APPENDIX 8.1 METHODOLOGY FOR ECOLOGICAL RISK ASSESSMENTS

Assessment Approach

1.1 Ecological Risk Assessment (ERA) consisted of the following phases:

- Problem Formulation
- COPC Identification and Selection of COC
- Exposure Characterization
- Ecological Effects Characterization
- Risk Characterization

1.2 The assessment approach for ERA was based on the approach suggested in the Study Brief, which is very similar to the assessment framework documented in Guidelines for Ecological Risk Assessment by USEPA (1998). The Guidelines consist of three phases: problem formulation, analysis phase (including evaluation data and models; characterization of exposure; characterization of ecological effects), risk characterization (including risk estimation; risk description).

Problem Formulation

1.3 The following tasks were accomplished in this phase:

- Establish objective of the assessment
- Establish scope of the assessment
- Establish focus of the assessment
- Construct Site Conceptual Model
- Define assessment endpoint(s)

1.4 The objective, scope and focus of the risk assessments have been discussed in **Section 8** of the EIA report.

Site Conceptual Model

1.5 The SCMs adopted in the risk assessments were presented graphically in **Figure 8.1**. As seen in the figure, there are 3 types of exposure pathway in terms of completeness and significance, namely "exposure pathway complete and significant", "exposure pathway complete, but insignificant or significance unknown" and "exposure pathway incomplete". For the exposure pathway "complete and significant", it means that contaminants can be up-taken by receptors through that pathway and the amount of uptake can be considerable to contribute to the risk level. This type of exposure pathway was considered in the risk assessment.

1.6 For the exposure pathway "complete, but insignificant or significance unknown", it means that contaminants can be up-taken by receptors through that pathway but the amount of uptake is not sufficiently large to affect the risk level or the amount of uptake through that pathway is uncertain for determining the risk level. This type of exposure pathway was not considered in the risk assessment. For the "incomplete exposure pathway", it means that the contaminants cannot be up-taken by the receptor through that pathway because there is no complete route for the contaminants to reach the receptor. This type of exposure pathway was not considered in the risk assessment.

1.7 The SCMs were presented in text as shown in **Tables 1** to **2**.

Table 1 SCM for Ecological Risk Assessment – Aquatic Life

Contaminant Source:	Effluent from the outfall of SCISTW
Receptor:	Aquatic life
Complete and Significant Exposure Media and Pathway:	• Direct contact of seawater • Gill uptake of seawater

Table 2 SCM for Ecological Risk Assessment – Marine Mammals

Contaminant Source:	Effluent from the outfall of SCISTW
Receptor:	Marine Mammals (dolphin/porpoise)
Complete and Significant Exposure Media and Pathway:	• Ingestion of seawater • Consumption of contaminated food

1.8 Direct contact (i.e. dermal exposure) with seawater was considered as a complete but insignificant pathway for marine mammals which have lungs, and therefore avoid the osmotic problem that occurs from saltwater. This is different from fish, which have gills that are relatively permeable to water. In addition, to obtain an osmotic balance with the surrounding saltwater, marine mammals must excrete water rather than take it in through dermal absorption to maintain an osmotic balance (Schmidt-Neilsen (1990) as in SSDS EIA (1998)). Therefore, the dermal exposure pathway was considered to be a "complete but insignificant pathway".

Assessment Endpoint

1.9 The assessment endpoint for the ERA – Aquatic Life is defined as protection of aquatic life at population level from chronic exposure to contaminants produced in disinfection process from SCISTW. The measurement endpoint for the ERA – Aquatic Life is the surface water concentration for a particular COC that is unlikely to produce adverse effects to any aquatic organisms over long-term chemical exposure.

1.10 The assessment endpoint for the ERA – Marine Mammals is defined as protection of marine mammals from chronic exposure of contaminants produced in disinfection process via the ingestion of diluted effluent from SCISTW and the dietary ingestion of food over a relatively long period of time. The measurement endpoint for the ERA – Marine Mammals is the dose chemical doses that are unlikely to produce adverse effects to dolphins or porpoises over long-term chemical exposure.

