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 Mirs Bay WCZ and close to the boundary of the Tolo Harbour and Channel WCZ. The applicable WQOs for these WCZs are presented in ***Table 3.1***.

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 Mirs Bay WCZ and Tolo Harbour and Channel WCZ

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
A	AESTHETIC APPEARANCE		
a)	Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole zone	Not applicable
b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone	Not applicable
c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to lasting foam.	Whole zone	Not applicable
d)	There should be no recognisable sewage-derived debris.	Whole zone	Not applicable
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	Not applicable
f)	Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole zone	Not applicable
g)	Waste discharges shall cause no noxious or offensive odour or offensive taint or colour in either waters or edible aquatic organisms in the subzone to be present in concentrations detectable by bioassay or organoleptic tests.	Not applicable	(i) Harbour subzone. (ii) Buffer subzone. (iii) Channel subzone.
h)	Waste discharges shall cause no visible foam, oil, grease, scum, litter or other objectionable matter in waters of the subzone.	Not applicable	(i) Harbour subzone. (ii) Buffer subzone. (iii) Channel subzone.
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 Subzones and Fish Culture Subzones	Secondary Contact Recreation Subzones and Fish Culture Subzones
b)	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.	Water Gathering Ground Sub-zones	Not applicable

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
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.	Other inland waters of the Zone	Not applicable
C	COLOUR		
a)	Waste discharges shall not cause the colour of water to exceed 30 Hazen units.	Water Gathering Ground Sub-zones	Not applicable
b)	Waste discharges shall not cause the colour of water to exceed 50 Hazen units	Other inland waters of the Zone	Not applicable
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	Not applicable
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	Not applicable
c)	Waste discharges shall not cause the level of dissolved oxygen to be less than 4 milligrams per litre.	Water Gathering Ground Sub-zones and Other inland waters of the Zone	Not applicable
d)	Waste discharges shall not cause the level of dissolved oxygen in waters of the subzone to be less than 2 milligrams per litre	Not applicable	Harbour subzone

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
	within two metres of the bottom, or to be less than 4 milligrams per litre in the remainder of the water column.		
e)	Waste discharges shall not cause the level of dissolved oxygen in waters of the subzone to be less than 3 milligrams per litre within two metres of the bottom, or to be less than 4 milligrams per litre in the remainder of the water column.	Not applicable	Buffer subzone
f)	Waste discharges shall not cause the level of dissolved oxygen in waters of the subzone to be less than 4 milligrams per litre at any point in the water column.	Not applicable	Channel subzone
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	Not applicable
b)	Waste discharges shall not cause the pH of the water to exceed the range of 6.5-8.5 units.	Water Gathering Ground Sub-zones	Not applicable
c)	The pH of the water should be within the range of 6.0-9.0 units.	Other inland waters of the Zone	Not applicable
d)	Waste discharges shall not cause the normal pH range of any waters of the subzone to be extended by greater than +/- 0.5 pH units at any time.	Not applicable	Harbour subzone
e)	Waste discharges shall not cause the normal pH range of any waters of the subzone to be extended by greater than +/- 0.3 pH units at any time.	Not applicable	Buffer subzone
f)	Waste discharges shall not cause the normal pH range of any waters of the subzone to be extended by greater than +/- 0.1 pH units at any time.	Not applicable	Channel subzone
F	TEMPERATURE		
a)	Waste discharges shall not cause the natural daily temperature range to change by more than 2.0 degree Celsius.	Whole Zone	Not applicable
b)	Waste discharges shall not cause the natural daily temperature range in waters of the subzone to be extended by greater than	Not applicable	(i) Harbour subzone. (ii) Buffer subzone.

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
	+/- 1.0℃ at any location or time. The rate of temperature change shall not exceed 0.5℃ per hour at any location, unless due to natural phenomena.		(iii) Channel subzone.
G	SALINITY		
a)	Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.	Whole Zone	Not applicable
b)	Waste discharges shall not cause the normal salinity range of any waters of the subzone to be extended by greater than +/- 3 parts per thousand at any time.	Not applicable	(i) Harbour subzone. (ii) Buffer subzone. (iii) Channel subzone.
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	Not applicable
b)	Waste discharges shall not cause the annual median of suspended solids to exceed 20 milligrams per litre.	Water Gathering Ground Sub-zones and Other inland waters of the Zone	Not applicable
I	AMMONIA		
	The un-ionized ammoniacal nitrogen level should not be more than 0.021 mg per litre, calculated as the annual average (arithmetic mean).	Whole Zone	Not applicable
J	NUTRIENTS		
	Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters	Not applicable
	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 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	Not applicable
K	5-DAY BIOCHEMICAL OXYGEN DEMAND		
a)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 milligrams per litre.	Water Gathering Ground Sub-zones	Not applicable

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
b)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 milligrams per litre.	Other inland waters of the Zone	Not applicable
L	CHEMICAL OXYGEN DEMAND		
a)	Waste discharges shall not cause the chemical oxygen demand to exceed 15 milligrams per litre.	Water Gathering Ground Sub-zones	Not applicable
b)	Waste discharges shall not cause the chemical oxygen demand to exceed 30 milligrams per litre.	Other inland waters of the Zone	Not applicable
M	TOXINS / TOXICANTS		
a)	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.	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 toxicants in waters of the subzone to attain such a level as to produce significant toxic effects in humans, fish or any other aquatic organism, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Not applicable	(i) Harbour subzone. (ii) Buffer subzone. (iii) Channel subzone.
N	CHLOROPHYLL-A		
a)	Waste discharges shall not cause the level of chlorophyll-a in waters of the subzone to exceed 20 milligrams per cubic metre, calculated as a running arithmetic mean of 5 daily measurements for any single location and depth.	Not applicable	Harbour subzone
b)	Waste discharges shall not cause the level of chlorophyll-a in waters of the subzone to exceed 10 milligrams per cubic metre, calculated as a running arithmetic mean of 5 daily measurements for any single location and depth.	Not applicable	Buffer subzone

	Water Quality Objective	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
c)	Waste discharges shall not cause the level of chlorophyll-a in waters of the subzone to exceed 6 milligrams per cubic metre, calculated as a running arithmetic mean of 5 daily measurements for any single location and depth.	Not applicable	Channel subzone
O	LIGHT PENETRATION		
a)	No changes in turbidity, suspended material, colour or other parameters arising from waste discharges shall reduce light transmission by more than 20 per cent of the normal level in the subzone at any location or any time.	Not applicable	Harbour subzone
b)	No changes in turbidity, suspended material, colour or other parameters arising from waste discharges shall reduce light transmission by more than 15 per cent of the normal level in the subzone at any location or any time.	Not applicable	Buffer subzone
c)	No changes in turbidity, suspended material, colour or other parameters arising from waste discharges shall reduce light transmission by more than 10 per cent of the normal level in the subzone at any location or any time.	Not applicable	Channel subzone
P	SETTLEABLE MATERIAL		
	Waste discharges shall give rise to no bottom deposits or submerged objects which adversely influence bottom living communities, alter the basic Harbour geometry or shipping channels, present any hazard to shipping or diving activities, or affect any other beneficial use of the waters of the subzone.	Not applicable	(i) Harbour subzone. (ii) Buffer subzone. (iii) Channel subzone.

