14. CONCLUSIONS & SUMMARY OF ENVIRONMENTAL OUTCOMES

Purpose and Scope of the Project

14.1 Stage 1 of HATS has brought about significant water quality improvements to the Victoria Harbour area and its positive effect has reached as far as Shek O beach. However, it has also concentrated the discharge of un-disinfected effluent from previously (pre-HATS Stage1) dispersed sources along the coastlines of Kowloon and eastern Hong Kong Island to a single point (i.e., the SCISTW outfall). Given the hydrodynamic conditions (i.e., tides and currents) of harbour waters, the net effect is increased E. coli levels at most of the bathing beaches on the Tsuen Wan coast. Together with water pollution caused by local sources (e.g., sewage from upland unsewered villages or squatter areas), the un-disinfected effluent from SCISTW has exacerbated the already unsatisfactory water quality at these beaches.

14.2 Before commissioning of HATS Stage 1 in December 2001, three beaches on the Tsuen Wan coast, (namely Anglers', Approach, and Ting Kau) have already been closed due to wastewater discharges from local pollution sources. After commissioning of HATS Stage 1, beach water quality has further deteriorated. In 2003, the Government closed four other beaches on the Tsuen Wan coast, i.e., Lido, Casam, Hoi Mei Wan, and Gemini.

14.3 The purpose of the Project is to bring about early improvement to water quality at the Tsuen Wan beaches. With this in mind, the specific objective of the advance disinfection facilities (ADF) is to disinfect the SCISTW CEPT effluent (as measured by a reduction in E. coli levels) to a level that would restore the Tsuen Wan beach water quality to pre-HATS Stage 1 conditions. This will have the benefit of facilitating the re-opening of those affected beaches at the earliest opportunity.

14.4 To select the most optimal disinfection technology for HATS ADF, a comprehensive multi-tiered, multi-criteria option evaluation exercise has been conducted. This exercise has considered a host of environmental and non-environmental factors and recommended that chlorination (purchase of sodium hypochlorite, with dechlorination) be selected as the preferred disinfection technology for the Project.

14.5 The key elements of the Project include a chlorination system, consisting of a sodium hypochlorite storage tank farm and associated dosing system, and a dechlorination system (which is consisted of a sodium bisulphite tank farm, and associated dosing system).

Summary of EIA Findings

14.6 This EIA study has provided an assessment of the potential environmental impacts associated with the construction and operation phases of the proposed advance disinfection facilities at SCISTW. The environmental issues below have been assessed in the EIA Study, in accordance with the EIA Study Brief (No. ESB-120/2004) registered under the EIAO for the Project:

- Air Quality Impact
- Noise Impact
- Water Quality Impact
- Human Health Risk and Ecological Risk
- Ecological Impact
- Fisheries Impact
- Waste Management Implications
- Hazard to Life
- Impact on Human Health and Man-made Environment

14.7 Specific mitigation measures necessary for avoiding or reducing impacts from the Project to acceptable levels, as well as environmental monitoring and auditing procedures to ensure full implementation of all mitigation measures and compliance with relevant standards and

guidelines, have been developed during the detailed assessments. The Implementation Schedules listing the recommended mitigation measures are presented in **Section 15**. The principal findings of this EIA Report are summarized below.

Air Quality Impact

14.8 In view of small scale of construction works and limited number of dusty activities to be taken, no adverse construction dust impact would be expected at the nearest representative ASRs with the implementation of the dust suppression measures stipulated in the *Air Pollution Control (Construction Dust) Regulation* and good site practices. No odour emission was identified during the construction phase as there is no temporary sewage treatment process/facilities would be provided. Dust monitoring and audit are recommended to be conducted during the construction phase to ensure the efficacy of the control measures.

14.9 The facilities in the chlorination/dechlorination plant are chemical storage areas, chemical feed pumps and dosing system. No additional sewage/sludge conveying facilities involved. As the chemicals, sodium hypochlorite and sodium bisulphite, would be stored in the closed vessels, no adverse air quality or odour impact on the ASRs in vicinity of the chlorination/dechlorination facilities would be expected during the operation phase of the Project. Requirement for environmental monitoring and audit for the operation phase of the Project is considered not necessary.