Identification of COPC and Selection of COC

Identification of COPC (from Chlorination/Dechlorination Process)

1.11 COPC is defined as a chemical with potential to cause adverse effects in exposed receptors. In this assessment, the COPCs identified for the chlorination/dechlorination (C/D) process is the chemicals that could be produced during the C/D process and cause adverse effects in exposed receptors.

1.12 A total of 35 chemicals have been identified as COPCs (for C/D process) in the risk assessments. The COPCs include 9 chlorination by-products (CBPs) regulated by USEPA National Primary Drinking Water Standards; 25 priority pollutants (which may contain potential CBPs) regulated by the USA National Pollutant Discharge Elimination System (NPDES)[1]; and total residual chlorine (as disinfectant residue). The list of COPCs is presented in **Table 3**.

Table 3 List of Contaminants of Potential Concern

CBPs regulated by USEPA National Primary Drinking Water Standards	Priority Pollutants listed in NPDES Permit Application Testing Requirements (40 CFR 122, Appendix D, Tables II to V), which may contain CBPs	Disinfectant Residue
Chloroform	Methylene chloride	Total residual chloride
Bromodichloromethane	Carbon tetrachloride	
Dibromochloromethane	Chlorobenzene	
Bromoform	1,1-dichloroethane	
Chloroacetic acid	1,2-dichloroethane	
Bromoacetic acid	1,1-dichloroethylene	
Dibromoacetic acid	1,2-dichloropropane	

[1] 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.

CBPs regulated by USEPA National Primary Drinking Water Standards	Priority Pollutants listed in NPDES Permit Application Testing Requirements (40 CFR 122, Appendix D, Tables II to V), which may contain CBPs	Disinfectant Residue
Dichloroacetic acid	Tetrachloroethylene	
Trichloroacetic acid	1,1,1-trichloroethane	
	1,1,2-trichloroethane	
	Trichloroethylene	
	2-chlorophenol	
	2,4-dichlorophenol	
	p-chloro-m-cresol	
	Pentachlorophenol	
	2,4,6-trichlorophenol	
	Bis(2-chloroethoxy)methane	
	1,4-dichlorobenzene	
	Hexachlorobenzene	
	Hexachlorocyclopentadiene	
	Hexachloroethane	
	1,2,4-trichlorobenzene	
	Alpha-benzene hexachloride	
	Beta-benzene hexachloride	
	Gamma-benzene hexachloride	

1.13 Unlike other conventional human health/ecological 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.

1.14 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.

1.15 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.

1.16 In short, the COPCs identified for the C/D process are the chemicals that are identified as potential CBPs in literature review and being regulated either by the USEPA National Primary Drinking Water Standards or USA NPDES. Therefore, the 35 COPCs identified from the chlorination/dechlorination process 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 (from which the COCs for risk calculation are selected) is considered sufficiently comprehensive as a basis to assess the potential risk to human health due to chronic exposure to the contaminants produced in the disinfection process and likely present in the effluent discharges.

1.17 The dechlorination agent - sodium bisulphite was not considered to pose an ecological risk issue but a physical stress related to water quality impact arising from dissolved oxygen uptake. Hence, chemical species (sodium, bisulphite, sulphite and sulphate) associated with sodium bisulphite were not identified as the COPCs in ERA.

Identification of COPC (from HATS CEPT / Secondary Treated Effluent)

1.18 A comprehensive chemical analysis was conducted under the HATS EEFS (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). One hundred analytes including metals, inorganic pollutants, organic pollutants, pesticides and organo-metallics, which are in the full list of toxic chemical analytes used in monitoring of CEPT/secondary treated effluent and ambient waters around Hong Kong, were identified as COPC and analyzed.