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

(2) CAP358B Tolo Harbour and Channel Water Control Zone Statement of Water Quality Objectives

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 Mirs Bay Water Control Zone (WCZ) and the Tolo Harbour and Channel WCZ. Long Harbour, where the proposed Outer Tap Mun FCZ is located, is an embayment in the northern Sai Kung Peninsula. The embayment is generally over 10 m deep except for the nearshore areas as well as the southern end. The embayment connects to the Mirs Bay in the northern direction, which itself is also an embayment. Water depth for the majority of Mirs Bay is around 10 m – 20 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 used to provide the baseline water quality conditions of the Assessment Area. The monitoring results from 1986 to 2020 at the selected monitoring stations are summarised in ***Table 3.2***. Locations of these stations are presented in ***Figure 3.1***.

According to EPD's *Marine Water Quality in Hong Kong in 2020*, Mirs Bay attained an overall marine WQO compliance rate of 98% in 2020. The water quality was very good with high DO, and low nutrient and *E. coli* levels. For the Tolo Harbour and Channel WCZ, the overall marine WQO compliance rate in 2020 was 93%. Tolo Harbour consistently complied with the bacteriological WQO for secondary contact recreational uses applicable to the entire marine waters of the WCZ. Tolo Channel, however, was subject to a natural hydrological phenomenon of water column stratification and associated lower bottom DO level due to restricted water exchange with the open waters. Compliance with the WQOs is generally observed in most parameters at the selected monitoring stations at the two WCZs. There have been exceedances of chlorophyll-a level at TM8 (Tolo Channel subzone) but the situation has significantly improved since the implementation of the Tolo Harbour Effluent Export Scheme (THEES) as well as a number of measures under the Livestock Waste Control Scheme (LWCS). According to EPD's *Marine Water Quality in Hong Kong* (various years), the percentage of samples taken at TM8 with ≤6 µg/L level of chlorophyll-a gradually increases from the low point of 70.7% in 1988 up to average of around 90% in the recent 10 years from 2011-2020 (with 100% in 2020).

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

Parameters	TM8	MM6	MM17
Temperature (°C)	22.7	23.1	23.8
	(11.7-30.4)	(11.1-29.9)	(14.1-29.7)
Salinity (psu)	32.1	32.2	32.2
	(26.8-35.4)	(26.8-34.3)	(30.3-34.3)
Dissolved Oxygen (mg/L)	6.1	6.5	6.2
	(1.4-14.2)	(3.6-11.3)	(4.2-9.0)
Dissolved Oxygen (mg/L) - Bottom	5.0	6.2	5.4
	(0.0-19.5)	(0.2-15.5)	(1.1-8.6)
Dissolved Oxygen (%saturation)	84	91	87
	(33-167)	(51-147)	(63-115)
Dissolved Oxygen (%saturation) - Bottom	68	85	75
	(0-200)	(3-200)	(16-109)
pH	8.2	8.1	8.0
	(7.5-8.9)	(6.7-8.6)	(7.6-8.3)

Parameters	TM8	MM6	MM17
Secchi Disc Depth (M)	3.5	3.8	3.7
	(0.5-13.0)	(1.0-8.5)	(1.5-7.0)
Turbidity (NTU)	3.9	4.1	1.4
	(0.2-33.1)	(0.2-32.1)	(0.1-5.5)
Suspended Solids (mg/L)	3.2	2.7	5.1
	(0.5-71.2)	(0.5-15.0)	(0.7-16.0)
5-day Biochemical Oxygen Demand (mg/L)	1.1	0.9	0.8
	(0.1-5.8)	(0.1-3.2)	(0.2-2.0)
Ammonia Nitrogen (mg/L)	0.044	0.033	0.029
	(0.01-0.68)	(0.01-0.53)	(0.01-0.08)
Unionised Ammonia (mg/L)	0.003	0.002	0.002
	(0.000-0.077)	(0.000-0.048)	(0.000-0.003)
Nitrite Nitrogen (mg/L)	0.013	0.010	0.011
	(0.002-0.103)	(0.002-0.064)	(0.002-0.067)
Nitrate Nitrogen (mg/L)	0.026	0.022	0.028
	(0.002-0.609)	(0.002-0.160)	(0.003-0.103)
Total Inorganic Nitrogen (mg/L)	0.07	0.06	0.06
	(0.01-0.70)	(0.01-0.54)	(0.01-0.15)
Total Kjeldahl Nitrogen (mg/L)	0.37	0.24	0.38
	(0.08-4.79)	(0.07-1.32)	(0.11-0.88)
Total Nitrogen (mg/L)	0.40	0.27	0.41
	(0.05-4.80)	(0.06-1.37)	(0.12-0.89)
Orthophosphate Phosphorus (mg/L)	0.013	0.009	0.008
	(0.002-0.068)	(0.002-0.035)	(0.002-0.028)
Total Phosphorus (mg/L)	0.05	0.04	0.04
	(0.02-0.58)	(0.02-0.32)	(0.02-0.11)
Silica (mg/L)	0.77	0.63	0.66
	(0.05-2.00)	(0.06-1.63)	(0.07-1.24)
Chlorophyll-a (µg/L)	3.4	2.5	2.1
	(0.3-120.8)	(0.3-14.4)	(0.3-5.1)
E. coli (cfu/100mL)	2	2	2
	(1-510)	(1-570)	(1-32)
Faecal Coliforms (cfu/100mL)	3	3	2
	(1-6000)	(1-10067)	(1-59)

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 relevant EPD monitoring stations were used to represent the sediment quality adjacent to the Project (***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).

