6. ECOLOGICAL RISK AND TOXICITY TO AQUATIC LIFE

Introduction

6.1 The Ecological Risk Assessment (ERA) in the EIA Report, which focused on assessing the potential risks to ecological resources due to chronic exposure to the contaminants produced in the disinfection process (i.e. disinfectant residual and chlorination by-products, CBPs) in the SCISTW effluent discharge, predicted that the potential total residual chlorine (TRC) and potential CBPs present in the chlorinated/dechlorinated SCISTW CEPT effluent discharge would not induce unacceptable risk to aquatic life and marine mammals.

6.2 Moreover, the compliance assessment on water quality criteria in terms of acute and chronic toxicity was conducted in the EIA Study to assess whether the water quality criteria in terms of acute and chronic toxicity would be complied with in the presence of Project effluent discharge. The assessment results revealed that effluent discharge from SCISTW would not exert increased acute toxicity at edge of Zone of Initial Dilution (ZID) and chronic toxicity at edge of mixing zone to aquatic life.

6.3 A monitoring programme for the concentration of TRC and potential CBPs in SCISTW effluent and seawater is recommended and detailed in **Section 4**. The monitoring programme aims to achieve the following objectives:

- To check whether the Project would cause an increase in TRC and CBP concentrations in seawater
- To verify the predictions of the Human Health Risk Assessment
- To verify the predictions of the ERA

6.4 Whole effluent toxicity test (WETT) for the chlorinated/dechlorinated SCISTW CEPT effluent discharge is proposed in order to achieve the following objectives:

- To determine the whole effluent toxicity of chlorinated/dechlorinated (C/D) CEPT effluent from SCISTW
- To verify the results of compliance assessment done in the EIA Report on water quality criteria in terms of acute and chronic toxicity
- To provide supplementary data to assist the verification of the predictions of the ERA for aquatic life

6.5 Details of the recommended CBPs monitoring programme and WETT are presented below.

Potential CBPs Monitoring Programme

6.6 The scope, requirements, methodology, equipment, monitoring locations and schedule of the CBPs monitoring programme (both baseline and operation phase monitoring) as well as the statistical analysis of monitoring data have been detailed in **Section 4** of the EM&A Manual.

Ecological Risk Assessment

6.7 If statistical analysis of baseline and operation phase monitoring data reveals that seawater concentration of TRC and/or CBPs (one or more) increases after operation of the Project, the monitoring data collected in effluent quality monitoring shall be used to provide information to investigate whether such increase is due to the effluent discharged by the Project. If such increase is found to be due to the Project operation, ERA – Aquatic Life and ERA – Marine Mammals using the operation phase monitoring data should be conducted to verify that the ecological risk due to TRC and CBPs discharged from SCISTW effluent impose to aquatic life and marine mammals is acceptable.

6.8 The ERA shall follow the approach and methodology adopted in the EIA Study which has been presented in **Appendix 7.1** of the EIA Report. The ERA will consist of the following 5 stages:

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

6.9 Apart from the chemical analysis data obtained from the monitoring programme, the following data are needed in the ERA:

- Marine mammals parameter values including ingestion rate of food and seawater as well as area use factor (for ERA – Marine Mammals)
- Parameters related to CBPs including bioconcentration factor and food chain multiplier (for ERA – Marine Mammals)
- TRC/CBP specific Toxicity Reference Value, derived from available water quality criteria/standards for protection of aquatic life or toxicity data to aquatic organisms from scientific literature (for ERA – Aquatic Life)
- TRC/CBP specific Toxicity Reference Dose, derived from toxicological effects data from scientific literature, database and guidelines (for ERA – Marine Mammals)

6.10 The above data items used in the EIA Study should be reviewed and updated by the Environmental Consultant (if more up-to-date data is available) when performing the ERA. Should the ERA results reveal that there is potential occurrence of considerable ecological risk, a review of ERA shall be conducted, which shall involve:

- Reviewing and using more realistic exposure assumptions for marine mammals (especially the area use factor) to refine the ERA – Marine Mammals results
- Extension of CBPs monitoring programme (in terms of frequency) may be considered to obtain more monitoring data for more representative risk estimation
- Reviewing the results of WETT conducted (also recommended in this EM&A Manual), which provides supplementary data on the potential adverse effect of SCISTW C/D CEPT effluent to aquatic life

Whole Effluent Toxicity Test

Test Species and Toxicity Test

6.11 The five WETTs conducted for the EIA Study shall be performed in the EM&A programme:

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

Test Schedule and Frequency

6.12 Since some of the test species are not available in both wet season and dry season, each WETT is proposed to be conducted once in the first year of operation the Project. Also, different test species will be available for testing in different time periods of a year, the five WETTs may not be conducted at the same time.