Selection of COC (from Chlorination/Dechlorination process)

1.19 COC are the chemicals selected from the COPC list to be included in the risk calculations, based on a number of criteria such as toxicity, frequency of detection, and the concentration in effluent and ambient water. The concentrations of the identified COPCs in C/D CEPT effluent from SCISTW (for assessment scenarios 1 to 2), secondary treated effluent from Shatin/Tai Po Sewage Treatment Works (for assessment scenario 3) and ambient seawater (2 sampling locations) were determined by chemical analysis. The COC selection and determination of COC effluent concentrations for risk assessments were based on the chemical analysis results and the following rules.

<u>Rules of COC Selection</u>

Rule A – COPCs without relevant toxicity values, standards or criteria are not selected as COCs for risk assessments.

Rule B - COPCs detected in the C/D effluent are selected as COCs for risk assessment. The highest value from the replicates of analysis is chosen as the effluent concentration to use in the risk assessment calculations.

Rule C – Non-detected COPCs with detection limit (for C/D effluent samples) that exceeds the Concentration of Interest [2] (COI) are selected as COCs. For these COCs, effluent that concentrations used in the risk assessments are one-half of the detection limit, which is a standard approach accepted by USEPA.

Rule D – COPCs with concentration in C/D effluent lower than the ambient seawater concentration are not selected as COCs.

<u>Rules of COC Ambient Seawater Concentration Determination</u>

Rule E – The highest COC concentration found in the replicates of ambient seawater analysis is used to represent the background concentrations in the risk assessment calculations.

Rule F – For COCs that are not detected in the ambient seawater samples, the background concentration is set as zero.

With reference to the chemical analysis results of HATS EIA study for the Provision of Disinfection Facilities at Stonecutters Island Sewage Treatment Works- Investigation, COCs selected for the risk assessments for Scenarios 1 to 2 and Scenario 3 are presented in **Tables 4 and 5** respectively.

Table 4 Results of COCs Selection (from Chlorination/Dechlorination Process) for Scenarios 1 to 2

COPC	Selected as COC for		Max. Conc. in C/D CEPT Effluent (µg/L)	Max. Conc. in Ambient Seawater (µg/L)	Note
	ERA – Aquatic Life	ERA – Marine Mammals			
Total residual chlorine	Yes	Yes	100	0	
Chloroform	Yes	Yes	7	0	
Bromodichloromethane			<5	0	
Dibromochloromethane			<5	0	
Bromoform			<5	0	

[2] The COIs for ecological resources were based on the water quality criteria or toxicity reference value derived in this study. The list of COIs are presented in Annex A of Appendix 7.1.

COPC	Selected as COC for		Max. Conc. in C/D CEPT Effluent (μg/L)	Max. Conc. in Ambient Seawater (μg/L)	Note
	ERA – Aquatic Life	ERA – Marine Mammals			
Chloroacetic acid	Yes	Yes	4	0	
Bromoacetic acid			<2	0	
Dibromoacetic acid	Yes	Yes	4	0	
Dichloroacetic acid	Yes	Yes	45.9	0	
Trichloroacetic acid	Yes	Yes	22	0	
Methylene chloride			<20	55	
Carbon tetrachloride			<0.5	0	
Chlorobenzene			<0.5	0	
1,1-dichloroethane			<0.5	0	A
1,2-dichloroethane			<0.5	0	
1,1-dichloroethylene			<0.5	0	
1,2-dichloropropane			<0.5	0	
Tetrachloroethylene	Yes	Yes	1.3	0	
1,1,1-trichloroethane			<0.5	0	
1,1,2-trichloroethane			<0.5	0	
Trichloroethylene	Yes	Yes	2	0	
2-chlorophenol			<0.5	0	
2,4-dichlorophenol			<0.5	0	
p-chloro-m-cresol			<0.5	0	
Pentachlorophenol			<2.5	0	
2,4,6-trichlorophenol	Yes	Yes	2	0	
Bis(2-chloroethoxy)methane			<0.5	0	
1,4-dichlorobenzene			<0.5	0	
Hexachlorobenzene	Yes	Yes	<0.5	0	B
Hexachlorocyclopentadiene			<2.5	0	
Hexachloroethane			<0.5	0	
1,2,4-trichlorobenzene			<0.5	0	
Alpha-benzene hexachloride			<0.5	0	
Beta-benzene hexachloride	Yes	Yes	<1	0	B
Gamma-benzene hexachloride	Yes	Yes	<1	0	B