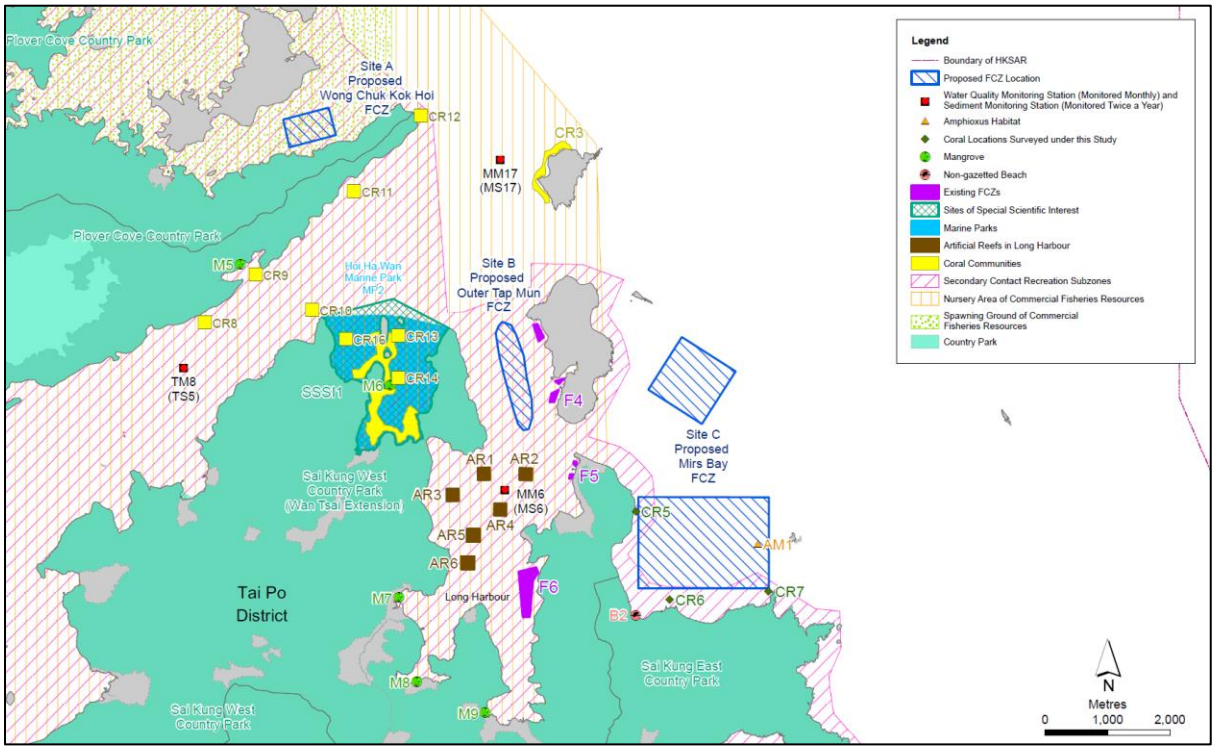
Table 3.3 Summary of EPD Routine Sediment Monitoring Data from Selected Stations of the Tolo Harbour and Channel WCZ and Mirs Bay WCZ (1986 – 2020)

Parameters	LCEL	UCEL	TS5	MS6	MS17
Arsenic (mg kg^{-1})	12	42	6.6	6.5	6.9
			(3.2-12.0)	(3.5-10.0)	(2.2-11.0)
Cadmium (mg kg^{-1})	1.5	4	0.5	0.5	0.3
			(0.1-7.5)	(0.1-7.6)	(<0.1-8.3)
Chromium (mg kg^{-1})	80	160	32.5	32.1	32.8

Parameters	LCEL	UCEL	TS5	MS6	MS17
			(11.0-85.0)	(22.0-49.0)	(6.0-44.0)
Copper (mg kg^{-1})	65	110	21.8	16.7	16.3
			(5.0-70.0)	(5.0-23.0)	(<0.2-55.0)
Lead (mg kg^{-1})	75	110	53.1	41.9	43.9
			(35.0-86.0)	(32.0-57.0)	(26.0-67.0)
Mercury (mg kg^{-1})	0.5	1	0.10	0.08	0.06
			(<0.05-0.59)	(0.05-0.40)	(<0.05-0.55)
Nickel (mg kg^{-1})	40	40	23.3	23.3	23.9
			(7.0-50.0)	(15.0-35.0)	(6.0-34.0)
Silver (mg kg^{-1})	1	2	<0.2	<0.2	<0.2
			(<0.2-<0.2)	(<0.2-<0.2)	(<0.2-0.5)
Zinc (mg kg^{-1})	200	270	121.3	100.0	96.9
			(64.0-220.0)	(66.0-150.0)	(36.0-170.0)
Total Polychlorinated Biphenyls (PCBs) (µg kg^{-1})	23	180	18	18	14
			(8-26)	(9-18)	(3-18)
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg kg^{-1})	550	3,160	<180	<180	<180
			(<180-<180)	(<180-<180)	(<180-185)
High Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs) (µg kg^{-1})	1,700	9,600	36	42	35
			(<32-130)	(<32-155)	(<32-139)
Chemical Oxygen Demand (mg kg^{-1})	--	--	18796	17075	16266
			(8300-40000)	(11000-26000)	(8400-38000)
Total Kjeldahl Nitrogen (mg kg^{-1})	--	--	737.4	708.8	669.7
			(23.0-2000.0)	(220.0-2000.0)	(18.0-1600.0)

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:

- Hoi Ha Wan Site of Special Scientific Interest (SSSI1);
- Hoi Ha Wan Marine Park (MP2);
- Recreational areas, such as secondary contact recreation subzones of WCZs [22];
- Existing FCZs at Tap Mun, Kau Lau Wan, Sham Wan and other nearby areas (F4 to F6);
- Proposed FCZs at Wong Chuk Kok Hoi and Mirs Bay (Site A and Site C);
- Ecological habitats for marine organisms including coral, amphioxus (AM1) [23] and benthic communities, and Finless Porpoise [24] at / near the Project site (CR3, CR5 to CR14, CR16, M5, M6, M7, M8, M9);
- Spawning ground and nursery area of commercial fisheries [25];
- Artificial reefs in Hoi Ha Wan Marine Park (MP2) and in Long Harbour (AR1 to AR6);
- Intertidal area of Sai Kung West Country Park and Sai Kung East Country Park (M5, M6, M7, M8, M9); and
- Non-gazetted beach (B2).

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.

(22) The entirety of the Tolo Harbour and Channel WCZ as well as the nearshore waters of the Mirs Bay 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, all WSRs identified under this Study except Site C, CR3 and AM1 are located within Secondary Contact Recreation Subzone.

(23) Amphioxus is commonly found in the eastern water of Hong Kong and is considered an areal WSR like Secondary Contact Recreation Subzone and some others. As stated in S.3.4.3.2(vii) of the Study Brief, amphioxus habitat to the east of Ko Lau Wan should be considered as WSR under this Study. To identify the location of amphioxus habitat, benthic survey was conducted under this Study and identified the species's presence in some locations within and around the proposed site. For modelling assessment, one observation point AM1, located close to benthic survey location MB9 which is the only station with amphioxus presence recorded in both seasons, was chosen as representative location for detailed assessment. This point is also located within the project boundary, and thus would provide conservative representation of potential impact for other amphioxus habitat locations at further away.

