# 7. ECOLOGICAL RISK ASSESSMENT

## Introduction

7.1 During the disinfection technology evaluation and selection exercise conducted under this Project, the Project Team need to answer "**Is chlorination an option for HATS at all?**" before shortlisting it for detailed evaluation in view of the concern on potential adverse environmental impacts due to discharge of chlorination by-products (CBPs) raised. A risk assessment has been conducted on the following types of risk to answer the above question on chlorination disinfection technology.

- Risk to human health
- Risk to aquatic ecological resources
- Acute toxicity to aquatic life
- Chronic toxicity to aquatic life

7.2 Apart from evaluating the environmental viability of chlorination for the disinfection technology selection, the risk assessment conducted also fulfils the EIA Study Brief requirement. With reference to Clause 3.4.3.6 (xi) of the EIA Study Brief, the EIA Study shall assess the adverse ecological effects that may result from exposure to toxic substances due to effluent discharges, and the potential human health risks associated with ingestion of and contact with contaminated seawater during swimming or engaging in other water related activities and with the consumption of potentially contaminated seafood.

7.3 The Ecological Risk Assessment (ERA), which covers the assessment of risk to ecological resources, and compliance assessment on water quality criteria in terms of acute and chronic toxicity are presented in this section of the EIA Report. Risk assessment for human health is presented in **Section 6** of the EIA Report.

## Objective, Scope and Focus of Assessments

7.4 The objective of the assessments are described as follows:

- ERA – Aquatic Life – to assess the adverse chronic effects to aquatic life associated with the exposure to toxic substances from effluent discharges of the Project
- ERA – Marine Mammals - to assess the adverse chronic effects to marine mammals associated with the exposure to toxic substances from effluent discharges of the Project
- Compliance Assessment on Water Quality Criteria – Acute and Chronic Toxicity
  - to assess whether the water quality criteria in terms of acute and chronic toxicity would be complied in the presence of Project effluent discharge. This assessment could provide additional information concerning the potential ecological risks

7.5 The study area of this assessment was in line with the one for water quality assessment according to Clause 3.4.3.2 of the EIA Study Brief, which shall cover the following Water Control Zones as designated under the Water Pollution Control Ordinance: North Western, Western Buffer, Victoria Harbour, Eastern Buffer, Junk Bay and Southern.

7.6 Since this project is to provide disinfection facilities at SCISTW, the assessment focused on assessing the potential risks/impacts to ecological resources due to chronic exposure to the contaminants produced in the disinfection process in the effluent discharge. Previous studies[1] for Harbour Area Treatment Scheme (HATS)/Strategic Sewage Disposal Scheme (SSDS) have assessed the impacts due to other toxic substances not related to the disinfection process (such as heavy metals and other organic pollutants).

7.7 Risk assessments in previous studies showed that SSDS/HATS effluent discharge would not induce unacceptable incremental risk to aquatic life, which was supported by the results of the whole effluent toxicity tests that diluted effluent would not acutely or chronically toxic to aquatic life at the zone of

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[1] MW (1998). Detailed Risk Assessment (Final Version). Technical Note 4, prepared as part of the Strategic Sewage Disposal Scheme (SSDS) – Environmental Impact Assessment Study. Referred to as "SSDS/EIAS DRA (1998)".
CDM (2004). Environmental and Engineering Feasibility Assessment Studies in Relation to the Way Forward of the Harbour Area Treatment Scheme (HATS). Referred to as "HATS EEFS".

initial dilution. Moreover, the previous studies revealed that there would be no unacceptable risk to marine mammals induced by the SSDS/HATS effluent discharge.

### Scenarios Considered in Assessments

7.8 Five project scenarios were considered in the assessments:

- Early commissioning of ADF (year 2009) – SCISTW discharges 1,576,300m$^3$ of chlorinated/dechlorinated (C/D) CEPT effluent per day (referred to as Project Scenario 1)
- Late ADF stage (year 2013) - SCISTW discharges 1,661,100m$^3$ of C/D CEPT effluent per day (referred to as Project Scenario 2)
- Late Stage 2A with disinfection (year 2020) - SCISTW discharges 2,341,600m$^3$ of C/D CEPT effluent per day (referred to as Project Scenario 3)
- Before commissioning of HATS Stage 2B – SCISTW discharges 2,800,000m$^3$ of C/D CEPT effluent per day (referred to as Project Scenario 4)
- HATS Stage 2B with disinfection (ultimate year) - SCISTW discharges 2,800,000m$^3$ of C/D secondary treated effluent per day (referred to as Project Scenario 5)

### Assessment Methodology

7.9 The detailed risk assessment methodologies for ERA – Aquatic Life and ERA – Marine Mammals were presented in **Appendix 7-1**. The framework of the risk assessments was presented below:

- Problem Formulation
- Contaminant of Potential Concern (COPC) Identification and Contaminant of Concern (COC) Selection
- Exposure and Ecological Effects Characterization
- Risk Characterization

7.10 A brief overview of the risk assessment methodology is presented below:

Problem Formulation

This stage of the risk assessment establishes objective, scope and focus of the assessment, constructs the Site Conceptual Model (SCM) and defines assessment endpoint. SCM presents an overview of the chemical sources, exposure pathways and receptors of the risk assessment. The SCMs adopted in the risk assessments were presented graphically in **Figures 7.1** and **7.2**. More detailed discussion was presented in **Appendix 7-1**.

COPC Identification

A total number of 35 chemicals were identified as COPCs in the risk assessments. The COPCs included 9 chlorination by-products (CBPs) regulated by USEPA National Primary Drinking Water Standards; 25 priority pollutants[2] (which may contain potential CBPs) regulated by the USA National Pollutant Discharge Elimination System (NPDES)[3]; and total residual chlorine (as disinfectant residue). Chemical analysis was conducted to determine the COPC concentrations in chlorinated/dechlorinated (C/D) CEPT effluent and ambient seawater for the subsequent tasks of the risk assessment.

Unlike other conventional risk assessments for air pollution source (e.g. incinerator) and contaminated land/groundwater, a look-up table of contaminants/list of possible COPC for CBPs risk assessment in effluent was not identified from local and overseas authorities. Moreover, according to the review of local and overseas practice, list of “regulated CBPs in sewage effluent” was not identified.

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[2] The 25 pollutants are regulated in NPDES due to their presence in industrial effluent but not their possible generation in chlorination process. However, a conservative approach is adopted to study all these regulated chlorinated organic substances, which are documented as potential CBPs, in US drinking water and wastewater discharge.

[3] The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into water of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

Hence, a conservative approach was adopted in this Study to include all the regulated CBPs in drinking water plus the 25 priority pollutants (may contain potential CBPs) regulated by NPDES as COPCs, although these pollutants are not regulated due to the concern of generation during chlorination process.

The NPDES practice was adopted because it contains the most comprehensive list of regulated pollutants for effluent discharge, based on the review of practice in the USA, the United Kingdom, Australia, Canada, China and Hong Kong. Moreover, the purpose of NPDES is to ensure the US National Water Quality Criteria are complied by regulating pollutant concentrations in effluent discharge directly to surface water, in order to protect the human health and aquatic life.

Therefore, the 35 COPCs identified for the risk assessment include all documented potential CBPs/disinfectant residue which are regulated due to their potential to cause impact to human health and/or ecological resources. The list of identified COPCs (which the COCs for risk calculation were selected from the list) was considered sufficiently comprehensive to assess the potential risk to human health due to chronic exposure to the contaminants produced in the disinfection process in the effluent discharges.

COC Selection

The COCs were selected from the COPCs based on a number of selection rules and their risks were determined in the risk assessment.

Exposure Characterization (for ERA – Aquatic Life)

COC exposure by aquatic life was characterized as the COC concentrations in seawater, which were determined by using dilution factors estimated in water quality modelling.

Exposure Characterization (for ERA – Marine Mammals)

This stage of the assessment involves water quality modelling, characterization of potential marine mammals receptors and calculation of COC exposure. COC bioconcentration and bioaccumulation along the food chain have been considered in the determination of COC concentration of preys. As such, the risks associated with COC bioconcentration and bioaccumulation have been considered and evaluated in the risk assessment.

Ecological Effects Characterization (for ERA – Aquatic Life)

This stage of the assessment characterizes the ecological effects of COC exposure to aquatic life by comparing the COC concentrations in the seawater at the receptor points to the Toxicity Reference Value (TRV) for aquatic life. TRVs for COCs were derived from water quality criteria/standards for protection of aquatic life when available; for COCs without such criteria/standards, toxicity values obtained from the scientific literature were used to derive TRVs.

Ecological Effects Characterization (for ERA – Marine Mammals)

This stage of the ERA characterizes the ecological effects of COC exposure to marine mammals by comparing the COC daily dose to the toxicity reference doses for the marine mammals, which were derived by reviewing the toxicological effects data from various scientific literature, database and guidelines.

Risk Characterization

In this stage of the assessment, the risk associated with the COCs to the ecological resources were characterized by COC-specific hazard quotients (HQs) and hazard index (HI).

### Assessment Criteria

7.11 The assessment results needed to compare against the established assessment criteria to evaluate the environmental acceptability of the chlorination disinfection technology option, which are presented below.

Risk to Ecological Resources - Aquatic Life and Marine Mammals

7.12 Hazard Quotient (HQ) and Hazard Index (HI)[4] were used as the measure for the risk to aquatic life and marine mammals. At present USEPA has taken 1.0 as the screening value for HQ and HI. A HQ and/or HI below the screening value (i.e. 1) would indicate that the risk of the proposed action does not present an unacceptable risk and no further investigation would be required.