Note: A) No available toxicity data for aquatic life
B) Detection limit exceeds the concentration of interest for aquatic life

Table 5 Results of COCs Selection (from Chlorination/Dechlorination Process) for Scenario 3

COPC	Selected as COC for		Max. Conc. in Secondary Treated Effluent (μg/L)	Max. Conc. in Ambient Seawater (μg/L)	Note
	ERA – Aquatic Life	ERA – Marine Mammals			
Total residual chlorine	Yes	Yes	<20	0	A
Chloroform			<5	0	
Bromodichloromethane			<5	0	
Dibromochloromethane	Yes	Yes	8	0	
Bromoform	Yes	Yes	49	0	
Chloroacetic acid			<2	0	
Bromoacetic acid			<2	0	
Dibromoacetic acid	Yes	Yes	10	0	
Dichloroacetic acid	Yes	Yes	3	0	
Trichloroacetic acid	Yes	Yes	7	0	
Methylene chloride			<20	55	
Carbon tetrachloride			<0.5	0	
Chlorobenzene			<0.5	0	

COPC	Selected as COC for		Max. Conc. in Secondary Treated Effluent (μg/L)	Max. Conc. in Ambient Seawater (μg/L)	Note
	ERA – Aquatic Life	ERA – Marine Mammals			
1,1-dichloroethane			<0.5	0	B
1,2-dichloroethane			<0.5	0	
1,1-dichloroethylene			<0.5	0	
1,2-dichloropropane			<0.5	0	
Tetrachloroethylene			<0.5	0	
1,1,1-trichloroethane			<0.5	0	
1,1,2-trichloroethane			<0.5	0	
Trichloroethylene			<0.5	0	
2-chlorophenol			<0.5	0	
2,4-dichlorophenol			<0.5	0	
p-chloro-m-cresol			<0.5	0	
Pentachlorophenol			<2.5	0	
2,4,6-trichlorophenol			<0.5	0	
Bis(2-chloroethoxy)methane			<0.5	0	
1,4-dichlorobenzene			<0.5	0	
Hexachlorobenzene	Yes	Yes	<0.5	0	A
Hexachlorocyclopentadiene			<2.5	0	
Hexachloroethane			<0.5	0	
1,2,4-trichlorobenzene			<0.5	0	
Alpha-benzene hexachloride			<0.5	0	
Beta-benzene hexachloride	Yes	Yes	<1	0	A
Gamma-benzene hexachloride	Yes	Yes	<1	0	A

Note: A) Detection limit exceeds the concentration of interest for aquatic life
B) No available toxicity data for aquatic life

Selection of COC (from HATS CEPT / Secondary Treated Effluent)

1.20 A number of selection rules were established in HATS EEFS Ecological and Health Risk Assessment (CDM, 2004) for selection of COCs and determination of COC effluent concentrations for risk assessments. The selection rules are presented as follows:

Rule 1 - COCs include all chemicals detected in analyses of BAF Pilot Plant effluent under HATS EEFS Study. For these COCs, the highest value from the duplicate analyses is chosen as the effluent concentration to use in the risk assessment calculations.

Rule 2 - COCs include any non-detect chemical where the detection limit (for effluent samples) exceeds the Concentration of Interest. For these chemicals, effluent concentrations used in the risk assessment are one-half of the detection limit.

Rule 3 - For human health risk assessment, only the data for total metals are used. For ecological risk assessment, only the data for dissolved metals are used.

Rule 4 - No chemical has been included as COC if the BAF Pilot Plant effluent concentration is lower than the background concentration.