(24) Similar to the case of Secondary Contact Recreation Subzone, ecological habitat for finless porpoise is an areal WSR with wide coverage. The predicted water quality at these areas are represented by other WSRs and thus do not have the respective WSRs for ecological habitat for finless porpoise only. Note that according to the latest AFCD Marine Mammal Monitoring Report 2021/22, no records of finless porpoise were recorded in the assessment area.

(25) Similar to the case of Secondary Contact Recreation Subzone and ecological habitat for finless porpoise, spawning ground and nursery area of commercial fisheries resources is an areal WSR with wide coverage. The predicted water quality at these areas are represented by other WSRs and thus do not have the respective WSRs for spawning ground and nursery area of commercial fisheries only. Specifically, WSRs identified under this Study which are located within nursery area of commercial fisheries resources include M5, M6, M7, M8, M9, CR3, CR8-CR16, F4-F6, AR1-AR6, MP2, Site A and the Project Site itself. Only Site A is located within spawning ground of commercial fisheries resources.

Table 3.4 Water Sensitive Receivers (WSRs) in the Vicinity of the Proposed FCZ Site at Outer Tap Mun

WSR ID	WSR	Distance to the Proposed FCZ site at Outer Tap Mun (km)
B2	Non-gazetted beach of Nam She Wan	3.4
CR3	Coral at Port Island	2.0
CR5	Coral at Nam She Wan	2.2
CR6	Coral at Nam She Wan	3.5
CR7	Coral at Nam She Wan	4.6
CR8	Coral at Wong Wan Tsai	4.7
CR9	Coral at Fung Wong Wat	4.0
CR10	Coral at Gruff Head	3.0
CR11	Coral at South Wong Wan Tsui	3.1
CR12	Coral at Wong Chuk Kok Tsui	3.5
CR13	Coral at Hoi Ha Wan Moon Island	1.5
CR14	Coral at Hoi Ha Wan Coral Beach	1.7
CR16	Coral at Heung Lo Kok	2.4
F4	Tap Mun Fish Culture Zone	0.3
F5	Kau Lau Wan Fish Culture Zone	0.9
F6	Sham Wan Fish Culture Zone	2.2
M5	Mangrove Stand / Intertidal at Fung Wong Wat	4.5
M6	Mangrove Stand / Intertidal at Hoi Ha Wan	2.6
M7	Mangrove Stand / Intertidal at Tai Tan [26]	3.3
M8	Mangrove Stand / Intertidal at To Kwa Peng	4.3
M9	Mangrove Stand / Intertidal at Chek Keng	4.5
MP2	Hoi Ha Wan Marine Park and Artificial Reef within the Marine Park	0.7
AR1	Artificial Reef in Long Harbour	1.0
AR2	Artificial Reef in Long Harbour	0.7
AR3	Artificial Reef in Long Harbour	1.5
AR4	Artificial Reef in Long Harbour	1.3
AR5	Artificial Reef in Long Harbour	1.9
AR6	Artificial Reef in Long Harbour	2.3
AM1	Amphioxus Habitat within and near Proposed Site	4.0
SSSI1	Hoi Ha Wan SSSI	0.7
Site A	Proposed Wong Chuk Kok Hoi FCZ	3.9
Site B	Proposed Outer Tap Mun FCZ	Project Site
Site C	Proposed Mirs Bay FCZ	1.8

3.4 Assessment Criteria

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

(26) AFCD (2013) Distribution. Available at: https://www.afcd.gov.hk/english/conservation/con_wet/con_wet_man/con_wet_man_dis/con_wet_man_dis.html [accessed on 12-07-2022]

Table 3.5 Summary of Assessment WQO Criteria

Parameters	Mirs Bay WCZ	Tolo Harbour and Channel WCZ
Dissolved Oxygen (Bottom) (mg/L)	Not less than 2 mg/L for 90% of samples	Not less than 2 mg/L for the Harbour subzone. Not less than 3 mg/L for the Buffer subzone. Not less than 4 mg/L for the Channel subzone.
Dissolved Oxygen (Depth-averaged) (mg/L)	Not less than 4 mg/L for 90% of samples	Not less than 4 mg/L.
Suspended Solids (mg/L)	Change not more than 30% due to waste discharge	Not applicable
Total Inorganic Nitrogen (mg/L)	≤ 0.3	Not applicable
Unionized Ammonia (mg/L)	≤ 0.021 mg/L	Not applicable
Chlorophyll-a (µg/L)	Not applicable	5-day running average not more than 20 µg/L for the Harbour subzone. 5-day running average not more than 10 µg/L for the Buffer subzone. 5-day running average not more than 6 µg/L for the Channel subzone.
E.coli (no./100mL)	≤ 610 no./100mL for the Secondary contact recreation subzone and the Fish culture subzones	≤ 610 no./100mL for the Secondary contact recreation subzone and the Fish culture subzones

In addition to the WQO criteria for various water quality parameter in two WCZs, reference has been made to other past approved EIAs / direct-to-permit application for applicable assessment criterion for protection of coral within the Tolo Harbour and Channel WCZ. Assessment criterion of 10 mg/L of total suspended solids levels would be adopted following the approved EIA of Development of a Bathing Beach at Lung Mei, Tai Po (AEIAR-123/2008), as well as direct-to-permit application of Sediment Removal at Yim Tin Tsai, Yim Tin Tsai (East) Fish Culture Zones and Shuen Wan Typhoon Shelter (DIR-191/2009). For fish culture zone in Mirs Bay, an additional criterion for chlorophyll-a of 20 µg/L would be adopted to protect the fish stock from excessive algal growth based on criterion adopted in previous Project WATERMAN Study [27]. 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.

