3. WATER QUALITY

3.1 Introduction

This ***Section*** presents an evaluation of the potential water quality impacts from the construction and operation of the Project, and the results were assessed with reference to the relevant environmental legislation, standards and criteria.

3.2 Relevant Legislation and Guidelines

The following legislation and relevant guidance or non-statutory guidelines are applicable to the evaluation of water quality impacts associated with the construction and operation of the Project:

- *Water Pollution Control Ordinance* (*WPCO*);
- *Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (*TM- ICW*);
- *Hong Kong Planning Standards and Guidelines (HKPSG)*; and
- *Environmental Impact Assessment Ordinance (EIAO) and the Technical Memorandum on EIA Process* (*EIAO-TM*), *Annexes 6* and *14*.

3.2.1 Water Pollution Control Ordinance (WPCO)

The Water Pollution Control Ordinance (WPCO) is the primary legislation for the control of water pollution and water quality in Hong Kong. Under the WPCO, Hong Kong waters are divided into 10 Water Control Zones (WCZs). Each WCZ has a designated set of statutory Water Quality Objectives (WQOs).

The proposed Project is located within the Southern WCZ. The applicable WQOs for the Southern WCZ are presented in ***Table 3.1***. The applicable WQOs for the Mirs Bay WCZ, are also presented in ***Table 3.1*** as some of the identified WSRs (such as coral locations around the Waglan Island as shown in ***Figure 3.1***) are located close to the Mirs Bay WCZ. However, given all the identified WSRs are located within the Southern WCZ, the WQOs for the Southern WCZ were adopted as the assessment criteria.

3.2.2 Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM-ICW)

All discharges from the construction and operation phases of the proposed Project are required to comply with the *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (*TM-ICW*) issued under Section 21 of the WPCO.

The TM-ICW defines acceptable discharge limits to different types of receiving waters. Under the *TM-ICW*, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs are subject to pollutant concentration standards for specified discharge volumes. These are defined by the Environmental Protection Department (EPD) and are specified in licence conditions for any new discharge within a WCZ.

3.2.3 Hong Kong Planning Standards and Guidelines (HKPSG)

Mariculture is identified as one of the sensitive uses under Section 5.3 of Chapter 9 of the HKPSG. The HKPSG highlighted the importance of good water quality for the mariculture environment, as well as the potential water quality impact from mariculture operation. Limitation on new effluent within 200m of the seaward boundaries and 100m of the landward boundaries of a marine fish culture zone should be observed. The HKPSG also highlighted the importance of good water circulation to allow pollutants be readily dispersed, as well as control of other sources of pollution that could affect water quality.

3.2.4 Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)

Annexes 6 and *14* of the *EIAO-TM* provide general guidelines and criteria to be used in assessing water quality impacts.

The *EIAO-TM* recognises that, in the application of the above water quality criteria, it may not be possible to achieve the WQO at the point of discharge as there are areas which are subjected to greater impacts (which are termed by the EPD as the mixing zones), where the initial dilution of the discharge takes place. The definition of this area is determined on a case-by-case basis. In general, the criteria for acceptance of the mixing zones are that it must not impair the integrity of the water body as a whole and must not damage the ecosystem.

Table 3.1 Summary of Water Quality Objectives for Southern and Mirs Bay WCZ

	Water Quality Objective	Southern WCZ	Mirs Bay WCZ
A	AESTHETIC APPEARANCE		
a)	Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole zone	Whole zone
b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone	Whole zone
c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to lasting foam.	Whole zone	Whole zone
d)	There should be no recognisable sewage-derived debris.	Whole zone	Whole zone
e)	Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole zone	Whole zone
f)	Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole zone	Whole zone
B	BACTERIA		
a)	The level of *Escherichia coli* should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in one calendar year.	Secondary Contact Recreation Subzone & Fish Culture Subzones	Secondary Contact Recreation Subzones and Fish Culture Subzones
b)	The level of *Escherichia coli* should not exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive in one calendar year. Samples should be taken at least 3 times in a calendar month at intervals of between 3 and 14 days.	Bathing Beach Subzones	Not applicable
c)	The level of *Escherichia coli* should not exceed 1 000 per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Not applicable	Other inland waters of the zone
d)	The level of Escherichia coli should be zero per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Not applicable	Water Gathering Ground Sub-zones
C	COLOUR		
a)	Waste discharges shall not cause the colour of water to exceed 30 Hazen units.	Not applicable	Water Gathering Ground Sub-zones
b)	Waste discharges shall not cause the colour of water to exceed 50 Hazen units	Not applicable	Other inland waters of the zone

	Water Quality Objective	Southern WCZ	Mirs Bay WCZ
D	DISSOLVED OXYGEN		
a)	Waste discharges shall not cause the level of dissolved oxygen to fall below 4 milligrams per litre for 90% of the sampling occasions during the year; values should be calculated as the water column average (arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth, and 1 metre above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 milligrams per litre within 2 metres of the seabed for 90% of the sampling occasions during the year.	Marine waters excepting Fish Culture Subzones	Marine waters excepting Fish Culture Subzones
b)	The dissolved oxygen level should not be less than 5 milligrams per litre for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth and 1 metre above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 milligrams per litre within 2 metres of the seabed for 90% of the sampling occasions during the year.	Fish Culture Subzones	Fish Culture Subzones
c)	Waste discharges shall not cause the level of dissolved oxygen to be less than 4 milligrams per litre.	Inland waters of the Zone	Water Gathering Ground Sub-zones and Other inland waters of the zone
E	pH		
a)	The pH of the water should be within the range of 6.5-8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	Marine waters excepting Bathing Beach Subzones; Mui Wo (A), Mui Wo (B), Miu Wo (C), Mui Wo (E) and Mui Wo (F) Subzones.	Marine waters
b)	The pH of the water should be within the range of 6.0-9.0 units.	Mui Wo (D) Sub-zone and other inland waters.	Other inland waters of the zone
c)	The pH of the water should be within the range of 6.0-9.0 units for 95% of samples. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 units.	Bathing Beach Subzones	Not applicable
d)	Waste discharges shall not cause the pH of the water to exceed the range of 6.5-8.5 units.	Not applicable	Water Gathering Ground Sub-zones
F	TEMPERATURE		
a)	Waste discharges shall not cause the natural daily temperature range to change by more than 2.0 degrees Celsius.	Whole zone	Whole Zone
G	SALINITY		
a)	Change due to waste discharge not to exceed 10% of natural ambient level	Whole zone	Whole Zone

	Water Quality Objective	Southern WCZ	Mirs Bay WCZ
H	SUSPENDED SOLIDS		
a)	Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters	Marine waters
b)	Waste discharges shall not cause the annual median of suspended solids to exceed 20 milligrams per litre.	Mui Wo (A), Mui Wo (B), Mui Wo (C), Mui Wo (E) and Mui Wo (F) Subzones.	Water Gathering Ground Sub-zones and Other inland waters of the Zone
c)	Waste discharges shall not cause the annual median of suspended solids to exceed 25 milligrams per litre.	Mui Wo (D) Sub-zone and other inland waters.	Not applicable
I	AMMONIA		
a)	The ammonia nitrogen level should not be more than 0.021 milligram per litre, calculated as the annual average (arithmetic mean), as unionised form.	Whole zone	Whole Zone
J	NUTRIENTS		
a)	Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters	Marine waters
b)	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.1 milligram per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth and 1 metre above seabed).	Marine waters	No applicable
c)	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed).	Not applicable	Marine Water
K	5-DAY BIOCHEMICAL OXYGEN DEMAND		
a)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 milligrams per litre.	Not applicable	Water Gathering Ground Sub-zones
b)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 milligrams per litre.	Inland waters	Other inland waters of the Zone
L	CHEMICAL OXYGEN DEMAND		
a)	Waste discharges shall not cause the chemical oxygen demand to exceed 15 milligrams per litre.	Not applicable	Water Gathering Ground Sub-zones

	Water Quality Objective	Southern WCZ	Mirs Bay WCZ
b)	Waste discharges shall not cause the chemical oxygen demand to exceed 30 milligrams per litre.	Inland waters	Other inland waters of the zone
M	TOXINS / TOXICANTS		
a)	Waste discharges shall not cause the concentrations of dangerous substances in marine waters to attain such levels as to produce significant toxic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Whole zone	Not applicable
b)	Waste discharges of dangerous substances shall not put a risk to any beneficial uses of the aquatic environment.	Whole zone	Not applicable
c)	Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Not applicable	Whole Zone
d)	Waste discharges of dangerous substances shall not put a risk to any beneficial uses of the aquatic environment.	Not applicable	Whole Zone

(1) CAP358I Southern Water Control Zone Statement of Water Quality Objectives.

(2) CAP358U Statement of Water Quality Objectives (Mirs Bay Water Control Zone)

3.3 Baseline Conditions

3.3.1 Assessment Area

In accordance with the Study Brief, the Assessment Area for water quality impact assessment covers the Southern Water Control Zone (WCZ). The proposed Po Toi (Southeast) FCZ is located at southeast of the Po Toi Island. Water around the Po Toi Island is generally deep and exceed 30 m at short distance from the shore. The water depth at the proposed Po Toi (Southeast) FCZ is around 20 m - 35 m.

3.3.2 Marine Water Quality

Baseline marine water quality of the Assessment Area has been determined through a review of EPD routine water quality monitoring data collected between 1986 and 2020. This dataset provides Hong Kong's most comprehensive long-term water quality monitoring data and allows an indication of temporal and spatial change in marine water quality in Hong Kong. Water quality monitoring data from EPD monitoring stations that are located within or close to the Assessment Area were reviewed and summarised in ***Table 3.2***. Locations of these stations are presented in ***Figure 3.1***. The WQO compliance in the Southern WCZ remains in the range of around 60% to 90%, with no obvious trend of improvement or deterioration despite of continuous development in Hong Kong and the Guangdong Province. Given the lack of notable trend on water quality, the adoption of long term data is deemed suitable for providing representative baseline conditions for the Assessment Area.

Compliance with the WQOs is generally observed in most parameters at the selected monitoring stations at these two WCZs. Occasional exceedance of total inorganic nitrogen (TIN) have been recorded at monitoring station SM1 and SM19. According to EPD's Marine Water Quality Report 2020, recorded TIN levels at SM1 and SM19 both showed non-compliance of the corresponding WQO criterion of 0.1 mg/L in 3 out of 5 recent years (2016-2020). Beside TIN, the water quality at this southeastern part of Hong Kong is generally good.