Rule 5 - No chemical is included as a COC if the amount detected in the associated rinsate blank is greater than 10% of a sample value for common laboratory contaminants, or greater than 20% of a sample value for other contaminants.

Rule 6 - COCs without toxicity values, standards or criteria are not included in the quantitative risk calculations.

1.21 COCs (from treated effluent) selected for Project Scenario 1 to 2 and Scenario 3 are presented in **Table 6** and **7** respectively.

Table 6 COCs (from Treated Effluent) Selected for Scenarios 1 to 2

COC	**Max. Conc. in CEPT Effluent (µg/L)***	**Max. Conc. in Ambient Seawater (µg/L)***
Aluminium	15.9	15.6
Antimony	0.721	0.258
Barium	23.2	6.65
Chromium III	9.58	0.28
Copper	8.59	0.02
Lead	0.128	0.055
Nickel	26.2	0.77
Selenium	0.31	0.07
Silver	0.182	0.006
Tin	0.844	0.14
Vanadium	29.5	1.73
Zinc	14.1	2.37
Ammonia	22,000	230
Sulphide	4,900	48
TCDD (I-TEQ)	0.1pg/L	0.039pg/L
Toluene	12	<1
Diazinon	0.048	<0.01
Malathion	0.031	<0.01

Note: * Dissolved concentration of metals for ecological risk assessment

Table 7 COCs (from Treated Effluent) Selected for Scenario 3

COC	**Max. Conc. in secondary treated Effluent (µg/L)***	**Max. Conc. in Ambient Seawater (µg/L)***
Antimony	0.782	0.258
Barium	23.7	6.65
Chromium III	8.44	0.28
Copper	6.63	0.02
Nickel	22.3	0.77
Selenium	0.13	0.07
Silver	0.099	0.006
Tin	0.457	0.14
Vanadium	31.3	1.73
Zinc	9.79	2.37
Ammonia	4,200	230
Sulphide	53	48
TCDD (I-TEQ)	0.062pg/L	0.039pg/L
Diazinon	0.058	<0.01
Malathion	0.015	<0.01

Note: * Dissolved concentration of metals for ecological risk assessment

Exposure Assessment

Ecological Risk Assessment – Aquatic Life

1.22 COC exposure by aquatic life was characterized as the COC concentrations in seawater. The COC concentrations in the seawater at the edge of the ZID and the edge of the mixing zone, which were determined by using dilution factors estimated in water quality modelling, were adopted as the COC exposure concentration by aquatic life.

1.23 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 (more details were presented below). Moreover, the averaging time of COC concentration used for hazard quotient calculation should match the averaging time of the TRV of the corresponding COC.

1.24 **Table 8** summarized the averaging time of different TRVs and the corresponding dilution factor for COC concentration calculation.

Table 8 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	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

Ecological Risk Assessment – Marine Mammals

1.25 This phase would comprise the following tasks:

- Water quality modelling
- Exposure setting characterization, which consists of the following tasks:
  - Characterize potential marine mammals receptors
  - Calculate the COC exposure

Water Quality Modelling

1.26 The water quality modelling has been conducted in this assignment and the results obtained were used for the risk assessment.

Exposure Setting Characterization

<u>Potential Marine Mammals Receptors Characterization</u>

1.27 The following parameters will be characterized for both dolphins and porpoises receptors:

- Contaminated water/seafood ingestion rate
- Proportion of dietary prey item (shellfish and fish) in diet
- Area use factor (the fraction of time for the receptor resides and feeds in the impacted area)
- Body weight

1.28 **Table 9** presented the parameter values of marine mammals receptors, which are consistent with the values adopted in the EIA Study for the Provision of Disinfection Facilities at SCISTW.

