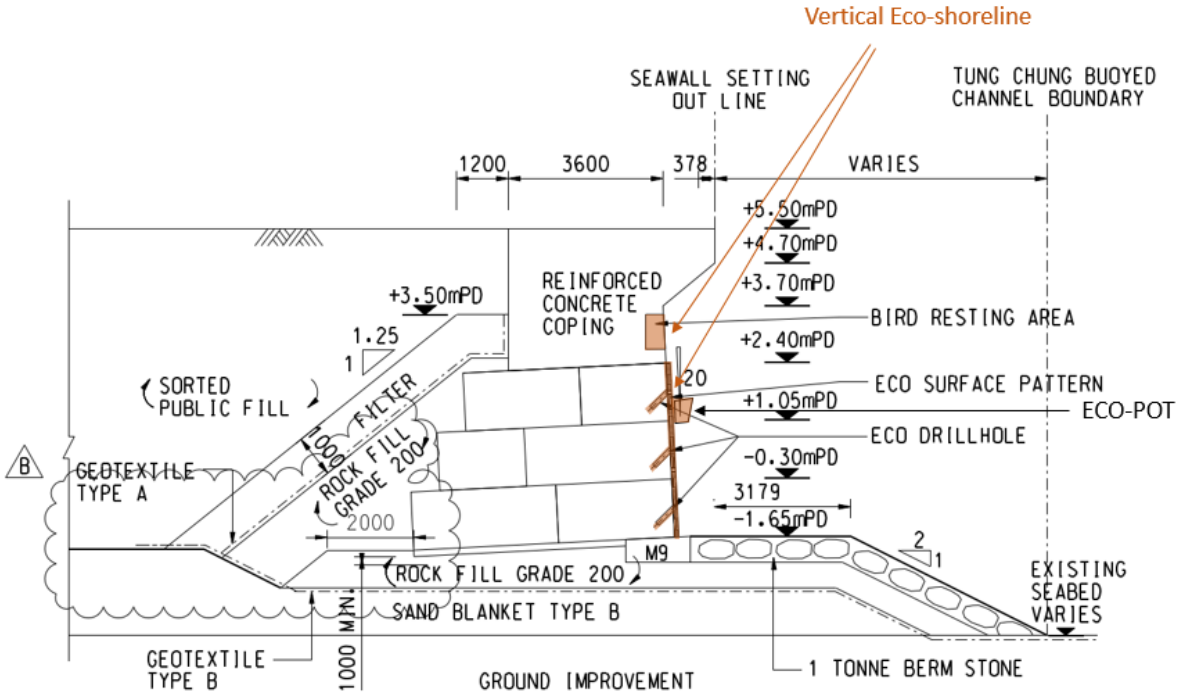


Diagram 2.4 – Typical Section of Vertical Eco-shoreline

3. ECO-SHORELINE DESIGN

3.1. Mangrove Eco-shoreline

Design Concept

3.1.1. The concept for the Mangrove Eco-shoreline is based on the wetland sill design, where a sill is constructed to provide a sheltered platform suitable for the establishment and growth of mangroves. The platform needs to be protected from wave action (which could lead to the scouring and loss of fine sediments from mudflats), while at the same time allowing tidal exchange required for mangrove growth and the movement of marine wildlife (e.g., marine larvae and fishes) in and out of the eco-shoreline area. The design would achieve this by using concrete blocks at the seaward edge of the eco-shoreline platform. Tidal exchange and the movement of wildlife through the sill will be facilitated by staggering the sill at approximately 30m intervals (**Diagram 3.1**). Some limited additional tidal exchange would occur through the base of the platform, where a geotextile fabric would allow water exchange while preventing the loss of fine sediments from mudflats.