Table 3.2 Summary of EPD Routine Water Quality Monitoring Data from Selected Stations of the Southern WCZ and Mirs Bay WCZ (1986 – 2020)

Parameters	SM1	SM19	MM8
Temperature (°C)	23.1	23.1	22.8
	(13.9-29.9)	(14.2-29.4)	(11.5-29.4)
Salinity (psu)	32.2	32.3	32.8
	(26.3-34.5)	(26.6-34.6)	(28.8-38.5)
Dissolved Oxygen (mg/L)	6.5	6.5	6.5
	(3.9-11.5)	(3.8-11.0)	(3.3-9.0)
Dissolved Oxygen (mg/L) - Bottom	6.1	6.0	6.0
	(2.0-10.5)	(0.9-11.6)	(2.0-9.5)
Dissolved Oxygen (%saturation)	92	90	89
	(57-139)	(54-133)	(44-124)
Dissolved Oxygen (%saturation) - Bottom	85	83	82
	(29-126)	(12-158)	(29-120)
pH	8.1	8.1	8.1
	(6.6-8.9)	(7.5-8.8)	(6.9-8.7)
Secchi Disc Depth (M)	2.8	2.9	3.8
	(1.0-6.5)	(1.0-9.0)	(1.0-10.0)
Turbidity (NTU)	5.2	6.2	5.9
	(0.1-25.7)	(0.2-23.9)	(0.6-77.8)
Suspended Solids (mg/L)	4.1	4.8	4.1
	(0.5-25.3)	(0.7-26.7)	(0.6-24.7)
5-day Biochemical Oxygen Demand (mg/L)	0.8	0.7	0.6
	(0.1-3.2)	(0.1-2.8)	(0.1-2.7)
Ammonia Nitrogen (mg/L)	0.029	0.027	0.025
	(0.01-0.12)	(0.01-0.11)	(0.01-0.22)
Unionised Ammonia (mg/L)	0.002	0.002	0.002
	(0.000-0.012)	(0.000-0.011)	(0.000-0.008)

Parameters	SM1	SM19	MM8
Nitrite Nitrogen (mg/L)	0.014	0.016	0.013
	(0.002-0.110)	(0.002-0.103)	(0.002-0.046)
Nitrate Nitrogen (mg/L)	0.063	0.070	0.054
	(0.002-0.670)	(0.002-0.413)	(0.002-0.235)
Total Inorganic Nitrogen (mg/L)	0.10	0.11	0.09
	(0.01-0.84)	(0.01-0.49)	(0.01-0.31)
Total Kjeldahl Nitrogen (mg/L)	0.25	0.24	0.23
	(0.05-1.47)	(0.06-1.27)	(0.06-1.30)
Total Nitrogen (mg/L)	0.32	0.32	0.29
	(0.06-1.52)	(0.07-1.27)	(0.05-1.31)
Orthophosphate Phosphorus (mg/L)	0.010	0.011	0.012
	(0.002-0.052)	(0.002-0.033)	(0.002-0.121)
Total Phosphorus (mg/L)	0.04	0.04	0.04
	(0.02-0.26)	(0.02-0.51)	(0.02-0.27)
Silica (mg/L)	0.67	0.71	0.66
	(0.08-2.80)	(0.12-2.60)	(0.09-1.83)
Chlorophyll-a (µg/L)	2.9	2.6	2.0
	(0.2-22.8)	(0.3-22.7)	(0.2-13.2)
E. coli (cfu/100mL)	4	3	2
	(1-122)	(1-360)	(1-800)
Faecal Coliforms (cfu/100mL)	6	3	3
	(1-350)	(1-2101)	(1-5002)

Notes:
1. Data presented are depth-averaged values calculated by taking the means of three depths, i.e. surface (S), mid-depth (M) and bottom (B), except as specified.
2. Data presented are annual arithmetic means except for *E. coli*, which are geometric means.
3. Shaded cells indicate non-compliance with the WQOs.

3.3.3 Marine Sediment Quality

Baseline marine sediment quality in the Assessment Area has been determined through a review of EPD routine sediment quality monitoring data collected between 1986 and 2020. Sediment monitoring data from EPD monitoring stations that are located within or close to the Assessment Area were reviewed and summarised in ***Table 3.3***. Locations of these stations are presented in ***Figure 3.1***.

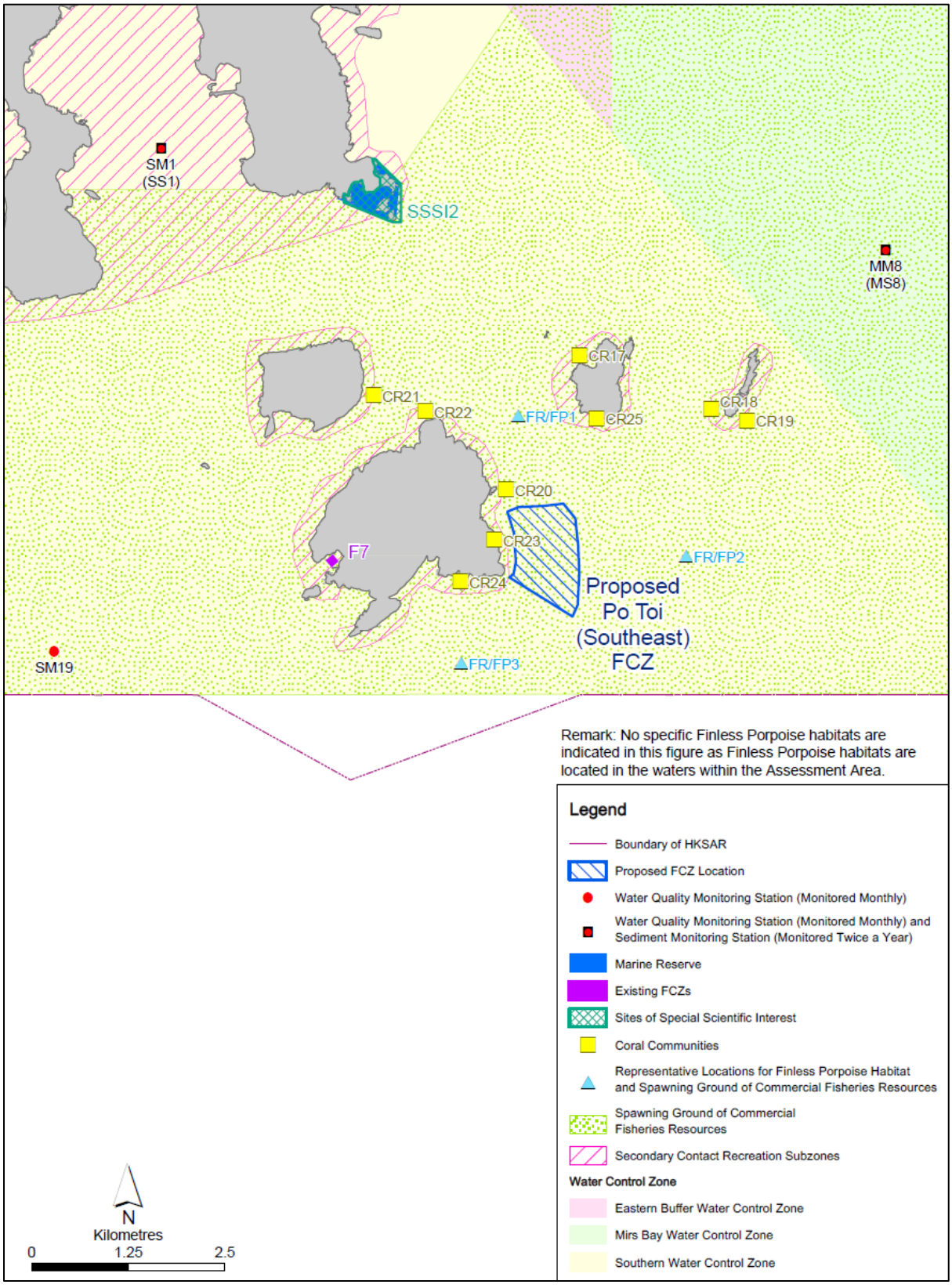
Sediment monitoring data from the EPD monitoring stations were compared with the relevant sediment quality criteria specified in *ETWB TC(W) No. 34/2002 Management of Dredged/Excavated Sediment*. The EPD routine monitoring data indicate that the contaminant levels in the sediments in the vicinity of the Project are all below the Lower Chemical Exceedance Level (LCEL).

Table 3.3 Summary of EPD Routine Sediment Monitoring Data from Selected Stations of the Southern WCZ and Mirs Bay WCZ (1986 – 2020)

Parameters	LCEL	UCEL	SS1	MS8
Arsenic (mg kg-1)	12	42	7.2	7.6
			(1.7-18.0)	(5.2-11.0)
Cadmium (mg kg^{-1})	1.5	4	2.7	<0.1
			(<0.1-8.9)	(<0.1-<0.1)
Chromium (mg kg^{-1})	80	160	25.0	32.3
			(11.0-45.0)	(16.0-43.0)
Copper (mg kg^{-1})	65	110	12.9	14.1
			(5.0-35.0)	(8.0-22.0)
Lead (mg kg^{-1})	75	110	29.6	34.3
			(21.0-59.0)	(21.0-42.0)
Mercury (mg kg^{-1})	0.5	1	0.08	0.06
			(0.05-0.32)	(0.05-0.13)
Nickel (mg kg^{-1})	40	40	17.5	23.2
			(10.0-33.0)	(11.0-31.0)
Silver (mg kg^{-1})	1	2	<0.2	<0.2
			(<0.2-<0.2)	(<0.2-<0.2)
Zinc (mg kg^{-1})	200	270	71.2	84.6
			(46.0-110.0)	(51.0-120.0)
Total Polychlorinated Biphenyls (PCBs) (µg kg^{-1})	23	180	17	18
			(5-18)	(18-20)
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg kg^{-1})	550	3,160	<180	<180
			(<180-<180)	(<180-204)
High Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg kg^{-1})	1,700	9,600	<32	41
			(<32-227)	(<32-308)
Chemical Oxygen Demand (mg kg^{-1})	--	--	10382	11346
			(5600-13000)	(8500-20000)
Total Kjeldahl Nitrogen (mg kg^{-1})	--	--	445.8	446.8
			(210.0-1200.0)	(240.0-680.0)

Note:
1. Data presented are arithmetic means; data in brackets indicate ranges.
2. All data are on a dry weight basis unless stated otherwise.

Figure 3.1 Location of Water Sensitive Receivers and Nearby EPD Marine Water / Sediment Quality Monitoring Stations



3.3.4 Water Sensitive Receivers

The water sensitive receivers (WSRs) have been identified in accordance with *Annex 14* of the *Technical Memorandum on EIA Process* (*EIAO, Cap.499, S.16*) and Section 3.4.3.2 of the Study Brief. These WSRs are illustrated in ***Figure 3.1*** and listed in ***Table 3.4***. Key WSRs include:

- Recreational areas, such as secondary contact recreation subzones of WCZs [(20)];
- Cape D'Aguilar Marine Reserve / Hok Tsui (Cape D'Aguilar) SSSI (SSSI2);
- Existing FCZ at Po Toi (F7);
- Ecological habitats for marine organisms including coral [(21)] and benthic communities (CR17 to CR25), and Finless Porpoise (FR/FP1 to FR/FP3) at / near the Project site; and
- Spawning ground of commercial fisheries resources (FR/FP1 to FR/FP3).