Table 9 Parameter Values of Marine Mammals Receptors

Parameter	Value		Unit
	Dolphin	Porpoise	
Ingestion rate of food	0.065	0.075	kg food/kg body weight/d
Ingestion rate of water	12.5	12.5	ml water/kg body weight/d
Body Weight	225	55	kg
Area use factor	0.25	0.15	fraction
Fraction of dietary prey item in diet (fish/shellfish percent)	90/10	50/50	percent

COC Exposure Calculation

1.29 The COC exposure would be calculated by the following equation, which is adopted from the EIA Study for the Provision of Disinfection Facilities at SCISTW.

$$Dose_i = \{(IR_{food} \times BW \times C_{fish} \times FP_{fish} \times AUF) + (IR_{food} \times BW \times C_{shellfish} \times FP_{shellfish} \times AUF) + (IR_{water} \times BW \times C_{water} \times AUF)\} / BW$$

Equation 1

Where
$Dose_i$ = Daily Dose of COC *i* (mg/kg/day)
$C_{fish/shellfish}$ = COC concentration in fish/shellfish (mg/kg)
C_{water} = COC concentration in seawater (mg/L)
$IR_{food/water}$ = Ingestion rate of food or effluent (kg food/kg/day or L water/kg/day)
BW = Body weight of receptor (kg)
AUF = Area use factor (fraction)
$FP_{fish/shellfish}$ = Fraction of dietary prey item in diet (fraction)

1.30 The COC concentration in the prey item (fish and shellfish) of the marine mammals would be calculated by the following equation, which is adopted from USEPA (1999b).

$$C_{is} = C_{iw} \times BCF_i \times FCM_i$$ Equation 2

Where
C_{is} = contaminant *i* concentration in fish/shellfish (mg/kg)
C_{iw} = contaminant *i* concentration in seawater (mg/kg)
BCF_i = water-to-fish/water-to-invertebrate bioconcentration factor for contaminant *i* (L/kg)
FCM_i = food chain multiplier of contaminant *i* (unitless)

1.31 COC concentrations at the edge of the ZID estimated by the water quality modelling (based on 10 %tile dilution factor, dry and wet season combined) were used for exposure calculation.

1.32 Bioconcentration factor and food chain multiplier for COCs were presented in **Table 10**.

Table 10 Bioconcentration Factor and FCM

COC	Water-to-fish Bioconcentration Factor	Trophic Level 4 FCM[a]	Water-to-aquatic invertebrates Bioconcentration Factor	Trophic Level 3 FCM[a]
Potential CBPs				
Total residual chlorine	N/A	N/A	N/A	N/A
Bromoform	13.3[e]	1.0	6.60[b]	1.0
Bromodichloromethane	8.26[e]	1.0	3.68[b]	1.0
Chloroform	6.92[e]	1.0	2.82[c]	1.0
Dibromochloromethane	10.4[e]	1.0	4.79[b]	1.0
Chloroacetic acid	0.26[f]	1.0	0.11[b]	1.0
Dibromoacetic acid	0.82[f]	1.0	0.31[b]	1.0
Dichloroacetic acid	1.13[f]	1.0	0.41[b]	1.0
Trichloroacetic acid	5.75[f]	1.0	0.88[b]	1.0
Tetrachloroethylene	82.8[e]	1.0	43.5[b]	1.1
2,4,6-trichlorophenol	56.1[e]	1.0	76.6[b]	1.1
Hexachlorobenzene	2400[e]	1.0	2595[c]	1.0
Beta-BHC	168[e]	1.0	89.1[b]	1.2
Gamma-BHC	168[g]	1.0	79.6[b]	1.2
Contaminants present in CEPT / Secondary Treated Effluent				
Aluminum	2.7[f]	1.0	0.13[b]	1.0
Antimony	40[e]	1.0	7[c]	1.0
Barium	633[e]	1.0	200[c]	1.0
Chromium (III)	19[e]	1.0	0.11[b]	1.0
Copper	710[f]	1.0	3,718[c]	1.0
Lead	0.09[e]	1.0	5,059[c]	1.0
Nickel	78[e]	1.0	28[c]	1.0