7.13 When the calculated HQ and HI are above the screening value, it does not immediately indicate that the proposed action would present an unacceptable risk. Rather, it triggers further investigation to examine whether the assumptions for the concerned chemicals are too conservative and whether the severities of the effect of the chemicals are of great concern.

7.14 The adoption of 1 as the screening value is consistent with the interpretation of HQ and HI in the approved "EIA for New Contaminated Mud Marine Disposal Facility at Airport East / East Sha Chau Area".

Water Quality Criteria in terms of Acute and Chronic Toxicity to Aquatic Life

7.15 Acute Toxicity Unit (TUa) and Chronic Toxicity Unit (TUc) were the endpoints for acute and chronic toxicity criteria respectively. For acute toxicity due to the project effluent, 1-hour average limit of 0.3 TUa should be met at the edge of initial dilution zone. While for chronic toxicity due to the project effluent, 4-day average limit of 1.0 TUc should be met at the edge of mixing zone.

### Data Collection

7.16 To obtain the data for the risk assessments, chemical analysis and whole effluent toxicity tests (WETT) were conducted for the chlorinated/dechlorinated (C/D) CEPT effluent from SCISTW and secondary treated effluent from Tai Po/Shatin Sewage Treatment Works. The chemical analysis aimed to determine the identified COPC concentrations in the C/D effluents and ambient seawater for COC selection and calculation of ecological risk; whereas the WETT aimed to determine the toxicity of C/D effluent in order to assess the compliance of acute and chronic toxicity criteria.

Chemical Analysis

7.17 Highest COPC concentrations determined among the replicates in the chemical analysis were adopted for COC selection and risk calculations. **Table 7.1** presented the summary of chemical analysis results.

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[4] HQ is the measure of health hazard due to exposure of a COC whereas HI is the measure of health hazard due to exposure of all identified COCs, which is calculated by summing the HQs of all identified COCs.

**Table 7.1 Summary of Chemical Analysis Results**

| COPC | Detection Limit (µg/L) | Max. Conc. in C/D CEPT Effluent (µg/L) | Max. Conc. in C/D Secondary Treated Effluent (µg/L) | Max. Conc. in Ambient Seawater (µg/L)[5] |
|---|---|---|---|---|
| Total residual chlorine | 20 | 100 | <20 | <20 |
| Bromoform | 5 | <5 | 49 | <5 |
| Bromodichloromethane | 5 | <5 | <5 | <5 |
| Chloroform | 5 | 7 | <5 | <5 |
| Dibromochloromethane | 5 | <5 | 8 | <5 |
| Bromoacetic acid | 2 | <2 | <2 | <5 |
| Chloroacetic acid | 2 | 4 | <2 | <5 |
| Dibromoacetic acid | 2 | 4 | 10 | <5 |
| Dichloroacetic acid | 2 | 45.9 | 3 | <5 |
| Trichloroacetic acid | 2 | 22 | 7 | <5 |
| Methylene chloride | 20 | <20 | <20 | 55 |
| Carbon tetrachloride | 0.5 | <0.5 | <0.5 | <0.5 |
| Chlorobenzene | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,1-dichloroethane | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,2-dichloroethane | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,1-dichloroethylene | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,2-dichloropropane | 0.5 | <0.5 | <0.5 | <0.5 |
| Tetrachloroethylene | 0.5 | 1.3 | <0.5 | <0.5 |
| 1,1,1-trichloroethane | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,1,2-trichloroethane | 0.5 | <0.5 | <0.5 | <0.5 |
| Trichloroethylene | 0.5 | 2 | <0.5 | <0.5 |
| 2-chlorophenol | 0.5 | <0.5 | <0.5 | <0.5 |
| 2,4-dichlorophenol | 0.5 | <0.5 | <0.5 | <0.5 |
| p-chloro-m-cresol | 0.5 | <0.5 | <0.5 | <0.5 |
| Pentachlorophenol | 2.5 | <2.5 | <2.5 | <2.5 |
| 2,4,6-trichlorophenol | 0.5 | 2 | <0.5 | <0.5 |
| Bis(2-chloroethoxy)methane | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,4-dichlorobenzene | 0.5 | <0.5 | <0.5 | <0.5 |
| Hexachlorobenzene | 0.5 | <0.5 | <0.5 | <0.5 |
| Hexachlorocyclopentadiene | 2.5 | <2.5 | <2.5 | <2.5 |
| Hexachloroethane | 0.5 | <0.5 | <0.5 | <0.5 |
| 1,2,4-trichlorobenzene | 0.5 | <0.5 | <0.5 | <0.5 |
| Alpha-BHC | 0.5 | <0.5 | <0.5 | <0.5 |
| Beta-BHC | 1 | <1 | <1 | <0.5 |
| Gamma-BHC | 1 | <1 | <1 | <0.5 |

Whole Effluent Toxicity Test

7.18 WETT was conducted to determine the whole effluent toxicity of C/D CEPT effluent from SCISTW and C/D secondary treated effluent from Tai Po/Shatin Sewage Treatment Works for the following five species:

- Amphipod (*Melita longidactyla*), with 48-hour survival test
- Barnacle larvae (*Balanus amphitrite*), with 48-hour survival test
- Fish (*Lutjanus malabaricus*), with 48-hour survival test
- Shrimp (*Metapenaeus ensis*), with 48-hour survival test
- Diatom (*Skeletonema costatum*), with 7-day growth inhibition test

7.19 The WETT followed the protocol agreed and adopted in previous study which aimed at establishing fisheries and marine ecological criteria appropriate to local marine biota and fisheries resources

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[5] For COPCs that were not detected in the ambient seawater samples, the background concentration was set as zero for risk calculation. Refer to Appendix 7.1 for details.

(Centre for Coastal Pollution and Conservation, 2001). The species used in the WETT were same to those used in the previous study, which were considered as the "representative local species" of great ecological and fisheries significance.

7.20 The test conditions of the WETT are shown as follows:

- Temperature: 22 ± 1°C
- Salinity: 30 ± 1ppt
- Illuminance: 500 – 1000 lux (2500 – 3000 lux for diatom)
- Photoperiod: 12h light : 12h dark

7.21 The toxicity tests for amphipod, barnacle larvae, fish and shrimp were to determine the acute toxicity of the effluents to the 4 animal species while the toxicity tests for diatom were to determine the chronic toxicity of the effluents to the plant species. **Tables 7.2a** to **7.2d** summarized the results obtained in the WETT.

**Table 7.2a Summary of WETT Result for CEPT Effluent (Acute Toxicity)**

| | **Composite CEPT Effluent** | | **Chlorinated/Dechlorinated CEPT Effluent** | |
|---|---|---|---|---|
| **Test Species** | **48-hr $LC_{50}$[a]** | **NOEC[b]** | **48-hr $LC_{50}$** | **NOEC** |
| **Amphipod** | N.D | >85.0% | N.D | >85.0% |
| **Barnacle Larvae** | 44.9% | 26.6% | 40.2% | 26.6% |
| **Fish** | N.D | 30.8% | N.D | >81.9% |
| **Shrimp** | N.D | >81.0% | N.D | >81.0% |

Note: [a] 48-hr $LC_{50}$, the lethal concentration of effluent to 50% of test animals after 48 hours of exposure.
[b] No-Observable-Effect-Concentration, the highest concentration of effluent producing effects not significantly different from responses to controls
N.D = Not Determined, due to less than 50% mortality was recorded when animal species were exposed to the highest concentration of effluent

**Table 7.2b Summary of WETT Result for CEPT Effluent (Chronic Toxicity)**

| | **Composite CEPT Effluent** | | **Chlorinated/Dechlorinated CEPT Effluent** | |
|---|---|---|---|---|
| **Test Species** | **7-day $IC_{50}$[a]** | **NOEC[b]** | **7-day $IC_{50}$[a]** | **NOEC** |
| **Diatom** | 34.9% | 27.2% | 39.7% | 27.2% |

Note: [a] 7-day $IC_{50}$, the inhibition concentration to 50% of organisms after 7 days of exposure.
[b] No-Observable-Effect-Concentration, the highest concentration of effluent producing effects not significantly different from responses to controls.

7.22 Statistical analysis was conducted for the toxicity test data of barnacle larvae and diatom to determine whether C/D process induced additional toxicity in the CEPT effluent. The analysis showed that the C/D process did not induce statistically significant difference to the toxicity effect in CEPT effluent to barnacle larvae and diatom, i.e. C/D process did not induce additional toxicity.