There is no seawater intake identified within 5 km from the Project Site, and other WSRs outside of 5 km from the Project Site is expected to be too far away to be impacted by the proposed mariculture operation.

In accordance with the Study Brief, the Project site itself is also considered as a sensitive receiver for assessment.

Table 3.4 Water Sensitive Receivers (WSRs) in the Vicinity of the Proposed FCZ Site at Po Toi (Southeast)

WSR ID	WSR	Distance to the Proposed FCZ site at Po Toi (Southeast) (km)
CR17	Coral at North Sung Kong Island	1.9
CR18	Coral at West Waglan Island	2.3
CR19	Coral at South Waglan Island	2.6
CR20	Coral at East Po Toi Island	0.3
CR21	Coral at Southeast Beaufort Island	2.3
CR22	Coral at North Po Toi Island	1.7
CR23	Coral at East Po Toi Island	0.3
CR24	Coral at Southeast Po Toi Island	0.6
CR25	Coral at South Sung Kong Island	1.2
F7	Po Toi Fish Culture Zone	2.3
SSSI2	Cape D'Aguilar Marine Reserve / Hok Tsui (Cape D'Aguilar) SSSI	4.0
FR/FP1	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	1.2
FR/FP2	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	1.4
FR/FP3	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	1.3
Site D	Proposed Po Toi (Southeast) FCZ	Project Site

(20) A notable swath of nearshore waters of south of Hong Kong Island are categorized as Secondary Contact Recreation Subzone. The predicted water quality at these areas are represented by other WSRs and thus do not have the respective WSRs for Secondary Contact Recreation Subzone only. Specifically, F7, SSSI2, CR17 to CR25 are located within Secondary Contact Recreation Subzone.

(21) Corals can be found along the coastline of outlying islands around the Project Site including Po Toi Island, Beaufort Island, Sung Kong Island and Waglan Island, as well as the Cape D'Aguilar (also known as Hok Tsui). Locations of CR17 to CR22 are selected as the representative locations for corals with higher ecological value for representative assessment.

3.4 Assessment Criteria

The proposed establishment of new fish culture zone would potentially result in an increase in pollution from fish farming operation. Such pollution may increase nutrient levels as well as decrease dissolved oxygen level in the surrounding waters. The relevant assessment criteria for WSRs are stipulated in the WQO and are shown in ***Table 3.5***.

Table 3.5 Summary of Assessment WQO Criteria

Parameters	Southern WCZ
Dissolved Oxygen (Bottom) (mg/L)	Not less than 2 mg/L for 90% of samples
Dissolved Oxygen (Depth-averaged) (mg/L)	Not less than 4 mg/L for 90% of samples
Suspended Solids (mg/L)	Change not more than 30% due to waste discharge
Total Inorganic Nitrogen (mg/L)	≤ 0.1 mg/L
Unionized Ammonia (mg/L)	≤ 0.021 mg/L
E.coli (no./100mL)	≤ 610 no./100mL for the Secondary contact recreation subzone and the Fish culture subzones

In addition to the WQO criteria for various water quality parameters in the Southern WCZ, an additional criterion for chlorophyll-a at existing and proposed FCZs would be adopted from *Wong et. al., 2012* [22] to protect the fish stock from excessive algal growth. A summary of applicable assessment criteria for each category of WSRs are provided below in ***Table 3.6***.

There will be no marine dredging or other major marine works that could cause significant sediment disturbance and the associated release of sediment-bounded contaminants. Therefore, assessment criteria for dissolved metals and organic compounds are not necessary for this Study.

(22) Wong *et.al.* (2012). Project WATERMAN Carrying Capacity of Fish Culture Zones in Hong Kong – Technical Note TN-2012-02

Table 3.6 Summary of Applicable Assessment Criterion for Identified WSRs

Category of WSR	ID	WSR	Annual								
			10th-percentile		Mean						Geomean
			Depth-averaged	Bottom	Depth-averaged	Bottom	Depth-averaged				
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* (1)
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(mg/L)	(no./100 mL)
Coral – Southern	CR17	Coral at North Sung Kong Island	≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610
	CR18	Coral at West Waglan Island									
	CR19	Coral at South Waglan Island									
	CR20	Coral at East Po Toi Island									
	CR21	Coral at Southeast Beaufort Island									
	CR22	Coral at North Po Toi Island									
	CR23	Coral at East Po Toi Island									
	CR24	Coral at Southeast Po Toi Island									
	CR25	Coral at South Sung Kong Island									
Fish Culture Zone – Southern	F7	Po Toi Fish Culture Zone	≥5	≥2	N/A	N/A	≤0.1	≤0.021	≤20 (2)	increase ≤30% baseline	≤610
	Site D	Proposed Po Toi (Southeast) FCZ									
Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources - Southern	FR/FP1	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610
	FR/FP2	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources									
	FR/FP3	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources									
SSSI – Southern	SSSI2	Cape D'Aguilar Marine Reserve / Hok Tsui (Cape D'Aguilar) SSSI	≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610

Note:
(1) WQO criterion for *E.coli* is only applicable to fish culture zones, bathing beaches as well as secondary contact recreation subzone. Given secondary contact recreation subzone covers both the coral locations (CR17-25) as well as SSSI (SSSI2) WSR identified, the criterion is deemed applicable to these WSRs groups as well.
(2) Recommended criterion for chlorophyll-*a* is adopted from *Wong et. al., 2012*.

3.5 Assessment Methodology

3.5.1 General Methodology

The methodology employed to quantitatively assess potential water quality impacts associated with the operation of the Project is presented in the Water Quality Modelling Plan (***Appendix 3A***), which provides full technical details of the modelling works as well as model validation. The WSRs assessed are presented in ***Figure 3.1***.

For other potential sources of water quality impact in construction and operation phase, qualitative approach would be adopted in the assessment.

3.5.2 Uncertainties in Assessment Methodology

The uncertainties associated with the operation phase water quality modelling and carrying capacity estimation include:

- Potential change in pollution loading from Guangdong Province; and
- Potential change in mariculture practice which leads to different level of pollution loading from fish farms.

Future year of 2023 was chosen because the future loading from the Guangdong Province of China is expected to decrease continuously and therefore the estimated loading in 2023 would be conservative (***Section 4*** of ***Appendix 3A*** referred). Model prediction of water quality under 2016 presented in ***Appendix 3D*** compared observed and predicted water quality at EPD Marine Water Quality Monitoring Stations. Results indicated the model developed can generally represents key water quality features including stratification and seasonal differences, while providing predictions that are generally more conservative than the observed conditions. This means the model would provide conservative estimation of water quality thus being acceptable.

In terms of change in mariculture practice, the overall trend has been heading towards a more environmentally friendly direction in the past decades. The wider adoption of pellet feed has reduced wastage. Improved fish farming practice has reduced overfeeding, disease and fish mortality. Future improvement in technology and fish farming practice is expected to further minimise environmental footprint for mariculture, and thus the current assumptions are considered conservative and appropriate for impact assessment. In particular, the pollution loading from mariculture operation at the Project site was based on feed conversion ratio (FCR) of 2, whereas literatures reviewed under this Study indicated typical pellet feed nowadays can achieve FCR of close to 1 [23] [24] [25]. The adoption FCZ of 2 instead of 1 means the amount of feed assumed for mariculture operation would be doubled, and the associated wastage, leachage [26] of nutrient from waste would be notably higher than typical average conditions for fish farm using pellet feeds. This will ensure conservative estimation of pollution load from the mariculture operation at the Project site.

It should be highlighted that the water quality modelling exercise covered a typical annual cycle based on typical hydrodynamic of spring neap cycle in dry and wet seasons. Extreme conditions, such as typhoon is not expected to result in water quality conditions much worse than the typical conditions given such conditions would typical result in stronger mixing (in case of strong wind / typhoon) or dilution (in case of heavy rain). Also, in case of deterioration of water quality, it is typical for mariculturists to move the mariculture operation within or out of the Project site temporarily, which in

(23) Sim SY, Rimmer MA, Toledo JD, Sugama K, Rumengan I, Williams KC, Phillips MJ (2005). A Practical Guide to Feeds and Feed Management for Cultured Groupers. NACA, Bangkok, Thailand. 18pp.

(24) FAO (2012). Transition from low-value fish to compound feeds in marine cage farming in Asia. Fisheries and Aquaculture Technical Paper No. 573

(25) AFCD (2009). Fish Feed Management. In Good Aquaculture Practices Series 1.

(26) “Leachage” refers to the release of dissolvable content from materials passing through the water column.

the sense of modelling exercise means moving sensitive receiver as well as pollution source. In this Study, such movement has not been taken into account and thus represents the worst case scenario where avoidance is not possible.

To ensure robustness of the modelling exercise, performance of the hydrodynamic and water quality prediction have been demonstrated to be on par with past approved model (Annex A-B of ***Appendix 3A***) and able to reproduce realistic water quality conditions in the past (***Appendix 3D***). This shows the adopted model would be able to predict the water quality conditions under the baseline and project scenarios of the Project with reasonable accuracy and reliability, ensure reliable assessment and conclusion be drawn.

3.6 Potential Sources of Impact

3.6.1 Construction Phase

The construction for this Project will not involve civil or marine works. Most of the construction works would involve the assembly of parts to form fish rafts for mariculture, as well as the towing and anchoring of fish rafts from other location(s) to the new FCZ using tug boat. Potential water quality impact from the assembly of parts to form fish rafts would include accidental spillage, construction waste, as well as sewage from construction workforce. Anchoring and de-anchoring of fish rafts may result in transient, localised elevation of suspended solids near seabed.

3.6.2 Operation Phase

Mariculture activities at the Project site would result in an increase in pollution loads primarily from fish feed, feed wastage, fish excretion and dead fish. The increase in pollution loads would result in a change in water quality in the receiving waters, affecting the water quality at nearby sensitive receivers, such as other existing FCZs, marine ecological as well as fisheries resources. Other potential operation phase water quality impacts include change in hydrology / flow regime due to the presence of fish rafts, spillage of fish drugs, chemical and feed, wastewater from workforces and increased marine traffic and visitor activities.

Maintenance dredging and sediment removal were typically needed at FCZs sited at shallow and sheltered as a result of building up of organic content at the seabed level of the FCZs because of prolong mariculture operation. Build-up of organic content could be contributed by fish faeces, unconsumed feed, lodged off attached growth from cleaning, etc., and could results in deterioration of local water quality, increased risk of local red tide and upwelling of anoxic and toxic gas [27]. The Project site was chosen to be deep enough to (1) allow sufficient dispersion of any mariculture waste (fish faeces, unconsumed feed, lodged off attached growth, etc.) that sinks could be brought away by tidal current and dispersed at a larger area of the seabed so there is no significant build-up of the seabed, and (2) provide sufficient distance from the seabed to the bottom level of fish cages. Specifically, at least 2 m of clearance from the seabed would be maintained at all times. Maintenance dredging and sediment removal are therefore not required for the Project and hence no water quality impact would be expected from maintenance dredging and sediment removal.