(27) 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						
			Depth-averaged	Bottom	Depth-averaged	Bottom	Depth-averaged				
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* Note
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(no./100 mL)
Non-gazetted beach – Mirs Bay	B2	Non-gazetted beach of Nam She Wan	≥4	≥2	N/A	N/A	≤0.3	≤0.021	N/A	increase ≤30% baseline	≤610
Coral – Mirs Bay	CR3	Coral at Port Island	≥4	≥2	N/A	N/A	≤0.3	≤0.021	N/A	increase ≤30% baseline	≤610
	CR5	Coral at Nam She Wan									
	CR6	Coral at Nam She Wan									
	CR7	Coral at Nam She Wan									
	CR12	Coral at Wong Chuk Kok Tsui									
Coral – Tolo Harbour and Channel	CR8	Coral at Wong Wan Tsai	N/A	N/A	≥4	≥4	N/A	N/A	≤6	≤10	≤610
	CR9	Coral at Fung Wong Wat									
	CR10	Coral at Gruff Head									
	CR11	Coral at South Wong Wan Tsui									
	CR13	Coral at Hoi Ha Wan Moon Island									
	CR14	Coral at Hoi Ha Wan Coral Beach									
	CR16	Coral at Heung Lo Kok									
Fish Culture Zone – Mirs Bay	F4	Tap Mun Fish Culture Zone	≥5	≥2	N/A	N/A	≤0.3	≤0.021	≤20	increase ≤30% baseline	≤610
	F5	Kau Lau Wan Fish Culture Zone									
	F6	Sham Wan Fish Culture Zone									
	Site A	Proposed Wong Chuk Kok Hoi FCZ									
	Project site	Proposed Outer Tap Mun FCZ									
	Site C1	Proposed Mirs Bay FCZ (Northern Part)									
	Site C2	Proposed Mirs Bay FCZ (Southern Part)									

Category of WSR	ID	WSR	Annual								
			10th-percentile		Mean						
			Depth-averaged	Bottom	Depth-averaged	Bottom	Depth-averaged				
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* Note
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(no./100 mL)
Mangrove Stand / Intertidal – Mirs Bay	M7	Mangrove Stand / Intertidal at Tai Tan	≥4	≥2	N/A	N/A	≤0.3	≤0.021	N/A	increase ≤30% baseline	≤610
	M8	Mangrove Stand / Intertidal at To Kwa Peng									
	M9	Mangrove Stand / Intertidal at Chek Keng									
Mangrove Stand / Intertidal – Tolo Harbour and Channel	M5	Mangrove Stand / Intertidal at Fung Wong Wat	N/A	N/A	≥4	≥4	N/A	N/A	≤6	≤10	≤610
	M6	Mangrove Stand / Intertidal at Hoi Ha Wan									
Marine Park – Tolo Harbour and Channel	MP2	Hoi Ha Wan Marine Park and Artificial Reef within the Marine Park	N/A	N/A	≥4	≥4	N/A	N/A	≤6	≤10	≤610
Artificial Reef – Mirs Bay	AR1	Artificial Reef in Long Harbour	≥4	≥2	N/A	N/A	≤0.3	≤0.021	N/A	increase ≤30% baseline	≤610
	AR2	Artificial Reef in Long Harbour									
	AR3	Artificial Reef in Long Harbour									
	AR4	Artificial Reef in Long Harbour									
	AR5	Artificial Reef in Long Harbour									
	AR6	Artificial Reef in Long Harbour									
Amphioxus Habitat – Mirs Bay	AM1	Amphioxus Habitat with and near Proposed Site	≥4	≥2	N/A	N/A	≤0.3	≤0.021	N/A	increase ≤30% baseline	≤610
SSSI – Tolo Harbour and Channel	SSSI1	Hoi Ha Wan SSSI	N/A	N/A	≥4	≥4	N/A	N/A	≤6	≤10	≤610

Note: 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 significant area around the Project Site and is represented by a lot of WSRs in this list, the criterion is deemed applicable to these WSRs as well.

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 the Guangdong side of Mirs Bay; 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 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 the trend on small 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 [28] [29] [30]. 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 [31] 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 and is typically not considered in other water quality simulation in past EIAs. 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 the sense of modelling exercise means moving sensitive

(28) 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.

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

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

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

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 [32]. 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 is 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.

(32) 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 more than 10 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 (33), 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 (34) 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 both wet and dry seasons. The carrying capacity estimation indicated the

(33) 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.

(34) 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.

Project site can support mariculture operation of 684.5 ton of standing stock based on typical mariculture practice in HK without significant deterioration of water quality under the typical average condition. The corresponding pollution load from such level of mariculture operation is presented in ***Appendix 3B***.

The estimated loading at the 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, as well as the other nearby proposed new fish culture zones at Wong Chuk Kok Hoi and Mirs Bay (each at their carrying capacity). 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 3.8*** (35). 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 most identified WSRs under both baseline and project scenarios except for certain embayed areas, mostly at the north, as a result of relatively high pollution loading from dry weather load and treated sewage effluent from the Starling Inlet (also known as Sha Tau Kok Hoi), as well as pollution load from Yantian area of Guangdong. Typical depth-averaged levels of dissolved oxygen were predicted to be around 5 mg/L to 7 mg/L, which were close to the observed range at EPD Marine Water Quality Monitoring Stations (***Table 3.2***). Predicted levels of dissolved oxygen are generally low in the bottom level and the predicted depth-averaged levels are typically slightly higher than that of the bottom level. Changes in dissolved oxygen due to mariculture production at the Project site and other locations were predicted to be limited at most locations away from these proposed new FCZ sites.

Within the Long Harbour embayment, the levels of dissolved oxygen were predicted to remain rather stable with and without project operation. Level of mean depth-averaged dissolved oxygen at the existing Tap Mun FCZ (which is one of the closest WSRs to the Project site) was predicted to be 6.5 mg/L for both scenarios and that for mean bottom dissolved oxygen was 6.4 mg/L for both scenarios. Level of mean depth-averaged and bottom dissolved oxygen at the existing Kau Lau Wan FCZ were predicted to be 6.6 mg/L and 6.5 mg/L respectively for both scenarios. For Sham Wan FCZ, the level of mean depth-averaged dissolved oxygen was predicted to be 6.5 mg/L under both scenarios. The mean bottom dissolved oxygen was predicted to be 6.3 mg/L under baseline scenario and 6.2 mg/L under project scenario. Similarly, level of mean depth-averaged dissolved oxygen at the Project site was predicted to be 6.3 mg/L and 6.2 mg/L respectively for baseline and project scenarios. And that for mean bottom dissolved oxygen was 5.8 mg/L and 5.7 mg/L for baseline and project scenarios. Overall, the mariculture operation at the Project site and other proposed FCZs would result in limited change in dissolved oxygen and the predicted dissolved oxygen level would comply with the corresponding WQO criterion stipulated under ***Table 3.5***.

Outside of the Long Harbour embayment, and the proposed new FCZ at Site A was predicted to have low DO level, with predicted 10th-percentile depth-averaged dissolved oxygen levels below the corresponding assessment criterion. As shown, the low dissolved oxygen levels were predicted under baseline scenario and were not shown to deteriorate (i.e. reduce) under the Project scenario. As such, no unacceptable change in dissolved oxygen level is expected at this WSR. It should be highlighted that even though the 10th-percentile depth-averaged dissolved oxygen levels at Site A was

(35) ***Table 3.8*** also include prediction at nearby EPD Marine Water Quality Monitoring Stations for reference. These EPD Marine Water Quality Monitoring Stations are not WSRs.

predicted to be lower than the corresponding assessment criterion of 5 mg/L, the dissolved oxygen levels predicted at the upper part of the water column (where the majority of fish stock is expected to stay) is generally higher. Based on AFCD's past records, dissolved oxygen levels of 4 mg/L or higher at surface level would not cause any notable impact to mariculture operation in general.