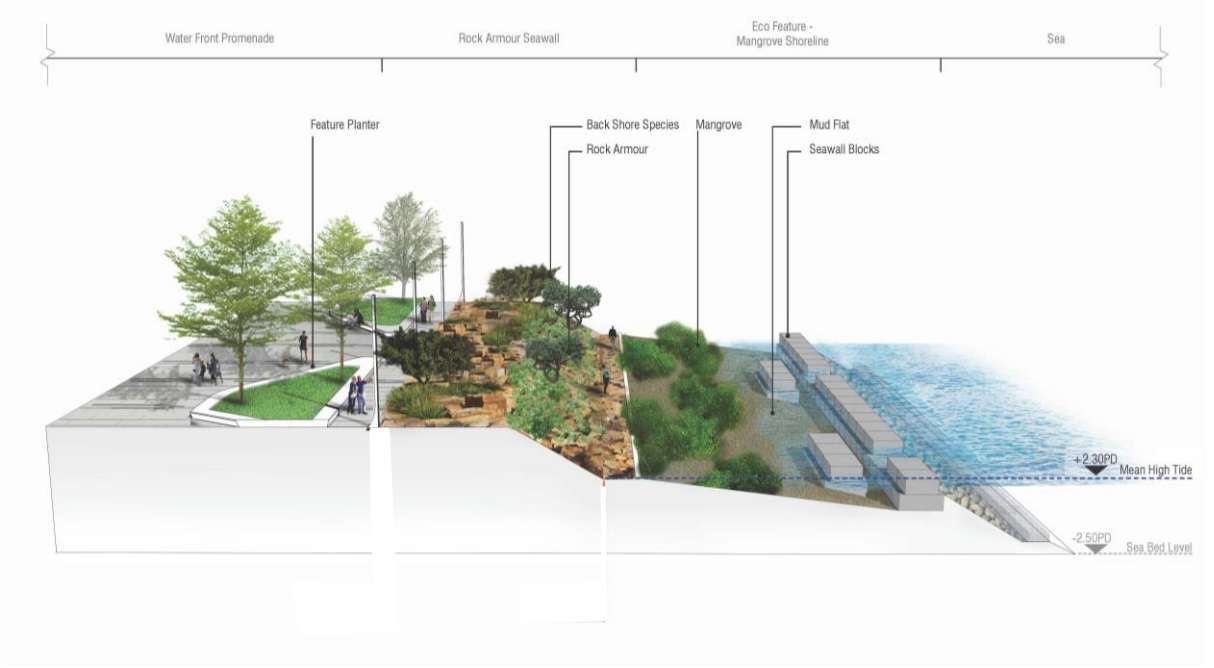


Diagram 3.1 – Design of Mangrove Eco-shoreline

3.1.2. Mangroves can grow in a variety of mudflats, from fine silts through to relatively coarse sand. While suitable mudflats for mangrove growth would likely accumulate naturally over time, the rate of accretion would be very slow. Artificial filling of the platform is therefore required. The mudflats (approximately 2m thick) should be graded to be at just below high tide (+2.29 mPD) at the landward side of the platform, down to mean low tide (+0.29 mPD) at the seaward side (**Diagram 2.2**). This would create a range of potential mangrove and mudflats habitats.

3.1.3. Mangroves grow relatively poorly in pure saltwater: higher growth rates are achieved in brackish waters with lower salinity. While salinity levels in the TCE are thought to be within the range found at naturally occurring mangrove stands in Hong Kong, additional freshwater input to mangrove eco-shoreline can be provided by directing stormwater run-off from the promenade area landward of the eco-shoreline directly into the mangrove area.

Planting

3.1.4. To speed up the establishment of the eco-shoreline, mangroves will be planted in the platform. Only mangrove species native to Hong Kong and common in the existing Tung Chung area will be utilised. Mangrove planting considers the following elements:

- Native species to be used in the planting include *Acanthus ilicifolius*, *Aegiceras corniculatum*, *Avicennia marina*, *Bruguiera gymnorhiza*, *Lumnitzera racemosa*, and *Kandelia obovata*.
- Where possible, seeds/droppers of these species should be collected from nearby established mangrove stands (e.g., Tung Chung Bay and/or Tai O), as using locally sourced seeds (as opposed to using nursery-grown plants from abroad) will maintain the integrity of local genetic stock diversity. Local seed stocks are also potentially better adapted to local conditions which may also be of importance for succession of locally-adapted secondary species.
- Collected seeds/droppers should be moved to a nursery area for establishment. Developing a small nursery close to mangrove planting sites is an established method for germinating and cultivating collected seeds/droppers. Typically, nurseries require the following:
  - **Size:** Experience from overseas (Hoang, V.T., and Pham, T.T. (2010), Management of Natural Resources in the Coastal Zone of Soc Trang Province: Mangrove Nursery Manual. GTZ: 44p) suggests around 325m^2 flat area is needed to grow 10,000 seedlings per year (allowing for 20% mortality), together with 100-200m^2 general working area.
  - **Water Supply:** mangrove seeds and seedlings need require daily watering, so an adequate water supply is needed. Although brackish or salt water can be used, germination success and growth rates for most species are much higher if freshwater is used
  - **Drainage:** adequate drainage is required to prevent flooding and washing out of seeds/seedlings.
- Established mangrove seedlings will be planted out in the mangrove/mudflat eco-shoreline at approximately 1 m intervals.

Viewing of Eco-shoreline

3.1.5. The public will be able to view the mangrove and mudflat habitat from the promenade constructed landward of the eco-shoreline.

3.1.6. Information signage will be provided to inform the public about the development of the eco-shoreline and the flora and fauna found in the eco-shoreline habitats. Appropriate signage will be provided to warn the public about potential hazards in the eco-shoreline area.

3.2. Rocky Eco-shoreline

Design Concept

3.2.1. The basic concept for the rocky eco-shoreline adopts rectangular shaped concrete blocks arranged to provide a natural looking shoreline. Concrete blocks were adopted for the following reasons:

- Natural stone is more difficult and expensive to source and dress to the dimensions needed.
- Using concrete provides an opportunity to cast holes, ledges and other surface structures that will increase the habitat value of the blocks.
- Some concrete solutions with lower pH and other characteristics have been designed to minimise toxicity and maximise ecologically usable surface.

3.2.2. The section shown in **Diagram 3.2** has been designed with a low gradient to maximise the intertidal area of the rocky shoreline, increasing the number of niches available for intertidal organisms. The block-size is approximately 1 m^3. By positioning some of the seaward blocks at a higher level than adjacent landward blocks, rock pools will be formed at low-tide that can provide a refuge for intertidal organisms (**Diagram 3.3**). Furthermore, holes, ledges and other surface structures will be cast into the blocks to further increase habitat value. It is important to create rockpools at different tidal levels to maximise species diversity; some habitat-specialist species are tidal-height specific, while other species require different tidal height pools throughout their life-cycle. To enhance the performance of bio-blocks to serve as the habitat for inter-tidal organism, the pH value of bio-block is also designed to be pH 9-10, which is less alkaline than the ordinary concrete of around pH13.