In case of adverse weather / water quality conditions or approaching of harmful algal bloom, there may be a need for mariculturists to temporarily relocate their fish rafts (or equivalent) to safe location(s) to avoid fish kill or other damage. During the brief period of relocation, the pollution load from the relocated mariculture operation would be released into the relocated locations, thus affect the local water quality.

(27) DIR-191/2009 Sediment Removal at Yim Tin Tsai, Yim Tin Tsai (East) Fish Culture Zones and Shuen Wan Typhoon Shelter.

3.7 Impact Assessment – Construction Phase

The towing and anchoring of fish rafts is expected to have very limited impact on water quality, as the level of sediment suspended in the water column from anchoring will be very limited, primarily localised near the seabed and the impact will be transient because suspended sediment will settle shortly close to the anchor. Anchoring is routinely conducted for all kinds of vessel activities and floating structures in the surrounding waters and is considered to have limited level of impact on water body. The Project site is typically more than 20 m in water depth such that propeller would not have interaction with the seabed sediment and so SS elevation due to propeller wash is not anticipated.

Depending on the design and specifications, required works to assemble fish rafts onsite could vary and may include tighten up connections by nuts and bolts, ropes or equivalent, assembling parts with pre-casted grooves, etc. Modern fish rafts are available in modular form and with appropriate surface treatment (28), hence the onsite assembly can be done quicker and will require less onsite use of equipment and materials. In general, construction materials and tools are inert and use of these items is not expected to result in notable changes in water quality. It is noted that wood or other structural materials that require surface treatment (e.g. water-proofing, anti-fouling) are generally treated offsite (in factories / workshops) instead of onsite during assembly. The use of chemicals onsite is expected to be minimal and no unacceptable water quality impact from the onsite installation of fish raft would be expected. Details of tools and materials adopted on-site would be determined by the future licensees.

Because of the lack of major works to be conducted, it is unlikely there will be a significant workforce presence during construction phase, and any sewage / wastewater generated shall be collected at the transportation / work vessel(s) for disposal at appropriate facilities on land. Discharge of sewage from workforce or other wastewater should be strictly forbidden. No unacceptable water quality impact from sewage / wastewater from workforce is anticipated.

In view of the above, no unacceptable water quality impact is anticipated from fish raft installation.

3.8 Impact Assessment – Operation Phase

3.8.1 Changes in Water Quality from Pollution Loadings arising from Mariculture Operation

Mariculture activities at the Project site would result in an increase in pollution loads primarily from fish feed, feed wastage, fish excretion and dead fish. The increase in pollution loads would result in a change in water quality in the receiving waters, affecting the water quality at nearby sensitive receivers, such as other existing FCZs, marine ecological as well as fisheries resources. A carrying capacity (29) estimation was conducted (detailed in ***Appendix 3B***) to determine the suitable production capacity allowed onsite to ensure mariculture activities there would not result in, or be affected by, water quality impact from over-stocking. The estimation of carrying capacity was conducted using the methodology and box model developed by Project WATERMAN which was used in the carrying capacity estimation for the existing FCZs in Hong Kong. The carrying capacity estimation took into account various aspects affecting the water quality for mariculture operation, including tidal flushing, loading contribution from mariculture activities, as well as various water quality parameters interaction (e.g. nitrogen, phosphorus, dissolved oxygen). Based on the WATERMAN model, the carrying capacity for mariculture operation at the Project Site is found to be limited by the criterion for total inorganic nitrogen in wet season. The carrying capacity estimation indicated the Project site can

(28) Surface treatment like waterproofing and rush control is typically necessary for floating facilities such as fish rafts. By using material with surface treatment completed offsite (e.g. in a factory or workshop), the time required for onsite works can be reduced.

(29) Carrying capacity is defined as the maximum standing stock of a FCZ without significant deterioration of water quality under the typical average condition. It is a measurement of standing stock, i.e. amount of biomass of fish being kept on site.

support mariculture operation of 1765.4 ton of standing stock based on typical mariculture practice in HK without significant deterioration of water quality at the proposed FCZ site under the typical average condition. The corresponding pollution load from such level of mariculture operation is presented in ***Appendix 3B***.

The estimated loading at Project site was taken into account in the Delft3D model to verify the acceptability of change in water quality at the Project site itself as well as to determine the offsite water quality impact on nearby WSRs. Two modelling scenarios were conducted. The baseline scenario covers the "without project" condition of the Assessment Area in 2023. The project scenario has taken into account the additional pollution load from the Project site. The change in water quality as a result of the additional mariculture activities were assessed according to the WQO. Statistics of key water quality parameters are presented in ***Table 3.7*** (30). Contour plots showing spatial distribution of key water quality parameters are presented in ***Appendix 3C***.

Following sections discuss the predicted level and change for key water quality parameters separately at the Project site as well as major nearby WSRs.

3.8.1.1 Dissolved Oxygen

Predicted levels of dissolved oxygen were generally good in all identified WSRs under both baseline and project scenarios. At all identified WSRs mean depth-averaged and bottom levels of dissolved oxygen were predicted to be around 6 mg/L, which were close to the observed averaged at nearby EPD Marine Water Quality Monitoring Stations (***Table 3.2***). Changes in dissolved oxygen due to mariculture production at the Project site and other locations were predicted to be limited at all identified WSRs including the Project site itself.

The mean level of depth-averaged dissolved oxygen at the existing Po Toi FCZ, which is the closest FCZ to the Project site, was predicted to be 6.7 mg/L for both scenarios, and the mean level of bottom dissolved oxygen was predicted to be 6.7 mg/L for both scenarios as well. Similarly, the mean level of depth-averaged dissolved oxygen at the Project site was predicted to be 6.5 mg/L for both scenarios, and the mean level of bottom dissolved oxygen was predicted to be 6.5 mg/L for both scenarios as well. The predicted 10^{th}-percentile depth-averaged dissolved oxygen levels at both the Po Toi FCZ and Project site are both above 5 mg/L, which is above the corresponding assessment criterion. This shows the depth-averaged dissolved oxygen levels at both the existing Po Toi FCZ and the Project site comply with the WQO criterion for existing and proposed FCZs of 5 mg/L. For the nearby coral WSRs identified as well as representative locations for finless porpoise habitat and spawning ground for commercial fisheries resources, the predicted 10^{th}-percentile depth-averaged dissolved oxygen levels is generally in the range of 5 mg/L to 6 mg/L, which is also above the corresponding assessment criterion of 4 mg/L. The comparison between the baseline and project scenarios shows that the mariculture operation at the Project site would result in limited change (at most 0.1 mg/L for 10^{th}-percentile bottom level, even less for other statistic metrics) in dissolved oxygen levels at the Project Site. The predicted change in dissolved oxygen levels were similar or even lower at other identified WSRs.

Overall, according to the results listed in ***Table 3.7***, there is limited change in the predicted dissolved oxygen levels between baseline and project scenarios at some WSRs, but the proposed mariculture operation at the Project site is not expected to result in significant deterioration of dissolved oxygen levels at the surrounding waters and identified WSRs. Full compliance to the WQO criteria for dissolved oxygen is expected for the Project.

(30) ***Table 3.7*** also include prediction at nearby EPD Marine Water Quality Monitoring Stations for reference. These EPD Marine Water Quality Monitoring Stations are not WSRs.

3.8.1.2 Total Inorganic Nitrogen

As a result of relatively high background contribution and stringent WQO criterion for total inorganic nitrogen in the Southern WCZ, all identified WSRs were predicted to have total inorganic nitrogen higher than the assessment criterion under baseline scenario. Similar level of exceedance or close to exceedance were observed at SM1 and SM19 as shown in ***Table 3.2***.

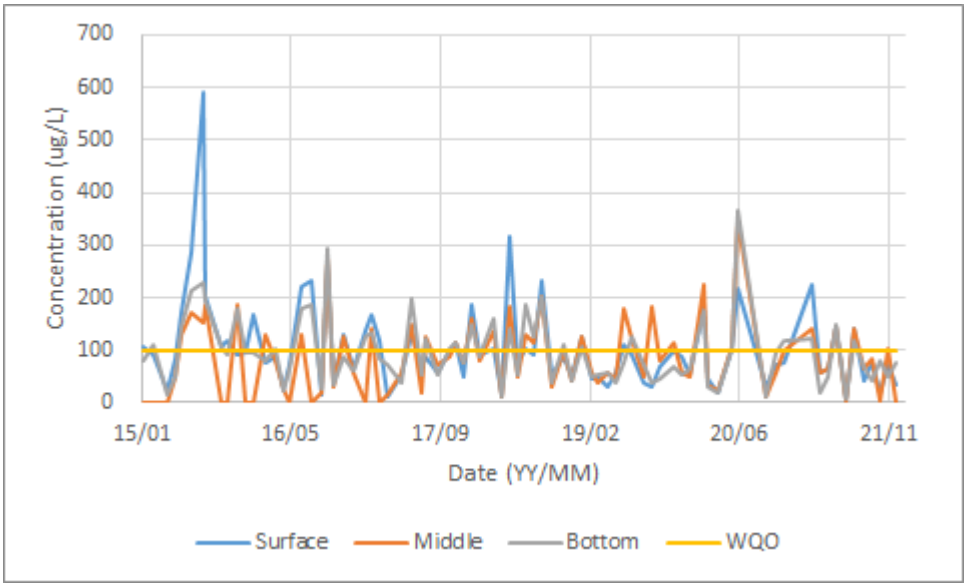
The predicted levels of total inorganic nitrogen at the Po Toi FCZ and Project site were both 0.12 mg/L under baseline scenario. While the predicted levels of total inorganic nitrogen at the Po Toi FCZ remains unchanged under the project scenario, the predicted levels at the Project Site increases slightly to 0.13 mg/L under the project scenario. According to the historical record at the nearby Po Toi FCZ by AFCD (***Figure 3.2*** referred), observed levels of total inorganic nitrogen exceeding 0.1 mg/L or even up 0.2 mg/L were occasionally recorded at the nearby existing FCZ, which is similar to the predicted levels under both the baseline and project scenarios. Moreover, there were no fish kill incidents recorded or major problems encountered by the mariculturists at Po Toi FCZ during such days with high total inorganic nitrogen level recorded. This means a minor increase in predicted total inorganic nitrogen levels would unlikely result in significant impact on the mariculture operation at both the existing Po Toi FCZ as well as at the planned Po Toi FCZ (Project Site). In fact, the predicted total inorganic nitrogen level at the Project site is within the suggested standard of total inorganic nitrogen level of 0.3 mg/L for mariculture operation in marine waters set out in the National Sea Water Quality Standard for mariculture (GB 3097-1997).