Effluent Sample Collection

6.13 Effluent sample for WETT shall be collected during the sampling works for effluent operation phase monitoring. The effluent sampling location and procedures have been detailed in **Section 4**. Similarly, the effluent sampling should be planned carefully to ensure appropriate volume of effluent sub-samples is collected to prepare sufficient amount of flow-weighted composite effluent sample for carrying out the WETT. Collected effluent samples and sub-samples should be kept in clean containers and contamination should be avoided. WETT should begin within 36 hours after the completion of composite effluent sampling period (i.e. holding time of effluent sample should be less than 36 hours).

Dilution Seawater Collection

6.14 Dilution seawater used for WETT should be collected at a point away from the discharge which is free from toxicity or other sources of contamination. Avoid collecting dilution seawater near areas of obvious road or agricultural runoff, storm sewers or other point source discharges.

Test Methodology and Procedures

6.15 The WETT methodology and procedures should follow those documented in Centre for Coastal Pollution and Conservation (2001)[1]. The test should consist of a minimum of five effluent concentrations and the WETT results will be used to provide data to determine whether target toxicity level of effluent (discussed below) is exceeded. Toxicity range-finding test for the effluent would not be needed as documented in USEPA document (2002a, 2002b)[2].

6.16 The WETT should be performed using at least four replicates of each control and effluent concentration so that parametric and non-parametric statistical tests can be performed for WETT data obtained.

Water Quality Parameters Testing

6.17 Water quality parameters including temperature, pH value, dissolved oxygen (DO) and salinity at all testing chambers of WETT should be measured at 12-hour interval.

Potential Pollutant Testing

6.18 At the beginning and the end of the toxicity test, ammonia, sulphide, suspended solids and TRC of testing media in all testing chambers shall be measured. The analysis method and detection limit are presented in **Table 6.1**. Moreover, at the beginning and the end of the toxicity test, a sample of testing media in all testing chambers shall be collected and preserved. The collected samples shall be analyzed for potential CBPs listed in **Table 6.2** if the target toxicity level of effluent is found to be exceeded.

Table 6.1 Analytical Method and Detection Limit for Ammonia, Sulphide, Suspended Solids and TRC

Determinant	Suggested Method	Suggested Detection Limit (mg/L)
Ammonia-N	APHA 17ed 4500-NH_3	0.01
Sulphide	APHA 17ed 4500-S^{2-}	0.1
Suspended Solids	APHA 17ed 2540D	2
Total residual chlorine	APHA 17ed 4500-Cl G	0.02

Table 6.2 Potential CBPs to be Analyzed

Determinant	Suggested Method	Suggested Detection Limit (μg/L)
Bromoform	USEPA 8260 (Purge & Trap GCMS)	0.1*
Bromodichloromethane		0.1*
Chloroform		0.1*
Dibromochloromethane		5
Bromoacetic acid	APHA 6251	2
Chloroacetic acid		2
Dibromoacetic acid		2
Dichloroacetic acid		2
Trichloroacetic acid		2
Methylene chloride	USEPA 8260	20
Carbon tetrachloride		0.5

[1] Centre for Coastal Pollution and Conservation (2001). Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment – Final Report, submitted to AFCD.
[2] USEPA (2002a). Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. USEPA (2002b). Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms.

Determinant	Suggested Method	Suggested Detection Limit (µg/L)
Chlorobenzene	(Purge and Trap GCMS)	0.5
1,1-dichloroethane		0.5
1,2-dichloroethane		0.5
1,1-dichloroethylene	USEPA 8270/GCMS	0.5
1,2-dichloropropane		0.5
Tetrachloroethylene		0.5
1,1,1-trichloroethane		0.5
1,1,2-trichloroethane		0.5
Trichloroethylene		0.5
2-chlorophenol		0.5
2,4-dichlorophenol		0.5
p-chloro-m-cresol		0.5
Pentachlorophenol		0.5*
2,4,6-trichlorophenol		0.5
Bis(2-chloroethoxy)methane		0.5
1,4-dichlorobenzene		0.5
Hexachlorobenzene		0.01*
Hexachlorocyclopentadiene		2.5
Hexachloroethane		0.5
1,2,4-trichlorobenzene		0.5
Alpha-BHC		0.01*
Beta-BHC		0.01*
Gamma-BHC		0.01*

* The suggested detection limit was in light of the concentration of interest (COI) for human health and/or ecological resources, which was based on local/international authority approved standard. Determinant at concentration below COI is not expected to induce concern to human health and ecological resources.