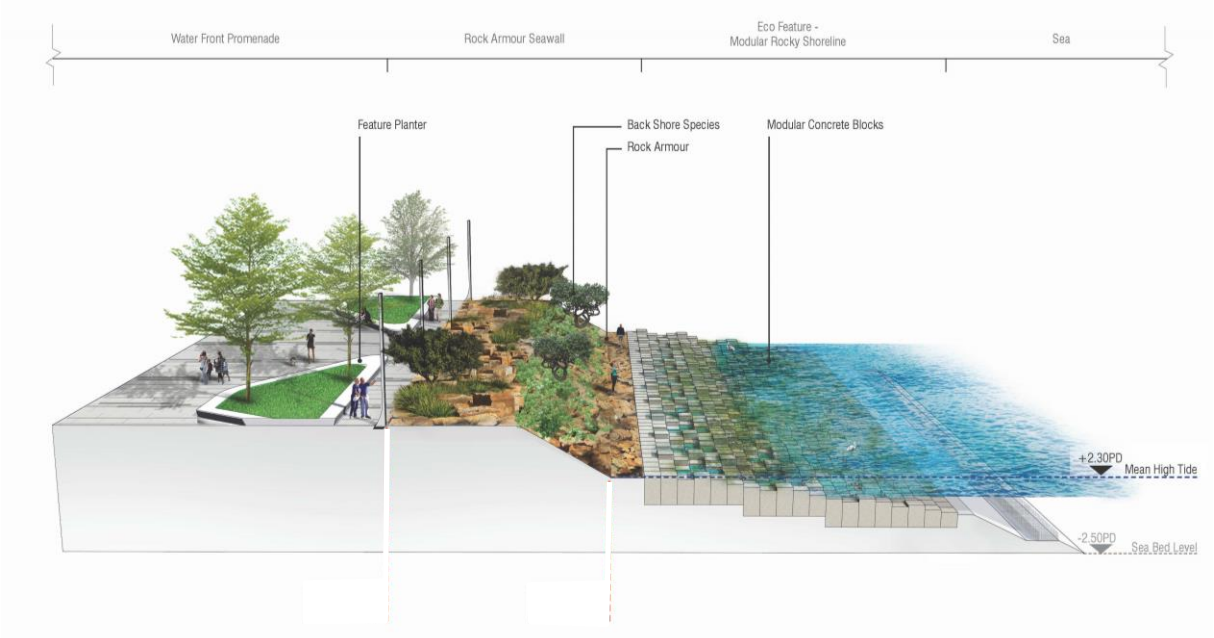


Diagram 3.2 – Design of Rocky Eco-shoreline

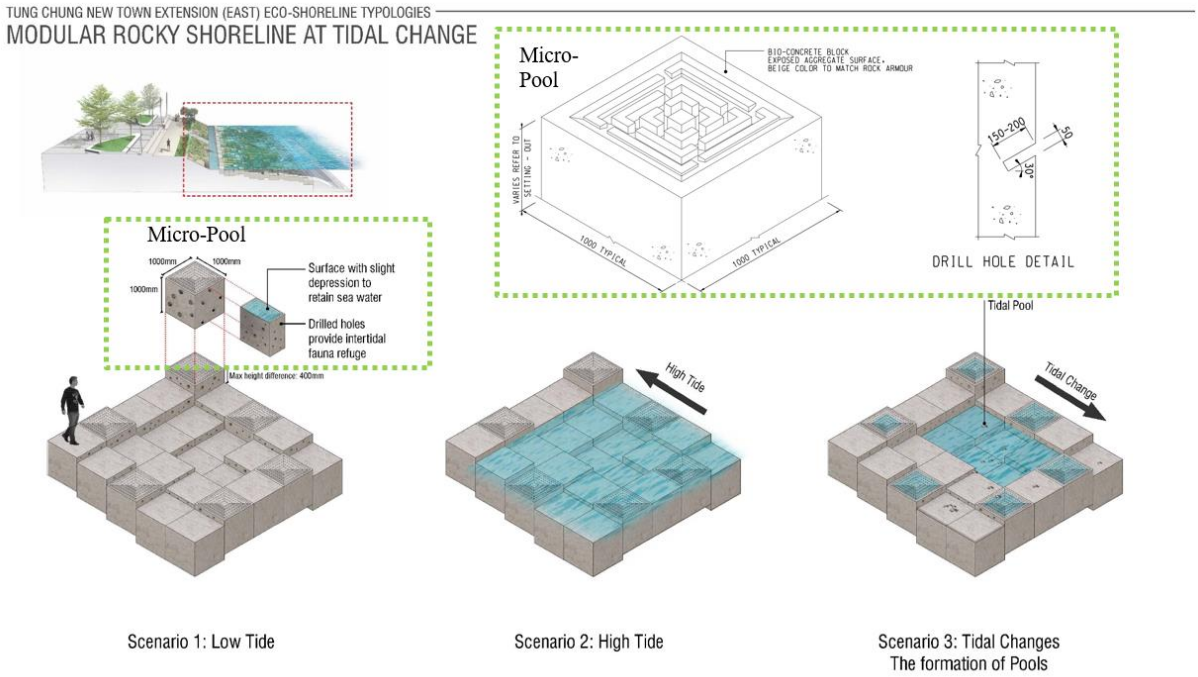


Diagram 3.3 – Detail of Bio-Block with Configuration and Micro-pools to Create Rockpools

Viewing of Eco-shoreline

3.2.3. The public will be able to view the rocky eco-shoreline from the promenade constructed landward of the eco-shoreline (labelled as water front promenade in **Diagram 3.2**).