**Table 7.2c Summary of WETT Result for Secondary Treated Effluent (Acute Toxicity)**

| | **Composite Secondary Treated Effluent** | | **Chlorinated/Dechlorinated Secondary Treated Effluent** | |
|---|---|---|---|---|
| **Test Species** | **48-hr $LC_{50}$** | **NOEC** | **48-hr $LC_{50}$** | **NOEC** |
| **Amphipod** | N.D[1] | N.D[2] | N.D[1] | N.D[2] |
| **Barnacle Larvae** | N.D[1] | N.D[2] | N.D[1] | N.D[2] |
| **Fish** | N.D[1] | N.D[2] | N.D[1] | N.D[2] |
| **Shrimp** | N.D[1] | N.D[2] | N.D[1] | N.D[2] |

N.D = Not Determined,
[1] $LC_{50}$ could not be determined due to less than 50% mortality was recorded when animal species were exposed to the highest concentration of effluent
[2] NOEC could not be determined; the highest concentration of effluent did not produce effects significantly different from controls

**Table 7.2d Summary of WETT Result for Secondary Treated Effluent (Chronic Toxicity)**

| | **Composite Secondary Treated Effluent** | | **Chlorinated/Dechlorinated Secondary Treated Effluent** | |
|---|---|---|---|---|
| **Test Species** | **7-day $IC_{50}$** | **NOEC** | **7-day $IC_{50}$** | **NOEC** |
| **Diatom** | N.D[1] | N.D[2] | N.D[1] | N.D[2] |

N.D = Not Determined,

[1] $IC_{50}$ could not be determined due to less than 50% growth inhibition was recorded when plant species were exposed to the highest concentration of effluent

[2] NOEC could not be determined; the highest concentration of effluent did not produce effects significantly different from controls

7.23 Acute toxicity unit (TUa) and chronic toxicity unit (TUc) of the C/D effluent were calculated using the 48-hr LC50 and 7-day IC50 obtained in the WETT. TUa and TUc can be calculated using the following equations, as documented in "Technical Support Document for Water Quality-based Toxics Control" (USEPA 1991):

$$TUa = 100/LC_{50} \qquad \text{Equation 1}$$

Where
$LC_{50}$ = % of effluent which gives 50% survival of the most sensitive of the range of species tested for acute toxicity effect

$$TUc = 100/NOEC\ (chronic) \qquad \text{Equation 2}$$

Where
NOEC (chronic) = No-Observable-Effect-Concentration, based on the most sensitive of the range of species tested for chronic toxicity effect

7.24 Apart from using Equation 2, by applying "acute-to-chronic ratio" (ACR)[6], available acute toxicity data of a barnacle larvae can be used to extrapolate to the chronic toxicity to the species. According to USEPA (1991), a value of 10 for ACR would be appropriate.

7.25 For TUa of C/D CEPT effluent, it was calculated based on the test result for barnacle larvae, because mortality of amphipod, shrimp and fish was insufficient to determine the LC50 values. By applying Equation 1, TUa of C/D CEPT effluent = 100 / 40.2 = 2.49.

7.26 For TUc of C/D CEPT effluent, it can be calculated based on the test result for diatom. By applying Equation 2, TUc of C/D CEPT effluent = 100 / 27.2 = 3.68. TUc can also be determined by applying ACR to the TUa calculated from acute toxicity data to barnacle larvae, which is:
TUc = TUa x ACR = 2.49 x 10 = 24.9.
Since the TUc determined by extrapolation from acute toxicity data was found to be greater than that calculated from chronic toxicity data, the former (i.e. 24.9) was used to determine the compliance of chronic toxicity criteria.

7.27 C/D secondary treated effluent generally did not exert acute and chronic toxicity effect to the species used in the WETT; no 48-hr LC50 for animal species and no NOEC for diatom could be determined and therefore no TUa and TUc could be calculated for C/D secondary treated effluent.

### Selected Contaminant of Concern and Effluent Concentration for Risk Assessments

7.28 From the 35 identified COPCs, COCs were selected and their effluent concentrations were determined for calculation of risks. The COC selection and effluent concentrations were based on the chemical analysis results and a number of established rules. The detailed COC selection and effluent concentration determination process were presented in Appendix 7-1; the selected COCs in risk

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[6] "Acute-to-Chronic Ratio" (ACR) is the ratio of the acute toxicity of an effluent to its chronic toxicity. ACR expresses the relationship between the concentration of whole effluent toxicity causing acute toxicity to a species and the concentration of whole effluent toxicity causing chronic toxicity to the same species. An ACR is commonly used to extrapolate to a "chronic toxicity" concentration using exposure considerations and available acute toxicity when chronic toxicity data for the species of concern are unavailable.

assessments and their determined effluent concentrations were summarized in **Tables 7.3a** (for Project Scenarios 1 to 4) and **7.3b** (for Project Scenario 5).

**Table 7.3a Selected COCs and Effluent Concentrations for ERA (Project Scenarios 1 to 4)**

| **COC** | **Effluent Conc. (µg/L)** |
|---|---|
| Total residual chloride | 100 |
| Chloroform | 7 |
| Chloroacetic acid | 4 |
| Dibromoacetic acid | 4 |
| Dichloroacetic acid | 45.9 |
| Trichloroacetic acid | 22 |
| Tetrachloroethylene | 1.3 |
| Trichloroethylene | 2 |
| 2,4,6-trichlorophenol | 2 |
| Hexachlorobenzene | 0.25[a] |
| Beta-benzene hexachloride | 0.5[a] |
| Gamma-benzene hexachloride | 0.5[a] |

Note: [a]Selected COCs with concentration below detection limit in C/D effluent, their effluent concentrations were assumed to be one-half of the detection limit. This is a standard approach accepted by USEPA.

**Table 7.3b Selected COCs and Effluent Concentrations for ERA (Project Scenario 5)**

| **COC** | **Effluent Conc. (µg/L)** |
|---|---|
| Total residual chloride | 10[a] |
| Bromoform | 48.9 |
| Dibromochloromethane | 8 |
| Dibromoacetic acid | 10 |
| Dichloroacetic acid | 3 |
| Trichloroacetic acid | 7 |
| Hexachlorobenzene | 0.25[a] |
| Beta-benzene hexachloride | 0.5[a] |
| Gamma-benzene hexachloride | 0.5[a] |

Note: [a]Selected COCs with concentration below detection limit in C/D effluent, their effluent concentrations were assumed to be one-half of the detection limit. This is a standard approach accepted by USEPA.

### Risk Assessment Results

Dilution Factors for ZID and Far-field COC Concentration

7.29 As discussed in Section 5 and shown in **Figure 5.20** and **Figure 5.21**, the effluent plume from SCISTW, Tai Po/Shatin STW and Pillar Point STW would not overlap each other. This means the CBPs potentially discharged from Tai Po/Shatin STW and Pillar Point STW (if chlorination is adopted as the disinfection technology under the assumed worst-case scenario) would not significantly contribute to the CBP concentrations at the edge of ZID, edge of mixing zone (of the effluent plume from SCISTW) and the Tsuen Wan beaches, which would be due to the C/D CEPT effluent from SCISTW.

7.30 Therefore, it is appropriate to apply the dilution factors calculated by water quality modelling at different exposure points (i.e. edge of ZID, edge of mixing zone and the nearest beach from SCISTW outfall) to calculate the contamination concentration.

7.31 In ERA – Aquatic Life, the risk of individual COCs was characterized by hazard quotient which was composed of COC concentration at exposure point as numerator and the derived COC-specific toxicity reference value (TRV) as denominator. The averaging time of COC concentration at exposure point used for hazard quotient calculation should match the averaging time of the TRV of the corresponding COC. **Table 7.4** summarized the averaging time of different TRVs and the corresponding dilution factor for COC concentration calculation. Calculations of hazard quotient and derivation of COC-specific TRV are presented in **Appendix 7-1** and **Annex B** respectively.

**Table 7.4 Averaging Time of TRVs and Corresponding Dilution Factor**

| **TRV Averaging Time** | **Dilution Factor at Edge of ZID** | **Dilution Factor at Edge of Mixing Zone** |
|---|---|---|
| Daily (maximum) | Minimum dilution factor in dry and wet season | Minimum dilution factor in dry and wet season |
| 4-day | Minimum dilution factor in dry and wet season$^a$ | Minimum 4-day average dilution factor in dry and wet season |
| Annual | Annual weighted average dilution factor | Annual weighted average dilution factor |
| "To be complied at least 90% of occasions" | 10 %tile dilution factor in dry and wet season$^b$ | 10 %tile dilution factor in dry and wet season$^b$ |
| Seasonal$^c$ | The lower value of weight average dilution factor estimated for dry season and that of wet season | The lower value of weight average dilution factor estimated for dry season and that of wet season |

Note: [a] Minimum dilution factor was adopted as a conservative estimate
[b] Dilution factor exceeded 90% of the time (i.e. 10% of values are below this value)
[c] For COC without water quality standard/criteria, which TRV was derived from toxicity data

7.32 10 %tile dilution factors (dry and wet season combined) achieved at the ZID were adopted for calculation of risk imposed to marine mammals**,** such approach has been adopted in previous relevant studies CDM (2004) and Montgomery Watson (1998). Since COC exposure by marine mammals occurs in both wet and dry season, dry and wet season combined dilution factors were adopted. Adopting 10 %tile dilution factor for risk calculation is an approach consistent with previous studies, which results in a more realistic yet conservative range of risk calculations.

7.33 **Tables 7.5a** to **7.5d** presented the estimated dilution factors at various exposure points for Project Scenarios 1 to 5 described in Section 7.8.