Over the last decade, there was only one red tide event recorded in 2014 near the existing Po Toi FCZ and the event did not result in fish kill. This indicated the area is generally not prone to red tide. *Xu et. al. (2009)* [31] highlighted multiple key factors for algal growth, including nutrients (nitrogen and phosphorus), sunlight availability as well as hydrodynamic stability (that allows algae to stay in the surface layer). *Xu et. al.* indicated nitrogen is not the limiting factor for the southern waters of Hong Kong in summer when sunlight is abundant for algal growth. Therefore, a slight increase in total inorganic nitrogen level is not expected to result in notable increase in algal bloom risk. Potential impact on water quality associated with predicted increase in total inorganic nitrogen at the Project Site would be further evaluated under ***Section 3.10.2***.

For the nearby identified coral WSRs as well as representative locations for finless porpoise habitat and spawning ground for commercial fisheries resources, no observable increase of total inorganic nitrogen level was predicted at all of these WSRs under the with-project scenario except one coral location at south of Po Toi Island. No observable increase in total inorganic nitrogen level was predicted at the representative locations of all other identified WSRs as well. For the coral location at southeast of Po Toi Island (CR24), predicted level of total inorganic nitrogen would increase from 0.12 mg/L in baseline scenario to 0.13 mg/L in project scenario. Also, as shown in ***Appendix 3C***, the presence of the proposed mariculture operation at the Project site would result in an overall slight increase of total inorganic nitrogen level to the local surrounding waters. This means for areal WSRs of finless porpoise habitat and spawning ground of commercial fisheries resources, elevation of total inorganic nitrogen would be expected but the elevation is predicted to be within the range of seasonal fluctuation recorded in the past EPD routine water quality monitoring data (see ***Table 3.2***) at the selected representative locations of FR/FP1 to FR/FP3. Compliance to the WQO criteria for total inorganic nitrogen is expected for the Project at the majority of identified WSRs outside the Project site. The residual impacts for increased total inorganic nitrogen level at coral location at southeast of Po Toi Island as well as areal WSRs of finless porpoise habitat and spawning ground of commercial fisheries resources, are further assessed in ***Section 3.10.2***.

(31) Xu J, Yin KD, Ho AYT; Lee JHW, Anderson DM, Harrison PJ (2009) Nutrient limitation in Hong Kong waters inferred from comparison of nutrient ratios, bioassays and ^{33}P turnover times.

Figure 3.2 Observed Total Inorganic Nitrogen Level at Po Toi FCZ from 2015-2021 (Source: AFCD Monitoring Data)



3.8.1.3 Unionized Ammonia

The increases at all WSRs between the baseline and project scenarios in unionized ammonia levels were undetectable at all identified WSRs including the Project Site. The predicted levels of unionized ammonia were between 0.004 to 0.005 mg/L at all identified WSRs, which is below the assessment criterion of 0.021 mg/L. Predicted levels of unionized ammonia at Po Toi FCZ were 0.004 mg/L in both scenarios. For the Project site, the identified coral WSRs as well as representative locations for finless porpoise habitat and spawning ground for commercial fisheries resources, the predicted levels of unionized ammonia were 0.004 mg/L in both scenarios. Full compliance to the WQO criteria for unionized ammonia is expected for the Project. No unacceptable elevation in unionized ammonia is expected from the proposed mariculture operation at the Project site.

3.8.1.4 Suspended Solids

Predicted levels of suspended solids were typically around 2 to 3 mg/L across the assessment area. There are limited or no change for the predicted levels between baseline and project scenarios at all identified WSRs. Predicted SS level at Po Toi FCZ was 2.8 mg/L under both scenarios. For the Project site the predicted SS level was 2.5 mg/L under both scenarios. None of the identified WSR show change in SS levels that exceed assessment criterion of 30% change level in baseline level. Compliance to the WQO criteria for suspended solids is expected for the Project. No unacceptable change in suspended solids level is expected at all identified WSRs.

3.8.1.5 Chlorophyll-a

Predicted levels of chlorophyll-a also were generally low across the assessment area, ranging up to around 1 to 3 µg/L. No observable difference in chlorophyll-a was predicted at all the identified WSRs under both scenarios. Within the Po Toi FCZ, predicted chlorophyll-a level was 3 µg/L in both scenarios.

While build-up of organic content could increase risk of local red tide, the Project area and the surrounding waters is very well flushed to allow good dispersion and dilution of pollution load from the Project. The lack of observable elevation in chlorophyll-a demonstrated that the increased risk of local red tide due to the Project is minimal. As stated in ***Section 3.8.1.2***, there was only 1 red tide event (without fish kill) recorded in the last decade near the existing Po Toi FCZ, which also indicated the area is not prone to red tide in general.

For the Project site, the predicted levels of chlorophyll-a were 1 mg/L in both scenarios. Compliance to the assessment criteria for chlorophyll-a at both FCZ WSRs is expected for the Project. No unacceptable change in chlorophyll-a level is expected at all identified WSRs.

3.8.1.6 E. coli

In both baseline and project scenarios, the predicted levels of *E. coli* around the Project site were predicted to be very low because of the lack of major sources of *E. coli* (e.g. sewage) for most of the identified WSRs. The predicted *E. coli* level at the Po Toi FCZ was predicted to be higher than the surrounding in the baseline scenario as a result of discharge from the limited population of the Po Toi Island and the level was not predicted to change under with project scenario. In traditional fish raft it is often the case to have dogs and / or cat kept onsite to provide various services. The service provided by dogs and cats in traditional fish rafts is expected to be no longer needed in the modernised and advanced mariculture operations. Also, the mariculture operation at the proposed FCZ is not expected to be manned continuously, thus the new FCZs are no longer suitable for keeping dogs and cats onsite. Since faecal pollution of dogs/cats is not expected within the Project site, the operation of fish farm at Project site will not introduce additional *E.coli* loading and thus the prediction under baseline and project scenarios are the same. Compliance to the WQO criteria for *E.coli* is expected for the Project. Further discussion on sewage and wastewater generation from staff and visitors onsite is provided under ***Sections 3.8.4*** and ***3.8.5*** below.

Table 3.7 Predicted Water Quality under Baseline and Project Scenario

ID	WSR	Scn.	Annual								
			10th-percentile		Mean						Geomean
			Depth-averaged	Bottom	Depth-averaged	Bottom	Depth-averaged				
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids Note2	*E.coli*
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)
Coral – Southern Assessment Criteria			≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610
CR17	Coral at North Sung Kong Island	Baseline	5.5	5.4	6.5	6.5	**0.13**	0.004	1.3	2.6	1
		Project	5.5	5.4	6.5	6.5	**0.13**	0.004	1.3	2.6	1
CR18	Coral at West Waglan Island	Baseline	6.0	5.9	6.5	6.5	**0.12**	0.004	1.1	2.4	0
		Project	6.0	5.8	6.5	6.5	**0.12**	0.004	1.1	2.4	0
CR19	Coral at South Waglan Island	Baseline	6.1	6.0	6.6	6.5	**0.12**	0.004	1.0	2.3	0
		Project	6.1	6.0	6.6	6.5	**0.12**	0.004	1.0	2.3	0
CR20	Coral at East Po Toi Island	Baseline	5.7	5.5	6.5	6.5	**0.13**	0.004	1.2	2.5	0
		Project	5.6	5.5	6.5	6.5	**0.13**	0.004	1.2	2.5	0
CR21	Coral at Southeast Beaufort Island	Baseline	5.4	5.3	6.5	6.5	**0.13**	0.004	1.3	2.6	3
		Project	5.3	5.3	6.5	6.5	**0.13**	0.004	1.3	2.6	3
CR22	Coral at North Po Toi Island	Baseline	5.5	5.4	6.5	6.5	**0.13**	0.004	1.2	2.6	1
		Project	5.4	5.4	6.5	6.5	**0.13**	0.004	1.2	2.6	1
CR23	Coral at East Po Toi Island	Baseline	5.7	5.6	6.5	6.5	**0.13**	0.004	1.1	2.5	0
		Project	5.7	5.6	6.5	6.5	**0.13**	0.004	1.1	2.5	0
CR24	Coral at Southeast Po Toi Island	Baseline	6.0	5.9	6.5	6.5	**0.12**	0.004	1.3	2.6	0
		Project	6.0	5.9	6.5	6.5	**0.13**	0.004	1.3	2.6	0
CR25	Coral at South Sung Kong Island	Baseline	5.8	5.8	6.5	6.5	**0.13**	0.004	1.1	2.5	0
		Project	5.8	5.7	6.5	6.5	**0.13**	0.004	1.1	2.5	0
Fish Culture Zone – Southern Assessment Criteria			≥5	≥2	N/A	N/A	≤0.1	≤0.021	≤20	increase ≤30% baseline	≤610
F7	Po Toi Fish Culture Zone	Baseline	6.1	6.1	6.7	6.7	**0.12**	0.004	3	2.8	43
		Project	6.1	6.1	6.7	6.7	**0.12**	0.004	3	2.8	43
Site D	Proposed Po Toi (Southeast) FCZ	Baseline	5.9	5.8	6.5	6.5	**0.12**	0.004	1	2.5	0
		Project	5.9	5.8	6.5	6.5	**0.13**	0.004	1	2.5	0
SSSI – Southern Assessment Criteria			≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610
SSSI2	Cape D'Aguilar Marine Reserve / Hok Tsui (Cape D'Aguilar) SSSI	Baseline	5.2	5.2	6.4	6.4	**0.14**	0.005	2	2.7	14
		Project	5.2	5.2	6.4	6.4	**0.14**	0.005	2	2.7	14
Other Ecology and Fisheries – Southern Assessment Criteria			≥4	≥2	N/A	N/A	≤0.1	≤0.021	N/A	increase ≤30% baseline	≤610
FR/FP1	Representative Location for Finless Porpoise Habitat and Spawning	Baseline	5.6	5.6	6.5	6.5	**0.13**	0.004	2.6	1.1	1
		Project	5.5	5.6	6.5	6.5	**0.13**	0.004	2.6	1.1	1

ID	WSR	Scn.	Annual								
			10th-percentile		Mean						Geomean
			Depth-averaged	Bottom	Depth-averaged	Bottom	Depth-averaged				
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids [Note2]	*E.coli*
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)
	Ground of Commercial Fisheries Resources										
FR/FP2	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	Baseline	6.1	6.1	6.6	6.6	**0.12**	0.004	2.4	1.0	0
		Project	6.1	6.1	6.6	6.6	**0.12**	0.004	2.4	1.0	0
FR/FP3	Representative Location for Finless Porpoise Habitat and Spawning Ground of Commercial Fisheries Resources	Baseline	6.0	5.8	6.5	6.5	**0.12**	0.004	2.6	1.1	0
		Project	6.0	5.8	6.5	6.5	**0.12**	0.004	2.6	1.2	0
EPD Marine WQ Monitoring Stations Assessment Criteria			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SM1	EPD Marine WQ Monitoring Station	Baseline	5.3	5.2	6.5	6.4	0.14	0.005	2	2.8	6
		Project	5.3	5.2	6.5	6.4	0.14	0.005	2	2.8	6
SM19	EPD Marine WQ Monitoring Station	Baseline	5.7	6.1	6.5	6.7	0.13	0.004	1	2.8	1
		Project	5.7	6.1	6.5	6.7	0.13	0.004	1	2.8	1
MM8	EPD Marine WQ Monitoring Station	Baseline	6.1	6.1	6.6	6.6	0.12	0.004	1	2.2	0
		Project	6.1	6.1	6.6	6.6	0.12	0.004	1	2.2	0

Note1: Values in exceedance of the corresponding assessment criteria are bold and shaded.
Note2: Assessment criterion for suspended solids is based on 30% of the predicted values for each WSRs under the baseline scenario and thus cannot be listed in the assessment criterion row for each group of WSRs. Please refer to ***Table 3.6*** for the exact values for each specific WSRs.