3.2.4. It is recognised that the lower shore would be colonised by algae (making surfaces slippery) and rock oysters (which have sharp shells) posing a potential hazard to the public. Appropriate signage will be provided to warn the public about potential hazards in the eco-shoreline area.

3.2.5. Information signage will be provided to inform the public about the development of the eco-shoreline and the flora and fauna found in the eco-shoreline habitats.

3.3. Vertical Eco-shoreline

Design Concept

3.3.1. The basic concept for the vertical eco-shoreline is to provide surface treatment to block-work used to form the sea-wall.

3.3.2. Additional enhancement features included in the vertical seawall design comprise:

- Small (e.g. 5 – 10 cm in diameter and 15 cm deep) holes will be drilled in the seawall at a 45 degree angle (so they retain water at low tide) to provide refuge for crabs, fish and other larger fauna. The holes will cover inter-tidal and sub-tidal areas of the seawall, and be provided at 50 cm – 100 cm intervals.

- Larger cavities (e.g. 80 cm high, 40 cm wide and deep) pre-cast into the concrete should be included above the high tide level every 10 m – 30 m. These will provide platforms for wetland birds (e.g. White Wagtail, *Motacilla Alba*) to hunt and rest.

- Eco-pots made of clay with internal dimension of 300mm (length) x 150mm (width) x 300mm (depth) and pot thickness of 40mm shall be attached to the vertical eco-

shoreline at 10m intervals with the top of the eco-pot at +1.3mPD. This will provide a refuge for marine organism by retaining water during low tide.

Public Information

3.3.3. Information signage will be provided to inform the public about the development of the eco-shoreline and the flora and fauna found in the eco-shoreline habitats. Appropriate signage will be provided to warn the public about potential hazards in the eco-shoreline area.

3.4. Oyster Baskets

Introduction

3.4.1. In addition to the three basic eco-shoreline typologies described in the previous sections, the project also presents other opportunities for ecological enhancement works. In the limited sub-tidal areas at the toe of proposed eco-shorelines, oyster baskets filled with oyster shells are deployed to increase habitat complexity and enhance ecosystem function and services.

3.4.2. For rocky and mangrove eco-shoreline, there will be a small platform (2-3m wide) at the toe of the seawall below average low tide level for deployment of oyster baskets as indicated in **Diagrams 2.2 and 2.3**. Examples of typical oyster basket design are shown in **Diagram 3.4**.

Diagram 3.4 – Oyster Basket filled with Oyster Shells

3.4.3. For the current project, oyster baskets with the following characteristics will be deployed:

- Mesh size of the oyster basket is about 5 cm.
- Dimension of oyster basket: 300 mm x 300 mm x 700 mm
- Oyster baskets will be made of stainless steel wire.
- Baskets can be filled to approximately 60% capacity with oyster shells.

4. IMPLEMENTATION PROGRAMME

4.1. General

4.1.1. The programme for implementation of the eco-shoreline is outlined in **Appendix A.**

5. DETAILED MANAGEMENT ARRANGMENTS

5.1. Vertical Eco-shoreline

5.1.1. The maintenance agents of vertical eco-shoreline are summarised in **Table 5.1**. The eco-features are installed on the vertical surface of the vertical seawall as shown in **Diagram 2.4**. The eco-features are part of the vertical seawall. There is no specific management issue for these eco-features

Item	Description	Maintenance Agent
1	Eco-features, including bird resting area, eco-surface pattern, eco-drillhole and eco-pot	Port Works Division/ CEDD

Table 5.1 – Maintenance Agents of Vertical Eco-shoreline

5.2. Mangrove and Rocky Eco-shoreline

5.2.1. The maintenance agents for mangrove and rocky eco-shoreline is summarized in **Table 5.2**. The eco-features are installed on the surface of the slopping seawall as shown in **Diagram 2.2 and 2.3**. The eco-features are part of the slopping seawall. There is no specific management issue for these eco-features.

Item	Description	Maintenance Agent
1	Planter for Mangrove	Port Works Division/ CEDD
2	Planter for Bio-blocks	Port Works Division/ CEDD
3	Oyster Basket	Port Works Division/ CEDD

Table 5.2 – Maintenance Agents of Mangrove and Rocky Eco-shoreline

6. MONITORING PROGRAMME WITH INDICATORS FOR SUCCESS

6.1. General

6.1.1. Section 9.11.2.2 of the Project EIA Report outlines eco-shoreline monitoring requirements: The colonisation and establishment of fauna and/or flora on the eco-shoreline at TCE PDA and Road P1 reclamation should be monitored. The monitoring survey should include quantitative ecological survey methods and measurements of water quality parameters, and cover dry and wet seasons. As it is expected that this measure will also benefit fisheries species in the marine ecosystems, besides ecological components, the monitoring should also include monitoring on fisheries resources (in particular the recruitments of fisheries species).