**Table 7.5a Estimated Dilution Factors (Project Scenario 1)**

| **Exposure Point** | **Season** | **Min. Dilution Factor** | **10 %tile Dilution Factor$^a$** | **Average Dilution Factor** | **Min. 4-day Average Dilution Factor** |
|---|---|---|---|---|---|
| Edge of ZID | Dry and Wet Season Combined | $47^b$ | $53^c$ | $74^d$ | Cannot be determined by near field model |
| | Dry Season | Not calculated – not used for risk assessments | | $83^e$ | |
| | Wet Season | | | $62^e$ | |
| Edge of Mixing Zone* | Dry and Wet Season Combined | $62^f$ | $115^g$ | $182^h$ | 197 |
| | Dry Season | 83 | 109 | $170^i$ | $197^j$ |
| | Wet Season | 62 | 125 | $193^i$ | $234^j$ |

**Table 7.5b Estimated Dilution Factors (Project Scenario 2)**

| **Exposure Point** | **Season** | **Min. Dilution Factor** | **10 %tile Dilution Factor$^a$** | **Average Dilution Factor** | **Min. 4-day Average Dilution Factor** |
|---|---|---|---|---|---|
| Edge of ZID | Dry and Wet Season Combined | $48^b$ | $53^c$ | $79^d$ | Cannot be determined by near field model |
| | Dry Season | Not calculated – not used for risk assessments | | $92^e$ | |
| | Wet Season | | | $62^e$ | |
| Edge of Mixing Zone* | Dry and Wet Season Combined | $60^f$ | $110^g$ | $173^h$ | 188 |
| | Dry Season | 79 | 103 | $162^i$ | $188^j$ |
| | Wet Season | 60 | 118 | $184^i$ | $222^j$ |

**Table 7.5c Estimated Dilution Factors (Project Scenario 3)**

| **Exposure Point** | **Season** | **Min. Dilution Factor** | **10 %tile Dilution Factor**[a] | **Average Dilution Factor** | **Min. 4-day Average Dilution Factor** |
|---|---|---|---|---|---|
| Edge of ZID | Dry and Wet Season Combined | 36[b] | 49[c] | 61[d] | Cannot be determined by near field model |
| | Dry Season | Not calculated – not used for risk assessments | | 65[e] | |
| | Wet Season | | | 57[e] | |
| Edge of Mixing Zone* | Dry and Wet Season Combined | 50[f] | 74[g] | 118[h] | 130 |
| | Dry Season | 53 | 69 | 111[i] | 130[j] |
| | Wet Season | 50 | 81 | 124[i] | 152[j] |

**Table 7.5d Estimated Dilution Factors (Project Scenarios 4 and 5)**

| **Exposure Point** | **Season** | **Min. Dilution Factor** | **10 %tile Dilution Factor**[a] | **Average Dilution Factor** | **Min. 4-day Average Dilution Factor** |
|---|---|---|---|---|---|
| Edge of ZID | Dry and Wet Season Combined | 34[b] | 46[c] | 61[d] | Cannot be determined by near field model |
| | Dry Season | Not calculated – not used for risk assessments | | 66[e] | |
| | Wet Season | | | 53[e] | |
| Edge of Mixing Zone* | Dry and Wet Season Combined | Cannot be determined as no mixing zone determined for dry season | | | |
| | Dry Season | No mixing zone determined | | | |
| | Wet Season | 43[f] | 64[g] | 104[h,i] | 127[j] |

Note: *The edge of mixing zone of bromoform (the COC with the largest mixing zone)

[a] Dilution factor exceeded 90% of the time (i.e. 10% of values are below this value)

[b] Applied to (1) assess the compliance of criteria for acute toxicity, (2) determine COC conc. at edge of ZID (COCs with established water quality criteria having daily and 4-day averaging time, for calculation in ERA – Aquatic Life)

[c] Applied to (1) determine COC conc. at edge of ZID (for calculation in ERA – Marine Mammals), (2) determine COC conc. at edge of ZID (COCs with established water quality criteria that need to be complied at least 90% of occasions, for calculation in ERA – Aquatic Life)

[d] Applied to determine COC conc. at edge of ZID (COC with established water quality criteria having annual averaging time, for calculation in ERA – Aquatic Life)

[e] The lower value was applied to determine COC conc. at edge of ZID (COC with toxicity reference value derived from toxicity data, for calculation in ERA – Aquatic Life)

[f] Applied to determine COC conc. at edge of mixing zone (COCs with established water quality criteria having daily averaging time, for calculation in ERA – Aquatic Life)

[g] Applied to determine COC conc. at edge of mixing zone (COCs with established water quality criteria that need to be complied at least 90% of occasions, for calculation in ERA – Aquatic Life)

[h] Applied to determine COC conc. at edge of mixing zone (COC with established water quality criteria having annual averaging time, for calculation in ERA – Aquatic Life)

[i] Applied to determine COC conc. at edge of mixing zone (COC with toxicity reference value derived from toxicity data, for calculation in ERA – Aquatic Life)

[j] Applied to (1) assess the compliance of criteria for chronic toxicity, (2) determine COC conc. at edge of mixing zone (COCs with established water quality criteria having 4-day averaging time, for calculation in ERA – Aquatic Life)

7.34 The edge of ZID is defined as the point when the plume reached the water surface or reached the maximum rise height. It can be observed from **Tables 7.5a** to **7.5d** that estimated highest initial dilution factors would not occur at the scenario with the lowest effluent flow. It is because the jet velocity would be smaller under the lowest effluent flow condition and there was not enough momentum for the effluent plume to reach the upper water layer. Under a higher effluent flow condition, the effluent plume may have larger momentum to induce more mixing and better dilution. This is an important factor influencing the initial dilution rate particularly in dry season where the effluent plume would have weaker buoyancy and would easily trap in the lower water layer if there is not enough jet velocity.

Ecological Risk Assessment – Aquatic Life

7.35 In the ERA – Aquatic Life, HQ due to exposure of individual selected COCs and HI due to exposure of all selected COCs by aquatic life at the edge of mixing zone[7] were determined for all the 5 project scenarios. The detailed assessment results were presented in **Appendix 7-2**. **Tables 7.6a** to **7.6e** presented the summarized results for the 5 project scenarios.

**Table 7.6a Estimated HQ and HI to Aquatic Life (Project Scenario 1) due to Potential CBPs**

| **COC** | **HQ in Edge of Mixing Zone** |
|---|---|
| Total Residual Chlorine | 0.124 |
| Chloroform | 0.00321 |
| Chloroacetic acid | 0.0000007 |
| Dibromoacetic acid | 0.0000341 |
| Dichloroacetic acid | 0.00117 |
| Trichloroacetic acid | 0.00000139 |
| Tetrachloroethylene | 0.000807 |
| Trichloroethlyene | 0.00110 |
| 2,4,6-trichlorophenol | 0.000972 |
| Hexachlorobenzene | 0.0458 |
| Beta-benzene hexachloride | 0.0597 |
| Gamma-benzene hexachloride | 0.0436 |
| Total HI | 0.280 |

**Table 7.6b Estimated HQ and HI to Aquatic Life (Project Scenario 2) due to Potential CBPs**

| **COC** | **HQ in Edge of Mixing Zone** |
|---|---|
| Total Residual Chlorine | 0.128 |
| Chloroform | 0.00337 |
| Chloroacetic acid | 0.0000008 |
| Dibromoacetic acid | 0.0000358 |
| Dichloroacetic acid | 0.00123 |
| Trichloroacetic acid | 0.0000015 |
| Tetrachloroethylene | 0.000849 |
| Trichloroethlyene | 0.00116 |
| 2,4,6-trichlorophenol | 0.00102 |
| Hexachlorobenzene | 0.0482 |
| Beta-benzene hexachloride | 0.0628 |
| Gamma-benzene hexachloride | 0.0459 |
| Total HI | 0.293 |

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[7] The mixing zone of dichloroacetic acid (the largest one among those of other COCs) was adopted for risk calculations for Scenarios 1 to 4; whereas the mixing of bromoform (the largest one among those of other COCs) was adopted for risk calculations for Scenario 5. The same mixing zones were adopted for cumulative risk impact assessment.

**Table 7.6c Estimated HQ and HI to Aquatic Life (Project Scenario 3) due to Potential CBPs**

| COC | HQ in Edge of Mixing Zone |
|---|---|
| Total Residual Chlorine | 0.154 |
| Chloroform | 0.00494 |
| Chloroacetic acid | 0.0000011 |
| Dibromoacetic acid | 0.0000522 |
| Dichloroacetic acid | 0.00180 |
| Trichloroacetic acid | 0.00000213 |
| Tetrachloroethylene | 0.00124 |
| Trichloroethlyene | 0.00169 |
| 2,4,6-trichlorophenol | 0.00149 |
| Hexachlorobenzene | 0.0706 |
| Beta-benzene hexachloride | 0.0921 |
| Gamma-benzene hexachloride | 0.0673 |
| Total HI | 0.395 |

**Table 7.6d Estimated HQ and HI to Aquatic Life (Project Scenario 4) due to Potential CBPs**

| COC | HQ in Edge of Mixing Zone |
|---|---|
| Total Residual Chlorine | 0.179 |
| Chloroform | 0.00561 |
| Chloroacetic acid | 0.0000012 |
| Dibromoacetic acid | 0.0000557 |
| Dichloroacetic acid | 0.00192 |
| Trichloroacetic acid | 0.0000023 |
| Tetrachloroethylene | 0.00141 |
| Trichloroethlyene | 0.00192 |
| 2,4,6-trichlorophenol | 0.00159 |
| Hexachlorobenzene | 0.0801 |
| Beta-benzene hexachloride | 0.105 |
| Gamma-benzene hexachloride | 0.0763 |
| Total HI | 0.452 |

**Table 7.6e Estimated HQ and HI to Aquatic Life (Project Scenario 5) due to Potential CBPs**

| COC | HQ in Edge of Mixing Zone |
|---|---|
| Total Residual Chlorine | 0.0179 |
| Bromoform | 0.00131 |
| Dibromochloromethane | 0.00226 |
| Dibromoacetic acid | 0.000139 |
| Dichloroacetic acid | 0.000125 |
| Trichloroacetic acid | 0.0000007 |
| Hexachlorobenzene | 0.0801 |
| Beta-benzene hexachloride | 0.105 |
| Gamma-benzene hexachloride | 0.0763 |
| Total HI | 0.283 |

7.36 As seen in **Tables 7.6a** to **7.6e**, the hazard index to aquatic life at the edge of mixing zone was found to be lower than the screening value in all project scenarios. Hence, the ecological risk to aquatic life due to the Project was considered to be acceptable.

### Ecological Risk Assessment – Marine Mammals

7.37 In the ERA – Marine Mammals, HQ due to exposure of individual selected COCs and HI due to exposure of all selected COCs by marine mammals were determined for all the 5 project scenarios. The detailed assessment results were presented in Appendix 7-3. **Tables 7.7a** and **7.7b** presented the summarized results for the 5 project scenarios.