COC	Water-to-fish Bioconcentration Factor	Trophic Level 4 FCM[a]	Water-to-aquatic invertebrates Bioconcentration Factor	Trophic Level 3 FCM[a]
Selenium	129[e]	1.0	1,262[c]	1.0
Silver	87.7[e]	1.0	298[c]	1.0
Tin	138[d]	1.0	138[d]	1.0
Vanadium	N/A	-	N/A	-
Zinc	2,060[e]	1.0	4,758[c]	1.0
Ammonia	N/A	-	N/A	-
Sulphide	N/A	-	N/A	-
Dioxins and furans (TEQ)	34,400[e]	27	1,560[c]	14
Toluene	171[e]	1.0	11.6[b]	1.0
Diazinon	171[e]	1.0	94.3[b]	1.2
Malathion	13.1[e]	1.0	6.12[b]	1.0

N/A: Not Available

Note: [a] The FCMs were developed using K_{ow} values reported in USEPA (1995), as in USEPA (1999b).

[b] No recommended BCF value identified. Regression equation was used to calculate the BCF values (Southworth *et al.* (1978), as in USEPA (1999b)).

[c] Recommended BCF value in USEPA (1999b).

[d] MW (1998)

[e] BCF values documented in USEPA (2005)

[f] No recommended BCF value identified. Regression equation was used to calculated the BCF values (Bintein et al. (1993), as in USEPA (1999b)).

[g] Same BCF adopted from isomer.

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Ecological Effects Characterization (for ERA – Aquatic Life)

1.33 The ecological effects of COC exposure to aquatic life were characterized by comparing the COC concentrations in the seawater at the edge of the ZID and the edge of the mixing zone to the 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. Details on the TRV derivation process were presented in **Appendix 8.4**; derived TRVs for risk calculations were presented in **Table 11**.

Table 11 Derived TRVs for Aquatic Life

COC	TRV for ecological resources (µg/L)	Averaging Time
Potential CBPs		
Total residual chloride	13 at edge of ZID, 8 at edge of mixing zone	Daily average
Chloroform	12	Annual average
Dibromochloromethane	34	Annual average
Bromoform	360	Annual average
Chloroacetic acid	32,000	Seasonal average
Bromoacetic acid	1,600	Seasonal average
Dibromoacetic acid	690	Seasonal average
Dichloroacetic acid	230	Seasonal average
Trichloroacetic acid	93,000	Seasonal average
Tetrachloroethylene	8.85	Annual average
Trichloroethylene	10	Annual average
2,4,6-trichlorophenol	12.1	Seasonal average
Hexachlorobenzene	0.03	Annual average
Beta-benzene hexachloride	0.046	Annual average
Gamma-benzene hexachloride	0.063	Annual average
Contaminants present in CEPT / Secondary Treated Effluent		
Aluminium	1500	Annual average
Antimony	4300	Annual average
Barium	5000	Seasonal average
Chromium III	27.4	Annual average
Copper	5	Not to exceed at 10% of occasions

COC	TRV for ecological resources (µg/L)	Averaging Time
Potential CBPs		
Total residual chloride	13 at edge of ZID, 8 at edge of mixing zone	Daily average
Lead	8.1	4-day average
Nickel	5	Not to exceed at 10% of occasions
Selenium	71	4-day average
Silver	1.4	Annual average
Tin	81.6	Seasonal average
Vanadium	100	Annual average
Zinc	20	Not to exceed at 10% of occasions
Ammonia	910	Annual average
Sulphide	100	Seasonal average
TCDD	0.000038	Seasonal average
Toluene	40	Annual average
Diazinon	0.01	Annual average
Malathion	0.02	Annual average

Ecological Effects Characterization (for ERA – Marine Mammals)