Overall, the mariculture operation at the Project site and other proposed FCZs would result in limited change in dissolved oxygen and the predicted dissolved oxygen level would comply with the corresponding WQO criterion stipulated under ***Table 3.5***. Also 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.

3.8.1.2 Total Inorganic Nitrogen

Predicted levels of total inorganic nitrogen were generally low in the assessment area. Predicted levels at WSRs were generally below 0.2 mg/L, which are lower than the WQO criterion of 0.3 mg/L for Mirs Bay. Similar levels were recorded at nearby EPD Marine Water Quality Monitoring Stations shown in ***Table 3.2***. The differences between baseline and project scenarios were predicted to be limited at WSRs away from proposed new FCZ sites at the Project site and other locations.

All mariculture WSRs identified within Long Harbour are predicted to have similar levels of total inorganic nitrogen ranging from 0.08 mg/L to 0.12 mg/L. The predicted levels of total inorganic nitrogen at Tap Mun FCZ were 0.08 mg/L and 0.10 mg/L for baseline and project scenarios respectively. The predicted levels of total inorganic nitrogen at Kau Lau Wan FCZ were 0.09 mg/L and 0.12 mg/L for baseline and project scenarios respectively. For Sham Wan FCZ, predicted level of total inorganic nitrogen increased from 0.09 mg/L to 0.11 mg/L under project scenario. Similarly, predicted levels of total inorganic nitrogen at the Project site increased from 0.10 mg/L to 0.12 mg/L under project scenario. Predicted levels of total inorganic nitrogen at all of these mariculture WSRs were below the WQO criterion of 0.3 mg/L. No unacceptable elevation in total inorganic nitrogen is expected from the proposed mariculture operation at the Project site.

Overall, no unacceptable change in TIN level at all the identified WSRs would be expected from the proposed mariculture operation at the Project site.

3.8.1.3 Unionized Ammonia

Given the small increase in total inorganic nitrogen level due to the operation of the Project, the corresponding predicted increase in unionized ammonia is also small. The increases at all WSRs between the baseline and project scenarios in unionized ammonia levels were either undetectable or at most 0.002 mg/L. The predicted levels of unionized ammonia were at or below 0.010 mg/L at all identified WSRs, which is below the assessment criterion of 0.021 mg/L. Predicted levels of unionized ammonia at Tap Mun FCZ, Kau Lau Wan FCZ and Sham Wan FCZ were in the range of 0.003 mg/L to 0.005 mg/L in both scenarios. Predicted levels of unionized ammonia at the Project Site were 0.004 mg/L and 0.005 mg/L respectively under baseline and project scenarios. 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 varies spatially across the assessment area, ranging from 1 to 6 mg/L. There is limited or no change for the predicted levels between baseline and project scenarios at all identified WSRs. Predicted SS level at Tap Mun FCZ, Kau Lau Wan FCZ, Sham Wan FCZ and the Project site were 1.5 mg/L, 1.7 mg/L, 2.2 mg/L and 1.4 mg/L respectively under baseline scenario, and those for project scenario were 1.6 mg/L, 1.8 mg/L, 2.4 mg/L and 1.5 mg/L respectively. None of the identified WSRs showed change in SS levels that exceeded assessment criterion of 30% change level in baseline level. No unacceptable change in suspended solids level to the identified WSRs is expected.

3.8.1.5 Chlorophyll-a

Predicted levels of chlorophyll-a also vary spatially across the assessment area, ranging up to over 20 µg/L. Similar to the case of dissolved oxygen, chlorophyll-a levels are generally higher at surface level and thus area with shallower depth tends to have higher chlorophyll-a levels. The differences between baseline and project scenarios were predicted to be limited at WSRs away from proposed new FCZ sites at the Project site and other locations. No exceedance of chlorophyll-a criterion was predicted at all identified WSRs. No unacceptable water quality impact on chlorophyll-a is expected from the mariculture operation.

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). Since faecal pollution of dogs/ cats is not expected within the Project site [(36)], the operation of fish farm at the Project site will not introduce additional *E.coli* loading and thus the prediction under baseline and project scenarios are the same. No unacceptable water quality impact on identified beach, secondary contact recreation subzone and fish culture zone is expected. Further discussion on sewage and wastewater generation from staff and visitors onsite is provided under ***Sections 3.8.4*** and ***3.8.5*** below.

3.8.1.7 Impact on the Use of IMTA

As discussed under ***Section 2.3.4***, the use of IMTA would be considered 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.

(36) The service provided by dogs and cats in traditional fish rafts is expected to be no longer needed in the more modern mariculture operations. Also, these new mariculture operation is not expected to be manned continuously, thus no longer suitable for keep dogs and cats onsite.

Table 3.7 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
Oxidized-N (g/day)	0.0968	7.1%	1.205	88.6%	95.7%	**1.3597**
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**
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**
TSS (g/day)	24.6477	92.2%	-		92.2%	**26.7298**

Filter feeders, including oysters, clams and mussels, which are commercially cultivated feed on planktons or suspended organic matters. According to Jansen *et. al.* (2019) [37], biodeposit 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. While the effect of IMTA on water quality cannot be quantified given the lack of detail design information, its effect would positively affect the water quality at the Project Site if implemented in sufficient scale.