**Table 7.7a Estimated HQ and HI for Marine Mammals (Dolphins) due to Potential CBPs**

| | **HQ** | | | | |
|---|---|---|---|---|---|
| **COC** | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** | **Scenario 5** |
| Total Residual Chlorine | 0.0000031 | 0.0000031 | 0.0000034 | 0.0000036 | 0.0000004 |
| Bromoform | - | - | - | - | 0.0000178 |
| Chloroform | 0.0000038 | 0.0000038 | 0.0000042 | 0.0000042 | - |
| Dibromochloromethane | - | - | - | - | 0.0000028 |
| Chloroacetic acid | 0.0000029 | 0.0000029 | 0.0000031 | 0.0000033 | - |
| Dibromoacetic acid | 0.0000472 | 0.0000472 | 0.0000510 | 0.0000543 | 0.000136 |
| Dichloroacetic acid | 0.000185 | 0.000185 | 0.000200 | 0.000213 | 0.0000139 |
| Trichloroacetic acid | 0.0000818 | 0.0000818 | 0.0000884 | 0.0000942 | 0.0000300 |
| Tetrachloroethylene | 0.0000047 | 0.0000047 | 0.0000051 | 0.0000055 | - |
| Trichloroethlyene | 0.0000006 | 0.0000006 | 0.0000007 | 0.0000007 | - |
| 2,4,6-trichlorophenol | 0.0000002 | 0.0000002 | 0.0000002 | 0.0000002 | - |
| Hexachlorobenzene | 0.000618 | 0.000618 | 0.000669 | 0.000712 | 0.000712 |
| Beta-benzene hexachloride | 0.000221 | 0.000221 | 0.000239 | 0.000254 | 0.000254 |
| Gamma-benzene hexachloride | 0.0000247 | 0.0000247 | 0.0000267 | 0.0000284 | 0.0000284 |
| Total HI | 0.00119 | 0.00119 | 0.00129 | 0.00137 | 0.00120 |

**Table 7.7b Estimated HQ and HI for Marine Mammals (Porpoises) due to Potential CBPs**

| | **HQ** | | | | |
|---|---|---|---|---|---|
| **COC** | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** | **Scenario 5** |
| Total Residual Chlorine | 0.0000019 | 0.0000019 | 0.0000020 | 0.0000022 | 0.0000002 |
| Bromoform | - | - | - | - | 0.0000097 |
| Chloroform | 0.0000020 | 0.0000020 | 0.0000022 | 0.0000023 | - |
| Dibromochloromethane | - | - | - | - | 0.0000015 |
| Chloroacetic acid | 0.0000016 | 0.0000016 | 0.0000017 | 0.0000018 | - |
| Dibromoacetic acid | 0.0000248 | 0.0000248 | 0.0000269 | 0.0000286 | 0.0000716 |
| Dichloroacetic acid | 0.0000961 | 0.0000961 | 0.000104 | 0.000111 | 0.0000072 |
| Trichloroacetic acid | 0.0000361 | 0.0000361 | 0.0000391 | 0.0000416 | 0.0000132 |
| Tetrachloroethylene | 0.0000027 | 0.0000027 | 0.0000029 | 0.0000031 | - |
| Trichloroethlyene | 0.0000003 | 0.0000003 | 0.0000004 | 0.0000004 | - |
| 2,4,6-trichlorophenol | 0.0000002 | 0.0000002 | 0.0000002 | 0.0000002 | - |
| Hexachlorobenzene | 0.000442 | 0.000442 | 0.000478 | 0.000509 | 0.000509 |
| Beta-benzene hexachloride | 0.000130 | 0.000130 | 0.000140 | 0.000150 | 0.000150 |
| Gamma-benzene hexachloride | 0.0000140 | 0.0000140 | 0.0000151 | 0.0000161 | 0.0000161 |
| Total HI | 0.000751 | 0.000751 | 0.000813 | 0.000866 | 0.000778 |

7.38 As seen in **Tables 7.7a** and **7.7b**, the hazard index to marine mammals was found to be lower than the screening value in all project scenarios. Hence, the ecological risk to marine mammals due to the Project was considered to be acceptable.

### Compliance Assessment on Water Quality Criteria – Acute and Chronic Toxicity

7.39 As discussed in **Sections 7.20** and **7.21**, the TUa and TUc value adopted for the C/D CEPT effluent was 2.49 and 24.9 respectively. No TUa and TUc could be determined for C/D secondary treated effluent from the WETT result because it generally did not exert acute and chronic toxicity effect to the species tested. To evaluate the compliance of acute and chronic toxicity criteria, the estimated minimum dilution factor at edge of ZID and minimum 4-day average dilution factor at edge of mixing zone were used to determine the resultant acute and chronic toxicities at these two locations. **Table 7.8** presented the acute and chronic toxicity results in the 5 project scenarios.

**Table 7.8 Acute and Chronic Toxicities at Edge of ZID and Edge of Mixing Zone**

| Project Scenario | Acute Toxicity at Edge of ZID | Chronic Toxicity at Edge of Mixing Zone |
|---|---|---|
| Scenario 1 | 2.49 / 47 = 0.053 | 24.9 / 197 = 0.126 |
| Scenario 2 | 2.49 / 48 = 0.052 | 24.9 / 188 = 0.132 |
| Scenario 3 | 2.49 / 36 = 0.069 | 24.9 / 130 = 0.192 |
| Scenario 4 | 2.49 / 34 = 0.073 | 24.9 / 127 = 0.196 |
| Scenario 5 | - | - |

7.40 As observed in **Table 7.8**, the estimated acute toxicity at edge of ZID and chronic toxicity at edge of mixing zone were below the established criteria (TUa < 0.3 at edge of ZID, TUc < 1.0 at edge of mixing zone) in Project Scenarios 1 to 4. As discussed above, since C/D secondary treated effluent did not exert acute and chronic toxicity effect to marine species tested, non-compliance of acute and chronic toxicity criteria in Project Scenario 5 would not be expected.

### Cumulative Impacts

7.41 While the assessment focused on assessing the potential risks/impacts to ecological resources due to chronic exposure to the contaminants produced in the disinfection process in the HATS effluent discharge, cumulative impact of the possible C/D effluent discharge from Tai Po/Shatin Sewage Treatment Works (TP/ST STW), Pillar Point Sewage Treatment Works (PPSTW) and other pollutants (not related to the disinfection process) in the effluent discharge from SCISTW was considered and evaluated.

Cumulative Impact of the Possible C/D Effluent Discharge from TP/STSTW and PPSTW

7.42 Results of water quality modelling showed that the effluent plume from SCISTW, TP/ST STW and PPSTW would not overlap each other. The results indicated that CBPs potentially discharged from TP/ST STW and PPSTW (if chlorination is adopted as the disinfection technology under assumed worst-case scenario) would not significantly contribute to the concentration of CBPs at the edge of ZID, edge of mixing zone (of the effluent plume from SCISTW) and the Tsuen Wan beaches. Therefore, possible C/D effluent from the TP/ST STW would not induce cumulative impact with the C/D effluent from SCISTW.

7.43 The evaluation above is further supported by the findings of approved EIA Study for Tai Po Sewage Treatment Works - Stage V. The EIA Study for TPSTW Stage V indicated that the impact from the TPSTW and STSTW effluent would be very localized and confined within the Kai Tak Approach Channel and the existing Kwun Tong Typhoon Shelter. The effluent plume from SCISTW and TPSTW/STSTW would not overlap with each other.

Cumulative Impact of Other Pollutants in SCISTW Effluent

7.44 Apart from potential CBPs generated in the C/D process, other pollutants (not related to C/D process) in the HATS effluent would also impose risks to ecological resources. The cumulative impact due to the risks from CBPs and other pollutants present in the HATS effluent was considered and evaluated.

7.45 A comprehensive chemical analysis was conducted under CDM (2004) to determine the pollutant concentrations in HATS CEPT effluent (Stage 1 and Stage 2A) and CEPT plus Biological Aerated Filters (BAF) effluent (Stage 2B). The chemical analysis data from the previous study was used to evaluate the cumulative impact.

7.46 The methodology for cumulative risk impact assessment was similar to the one presented in **Appendix 7-1**. Additional information for the cumulative risk impact assessment was presented **Appendix 7-4**.

Aquatic Life

7.47 The detailed assessment results were presented in **Appendix 7-5**. **Tables 7.9a** to **7.9d** presented the summarized results for the 5 project scenarios.