3.8.1.7 Impact on the Use of IMTA

As discussed under ***Section 2.6.2.3***, subject to the mariculture proposal submitted by future applicant and approval by AFCD, IMTA culture may be adopted at the Project Site to (1) enhance productivity and (2) reduce environmental impact by utilizing waste feed and other waste from the fish stock onsite. Given the uncertain nature of its implementation (e.g. trophic levels / species involved / other designs), the effect on the pollution loading from these non-fish secondary trophic level(s) has not been taken into account in the pollution loading estimation for the proposed mariculture operation at the Project Site. The following section provides a simple analysis on the potential impact on pollution loading estimation from these non-fish trophic level.

Deposit feeders in IMTA typically feed on wasted feed, fecal matters and other waste sink from the fish stock on top. This means their presence would reduce the pollution loading from waste feed and fish faeces from the mariculture operation. According to the pollution loading estimation provided under ***Table 4.16*** of ***Appendix 3A***, the combined contribution of these two sources of pollution from mariculture would be over 90% of all pollution from mariculture for all parameters except for ammonia-N (which is mainly contributed from fish excretion). Since these deposit feeders will only consume and assimilate the organic part of these waste, therefore the introduction of deposit feeders could potential affect about 13.9% of the total nitrogen budget, 67.4% of the total phosphorus budget and 100% of the 5-day biochemical oxygen demand budget (***Table 3.8***).

Table 3.8 Pollution Loading Contribution from Wasted Feed and Fish Faeces for Production Level of 1 ton at Proposed FCZs

Sources	Wasted Feed	% Contribution	Fish Faeces	% Contribution	Total % Contribution	Total	Analysis of Budget accessible by Deposit Feeders
Oxidized-N (g/day)	0.0968	7.1%	1.205	88.6%	95.7%	**1.3597**	Total N = 275.5835 Accessible by Deposit Feeders = 38.1865 (13.9%)
Ammonia-N (g/day)	0.0415	0.0%	0.371	0.2%	0.2%	**236.0373**	
Org-N (g/day)	21.9176	57.4%	16.265	42.6%	100.0%	**38.1865**	
TIP (g/day)	0.0394	2.3%	1.624	95.7%	98.0%	**1.6969**	Total P = 5.2088 Accessible by Deposit Feeders = 3.5119 (67.4%)
TOP (g/day)	2.6986	76.8%	0.813	23.1%	100.0%	**3.5119**	
BOD (g/day)	45.2051	8.4%	495.095	91.6%	100.0%	**540.3082**	Accessible by Deposit Feeders = 540.3082 (100.0%)
TSS (g/day)	24.6477	92.2%	-		92.2%	**26.7298**	N/A

Filter feeders, including oysters, clams and mussels, which are commercially cultivated feed on planktons or suspended organic matters. According to Jansen *et. al.* (2019) [32], biodeposit

([32]) Henrice Maria Jansen, Øivind Strand, Wouter van Broekhoven, Tore Strohmeier, Marc C. Verdegem, and Aad C. Smaal (2019) Feedbacks from Filter Feeders: Review on the Role of Mussels in Cycling and Storage of Nutrients in Oligo- Meso- and Eutrophic Cultivation Areas.

represents a significant pathway in bivalve nutrient recycling. Jansen *et. al.* reviewed a number of literature for mussel farming and indicated biodeposition rate could be up to around 10% of soft body weight of the mussel population in a culture area. The biodeposit could constitute of 0.3% to 2.3% of nitrogen and 0.08% to 0.3% phosphorus. Since biodeposit is solids and could sink to the bottom, a significant portion of the nutrient would be lock up and will not return to the water column quickly. Furthermore, the growth of fleshy tissues of these bivalves also lock up a notable amount of organic nutrients from the water column. For instance, Jansen *et. al.* reviewed a number of literature for nutrients composition in mussel tissue, which constitutes of 33.3% to 62.3% of organic carbon, 5.5% to 12.6% of organic nitrogen and 0.4% to 1.2% of organic phosphorus. While these figures are indicative of only several species covered in the review and may vary from species, locations and cultivation method, this still support the notion of additional cultivation of filter feeders would result in a net reduction of pollution load from the water column, thus be beneficial to the water quality.

Overall, the inclusion of IMTA would result in different levels of pollution reduction from the proposed mariculture operation at the Project Site by means of (1) reduction of wasted feed, fecal matters and other waste, and (2) filter feeding of plankton and biodeposition. Therefore it is expected that the predicted levels of key water quality parameters presented in ***Table 3.7*** would be further reduced with the adoption of the IMTA.

3.8.1.8 Temporary Relocation of Fish Rafts under Circumstances

In general, relocation of fish rafts adopting advanced mariculture technologies are not necessary under adverse weather (e.g. typhoon) given the framework of fish cages would use weather-resistant and durable materials (e.g. HDPE cages, steel truss cages). For other potential circumstances (e.g. red tide event, outbreak of fish disease), the licensees will review the need of fish raft relocation and propose the fish raft relocation plan as necessary for agreement with AFCD on a case-by-case basis, depending on the type of algal bloom (any toxicity to fish), expected duration of such circumstances, feasibility for early harvesting of fish stock, feasibility of implementing onsite control measures etc. In case fish raft relocation is considered necessary, the fish rafts will be relocated away from the areas of circumstances, avoid marine fairways and utilities and at some distance away from ecological and fisheries sensitive receivers (e.g. about 200 m away from established coral communities) to minimise potential impacts to these sensitive receivers. Such relocation will be temporary (e.g. a few weeks) and the fish rafts will return to the Project site upon the cease of the circumstances. Given the temporary nature of the fish raft relocation and the sufficient buffer distance to the ecological and fisheries sensitive receivers, unacceptable water quality impacts to these sensitive receivers near the relocated sites are not anticipated. In addition, the relocated pollution load from these mariculture operation would likely be distributed at a wider area around the proposed site. As shown in the water quality modelling exercise, the presence of additional pollution load from the mariculture operation at 1765.4 ton of standing stock at the proposed site would not result in notable change in water quality. If some of the mariculture operation is temporarily relocated, the associated pollution load would likely to be more spread out and the potential change in water quality would be less significant. The relocation would involve anchoring and de-anchoring, which would result in minor disturbance to the bottom sediment as assessed under ***Section 3.7***. In general, the water depth at around Po Toi Island is more than 20 - 30 m. Given the sufficient water depth at the surrounding water, sufficient clearance from the seabed is expected from the structure of fish fam during the relocation, and thus sediment disturbance is not expected during the relocation. Based on the above assessment, given the temporary nature of the fish raft relocation, relocation to be sited minimising the impacts to sensitive receivers, pollution load would spread out and potential change in water quality would be less significant than normal operation, the potential impacts due to temporary relocation of fish rafts under circumstances are expected to be minor.

3.8.1.9 Summary of Findings and Recommendations

The results of the water quality simulations indicated that the proposed mariculture operation would only result in very limited and very localized changes of water quality parameters at identified WSRs,

including recreational areas, existing and proposed FCZs, ecological habitats, spawning ground of commercial fisheries resources and other fisheries sensitive receivers. For most WSRs identified, the water quality parameters were predicted to be in compliance with the corresponding WQO criteria under baseline conditions, and project operation would not result in notable deterioration. The baseline levels of dissolved oxygen levels were predicted to be well above the corresponding WQO criteria and project contribution to dissolved oxygen depletion was at most 0.1 mg/L. As a result, no non-compliance to the WQO dissolved oxygen criteria was predicted. Relatively high baseline (when compared with the corresponding WQO criterion for) total inorganic nitrogen level has resulted in exceedance of the assessment criterion at all identified WSRs within the Southern WCZ without the Project based on the modelling results. The mariculture operation of the Project would result in limited elevation of total inorganic nitrogen at the Project site itself as well as the adjoining waters, including WSR CR24 as well as areal WSRs of finless porpoise habitat and spawning ground of commercial fisheries resources. For other water quality parameters including unionized ammonia, chlorophyll-a, suspended solids and *E. coli*, the predicted levels under both baseline and project conditions were in compliance with the corresponding WQO / assessment criteria. The licensees will adopt the operational measures and best practice for mariculture activities as stated in ***Appendix 2A*** to further minimise water quality impacts from the mariculture activities of the Project.

3.8.2 Changes in Hydrology and Flow Regime due to Presence of Mariculture Facilities

Structures of fish raft are highly porous to allow water flow and removal of excreta. Fouling by attached growth would increase drag and would typically be cleared regularly by mariculturists therefore such increase in drag would be limited. Separation distance of around 100 m will be provided between each fish rafts / cages with typical size around one hectare of sea area. The detailed number, size and separation distance of the fish rafts / cages would be determined during the later detailed design stage. The maintenance of separation distance will form a licensing condition for prospective licensees. Therefore, the presence of floating structures of fish rafts will not exert significant drag on the tidal stream and no notable change in flow regime due to the presence of floating structures would be expected.

3.8.3 Spillage of Fish Drugs, Pharmaceutical Chemicals, Feed Additives

The use and storage of chemicals would be limited to pharmaceuticals for fish, as well as those required to maintain equipment for the fish farm operation. Mariculturists at the Project site would be required to strictly observe the requirement under *Cap. 529 Veterinary Surgeons Registration Ordinance* and have strict control on prescription drugs. In addition, the mariculturists will follow the rules for using fish drugs as described in *Good Aquaculture Practices* published by AFCD [33] which detail the appropriate dosage of drugs and prohibit the use any fish drugs not prescribed by AFCD or registered veterinarian. AFCD will also provide technical support on the use of pharmaceuticals for fish. In AFCD's regular inspection of existing FCZs in recent years, there was no identified case of excessive storage of drugs or pharmaceuticals. Therefore, it is expected that there would be very limited pharmaceuticals for fish kept onsite and those would be stored at secured locations, and discharge of water containing pharmaceuticals is not expected from daily operation. In view of the above, the risk of spillage of fish drugs or pharmaceuticals is low.