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

Table 3.8 Predicted Water Quality under Baseline and Project Scenario

ID	WSR	Scn.	Annual								
			10th-percentile		Mean		Depth-averaged				
			Depth-averaged	Bottom	Depth-averaged	Bottom					
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* Note2
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(mg/L)	(no./100 mL)
Non-gazetted beach – Mirs Bay Assessment Criteria			**≥4**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**N/A**	**increase ≤30% baseline**	**≤610**
B2	Non-gazetted beach of Nam She Wan	Baseline	4.2	3.3	6.0	5.6	0.16	0.008	4	1.5	0
		Project	4.0	3.0	5.8	5.3	0.21	0.010	4	1.6	0
Coral – Mirs Bay Assessment Criteria			**≥4**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**N/A**	**increase ≤30% baseline**	**≤610**
CR3	Coral at Port Island	Baseline	5.2	5.1	6.4	6.2	0.07	0.003	4	1.5	0
		Project	5.2	5.1	6.4	6.2	0.08	0.003	5	1.6	0
CR5	Coral at Nam She Wan	Baseline	5.1	4.5	6.1	6.0	0.14	0.005	3	1.3	0
		Project	4.9	4.3	6.0	5.9	0.19	0.007	3	1.4	0
CR6	Coral at Nam She Wan	Baseline	4.3	4.2	6.0	5.7	0.16	0.007	2	1.3	0
		Project	4.2	3.7	5.8	5.5	0.21	0.009	3	1.4	0
CR7	Coral at Nam She Wan	Baseline	5.2	4.5	6.1	5.9	0.15	0.006	3	1.3	0
		Project	5.1	4.3	6.0	5.8	0.19	0.008	3	1.4	0
CR12	Coral at Wong Chuk Kok Tsui	Baseline	5.2	5.0	6.3	6.2	0.07	0.003	5	1.7	0
		Project	5.2	5.0	6.3	6.2	0.09	0.004	6	1.8	0
Coral – Tolo Harbour and Channel Assessment Criteria			**N/A**	**N/A**	**≥4**	**≥4**	**N/A**	**N/A**	**≤6**	**≤10**	**≤610**
CR8	Coral at Wong Wan Tsai	Baseline	5.1	4.4	6.2	6.0	0.07	0.003	3	1.4	0
		Project	5.0	4.3	6.1	5.9	0.09	0.004	3	1.5	0
CR9	Coral at Fung Wong Wat	Baseline	5.1	4.7	6.2	6.1	0.07	0.003	3	1.4	0
		Project	5.0	4.5	6.1	6.0	0.09	0.004	3	1.5	0
CR10	Coral at Gruff Head	Baseline	5.2	4.6	6.3	6.0	0.07	0.003	3	1.5	0
		Project	5.1	4.4	6.2	5.9	0.09	0.004	4	1.6	0
CR11	Coral at South Wong Wan Tsui	Baseline	5.1	4.8	6.2	6.2	0.07	0.003	3	1.4	0
		Project	4.9	4.6	6.2	6.1	0.09	0.004	4	1.5	0
CR13	Coral at Hoi Ha Wan Moon Island	Baseline	5.1	4.5	6.2	6.0	0.09	0.004	3	1.4	0
		Project	5.0	4.3	6.1	5.9	0.11	0.004	4	1.5	0
CR14	Coral at Hoi Ha Wan Coral Beach	Baseline	5.2	4.3	6.3	6.0	0.08	0.004	4	1.6	0
		Project	5.1	4.3	6.2	5.9	0.10	0.005	5	1.7	0
CR16	Coral at Heung Lo Kok	Baseline	5.1	4.4	6.2	6.0	0.09	0.004	3	1.4	0
		Project	5.0	4.3	6.1	5.9	0.10	0.004	4	1.5	0
Fish Culture Zone – Mirs Bay Assessment Criteria			**≥5**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**≤20**	**increase ≤30% baseline**	**≤610**
F4	Tap Mun Fish Culture Zone	Baseline	5.4	5.2	6.5	6.4	0.08	0.003	4	1.5	0
		Project	5.4	5.2	6.5	6.4	0.10	0.004	5	1.6	0

ID	WSR	Scn.	Annual								
			10th-percentile		Mean		Depth-averaged				
			Depth-averaged	Bottom	Depth-averaged	Bottom					
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* Note2
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(mg/L)	(no./100 mL)
F5	Kau Lau Wan Fish Culture Zone	Baseline	6.0	5.4	6.6	6.5	0.09	0.004	6	1.7	0
		Project	5.6	5.4	6.6	6.5	0.12	0.004	7	1.8	0
F6	Sham Wan Fish Culture Zone	Baseline	5.5	5.0	6.5	6.3	0.09	0.004	8	2.2	0
		Project	5.3	4.9	6.5	6.2	0.11	0.005	9	2.4	0
Site A	Proposed Wong Chuk Kok Hoi FCZ Note3	Baseline	**4.0**	2.9	5.8	5.2	0.10	0.006	6	2.0	0
		Project	**4.0**	2.8	5.8	5.1	0.13	0.008	7	2.1	0
Project site	Proposed Outer Tap Mun FCZ	Baseline	5.2	4.2	6.3	5.8	0.10	0.004	3	1.4	0
		Project	5.2	4.2	6.2	5.7	0.12	0.005	4	1.5	0
Site C1	Proposed Mirs Bay FCZ (Northern Part)	Baseline	5.2	4.2	6.1	5.7	0.12	0.005	3	1.4	0
		Project	5.1	4.2	6.1	5.6	0.15	0.006	3	1.4	0
Site C2	Proposed Mirs Bay FCZ (Southern Part)	Baseline	5.2	4.3	6.1	5.8	0.14	0.006	2	1.3	0
		Project	5.1	4.2	6.0	5.6	0.18	0.008	2	1.4	0
Mangrove Stand / Intertidal – Mirs Bay Assessment Criteria			**≥4**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**N/A**	**increase ≤30% baseline**	**≤610**
M7	Mangrove Stand / Intertidal at Tai Tan	Baseline	6.0	5.7	7.0	6.9	0.04	0.002	16	3.1	0
		Project	6.0	5.6	7.1	7.0	0.05	0.003	19	3.6	0
M8	Mangrove Stand / Intertidal at To Kwa Peng	Baseline	5.6	4.8	6.7	6.5	0.03	0.002	19	4.4	0
		Project	5.5	4.5	6.8	6.4	0.04	0.003	22	5.0	0
M9	Mangrove Stand / Intertidal at Chek Keng	Baseline	4.8	4.2	6.4	6.2	0.05	0.004	24	5.7	0
		Project	4.4	3.9	6.4	6.1	0.06	0.005	27	6.5	0
Mangrove Stand / Intertidal – Tolo Harbour and Channel Assessment Criteria			**N/A**	**N/A**	**≥4**	**≥4**	**N/A**	**N/A**	**≤6**	**≤10**	**≤610**
M5	Mangrove Stand / Intertidal at Fung Wong Wat	Baseline	5.2	5.1	6.3	6.2	0.06	0.003	4	1.5	0
		Project	5.2	5.0	6.3	6.1	0.08	0.003	4	1.6	0
M6	Mangrove Stand / Intertidal at Hoi Ha Wan	Baseline	5.2	4.5	6.3	6.1	0.08	0.004	4	1.6	0
		Project	5.0	4.3	6.2	6.0	0.10	0.004	5	1.7	0
Marine Park – Tolo Harbour and Channel Assessment Criteria			**N/A**	**N/A**	**≥4**	**≥4**	**N/A**	**N/A**	**≤6**	**≤10**	**≤610**
MP2	Hoi Ha Wan Marine Park and Artificial Reef within the Marine Park	Baseline	5.2	4.6	6.2	6.0	0.09	0.004	4	1.5	0
		Project	5.1	4.4	6.2	5.9	0.11	0.004	4	1.6	0
Artificial Reef – Mirs Bay Assessment Criteria			**≥4**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**N/A**	**increase ≤30% baseline**	**≤610**
AR1	Artificial Reef in Long Harbour	Baseline	5.2	4.4	6.2	5.9	0.12	0.005	3	1.4	0
		Project	5.1	4.3	6.1	5.8	0.15	0.006	4	1.5	0
AR2	Artificial Reef in Long Harbour	Baseline	5.2	4.8	6.3	6.0	0.11	0.004	4	1.5	0
		Project	5.2	4.4	6.2	5.9	0.14	0.005	4	1.6	0