**Table 7.9a Estimated HQ and HI to Aquatic Life (Project Scenario 1, due to CBPs and other Pollutants)**

| | HQ | | | |
|---|---|---|---|---|
| **COC** | **Edge of Mixing Zone[a] – due to the Project** | **Edge of Mixing Zone[a] – due to CEPT effluent (without CBP)** | **Background[b]** | **Total (due to Project + CEPT effluent + background)** |
| CBPs | 0.280 | - | 0 | 0.28 |
| Aluminium | - | 0.00006 | 0.0104 | 0.01046 |
| Antimony | - | 0.0000009 | 0.0000600 | 0.0000609 |
| Barium | - | 0.00003 | 0.00133 | 0.00136 |
| Chromium III | - | 0.00192 | 0.0102 | 0.01212 |
| Copper | - | 0.01494 | 0.00400 | 0.01894 |
| Lead | - | 0.00008 | 0.00679 | 0.00687 |
| Nickel | - | 0.04557 | 0.154 | 0.19957 |
| Selenium | - | 0.00002 | 0.000986 | 0.001006 |
| Silver | - | 0.00071 | 0.00429 | 0.005 |
| Tin | - | 0.00006 | 0.00172 | 0.00178 |
| Vanadium | - | 0.00162 | 0.0173 | 0.01892 |
| Zinc | - | 0.00613 | 0.119 | 0.12513 |
| Ammonia | - | 0.13283 | 0.253 | 0.38583 |
| Sulphide | - | 0.28824 | 0.480 | 0.76824 |
| Dioxins and Furans | - | 0.00002 | 0.00103 | 0.00105 |
| Toluene | - | 0.00165 | 0 | 0.00165 |
| Diazinon | - | 0.02637 | 0 | 0.02637 |
| Malathion | - | 0.00852 | 0 | 0.00852 |
| Total HI | 0.280 | 0.529 | 1.06 | 1.87 |

**Table 7.9b Estimated HQ and HI to Aquatic Life (Project Scenario 2, due to CBPs and other Pollutants)**

| | HQ | | | |
|---|---|---|---|---|
| **COC** | **Edge of Mixing Zone[a] – due to the Project** | **Edge of Mixing Zone[a] – due to CEPT effluent (without CBP)** | **Background[b]** | **Total (due to Project + CEPT effluent + background)** |
| CBPs | 0.293 | - | 0 | 0.293 |
| Aluminium | - | 0.00006 | 0.0104 | 0.01046 |
| Antimony | - | 0.000001 | 0.0000600 | 0.000061 |
| Barium | - | 0.00003 | 0.00133 | 0.00136 |
| Chromium III | - | 0.00202 | 0.0102 | 0.01222 |
| Copper | - | 0.01562 | 0.00400 | 0.01962 |
| Lead | - | 0.00008 | 0.00679 | 0.00687 |
| Nickel | - | 0.04764 | 0.154 | 0.20164 |
| Selenium | - | 0.00002 | 0.000986 | 0.001006 |
| Silver | - | 0.00075 | 0.00429 | 0.00504 |
| Tin | - | 0.00006 | 0.00172 | 0.00178 |
| Vanadium | - | 0.00171 | 0.0173 | 0.01901 |
| Zinc | - | 0.00641 | 0.119 | 0.12541 |
| Ammonia | - | 0.13974 | 0.253 | 0.39274 |
| Sulphide | - | 0.30247 | 0.480 | 0.78247 |
| Dioxins and Furans | - | 0.00002 | 0.00103 | 0.00105 |
| Toluene | - | 0.00173 | 0 | 0.00173 |
| Diazinon | - | 0.02775 | 0 | 0.02775 |

| | | | | |
|---|---|---|---|---|
| Malathion | - | 0.00896 | 0 | 0.00896 |
| Total HI | 0.293 | 0.555 | 1.06 | 1.91 |

**Table 7.9c Estimated HQ and HI to Aquatic Life (Project Scenario 3, due to CBPs and other Pollutants)**

| | HQ | | | |
|---|---|---|---|---|
| **COC** | **Edge of Mixing Zone[a] – due to the Project** | **Edge of Mixing Zone[a] – due to CEPT effluent (without CBP)** | **Background[b]** | **Total (due to Project + CEPT effluent + background)** |
| CBPs | 0.395 | - | 0 | 0.395 |
| Aluminium | - | 0.00009 | 0.0104 | 0.01049 |
| Antimony | - | 0.000001 | 0.0000600 | 0.000061 |
| Barium | - | 0.00004 | 0.00133 | 0.00137 |
| Chromium III | - | 0.00296 | 0.0102 | 0.01316 |
| Copper | - | 0.02322 | 0.00400 | 0.02722 |
| Lead | - | 0.00012 | 0.00679 | 0.00691 |
| Nickel | - | 0.07081 | 0.154 | 0.22481 |
| Selenium | - | 0.00003 | 0.000986 | 0.001016 |
| Silver | - | 0.00110 | 0.00429 | 0.00539 |
| Tin | - | 0.00009 | 0.00172 | 0.00181 |
| Vanadium | - | 0.00250 | 0.0173 | 0.0198 |
| Zinc | - | 0.00953 | 0.119 | 0.12853 |
| Ammonia | - | 0.20488 | 0.253 | 0.45788 |
| Sulphide | - | 0.44144 | 0.480 | 0.92144 |
| Dioxins and Furans | - | 0.00002 | 0.00103 | 0.00105 |
| Toluene | - | 0.00254 | 0 | 0.00254 |
| Diazinon | - | 0.04068 | 0 | 0.04068 |
| Malathion | - | 0.01314 | 0 | 0.01314 |
| Total HI | 0.395 | 0.813 | 1.06 | 2.27 |

**Table 7.9d Estimated HQ and HI to Aquatic Life (Project Scenario 4, due to CBPs and other Pollutants)**

| | HQ | | | |
|---|---|---|---|---|
| **COC** | **Edge of Mixing Zone[a] – due to the Project** | **Edge of Mixing Zone[a] – due to CEPT effluent (without CBP)** | **Background[b]** | **Total (due to Project + CEPT effluent + background)** |
| CBPs | 0.452 | - | 0 | 0.452 |
| Aluminium | - | 0.00010 | 0.0104 | 0.0105 |
| Antimony | - | 0.000002 | 0.0000600 | 0.000062 |
| Barium | - | 0.00004 | 0.00133 | 0.00137 |
| Chromium III | - | 0.00336 | 0.0102 | 0.01356 |
| Copper | - | 0.02684 | 0.00400 | 0.03084 |
| Lead | - | 0.00012 | 0.00679 | 0.00691 |
| Nickel | - | 0.08188 | 0.154 | 0.23588 |
| Selenium | - | 0.00003 | 0.000986 | 0.001016 |
| Silver | - | 0.00125 | 0.00429 | 0.00554 |
| Tin | - | 0.00010 | 0.00172 | 0.00182 |
| Vanadium | - | 0.00284 | 0.0173 | 0.02014 |
| Zinc | - | 0.01102 | 0.119 | 0.13002 |
| Ammonia | - | 0.23246 | 0.253 | 0.48546 |
| Sulphide | - | 0.47115 | 0.480 | 0.95115 |
| Dioxins and Furans | - | 0.00003 | 0.00103 | 0.00106 |
| Toluene | - | 0.00288 | 0 | 0.00288 |
| Diazinon | - | 0.04615 | 0 | 0.04615 |

| | | | | |
|---|---|---|---|---|
| Malathion | - | 0.01490 | 0 | 0.0149 |
| Total HI | 0.452 | 0.895 | 1.06 | 2.41 |

**Table 7.9e Estimated HQ and HI to Aquatic Life (Project Scenario 5, due to CBPs and other Pollutants)**

| | HQ | | | |
|---|---|---|---|---|
| **COC** | **Edge of Mixing Zone[a] – due to the Project** | **Edge of Mixing Zone[a] – due to secondary treated effluent (without CBP)** | **Background[b]** | **Total (due to Project + secondary treated effluent + background)** |
| CBPs | 0.283 | - | 0 | 0.283 |
| Antimony | - | 0.000002 | 0.0000600 | 0.000062 |
| Barium | - | 0.00005 | 0.00133 | 0.00138 |
| Chromium III | - | 0.00296 | 0.0102 | 0.01316 |
| Copper | - | 0.02072 | 0.00400 | 0.02472 |
| Nickel | - | 0.06969 | 0.154 | 0.22369 |
| Selenium | - | 0.00001 | 0.000986 | 0.000996 |
| Silver | - | 0.00068 | 0.00429 | 0.00497 |
| Tin | - | 0.00005 | 0.00172 | 0.00177 |
| Vanadium | -- | 0.00301 | 0.0173 | 0.02031 |
| Zinc | - | 0.00765 | 0.119 | 0.12665 |
| Ammonia | - | 0.04438 | 0.253 | 0.29738 |
| Sulphide | - | 0.00510 | 0.480 | 0.4851 |
| Dioxins and Furans | - | 0.00002 | 0.00103 | 0.00105 |
| Diazinon | - | 0.05577 | 0 | 0.05577 |
| Malathion | - | 0.00721 | 0 | 0.00721 |
| Total HI | 0.283 | 0.217 | 1.06 | 1.55 |

Note: [a] The mixing zone of dichloroacetic acid and bromoform (the largest one among those of other COCs) was adopted for risk calculations for Scenarios 1 to 4 and Scenario 5 respectively
[b] For COCs that were not detected in ambient seawater samples, the background concentration was set as zero for risk calculation

7.48 As seen in **Tables 7.9a** to **7.9e**, the HQ of all COCs (due to the combined effect of the Project, CEPT/secondary treated effluent and background) was calculated to be less than 1 at the edge of mixing zone, indicating that concentration of all COCs would be complied with available local/overseas water quality standards at the edge of mixing zone. A considerable portion of risk to aquatic life is contributed by the background level of contaminants in ambient water (HI of 1.06), which already exceeds the screening value. Also, it can be observed from the results that the hazard indices due to the Project (0.28 to 0.45 at edge of mixing zone) are only around 15 – 19% of the cumulative hazard indices (1.55 to 2.41 at edge of mixing zone). The results showed that the chlorination/dechlorination process would not induce a high level of incremental risk to aquatic life, because the incremental risk due to Project was found to be lower than the risk from pollutants already present in the effluent and in ambient seawater.

7.49 Taking the hazard index due to the pollutants at background level (1.06) and those due to the pollutants already presented in CEPT/secondary treated effluent (0.217 to 0.895 at edge of mixing zone) into consideration, the cumulative hazard indices to aquatic life at the edge of mixing zone in the 5 Project Scenarios were found to be slightly higher than the screening value of 1(1.55 to 2.41). Note that the hazard index due to pollutants at background level (1.06) already exceeds the screening value, the incremental hazard indices due to the Project itself are much lower than the hazard index due to pollutants at background level and are below the screening value. According to USEPA (2005), the calculated HI exceeding the screening value (in this Study: 1) would not indicate that the proposed action is not safe or that it presents an unacceptable risk. Rather, it triggers further investigation. Further investigation on the risk to aquatic life was carried out based on the results of WETT, which is able to assess the impacts caused by aggregate toxic effect of the mixture of pollutants in effluent.