6.1.2. Section 11.4.6 of the project EM&A Report further details eco-shoreline monitoring requirements, which are reproduced here for ease of reference:

- The colonisation and establishment of fauna and/or flora on the eco-shoreline at TCE PDA and Road P1 reclamation should be monitored. Marine ecosystems are expected to be enhanced by the eco-shoreline, and hence monitoring of the eco-shoreline shall include quantitative ecological survey methods and measurements of water quality parameters, and cover dry and wet seasons. As it is expected that this measure will also benefit fisheries species in the marine ecosystems, besides ecological components, the monitoring should also include monitoring on fisheries resources (in particular the recruitments of fisheries species). Monitoring shall be conducted for at least 3 years after the completion of reclamation works, twice in wet season and twice in dry season, in order to determine the effectiveness of the eco-shoreline. Reference sites shall be selected in nearby artificial seawalls, to be monitored following the same methods, to facilitate comparisons and evaluation of effectiveness. The need of extension of monitoring will be reviewed upon completion of the monitoring and subject to the findings of the monitoring surveys.

- Marine ecosystems include intertidal communities and subtidal hard substrate communities, which should be conducted both qualitatively and quantitatively. Species and abundance of biota should be recorded. Diversity index and evenness index should be provided for evaluation and comparison purposes.

- Parameters for water quality monitoring include dissolved oxygen (DO), dissolved oxygen saturation (DO%), temperature, turbidity, salinity, pH and suspended solids (SS), and the measure methodology could make reference to Water Quality monitoring.

- Regarding the monitoring of fisheries recruitment, it is recommended the monitoring survey should be monthly covering May to August (the spawning periods of marine fishes). The principal sampling method may involve the use of small seine net or plankton net. Other sampling methods such as fish cages, tidal nets and night-time survey could also be considered and recommended where appropriate. Reference sites shall be selected in nearby locations, to be monitored following the same methods, to facilitate comparisons and evaluation of effectiveness.

6.1.3. Based on these specifications, monitoring locations, methodologies and programme have been developed.

6.2. Monitoring Locations

6.2.1. Eco-shoreline Monitoring locations are shown in **Diagram 6.1.**

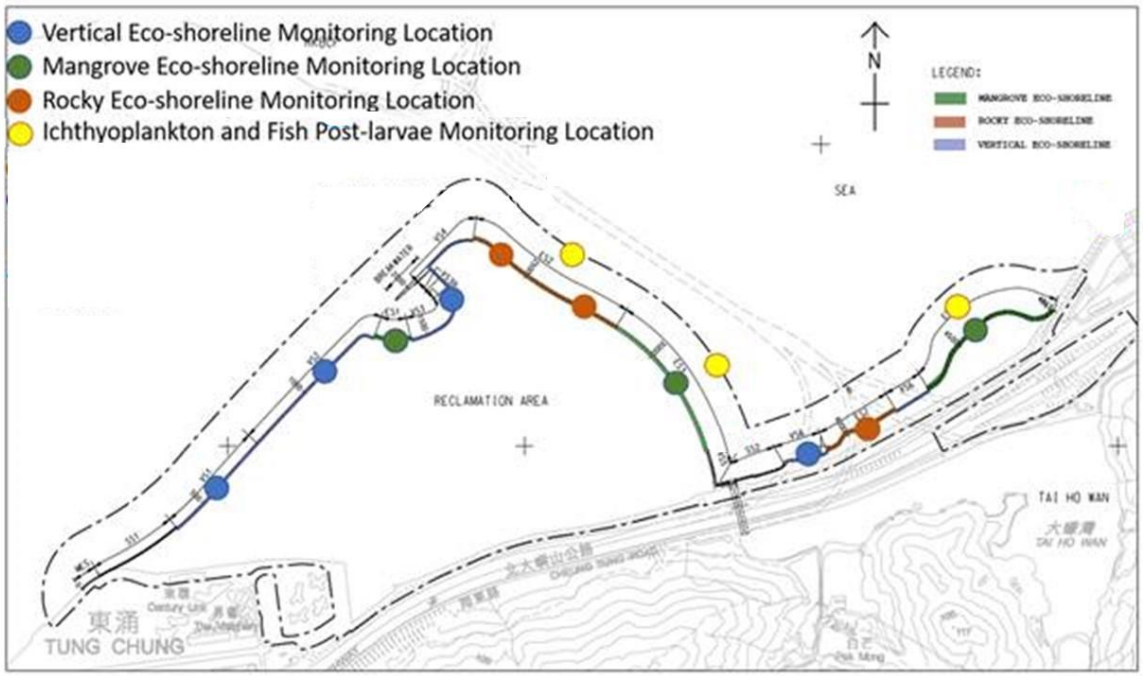


Diagram 6.1 – Location of Eco-shoreline Sampling Locations

6.2.2. Reference monitoring locations are shown in **Diagram 6.2**. These locations were selected along typical sloping rip-rap shoreline close to the proposed eco-shoreline (presumably with similar environmental conditions). An additional fish sampling location is included at Tung Chung Bay to compare the species abundance at a natural mangrove site. Representative photographs of the reference locations are provided in **Diagram 6.3**