Noise Impact

Construction Phase

14.10 The potential noise impact arising from construction of the proposed dechlorination plant and chlorination plant/day tank on the barrack buildings (NSR N1) and planned FSD Diving Training Centre (NSR P1) was assessed. The predicted noise levels at NSR N1 were in the range of 70 to 77 dB(A), while the predicted noise levels at NSR P1 were in the range of 62 to 70 dB(A). The noise level at the NSR N1 would exceed the daytime noise criteria of 75 dB(A) during the construction activities of site formation, excavation & backfilling, erection of formwork and fabrication of steelwork.

14.11 With the adoption of quiet PME and good site practices, the predicted construction noise levels at NSR N1 would not exceed the relevant noise criteria. The mitigated noise levels at NSR N1 would range from 62 to 73 dB(A). Although the predicted construction noise levels at the NSR P1 would comply with the noise criteria of 75 dB(A) throughout the construction period, use of slienced types of PME would still be recommended for the construction of chlorination plant and day tank in order to provide a better working environment within the SCISTW.

Operation Phase

14.12 The noise impacts associated with the operation of the Project were also assessed. The operation noise levels at NSRs N1 and P1 were predicted to be 53 dB(A) and 48 dB(A), respectively. No exceedances of relevant daytime and night-time noise criteria would be expected with the proper designs of chlorination plant, day tank and dechlorination plant.

Water Quality Impact

Construction Phase

14.13 Minor water quality impact, if any, would be associated with land-based construction. Impacts may result from the surface runoff and sewage from on-site construction workers. Impacts could be controlled to comply with the Water Pollution Control Ordinance (WPCO) standards by implementing the recommended mitigation measures. Unacceptable residual impacts on water quality would not be expected.

Operation Phase Impact

14.14 Chlorination is proposed as the disinfection technology for the Stonecutters Island Sewage Treatment Works (SCISTW) which would however generate total residual chlorine (TRC) and chlorination by-products (CBP) in the Project effluent. Dechlorination will be applied to eliminate the discharge of TRC into the marine environment. An assessment of water quality impact due to the operation of the Project was made using the Delft3D model. Impacts were assessed over a series of 30-day simulation periods.

14.15 The model results indicated that the provision of disinfection facilities at SCISTW would be needed to satisfy the requirement for protection of the identified water sensitive receivers and help to improve water quality in the Western Buffer water control zone (WCZ) and western Victoria Harbour.

14.16 Sensitivity model runs were performed to estimate the optimum disinfection levels and durations for the disinfection facilities, on one hand, to safeguard the beneficial uses of nearby water sensitive receivers and, on the other hand, to minimize the chlorine dose and thus the potential generation of CBP.

14.17 The model results indicated that the gazetted beaches in Tsuen Wan District would be adversely affected by the un-disinfected effluent from SCISTW during HATS Stage 1 and Stage 2A under both bathing and non-bathing seasons. Thus, year round disinfection would be needed if these beaches are to be opened at all times. The model also predicted that year round disinfection would be needed to protect the beneficial use of the Water Supplies Department (WSD) flushing water intakes in western Victoria Harbour.

14.18 Based on the water quality modelling results, discharge standards are recommended for the SCISTW effluent after the Project commissioned as shown in **Table 14.1**. The advance disinfection facilities (ADF) under Stage 1 and the permanent disinfection facilities under Stage 2A would be designed to cater for the recommended disinfection levels. Allowances would be provided in the design with capacities higher than those required for the recommended operational range. An operation plan has been developed for the chemical dosing. The dosing system would be designed to allow adjustment for compliance with the effluent standards. Monitoring of effluent quality is recommended for operational stage and under the perspective of the WPCO.

Table 14.1 Recommended Effluent Standards for the HATS

Stage	Operation Range of Chlorine Dosage (mg/l)	*E. coli* (no. per 100 ml)		TRC (mg/l)	
		Geometric Mean	95 Percentile	95 Percentile	Maximum
HATS – ADF Stage	11-15	200,000	3,000,000	0.2	0.4
HATS – Stage 2A	10-14	20,000	300,000	0.2	0.4
HATS – Stage 2B	2-3	20,000	300,000	0.2	0.4

14.19 The water quality model results showed that, with the adoption of effluent standards recommended in Table 5.54, the discharge of HATS effluent after chlorination and dechlorination would be unlikely to cause adverse water quality impact. Although the model input parameters were conservative, the model predicted that the disinfected HATS effluent would not cause any non-compliance with the marine water quality criteria.