1.34 The ecological effects of COC exposure to marine mammals are characterized by comparing the COC daily dose to the toxicity reference doses for the marine mammals, which will be derived by reviewing the toxicological effects data from various scientific literature, database and guidelines. No toxicity data on specific to marine mammals were identified in the literature review for the TRD derivation. Therefore toxicity data for surrogate species (e.g. rat, mouse or other mammals) were used for deriving TRD. The use of toxicity data for surrogate species may induce uncertainties in the calculation of ecological risk level in the risk assessment. However, safety factors were applied in the course of TRD derivation to provide conservatism. Details on the toxicity reference dose derivation process are presented in **Appendix 8.5**; derived toxicity reference dose for risk calculations are presented in **Table 12.**

Table 12 Derived Toxicity Reference Dose for Marine Mammals

COC	Toxicity Reference Dose Derived (mg/kg/d)
Potential CBPs	
Bromoform	12.5
Chloroform	3.75
Dibromochloromethane	10.0
Dibromoacetic acid	0.025
Chloroacetic acid	0.1875
Dichloroacetic acid	0.095
Trichloroacetic acid	0.45
Total residual chlorine	1.875
Tetrachloroethylene	6.7
Trichloroethylene	13.7125
2,4,6-trichlorophenol	169.5
Hexachlorobenzene	0.3
Beta-BHC	0.1125
Gamma-BHC	1
Contaminants present in CEPT / Secondary Treated Effluent	
Aluminum	6.125
Antimony	0.015625
Barium	1.875
Chromium (III)	342.125

COC	Toxicity Reference Dose Derived (mg/kg/d)
Copper	1.5
Lead	1
Nickel	5
Selenium	0.02625
Silver	2.7775
Tin	2.925
Vanadium	0.02625
Zinc	20
Ammonia	5.15
Sulphide	No toxicological data available
Dioxins and furans (TEQ)	8.875E-6
Toluene	3.25
Diazinon	1.5
Malathion	4.4875

Risk/Hazard Characterization

Ecological Risk Assessment – Aquatic Life

1.35 The risk associated with the COCs to the aquatic life were characterized by COC-specific hazard quotients (HQs) and hazard index (HI), estimated by the following equations:

HQ_i = Conc. of COC *i* in effluent or seawater / TRV for COC *i* Equation 3

Where
HQ_i = Hazard Quotient for exposure to identified COC_i

$HI = \Sigma HQ_i$ Equation 4

Where
HI = Hazard Index, total hazard attributable to exposure to all identified COCs

Ecological Risk Assessment – Marine Mammals

1.36 The risk associated with the COCs to the marine mammals were characterized by COC-specific hazard quotients (HQs) and hazard index (HI), estimated by the following equations:

HQ_i = Daily Dose of COC *i* / Toxicity Reference Dose for COC *i* Equation 5

$HI = \Sigma HQ_i$ Equation 6

Output of the Risk Assessment

Output of the ERA – Aquatic Life

1.37 The output of the ERA – Aquatic Life are listed as follows:

- The hazard quotient of exposure to individual identified COCs (contributed by both HATS effluent and “background” COC concentrations existing in ambient seawater) by aquatic life at the edge of ZID
- The hazard quotient of exposure to individual identified COCs (contributed by both HATS effluent and “background” COC concentrations existing in ambient seawater) by aquatic life at the edge of mixing zone
- The hazard index of exposure to all identified COCs (contributed by both HATS effluent and “background” COC concentrations existing in ambient seawater) by aquatic life at the edge of ZID
- The hazard index of exposure to all identified COCs (contributed by both HATS effluent and “background” COC concentrations existing in ambient seawater) by aquatic life at the edge of

mixing zone

Output of ERA – Marine Mammals

1.38 The output of the ERA – Marine Mammals are listed as follows:

- Hazard quotient due to exposure of identified individual COCs (contributed by both HATS effluent and "background" COC concentrations existing in ambient seawater) by consumption of contaminated seawater and seafood
- Hazard index due to exposure of all identified COCs (contributed by both HATS effluent and "background" COC concentrations existing in ambient seawater) by consumption of contaminated seawater and seafood

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