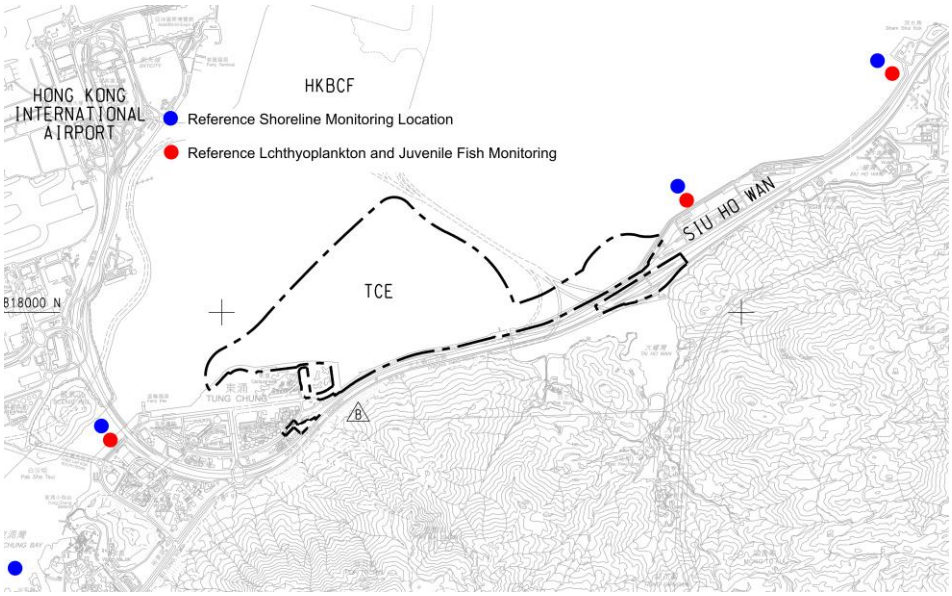


Diagram 6.2 – Location of Proposed Reference Monitoring Locations

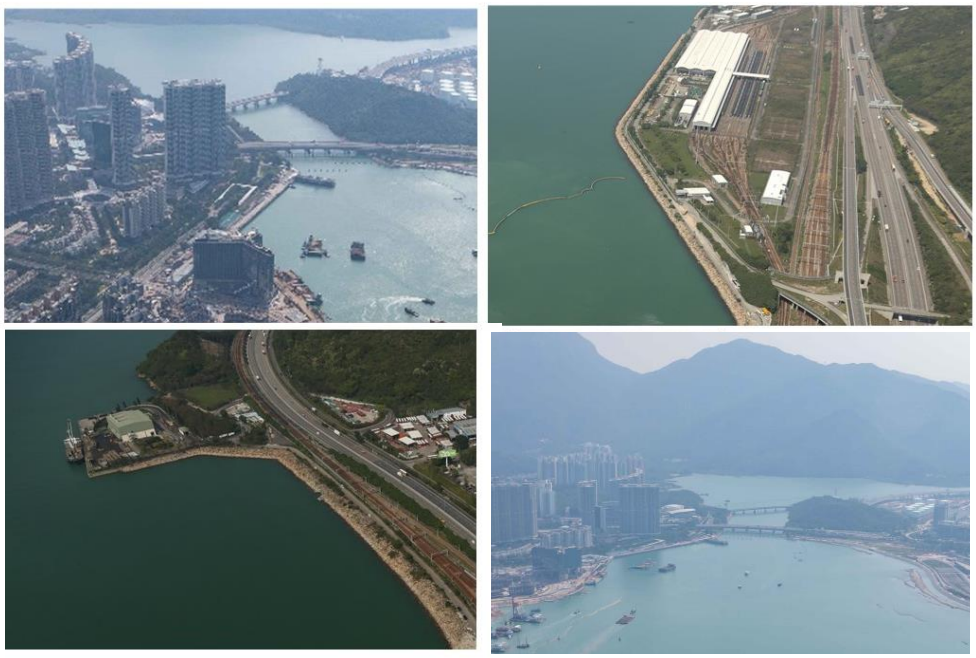


Diagram 6.3 – Photos of Proposed Reference Monitoring Locations

6.3. Monitoring Methodologies

Mangrove Eco-shoreline

6.3.1. Mangrove eco-shoreline monitoring methodology at each survey location is described in **Table 6.1**.

Table 6.1 – Mangrove Eco-shoreline Monitoring Methodology

Parameter	Methodology	No. of Sample	Details
Avifauna	Point count	1	Single point count undertaken at each sampling point. Surveys undertaken for a period of 15min covering all visible areas (i.e., 360º) at a radius of 100m from the survey point. Record made of avifauna species richness and abundance in different habitats (i.e., mangrove, mudflat, open water, seawall, landscape promenade) as well as any notable behaviour (hunting, roosting, nesting).
Epifauna	Transect	3	$1m^2$ quadrat surveyed at three points (high, medium and low shore) along each transect. Species richness and abundance/frequency recorded. Diversity index and evenness index should be calculated.
Infauna	Transect	3	$0.25m^2$ quadrat surveyed at three points (high, medium and low shore) along each transect. The top 0.1m mudlfat layer within the quadrat will be collected and screened through 0.5mm mesh size sieve. Fauna sorted will be identified and counted.
Vegetation	Transect	3	$2m^2$ quadrat surveyed at three points (high, medium and low shore) along each transect. The following information about each plant within the quadrat will be recorded: species, height, number of leaves and health (signs of chlorosis/necrosis).
	Fixed Point Sample	3	General mangrove health (% mortality) at each location will be recorded, with fixed point photographs taken for easy comparison of mangrove health/
Mudflat Properties	Core Sample	3	2-3cm diameter core sample taken at high, middle and low shore. Particle size, organic content, C, N, pH and salinity, should be measured.
Mudflat Level	Fixed gauge at seaward and landward side of the mangrove area	3	Measure top level of mudflat.
Water Quality	Spot sample	3	Dissolved oxygen (DO), dissolved oxygen saturation (DO%), temperature, turbidity, salinity, pH and suspended solids (SS), should be measured.

Rocky Eco-shoreline

6.3.2. Rocky eco-shoreline monitoring methodology at each survey location is described in **Table 6.2**.

Table 6.2 – Rocky Eco-shoreline Monitoring Methodology

Parameter	Methodology	No. of Sample	Details
Avifauna	Point count	1	Single point count undertaken at each sampling point. Surveys undertaken for a period of 15min covering all visible areas (i.e., 360º) at a radius of 100m from the survey point. Record made of avifauna species richness and abundance in different habitats (i.e., mangrove, mudflat, open water, seawall, landscape promenade) as well as any notable behaviour (hunting, roosting, nesting).
Epifauna	Transect	3	$1m^2$ quadrat surveyed at three points (high, medium and low shore) along each transect. Species richness and abundance/frequency recorded. Diversity index and evenness index should be calculated.
Water Quality	Spot sample	3	Dissolved oxygen (DO), dissolved oxygen saturation (DO%), temperature, turbidity, salinity, pH and suspended solids (SS), should be measured.