ID	WSR	Scn.	Annual								
			10th-percentile		Mean		Depth-averaged				
			Depth-averaged	Bottom	Depth-averaged	Bottom					
			Dissolved Oxygen				Total Inorganic Nitrogen	Unionized Ammonia	Chlorophyll-a	Suspended Solids	*E.coli* Note2
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(mg/L)	(no./100 mL)
AR3	Artificial Reef in Long Harbour	Baseline	5.1	4.2	6.2	5.8	0.12	0.005	3	1.4	0
		Project	4.7	4.2	6.1	5.7	0.15	0.006	4	1.5	0
AR4	Artificial Reef in Long Harbour	Baseline	5.2	4.3	6.3	5.9	0.11	0.005	4	1.6	0
		Project	5.2	4.2	6.2	5.8	0.14	0.005	5	1.7	0
AR5	Artificial Reef in Long Harbour	Baseline	5.2	4.2	6.3	5.7	0.11	0.005	5	1.6	0
		Project	5.1	4.1	6.2	5.6	0.14	0.006	5	1.8	0
AR6	Artificial Reef in Long Harbour	Baseline	5.1	4.2	6.2	5.7	0.11	0.005	5	1.8	0
		Project	4.7	3.7	6.1	5.5	0.13	0.006	6	1.9	0
Amphioxus Habitat – Mirs Bay Assessment Criteria			**≥4**	**≥2**	**N/A**	**N/A**	**≤0.3**	**≤0.021**	**N/A**	**increase ≤30% baseline**	**≤610**
AM1	Amphioxus Habitat	Baseline	5.2	4.3	6.1	5.8	0.14	0.006	2	1.3	0
		Project	5.1	4.2	6.0	5.7	0.17	0.007	2	1.4	0
SSSI – Tolo Harbour and Channel Assessment Criteria			**N/A**	**N/A**	**≥4**	**≥4**	**N/A**	**N/A**	**≤6**	**≤10**	**≤610**
SSSI1	Hoi Ha Wan SSSI	Baseline	5.1	4.3	6.2	5.9	0.09	0.004	3	1.4	0
		Project	5.1	4.3	6.1	5.8	0.11	0.005	4	1.5	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**
TM8	EPD Marine WQ Monitoring Station	Baseline	5.2	4.2	6.2	5.8	0.07	0.003	3	1.5	0
		Project	5.1	4.2	6.2	5.6	0.08	0.004	4	1.6	0
MM6	EPD Marine WQ Monitoring Station	Baseline	5.2	4.4	6.3	6.0	0.11	0.005	4	1.5	0
		Project	5.2	4.3	6.2	5.8	0.14	0.005	4	1.6	0
MM17	EPD Marine WQ Monitoring Station	Baseline	4.3	3.3	5.9	5.2	0.10	0.004	3	1.5	0
		Project	4.3	3.2	5.9	5.1	0.11	0.005	3	1.5	0

Note1: Values in exceedance of the corresponding assessment criteria are bold and shaded.
Note2: 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 significant area around the Project Site and is represented by a lot of WSRs in this list, the criterion is deemed applicable to these WSRs groups as well.
Note3: In the EIA for the proposed new FCZ at Site A, it is assumed that measure to increase dissolved oxygen level would be taken by mariculturists as necessary. For details, please refer to the corresponding EIA.

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 684.5 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 around Outer Tap Mun is more than 10 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, marine parks, existing and proposed FCZs, ecological habitats (including amphioxus), spawning ground and nursery area of commercial fisheries resources and other fisheries sensitive receivers, artificial reefs, intertidal areas of various country parks, and beach. For all WSRs identified except Site A, the water quality parameters were predicted to be in compliance with the corresponding WQO criteria, and project operation would not result in notable deterioration. The low dissolved oxygen levels at Site A were predicted under baseline scenario and were not shown to deteriorate (i.e. reduce) under the Project scenario. Therefore, it is concluded that the proposed mariculture operation at the carrying capacity of 684.5 ton of standing stock or below would not result in unacceptable change in water quality at the nearby WSRs. 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 [38] 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 significant water quality impact. In view of this, together with the adoption of the operational measures and best practice for mariculture activities as stated in ***Appendix 2A***, 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 [39], 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.

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

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

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.). 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 *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 684.5 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 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

Modelling results indicated that compliance with WQO criterion is achieved at most of the water sensitive receivers, and no project contribution to exceedance in baseline scenario would be expected from the operation phase of the Project. No unacceptable operation phase water quality impact is expected.

3.11 Cumulative Impact

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 existing FCZs within Mirs Bay and Tolo Harbour and Channel [(40)];
- proposed mariculture operation at Site A (Wong Chuk Kok Hoi) and Site C (Mirs Bay);
- dry weather flow (i.e. pollution load from land drainage) within Mirs Bay and Tolo Harbour and Channel;
- rainfall-related load within Mirs Bay and Tolo Harbour and Channel;
- treated sewage effluent from the Sha Tau Kok Sewage Treatment Works; and
- other sources including pollution load from the Guangdong side of 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 is expected

(40) Note that other mariculture operation outside of Mirs Bay and Tolo Harbour and Channel are also taken into account indirectly through model nestling for generation of boundary condition of water quality boundary.

to achieve 75% of the carrying capacity [41] (i.e. 684.5 ton x 75% = 513.4 ton) or when the standing stock is expected to achieve 95% of the carrying capacity (i.e. 684.5 ton x 95% = 650.3 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 this 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 indicated the Project site can support mariculture operation of 684.5 ton of 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. Compliance with WQO criterion is achieved at most of the identified water sensitive receivers, and no project contribution to exceedance in baseline scenario is expected from the proposed mariculture operation at the Project site. The results indicated project operation would not result in a significant change in water quality with 684.5 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.

(41) 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.