7.50 As mentioned above, the WETT conducted under this Study followed the protocol agreed and adopted in previous study (including the use of artificial seawater as dilution water), which is consistent with the WETT practice accepted by USEPA. WETT is a common tool adopted in USA NPDES to regulate and monitor effluent discharges, in order to protect receiving waters against adverse impacts upon water quality and aquatic life, and also to ensure "no toxics in toxic amounts" in ambient waters.

7.51 Results of WETT on C/D effluent are useful to supplement the ecological risk assessment, which provide information to determine whether the C/D effluent would induce adverse effects to aquatic life. The WETT is capable of considering all the chemical species present in the C/D effluent (including those not identified as COC in the ERA – Aquatic Life) and the possible additive/synergistic/antagonistic interactive effects among them. As presented in **Table 7.8** above, the established toxicity criteria in all Project Scenarios were found to be well complied at both edge of ZID (0.05 to 0.07 TUa against acute toxicity criterion of 0.3 TUa) and edge of mixing zone (0.13 to 0.20 TUc against chronic criterion of 1.0 TUc). The results suggested that the potential risks due to C/D effluent imposed to aquatic life would be acceptable; with the comfortable margin (about 4/5 of the criteria value) to the established toxicity criteria, it is expected that the aquatic life present in the receiving water would not experience unacceptable toxicity even taking into account the background seawater conditions. This is further supported by the assessment results that concentration of all COCs would be complied with available local/overseas water quality standards at the edge of mixing zone. Moreover, as mentioned above, statistical analysis of WETT data revealed that C/D process did not induce additional toxicity to the sewage effluent.

7.52 In view of the findings of the ERA – aquatic life with supplement of WETT results, the potential ecological risk imposed to aquatic life due to C/D effluent would be considered acceptable.

Marine Mammals

7.53 The detailed assessment results were presented in Appendix 7-6. **Tables 7.10a** and **7.10b** presented the summarized results for the 5 project scenarios.

**Table 7.10a Estimated HQ and HI for Dolphins (due to CBPs and Other Pollutants)**

| | **HQ** | | | | |
|---|---|---|---|---|---|
| **COC** | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** | **Scenario 5** |
| Chlorination By-products | 0.00119 | 0.00119 | 0.00129 | 0.00137 | 0.00120 |
| Aluminium | 0.000109 | 0.000109 | 0.000109 | 0.000109 | - |
| Antimony | 0.0102 | 0.0102 | 0.0103 | 0.0103 | 0.0103 |
| Barium | 0.0356 | 0.0356 | 0.0357 | 0.0358 | 0.0359 |
| Chromium III | 0.0000004 | 0.0000004 | 0.0000004 | 0.0000004 | 0.0000004 |
| Copper | 0.00199 | 0.00199 | 0.00213 | 0.00226 | 0.00179 |
| Lead | 0.000464 | 0.000464 | 0.000465 | 0.000465 | 0.000294 |
| Nickel | 0.000297 | 0.000297 | 0.000307 | 0.000315 | 0.0107 |
| Selenium | 0.0112 | 0.0112 | 0.0112 | 0.0113 | 0.0107 |
| Silver | 0.0000059 | 0.0000059 | 0.0000061 | 0.0000063 | 0.00000511 |
| Tin | 0.000118 | 0.000118 | 0.000119 | 0.000119 | 0.000113 |
| Vanadium | 0.000268 | 0.000268 | 0.000273 | 0.000278 | 0.000282 |
| Zinc | 0.00491 | 0.00491 | 0.00494 | 0.00497 | 0.00479 |
| Ammonia | 0.000389 | 0.000389 | 0.000409 | 0.000427 | 0.000192 |
| Dioxins and Furans | 0.0616 | 0.0616 | 0.0618 | 0.0619 | 0.0606 |
| Toluene | 0.000176 | 0.000176 | 0.000190 | 0.000203 | - |
| Diazinon | 0.0000016 | 0.0000016 | 0.0000018 | 0.0000019 | 0.0000023 |
| Malathion | 0.00000003 | 0.00000003 | 0.00000003 | 0.00000003 | 0.00000002 |
| Total HI | 0.129 | 0.129 | 0.129 | 0.130 | 0.126 |

**Table 7.10b Estimated HQ and HI for Porpoises (due to CBPs and Other Pollutants)**

| | **HQ** | | | | |
|---|---|---|---|---|---|
| **COC** | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** | **Scenario 5** |
| Chlorination By-products | 0.000751 | 0.000751 | 0.000813 | 0.000866 | 0.000778 |
| Aluminium | 0.000045 | 0.000045 | 0.000045 | 0.000045 | - |

| | | | | | |
|---|---|---|---|---|---|
| Antimony | 0.00455 | 0.00455 | 0.00456 | 0.00457 | 0.00459 |
| Barium | 0.0174 | 0.0174 | 0.0175 | 0.0175 | 0.0176 |
| Chromium III | 0.0000001 | 0.0000001 | 0.0000002 | 0.0000002 | 0.0000001 |
| Copper | 0.00302 | 0.00302 | 0.00324 | 0.00343 | 0.00272 |
| Lead | 0.00160 | 0.00160 | 0.00161 | 0.00161 | 0.000148 |
| Nickel | 0.000150 | 0.000150 | 0.000154 | 0.000158 | 0.0213 |
| Selenium | 0.0222 | 0.0222 | 0.0223 | 0.0224 | 0.0213 |
| Silver | 0.0000073 | 0.0000073 | 0.0000075 | 0.0000077 | 0.0000063 |
| Tin | 0.0000815 | 0.0000815 | 0.0000820 | 0.0000825 | 0.0000781 |
| Vanadium | 0.000161 | 0.000161 | 0.000164 | 0.000167 | 0.000169 |
| Zinc | 0.00497 | 0.00497 | 0.00500 | 0.00503 | 0.00485 |
| Ammonia | 0.000233 | 0.000233 | 0.000245 | 0.000256 | 0.000115 |
| Dioxins and Furans | 0.0242 | 0.0242 | 0.0242 | 0.0243 | 0.0238 |
| Toluene | 0.0000717 | 0.0000717 | 0.0000775 | 0.0000826 | - |
| Diazinon | 0.0000010 | 0.0000010 | 0.0000011 | 0.0000011 | 0.0000014 |
| Malathion | 0.00000001 | 0.00000001 | 0.00000002 | 0.00000002 | 0.000000008 |
| Total HI | 0.0795 | 0.0795 | 0.0800 | 0.0806 | 0.0761 |

7.54 As seen in **Tables 7.10a** and **7.10b**, the hazard index to marine mammals was found to be lower than the screening value in all project scenarios. Hence, the ecological risk to marine mammals due to CBPs and other pollutants in HATS effluent was considered to be acceptable. Also, it can be observed that the risk due to CBPs is around 100 times lower than that due to pollutants existed in CEPT effluent. The results showed that the chlorination/dechlorination process for CEPT effluent would only induce a very low level of incremental risk to marine mammals.

**Assumptions in Risk Assessments**

Ecological Risk Assessment – Aquatic Life

7.55 A description of the assumptions associated with the ERA – Aquatic Life is presented below.

- For each COC, the maximum effluent concentration and the maximum background concentration were used to calculate the COC concentration at exposure point. This conservative approach yielded higher estimated risk than using mean concentrations.

- It was assumed that after the effluent is discharged, COCs in the effluent would only have their concentrations decrease as a result of dilution and dispersion. It was a conservative approach because COCs concentrations in the water column would also decrease because of different mechanisms such as degradation and / or volatilization.

- While calculating the risk to aquatic life at edge of mixing zone, the aquatic organisms were assumed to live their entire lives at the mixing zone. For planktonic and pelagic organisms that are mobile or migratory (e.g. zooplankton, fish), this assumption would overestimate the risk. In addition, some organisms may exhibit avoidance behaviour toward some chemicals, and their home range may extend beyond the mixing zone.

- Since a list of “regulated CBPs in sewage effluent” is not available locally or overseas, the COPC identification was based on literature search of documented potential CBPs[8] and regulatory practice of chlorinated organic substances in drinking water/sewage effluent[9]. This approach was conservative, as it may include chemicals that actually are not produced as COPC by chlorination of HATS effluent, as reflected by the fact that most of the identified COPC were not detected in C/D effluent. Nevertheless, for the purposes of the risk assessment, a concentration equivalent to half of the analytical detection limit of each undetected COC was adopted in the risk calculation. This conservative approach served to counter the possibility

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[8] Some of the documented potential CBPs were generated by applying very high chlorine dose (in the order of hundreds or thousands mg/L ) to sewage effluent, which would not occur in the HATS scenario.

[9] Regulation of chlorinated organic substances was due to their presence in industrial effluent but not their possible generation in chlorination process.

that some chemicals from chlorination of HATS effluent may be present but were not included as a COPC in the risk calculation. Overall, in line with common practice, this approach to COPC identification is considered sufficiently comprehensive to assess the potential risk to ecological resources.