Vertical Eco-shoreline

6.3.3. Vertical eco-shoreline monitoring methodology at each survey location is described in **Table 6.3**.

Table 6.3 – Vertical Eco-shoreline Monitoring Methodology

Parameter	Methodology	No. of Sample	Details
Avifauna	Point count	1	Single point count undertaken at each sampling point. Surveys undertaken for a period of 15min covering all visible areas (i.e., 360º) at a radius of 100m from the survey point. Record made of avifauna species richness and abundance in different habitats (i.e., mangrove, mudflat, open water, seawall, landscape promenade) as well as any notable behaviour (hunting, roosting, nesting).
Epifauna	Transect	3	$1m^2$ quadrat surveyed at three points (high, medium and low shore) along each transect. Species richness and abundance/frequency recorded. Diversity index and evenness index should be calculated.
Water Quality	Spot sample	3	Dissolved oxygen (DO), dissolved oxygen saturation (DO%), temperature, turbidity, salinity, pH and suspended solids (SS), should be measured.

Ichthyoplankton and Juvenile Fish Monitoring

6.3.4. Ichthyoplankton and juvenile fish monitoring methodology at each survey location is described in **Table 6.4**.

Table 6.4 – Ichthyoplankton and Juvenile Fish Monitoring Methodology

Parameter	Methodology	No. of Sample	Details
Ichthyoplankton	Plankton net	1	Sampling undertaken with one pair of bongo net with 0.5mm mesh size, towed at a speed of around 1 - 2 knots against the flow. Samples to be sorted in the laboratory, with all fish larvae to be identified and counted, and diversity/ eveness should be calculated.
Juvenile Fish	Purse Seine	3	Sampling undertaken with purse seine nets and cage traps with 2cm mesh size: - Purse seine survey to be completed in around 20 minutes. - Five baited cage traps to be deployed overnight at each sampling location The catches were identified to species level as far as practicable and the species composition, abundance, size and biomass in weight were measured, and diversity/ evenness should be calculated.

Reference Site Monitoring

6.3.5. Reference monitoring should be undertaken using the same methodologies adopted for Rocky Eco-shoreline Monitoring (**Table 6.2**) and Ichthyoplankton and Juvenile Fish Monitoring (**Table 6.4**).

6.4. Monitoring Programme

6.4.1. Eco shoreline is scheduled to be completed in 3 stages (i.e.Q1 2022, Q2 2022 and Q3 2023). Monitoring shall be conducted for 3 years after the completion of all stages of the eco-shoreline.

Mangrove, Rocky and Vertical Eco-shoreline

6.4.2. Each year every point (including reference point) shall be monitored at low tide, twice in wet season and twice in dry season.

Ichthyoplankton and Juvenile Fish Monitoring

6.4.3. Each year every point (including reference point) shall be monitored quarterly, covering wet, dry and transitional seasons.

6.5. Analysis and Reporting

6.5.1. During the monitoring period, progress reports should be prepared in half-year basis for outlining monitoring activities undertaken during the reporting period, summarizing monitoring results (including any key findings), and summarizing works to be undertaken in the next monitoring period.