Unlike spillage of chemical, spilled/ excess fish feed with feed additives generally does not persist for considerable amount of time as the presence of fish feed with feed additives would attract existing fish population to feed on the spill feed. For floating type fish feed, the majority of feed spilled can simply be recovered by the mariculturists. Commercially available fish feed with feed additives comes in tough fabric bags of 20-25 kg each. In case such bags of feed dropping into the sea during storage or transportation, they will be recovered by the crew. Even if not recovered, the bag would limit the exchange materials such that the nutrient content would unlikely be released all at once and result in

(33) Good Aquaculture Practices Series 4 - Prevention and Treatment of Fish Diseases. AFCD, 2009

significant water quality impact. In view of this, the risk and consequence of such scenario are deemed minimal and no unacceptable impact on water quality is expected.

3.8.4 Wastewater from Daily Operation of Fish Farms, Disinfection of Gears, and Sewage from Workforce

Operational activities would involve the removal of fouling organisms of the rafts. Fouling organisms are usually removed mechanically (e.g. using pressurised jet of seawater) so chemical is generally not required. Dislodged fouling biomass falling into the sea would not constitute additional pollution load because such biomass has fed on the original pollution source from the fish farm operation.

Disinfection of culture gears (primarily nets and cages) is required for disease control on regular basis (e.g. once a year prior to the start of fish farming cycle). According to AFCD's recommendation for good practice [(34)], disinfection could be done via steaming, or submerge under water dosed with formaldehyde or bleach within enclosed containers. For any fishing gears that need to be disinfected onsite, solution of any chemical used will be required to be stored properly onsite and disposed of by licensed contractor and no onsite disposal would be allowed. It should be noted that disinfection under sunlight is considered more effective and practical option for cultural gears of large size and chemicals are not necessary to be dosed. In addition, based on the past experience of existing FCZs, it is not necessary to store and use a large amount of chemicals during FCZ operation. Therefore, it is not anticipated a large amount of chemicals would be stored and disposed during the operation of the Project.

Deep water mariculture operation at the Project site is typically manned minimally onsite and relies mostly on automated / remote control. Therefore, generation of sewage by staff and visitors onsite would be limited. Sewage shall be stored on vessels or at the mariculture facilities and be regularly disposed by licensed contractor, and no sewage from staff and visitors will be discharged into the sea.

Storage of chemicals / lubricant oil onsite would be maintained at minimal level. If maintenance of gears or machineries onsite is needed, technicians / relevant staff should be brought to the site together with the necessary tools and chemicals. Remaining chemicals, together with any chemical waste generated from the maintenance process should be taken away by the same crew for disposal to appropriate facilities or licensed contractor when the crew leave the site. Given the limited exposure period as well as proper storage and control, together with the adoption of the operational measures and best practice for mariculture activities as stated in ***Appendix 2A***, no unacceptable change in water quality associated with the storage of chemicals onsite is expected.

Latest mariculture operation often rely on renewable sources of energy (solar and wind), supplemented by minor backup generator for prolonged cloudy / windless period. Limited amount of fuel may be stored onsite. To minimize potential risk of fuel spillage, fuel should be stored at sheltered and secure location for each mariculture operation. Excessive storage of fuel should be prohibited onsite as a risk control measure. Given the limited storage as well as other safety measures regarding proper storage, together with the adoption of the operational measures and best practice for mariculture activities as stated in ***Appendix 2A***, no unacceptable change in water quality associated with the storage of fuel onsite is expected.

3.8.5 Increased Marine Traffic, Boating and Visitor Activities

Increased marine traffic would be anticipated at the Project site for moving of staff and visitors and goods (fish feed and gears, waste and produced fish etc.) and it is expected the staff and visitors will make use of small marine vessels such as sampans and speed boats for a few trips a day. Such marine traffic activities would not result in notable change in water quality. To ensure no sewage from staff and visitors be discharged into the sea, sewage should be stored on vessels or at the mariculture facilities and be regularly disposed by licensed contractor. Littering in the sea is an offence under

(34) Good Aquaculture Practices Series 4 - Prevention and Treatment of Fish Diseases. AFCD, 2009

Cap. 228 Summary Offences Ordinance and all staff and visitors should be warned against littering in the sea. Unacceptable water quality impacts due to the increased marine traffic, boating and visitor activities are not anticipated.

3.9 Mitigation Measures

3.9.1 Construction Phase

No marine work or other major source of pollution is expected from the construction phase of the Project. It is unlikely there will be a significant workforce presence during construction phase (because of the lack of major works to be conducted), and any sewage / wastewater generated should be collected at the transportation / work vessel(s) for disposal at appropriate facilities on land.

3.9.2 Operation Phase

During operation, the licensees will adopt the operational measures and best practice for mariculture activities as stated in ***Appendix 2A***. Apart from these measures, the following precautionary/ mitigation measures should be implemented to minimize water quality impact from the proposed mariculture operation at the Project site:

- Standing stock should not exceed 1765.4 ton at any given time. AFCD will ensure the production scale of the Project site will not exceed the maximum standing stock level by controlling the mariculture production scale permitted under individual license.
- In case of potential circumstances (e.g. red tide event, outbreak of fish disease), the licensees will review the need of fish raft relocation and propose the fish raft relocation plan as necessary for agreement with AFCD.
- Only pellet feed or alternative feed with better feed conversion ratio will be permitted within the proposed FCZ.
- No chemically-laden solution from culture gears disinfection should be discharged into the sea.
- Onsite storage of chemicals should be controlled and minimized as far as practicable. Excess chemicals as well as chemical waste generated should be removed from the site for disposal at appropriate facilities by licensed contractor as soon as possible.
- Fuel storage onsite should be minimized, and if needed, be located at sheltered and secure location.
- Littering of the sea should be prohibited.

3.10 Residual Impact

3.10.1 Construction Phase

No marine work or other major source of pollution is expected from the construction phase of the Project. No unacceptable construction phase water quality impact is expected.

3.10.2 Operation Phase

During operation phase, slight increase of total inorganic nitrogen level was predicted at the proposed new FCZ site at Po Toi (Southeast), coral location at southeast of Po Toi Island (CR24) and at a small stretch of the adjoining waters to the east to south of Po Toi which falls within the finless porpoise habitat and spawning ground for commercial fisheries, where the predicted mean total inorganic nitrogen level under baseline scenario was already higher than the WQO. The residual water quality impacts from Project operation are expected to the minor, based on the following factors:

- Non-compliance and deterioration of water quality is only predicted for one water quality parameter, total inorganic nitrogen. There is no notable deterioration in other water quality

parameters and they all comply with the corresponding assessment criteria. This means the potential impact would be limited to the level of total inorganic nitrogen level at these identified WSRs within the Project site, coral location CR24 and the adjoining waters only.

- Relative high levels of total inorganic nitrogen were predicted at all WSRs within the Southern WCZ under the baseline scenario, which reflects relatively high background level contributed by other sources. The predicted elevation of total inorganic nitrogen is minor (only about 10% of WQO) and it is within the seasonal fluctuation range of total inorganic nitrogen level recorded in Southern WCZ in the past years. Total inorganic nitrogen in general is not harmful to marine organism and fish. The key concern is eutrophication may cause excessive algal growth / blooms which in term may result in depletion of oxygen in the waters. As discussed under ***Section 3.3.2***, such phenomenon of relative high levels of total inorganic nitrogen is not uncommon in the Southern WCZ. Furthermore, relevant criterion for total inorganic nitrogen for mariculture operation is 0.3 mg/L under *GB3097-1997 Sea Water Quality Standard* for mariculture (category 2) [(35)]. This means the predicted level of total inorganic nitrogen at the proposed Site D at Po Toi (Southeast) is suitable for mariculture operation and no unacceptable impact on the mariculture operation would be expected from the predicted level of total inorganic nitrogen.
- Based on the recent water quality data obtained at Po Toi FCZ from 2015-2021 (***Figure 3.2***), observed levels of total inorganic nitrogen exceeding 0.1 mg/L or even up 0.2 mg/L were occasionally recorded. Only one red tide event was recorded at Po Toi FCZ in the past decade and there was no fish kill occurred at Po Toi FCZ due to the red tide. This indicates that the relatively high levels of total inorganic nitrogen do not have unacceptable impacts to mariculture operation nor the beneficial uses as spawning ground for commercial fisheries resources.
- For areal WSRs including finless porpoise habitat and spawning ground for commercial fisheries resources, the predicted elevation of TIN expected to be affecting area close to the Project Site, while the vast majority of the area for these areal WSRs is not affected, as indicated by the lack of change in predicted levels at the selected representative locations of FR/FP1 to FR/FP3.
- No red tide event was recorded at water to the east of Po Toi Island and south of Sung Kong Island (i.e. immediate surrounding of the proposed Project site) in past decade where elevation of total inorganic nitrogen is predicted. Apart from level of total inorganic nitrogen, there are other factors that would lead to red tides, such as nitrogen/phosphorus (N:P) ratio, climatic and hydrodynamic conditions. As stated in ***Section 3.8.1.2***, past records indicated the area is not prone to algal bloom / red tide and literature suggested algal growth in the area is not limited by nitrogen [(36)]. The concerned waters at Po Toi are located at exposed location which is subject to strong hydrodynamic mixing and dilution that limit the growth of phytoplankton. These imply the slight increase in total inorganic nitrogen levels at these identified WSRs and the surrounding affected waters is not expected to result in increased risk for red tide / algal bloom.
- The elevation of total inorganic nitrogen alone is not expected to result in notable adverse change in water quality on the identified coral WSR at CR24. Literatures suggested that the corals in Hong Kong have adapted to eutrophic condition with higher nitrogen concentrations [(37)(38)]. In addition, as stated in ***Section 3.8.1.2***, past records indicated the area is not prone to algal bloom

(35) Available at https://english.mee.gov.cn/Resources/standards/water_environment/quality_standard/200710/W020061027511546974673.pdf

(36) Xu J, Yin KD, Ho AYT; Lee JHW, Anderson DM, Harrison PJ (2009) *Op cit.*

(37) Zhao Y, Law YS, Zhai XH, Zhou K, Chen MR, Qiu JW (2022). Urban coral communities and water quality parameters along the coasts of Guangdong Province, China. Marine Pollution Bulletin 180: 113821.

(38) Duprey NN, Yasuhara M, Baker DM (2016). Reefs of tomorrow: eutrophication reduces coral biodiversity in an urbanized seascape. Global Change Biology 22: 3550–3565.

/ red tide and literature suggested algal growth in the area is not limited by nitrogen [39]. These imply the slight increase in total inorganic nitrogen levels at the identified coral WSR is not expected to result in increased risk for red tide / algal bloom.