Quality Assurance / Quality Control (QA/QC)

6.19 The results of water quality parameters measurement can provide documentation of conditions within the test chambers during toxicity test. Conditions that are acceptable to maintain the health of the testing organisms shall be defined with reference to those documented in the Centre for Coastal Pollution and Conservation (2001). If water quality parameters are found outside the acceptability criteria, the validity of WETT data will need to be reviewed.

6.20 Negative control, which provides a measure of test organism health, should be conducted concurrent to each toxicity test. The negative control should consist of 100% dilution seawater as the test medium. Acceptable limit for negative controls shall be defined with reference to those documented in the Centre for Coastal Pollution and Conservation (2001). If the responses in negative controls do not meet the acceptability criteria, the validity of WETT data should be evaluated and the test may need to be repeated.

6.21 Positive control, which provides a relative measure of test organism sensitivity, should also be conducted concurrent to each toxicity test. The positive control should consist of dilution seawater with a defined concentration of reference toxicant (e.g. cadmium ion) as test medium. The results of the positive controls shall be compared with control charts generated by the testing laboratory for the species and toxicant tested. Positive control results which are within two standard deviations of the cumulative mean can be considered to be similar in sensitivity to previous test populations. If the test results are not found within the two standard deviations of the cumulative mean, the validity of WETT data will need to be reviewed.

Target Toxicity Level

6.22 Effluent from SCISTW is considered not inducing unacceptable toxicity to aquatic life if acute toxicity at edge of ZID is < 0.3 acute toxicity unit (TUa) and chronic toxicity at edge of mixing zone is < 1.0 chronic toxicity unit (TUc). Based on the findings in the EIA Study, the above can be attained when TUa and TUc of SCISTW effluent is less than 14.1 and 197 respectively. Therefore, the effluent is considered not inducing unacceptable acute toxicity to aquatic life when the median lethal concentration (LC50) determined for SCISTW effluent in the acute toxicity tests is ≥ 7.1%.

6.23 For chronic toxicity, TUc can be calculated by using No-Observable-Effect-Concentration (NOEC) determined in chronic toxicity test or applying "acute-to-chronic ratio" (ACR) of 10 to TUa of effluent[3]. As such, the effluent is considered not inducing unacceptable chronic toxicity when the NOEC determined in the 7-day diatom growth inhibition test is ≥ 0.51% and LC50 determined in the acute toxicity tests is ≥ 5.1%[4]. The target toxicity levels of effluent are summarized in **Table 6.3**.

Table 6.3 Target Toxicity Levels of SCISTW Effluent

Effluent Characteristics	**Target Level**
Acute Toxicity	
LC50 in 48-hr amphipod survival test	≥ 7.1%
LC50 in 48-hr barnacle larvae survival test	≥ 7.1%
LC50 in 48-hr fish survival test	≥ 7.1%
LC50 in 48-hr shrimp survival test	≥ 7.1%
Chronic Toxicity	
NOEC in 7-day diatom growth inhibition test	≥ 0.51%
LC50 in 48-hr amphipod survival test	≥ 5.1%
LC50 in 48-hr barnacle larvae survival test	≥ 5.1%
LC50 in 48-hr fish survival test	≥ 5.1%
LC50 in 48-hr shrimp survival test	≥ 5.1%

6.24 Should the target toxicity levels are exceeded, further investigation works shall be conducted to identify pollutants contributing to the toxicity, which shall involve:

- Analyze the samples collected from testing chambers at the beginning and the end of toxicity test for CBPs listed in **Table 6.2**
- Reviewing the data obtained in the pollutant testing (including ammonia, sulphide, suspended solids, TRC and CBPs) to identify the pollutant(s) that mainly contribute(s) to the observed toxicity (e.g. by observing the correlation of toxicity and pollutant concentration in testing chamber media)
- If the TRC and/or CBPs in the effluent are found to the major contributors for the exceedance of target toxicity level, re-test for the WETT(s) that has/have target toxicity level exceedance shall be arranged to determine whether the target toxicity level exceedance continues
- Measures to reduce TRC and/or CBP concentrations in effluent shall be considered if re-test results reveal that TRC and/or CBPs in the effluent have caused the target toxicity level exceedance

[3] TUc = TUa x ACR = TUa x 10
[4] The TUa of effluent is < 19.7 and TUc of effluent is < 197 when LC50 in acute toxicity test is ≥ 5.1%