6.5.2. During the monitoring period, an annual report should be prepared that includes the following:

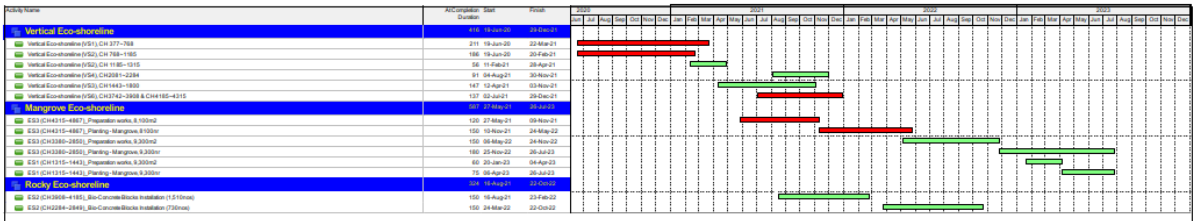
- Description of monitoring works undertaken in the Reporting period

- Presentation of the results of monitoring works
- Comparison of monitoring results with reference sites
- Comparison of monitoring results with previous monitoring periods
- Analysis of monitoring data. For large data sets where samples are not independent (due to proximity of the monitoring sites), it is recommended multivariate analysis is adopted for data analysis. Non-metric Multidimensional Scaling can be used to identify trends in biological data across different sampling locations, and correlate these with environmental data.
- Identification of management and maintenance issues
- Identification of opportunities for further enhancement works

6.5.3. A final report should be produced at the end of the monitoring period detailing all of the monitoring results, conclusion and recommendation.

Appendix A

Implementation Programme for Eco-shoreline


Activity Name
Act Completion Duration
Start
Finish
2020
2021
2022
2023
Vertical Eco-shoreline 416 19-Jun-20 29-Dec-21
Vertical Eco-shoreline (VS1), CH 377–769 211 19-Jun-20 22-Mar-21
Vertical Eco-shoreline (VS2), CH 768–1165 186 19-Jun-20 20-Feb-21
Vertical Eco-shoreline (VS2), CH 1185–1315 56 11-Feb-21 28-Apr-21
Vertical Eco-shoreline (VS4), CH2081–2284 91 04-Aug-21 30-Nov-21
Vertical Eco-shoreline (VS3), CH1443–1800 147 12-Apr-21 03-Nov-21
Vertical Eco-shoreline (VS6), CH3742–3908 & CH4185–4315 137 02-Jun-21 29-Dec-21
Mangrove Eco-shoreline 597 27-May-21 26-Jul-23
ES3 (CH4315–4867)_Preparation works, 8,100m2 120 27-May-21 09-Nov-21
ES3 (CH4315–4867)_Planting - Mangrove, 8100/m² 150 10-Nov-21 24-May-22
ES3 (CH3380–2850)_Preparation works, 9,300m2 150 06-May-22 24-Nov-22
ES3 (CH3380–2850)_Planting- Mangrove, 9,300/m² 180 25-Nov-22 26-Jul-23
ES1 (CH1315–1443)_Preparation works, 9,300m2 60 20-Jan-23 04-Apr-23
ES1 (CH1315–1443)_Planting- Mangrove, 9,300/m² 70 06-Apr-23 26-Jul-23
Rocky Eco-shoreline 324 16-Aug-21 22-Oct-22
ES2 (CH3908–4185)_Bio-ConcreteBlocks Installation (1,510/mos) 150 16-Aug-21 23-Feb-22
ES2 (CH2284–2849)_Bio-ConcreteBlocks Installation (730/mos) 150 24-Mar-22 22-Oct-22

Appendix B

Implementation Schedule for Eco-shoreline

Environmental Mitigation Implementation Schedule – Eco-shoreline Implementation Plan

Recommended Mitigation Measures	Objectives of the Recommended Measures & Main Concerns to address	Implementation Agent	Location / Timing	Implementation Stage	Requirements and / or standards to be achieved
Adopting Mangrove Eco-shoreline design by providing a sheltered platform suitable for the establishment and growth of mangroves	To mitigate the impact of the marine loss by create a range of potential mangrove and mudflat habitats.	CEDD	Eco-shoreline	Construction stage	- EIA - Contractual requirements
Adopting Rocky Eco-shoreline design by adopting rectangular shaped concrete blocks arranged to provide a natural looking shoreline	To mitigate the impact of the marine loss by increasing the habitat value of the blocks for inter-tidal organism	CEDD	Eco-shoreline	Construction stage	- EIA - Contractual requirements
Adopting Vertical Eco-shoreline design by treatment to block-work used to form the sea-wall	To mitigate the impact of the marine loss by increasing the habitat value of the blocks for inter-tidal organism	CEDD	Eco-shoreline	Construction stage	- EIA - Contractual requirements
Adopting oyster baskets filled with oyster shells in the limited sub-tidal areas at the toe of Eco-shoreline design	To increase habitat complexity and enhance ecosystem function and services.	CEDD	Eco-shoreline	Construction stage	- EIA - Contractual requirements
Adopting monitoring works	To monitor colonisation and establishment of fauna and/or flora on the eco-shoreline	CEDD	Eco-shoreline	After completion of reclamation	- EIA - Contractual requirements

Appendix B