Evaluation of the residual impact also takes into account the likelihood of the impacts occurring. The likelihood of such effect is considered to be low in view of the followings:

- The proposed new FCZ site at Po Toi (Southeast) (Project site itself) is not expected to suffer from adverse impact as the predicted total inorganic nitrogen level is within the suggested TIN level for mariculture operation of 0.3 mg/L under *GB3097-1997 Sea Water Quality Standard* for mariculture.
- The estimated pollution loading for the proposed new FCZs were calculated based on conservative estimation. One of the key factors, the feed conversion ratio, were assumed to be 2 even though literature review indicated the value for modern mariculture operation using pellet feed would be close to 1. This means the modelled scenario was conducted based on worst case scenario in terms of conservative pollution loading from mariculture which is unlikely to occur.
- Pollution loading for other sources in Hong Kong and in China were estimated based on conservative assumptions as well. For the southeastern water of Hong Kong around Po Toi, the Hong Kong side is generally less developed and thus the relative contribution of pollution loading from the Guangdong side is more significant. Conservative estimation, in term of selecting the worst case timeline for highest possible pollution load, were adopted for estimation of Guangdong's contribution for pollution loading into the model domain (***Section 4*** of ***Appendix 3A*** referred). This means the estimated water quality under both baseline and project scenarios would likely be higher than the time horizon when the project actually commences.

With reference to Section 4.4.3 of the EIAO-TM, the following factors have been considered:

- (i) effects on public health and health of biota or risk to life: The nature of the affected FCZ WSR, i.e. the proposed FCZ operation at Project Site, is for mariculture operation. The potential change in water quality and associated exceedance to assessment criterion for total inorganic nitrogen poses risk on mariculture operation but not any direct harm to public health, health of biota or risk to life. The slight increase in total inorganic nitrogen levels at the identified coral WSR and the areal WSRs including finless porpoise habitat and spawning ground for commercial fisheries resources is not expected to result in increased risk for red tide / algal bloom and thus it is expected to have no effect on health of biota / corals.
- (ii) the magnitude of the adverse environmental impacts: As discussed in Section 3.8.1, the magnitude of potential water quality impact is considered minor.
- (iii) the geographic extent of the adverse environmental impacts: Apart from the Project site itself, small elevation of total inorganic nitrogen due to the Project was predicted at the coral location CR24 (about 0.6 km away) and the adjoining waters (including finless porpoise habitat and spawning ground for commercial fisheries resources). For all other identified WSRs beyond 0.6 km, elevation of total inorganic nitrogen due to the Project was predicted to be negligible.
- (iv) the duration and frequency of the adverse environmental impacts: The predicted increase in total inorganic nitrogen at the Project Site occur throughout the year.
- (v) the likely size of the community or the environment that may be affected by the adverse impacts: The impacted community would include the mariculturists at the proposed new FCZ site at Project Site. Only limited numbers of people or areas of ecosystem would be impacted. The elevated level of total inorganic nitrogen is expected to affect coral community on the southeastern side of Po Toi Island close to the Project Site as well as the adjoining waters. The

(39) Xu J, Yin KD, Ho AYT; Lee JHW, Anderson DM, Harrison PJ (2009) *Op cit.*

ecological and fisheries resources there could be affected, and fishermen who work in the vicinity could be affected indirectly.

- (vi) the degree to which the adverse environmental impacts are reversible or irreversible: Adverse impact on the mariculture operation as a result of the predicted increase in total inorganic nitrogen level is not expected. Overall, the potential change is considered reversible.
- (vii) the ecological context: The affected site of the proposed FCZ will be designated for mariculture operation. It is not considered ecologically important / fragile and/or rare or undisturbed or an area which have little resilience to imposed stresses. The identified coral WSR of CR24 represents the coastal coral population on the southeastern side of Po Toi Island which is a small fraction of coral (about 3% in terms of the length of coastline with elevated total inorganic nitrogen against the coastline of Po Toi Island) along the coastline of Po Toi Island. For the majority of coral locations in the vicinity (which are generally further away), the level of total inorganic nitrogen elevation would be lower. The coral coverage at CR24 is relatively low when comparing to other locations at Po Toi (northeast), Beaufort Island (east to southeast), Sung Kong (northwest) and Waglan Island (southwest and southeast) where elevation of total inorganic nitrogen due to the Project is not observed at these sensitive receivers. In addition, literatures suggested that the corals in Hong Kong have adapted to eutrophic condition with higher nitrogen concentrations. Unacceptable impacts to corals due to the slight increase of total inorganic nitrogen level are not anticipated. For the finless porpoise habitat and spawning ground for commercial fisheries resources in the adjoining water to the Project Site, the affect area is only a small fraction of the entire habitat in southern waters. Also as stated in ***Section 3.8.1.2***, slight elevation in total inorganic nitrogen around the Project Site is not expected to result in increased risk in algal bloom (which poses threat to these ecological and fisheries WSRs) as nitrogen is not the limiting factor for the southern waters of Hong Kong.
- (viii) the degree of disruption to sites of cultural heritage: The affected site is not considered to be of archaeological, historical and/or palaeontological significance. The predicted change in water quality would not involve any cultural heritage context.
- (ix) international and regional importance: The affected site is not known to be of international or regional importance.
- (x) both the likelihood and degree of uncertainty of adverse environmental impacts: Residual impact for change in water quality at the proposed Project Site, coral WSR CR24 and adjoining waters, which is expected to be minor in scale, are based on conservative assumptions and has low likelihood of occurring. The proposed new FCZ site at Po Toi (Southeast) (Project site itself) is not expected to suffer from adverse impact as the predicted total inorganic nitrogen level is within the suggested TIN level for mariculture operation of 0.3 mg/L under *GB3097-1997 Sea Water Quality Standard* for mariculture. The conservatively estimated levels of pollution loading from both the background level as well as the proposed mariculture operation are unlikely to occur over an extended time-period. The increased level of total inorganic nitrogen is unlikely to result in notable increase risk in algal bloom that materially affect the coral WSR CR24, as well as the areal WSRs of finless porpoise habitat and spawning ground for commercial fisheries resources in the adjoining waters. Likelihood of adverse water quality impact is considered to be low and the effect is considered to be reversible.

Therefore, it is concluded that the proposed mariculture operation at 1765.4 ton of standing stock or below throughout the year would not result in unacceptable change in water quality at the nearby WSRs.

3.11 Cumulative Impact

There are no other concurrent projects in the vicinity of the Project site during the construction and operation phases.

No marine work or other major source of pollution is expected from the construction phase of the Project. No unacceptable cumulative construction phase water quality impact is expected.

For operation phase, the water quality modelling assessment has already taken into account the following sources of pollution:

- mariculture operation at the Project site;
- mariculture operation at all existing FCZs in Hong Kong including Po Toi FCZ;
- dry weather flow (i.e. pollution load from land drainage) from Hong Kong;
- rainfall-related load from Hong Kong;
- treated sewage effluent from Hong Kong; and
- other sources including pollution load from Guangdong via Pearl River Delta and Mirs Bay.

The assessment confirmed that no unacceptable cumulative water quality impact is expected.

3.12 Environmental Monitoring and Audit

With the implementation of proposed mitigation / precautionary measures, the construction and operation of the Project would not result in unacceptable change water quality at and around the Project site. Environmental monitoring is considered not necessary for construction of the Project. For project operation, water quality monitoring is recommended when the standing stock reaches 75% of the carrying capacity [40] (i.e. 1765.4 ton x 75% = 1324.1 ton) or when the standing stock reaches 95% of the carrying capacity (i.e. 1765.4 ton x 95% = 1677.1 ton) for at least a month in a fish farming cycle, to ensure no unacceptable change in water quality at the nearby water sensitive receivers. Detailed recommendations would be provided in the stand-alone Environmental Monitoring and Audit Manual of the EIA.

In additional to the standard EM&A exercise under EIAO, AFCD will conduct regular water quality monitoring within and outside the Project site during Project operation to check the water quality (e.g. suspended solids and nutrients) for detection of abnormality and issuance of alerts to mariculturists as part of the management measures for the Project. Real time water quality monitoring stations will also be installed by AFCD at the Project site, and notification to mariculturists for the Project site will be implemented to ensure timely actions be taken. With reference to AFCD's previous installation of real time water quality monitoring stations at the other existing FCZs including Tung Lung Chau FCZ, Sok Kwu Wan FCZ and Lo Tik Wan FCZ, mariculturists there will be alerted in case of substantial deterioration of water quality (e.g. red tide, low dissolved oxygen level). Monitoring parameters would include temperature, salinity and dissolved oxygen (level and saturation).

3.13 Conclusion

3.13.1 Construction Phase

No marine work or other major source of pollution is expected from the construction phase of the Project. No unacceptable construction phase water quality impact is expected.

3.13.2 Operation Phase

Carrying capacity estimation at the Project site has been conducted to determine the production scale that would not result in an unacceptable change in water quality. The carrying capacity estimation

(40) From the modelling results, the 95th-percentile safety margin of the carrying capacity, which is a conservative estimate taking into account possible fluctuations in the weather, hydrodynamic and environmental conditions as well as the farming practices, is about 75% of the estimated carrying capacity under typical average condition. Therefore, it is considered representative to conduct operational water quality monitoring at 75% of the maximum allowable standing stock level to monitor potential water quality at the surrounding sensitive receivers during project operation.

indicated the Project site can support mariculture operation of an average of 1765.4 ton standing stock based on typical mariculture practice in HK without significant deterioration of water quality under the typical average condition. Accordingly, the corresponding pollution load generated is calculated for subsequent Delft3D modelling.

Delft3D water quality modelling has been conducted to predict the potential change in water quality at the WSRs of the Assessment Area. The baseline levels of dissolved oxygen levels were predicted to be well above the corresponding WQO criteria and project contribution to dissolved oxygen depletion was at most 0.1 mg/L. Full compliance to the WQO criteria for dissolved oxygen is expected for the Project. Compliance with other WQO criteria is achieved at the identified water sensitive receivers, except for total inorganic nitrogen. The residual impacts of elevation in total inorganic nitrogen to marine ecological and fisheries sensitive receivers were further assessed in the respective marine ecology and fisheries impact assessment and considered as minor and acceptable. The slight increase in total inorganic nitrogen levels at these identified WSRs is not expected to result in increased risk for red tide / algal bloom. The results indicated project operation would not result in a significant change in water quality with 1765.4 ton of standing stock. Unacceptable water quality impact from Project operation is not anticipated.

Other potential sources of water quality impacts from operation have been identified and assessed. Appropriate precautionary and mitigation measures have been recommended to minimise the potential water quality impact from these sources. The licensees will also adopt the operational measures and best practice for mariculture activities as stated in ***Appendix 2A***. No unacceptable adverse impact on water quality is expected from Project operation.