- The COC concentrations of chlorinated/dechlorinated effluent were obtained from a number of bench scale process simulating the C/D treatment using a higher hypochlorite dosage (higher than the dosage in actual full-scale process implementation) to provide conservatism.
- Dilution factor estimated by water quality modelling was used to predict the COC dispersion in water and the COC concentrations at exposure points. Computer models are sophisticated tools used to simulate mother-nature, and uncertainties inherent in these models have been minimized by vigorous model calibration and verification.
- The total hazard index to aquatic life was determined by summing COC-specific hazard quotients that were calculated utilizing TRVs based on different effects, toxicity endpoints and/or exposure durations. This approach to calculate hazard index is a well-established practice for risk characterization, which has been adopted in similar ecological risk assessments internationally. In addition, the compliance of acute and chronic toxicity water quality criteria suggests that the potential risk due to C/D HATS effluent imposed to aquatic life would be acceptable.

Ecological Risk Assessment – Marine Mammals

7.56 A description of the assumptions associated with the ERA – Marine Mammals is presented below.

- For each COC, the maximum effluent concentration and the maximum background concentration were used to calculate the COC concentration at exposure point. This conservative approach yielded higher estimated risk than using mean concentrations.
- It was assumed that after the effluent is discharged, COCs in the effluent would only have their concentrations decrease as a result of dilution and dispersion. It was a conservative approach because COCs concentrations in the water column would also decrease because of different mechanisms such as degradation and / or volatilization.
- Calculated COC concentration in preys of marine mammals are based on the bioconcentration factors derived primarily from laboratory experiments in which test animals are continuously exposed to relatively high concentration of COCs. In the marine environment, exposures to relatively high concentration of COCs are probably limited to areas immediately adjacent to the outfall. These laboratory tests are therefore conservative in deriving the bioconcentration factors for preys living in the open sea.
- The area use factors for dolphin (0.25) and porpoise (0.15) adopted from Montgomery Watson (1998) are considered to be conservative in view of their wide home range[10], relative small area size of the ZID (less than 0.1km$^2$) and the fact that western harbour area is not a predominant habitat for dolphins and porpoises[11]. Even an unrealistically conservative area use factor of 1 (i.e. assume the marine mammals spend their whole live within the initial dilution zone) is adopted, the calculated hazard index is still less than the screening value of 1.
- Since a list of "regulated CBPs in sewage effluent" is not available locally or overseas, the COPC identification was based on literature search of documented potential CBPs and regulatory practice of chlorinated organic substances in drinking water/sewage effluent. This approach was conservative, as it may include chemicals that actually are not produced as

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[10] The dolphins were observed from northern, western and southwestern Lantau Island where highest concentrations of sightings were made, to southern Hong Kong Island and Western Buffer Water Control Zone where very few individuals were observed. The porpoise were found primarily in the southern and eastern waters of Hong Kong, and are also sighted in adjacent Chinese waters just south of Hong Kong. (refers to Section 8 for details).

[11] Less than 3 dolphin individuals per 100km$^2$ were recorded in Western Buffer Water Control Zone within 3 years surveying effort (refers to Section 8 for details).

COPC by chlorination of HATS effluent, as reflected by the fact that most of the identified COPC were not detected in C/D effluent. Nevertheless, for the purposes of the risk assessment, a concentration equivalent to half of the analytical detection limit of each undetected COC was adopted in the risk calculation. This conservative approach served to counter the possibility that some chemicals from chlorination of HATS effluent may be present but were not included as a COPC in the risk calculation. Overall, in line with common practice, this approach to COPC identification is considered sufficiently comprehensive to assess the potential risk to ecological resources.

- The COC concentrations of chlorinated/dechlorinated effluent were obtained from a number of bench scale process simulating the C/D treatment using a higher hypochlorite dosage (higher than the dosage in actual full-scale process implementation) to provide conservatism.

- Dilution factor estimated by water quality modelling was used to predict the COC dispersion in water and the COC concentrations at exposure points. Computer models are sophisticated tools used to simulate mother-nature, and uncertainties inherent in these models have been minimized by vigorous model calibration and verification. Also, the approach of using 10%tile dilution factor[12] for risk calculation is a conservative approach that provides conservative risk estimates.

- Toxicity data specific to the dolphin or porpoise were not available. Therefore, toxicity data for surrogate species were used to derive toxicity reference dose (TRD) for hazard quotient calculation in the risk assessment. The use of toxicity data for surrogate species[13] may induce uncertainties. However, it should be noted that safety factors (from 0.0125 to 0.125[14]) were applied in the course of derivation of TRD to provide conservatism.

- Much of the information on the estimated fraction of fish and shellfish consumed by the dolphin and porpoise was based on data from stranded animals. Since stranded dolphins and/or porpoises are usually sick and stressed, they may not consume food in the same quantity or proportions as unstressed animals. Therefore, the type of food found in their stomachs may not be representative of the typical diet taken by active healthy animals. In addition, stomach contents are usually at least partially decomposed, making it very difficult to identify accurately the organisms that were consumed. Nevertheless, the fish / shellfish consumption fraction was estimated based on the best available data, which is an established practice for assessment of this kind.

- Ingestion rates (0.065 kg food/kg body weight/d for dolphins; 0.075 kg food/kg body weight/d for porpoises) were based on best available data. The ingestion rates adopted are considered on the conservative side as in similar ecological risk assessment studies.

7.57 In summary the ecological risk assessment for aquatic life and marine mammals by design is very protective of ecological resources by overstating potential exposures and risks. Conservative assumptions made in the risk assessment include (i) adopting maximum effluent concentration and background seawater concentration for risk calculation; (ii) assuming COCs in effluent would only have their concentrations decrease as a result of dilution and dispersion; (iii) applying conservative exposure parameters (i.e. assumes aquatic life live their entire lives at the mixing zone and assumes conservative area use factor for marine mammals). Despite uncertainties involved in some aspects of the risk assessment, conservative treatments (e.g. applied safety factors in derivation of toxicity reference dose) were applied where appropriate. The ecological risk assessment represents the most useful tool that can be used to determine and protectively manage the risk to ecological resources. It is considered that the ecological risk assessment overall provided a conservative estimate of risk level and would not underestimate the risk.

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[12] The 10%tile dilution factor is exceeded 90% of the time

[13] Details of the TRD derivation (including the surrogate species used) are presented in Annex C.

[14] The use of safety factors (from 0.0125 to 0.125) reduced the derived TRD by 8 to 80 times. Lower TRD will lead to higher calculated hazard quotient in the risk calculation.

### Evaluation of Residual Impacts

7.58 The above ecological risk assessment (with supplementation of WETT results) indicated that calculated risks of all scenarios were found to be acceptable under the established criteria. In view that the inherent conservative ecological risk assessment indicated acceptable ecological risk levels, no residual impact from the Project on ecological resources is anticipated.

### Mitigation of Environmental Impact

7.59 Dechlorination process was incorporated into the effluent disinfection process to remove TRC and reduce formation of CBPs. As discussed above there would be no unacceptable ecological risk induced by the Project and therefore no mitigation measures would be required.

### Environmental Monitoring and Auditing

7.60 It is recommended to establish a monitoring programme to determine whether the Project would induce increase of TRC and CBP concentrations in seawater and to verify the predictions of the risk assessment. Details of the programme are provided in a stand-alone EM&A Manual.

### Conclusions

7.61 A detailed risk assessment was conducted to assess the potential adverse ecological effects that may result from exposure of toxic substances due to HATS effluent discharge. The findings were summarized below:

#### Ecological Risk – Aquatic Life

7.62 According to the findings of Ecological Risk Assessment – Aquatic Life, potential risk to aquatic life due to CBPs present in C/D HATS effluent would be lower than the screening value and considered acceptable. Cumulative risk assessment revealed that CBPs and other pollutants present in the C/D HATS effluent, together with the pollutants present in the ambient water, may induce a total hazard index level above the screening value of 1.0. It was noted that hazard index to aquatic life due to pollutants present in the background already exceeds the screening value. Effluent discharge from SCISTW would only induce low incremental risk (i.e. hazard quotient < 1) at edge of mixing zone for all pollutants considered, indicating that concentration of CBPs and pollutants would be complied with available local/overseas water quality standards at the edge of mixing zone.

7.63 According to USEPA (2005), the calculated HI exceeding the screening value would not indicate that the proposed action is not safe or that it presents an unacceptable risk. Rather, it triggers further investigation. Further investigation was carried out based on the results of WETT, which is able to assess the impacts caused by aggregate toxic effects of the mixture of pollutants in effluent.

7.64 Results of WETT on C/D effluent were used to supplement the findings of ERA – Aquatic Life and determine whether the C/D effluent would induce adverse effects to aquatic life. Statistical analysis of WETT data revealed that C/D process did not induce additional toxicity to the sewage effluent. Also, it was found that the established toxicity criteria were well complied at both edge of ZID and edge of mixing zone in all Project Scenarios. With the comfortable margin (about 4/5 of the toxicity criteria value) to the established toxicity criteria, it is expected that the aquatic life present in the receiving water would not experience unacceptable toxicity even taking into account the background seawater conditions. This is supported by the assessment results that concentration of all COCs would be complied with available local/overseas water quality standards at the edge of mixing zone. Therefore, the potential risks due to C/D effluent imposed to aquatic life were expected to be acceptable.

#### Ecological Risk – Marine Mammals

7.65 Results of Ecological Risk Assessment – Marine Mammals indicated that potential risk to marine mammals due to CBPs present in C/D HATS effluent would be lower than the screening value and considered acceptable. Cumulative risk assessment revealed that CBPs and other pollutants present in the C/D HATS effluent in all the 5 Project Scenarios (Hazard Index from 0.126 to 0.130 for dolphins; Hazard Index from 0.0761 to 0.0806 for porpoises) would also be lower than the screening level and considered acceptable.

7.66 According to the risk assessment results, the Project would not cause unacceptable risk to ecological resources. Therefore, the Project was considered to be environmentally acceptable in terms of risks/impacts to marine ecological resources.

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