Human Health Risk and Ecological Risk

14.20 A detailed risk assessment was conducted to assess the potential adverse human health and ecological effects that may result from exposure of toxic substances due to HATS effluent discharge. The findings can be summarized in the three categories: risk to human health, risk to aquatic life and risk to marine mammals.

Risk to Human Health

14.21 Results of Human Health Risk Assessment revealed that potential risk/hazard impact due to chlorination by-products present in the chlorinated/dechlorinated HATS effluent would be low and acceptable under established assessment criteria in all the 5 Project Scenarios. Cumulative risk assessment indicated that the potential risk/hazard impact due to CBPs and other pollutants present in the C/D HATS effluent would also be low and acceptable under established assessment criteria in all the 5 Project Scenarios.

Risk to Aquatic Life

14.22 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 risk 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 of greater than 1.0. It was noted that pollutants present in the background contributed to a considerable portion of risk to aquatic life (Hazard Index of 1.06), which already exceeds the screening value (in this Study: 1). The incremental hazard indices due to the Project itself are much lower than the hazard index due to the pollutants at background level and are below the screening value.

14.23 According to USEPA (2005), the calculated Hazard Index 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 on the risk to aquatic life was carried out based on the results of Whole Effluent Toxicity Test (WETT), which is able to assess the impacts caused by aggregate toxic effect of the mixture of pollutants in effluent.

14.24 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 Contaminants of Concern 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.

Risk to Marine Mammals

14.25 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 risk screening value and considered acceptable. Cumulative risk assessment revealed that potential impact due to CBPs and other pollutants present in the C/D HATS effluent would also be negligible and acceptable in all the 5 Project Scenarios.

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

Ecological Impact

14.27 A literature review has been conducted to establish the ecological baseline condition of the Assessment Area and assessment of potential impacts conducted in accordance with the EIAO TM requirements.

14.28 The water quality impact modelling results indicated that the potential impact zone would be restricted to the Victoria Harbour and Western Buffer WCZs. No impact on ecological resources outside of this zone is expected.

14.29 The existing SCISTW outfall location was chosen in an area with low ecological resources. No adverse ecological impact is anticipated from the Project because :

- Improvement in water quality with reduction in *E. coli* levels in Western Buffer WCZ and western Victoria Harbour WCZ;
- Localised and small changes in TRC, CBP and DO at around the existing SCISTW outfall;
- No unacceptable ecological risk on marine mammal and marine life in relation to acute and chronic effects; and
- Western Buffer WCZ and western Victoria Harbour WCZ does not support high rich ecological resources in terms of species richness.

14.30 As there would be no adverse marine ecological impact from the proposed disinfection facilities, no mitigation measure would be required. A dosing system will be used at the ADF, to minimize the chlorine dose needed for disinfection therefore reducing the potential for generation of CBPs and TRC. Environmental monitoring and auditing requirements in relation to ecological resources protection are covered in the water quality assessment and ecological risk assessment.

Fisheries Impact

14.31 A literature review has been conducted to establish the fisheries baseline condition of the Assessment Area. The water quality impact modelling results indicated that the potential impact zone would be restricted to the Victoria Harbour and Western Buffer WCZs. WQOs would be met and no adverse impact at the Ma Wan FCZ is predicted by the water quality modelling.

14.32 The existing SCISTW outfall location was chosen in an area with low fisheries resources. No adverse fisheries impacts are anticipated from the Project because :

- Improvement in water quality with reduction in *E coli* levels in Western Buffer WCZ and western Victoria Harbour WCZ;
- Localised and small changes in TRC, CBPs and DO at around the existing SCISTW outfall;
- No unacceptable ecological risk on fisheries in relation to acute and chronic effects, which is supported by the whole effluent toxicity test results indicating that C/D CEPT and C/D secondary treated effluent do not induce acute toxicity to fish species *Lutjanus malabaricus*, which is a common species for the local mariculture industry and has a wide geographic distribution in Hong Kong. In view that no acute toxicity was imposed to fish species continuously exposed to C/D effluent during the toxicity testing period, the caged fishes at water quality sensitive receivers including Ma Wan FCZ, which would be exposed to greatly diluted C/D effluent from HATS, would not be adversely affected by the discharged effluent; and
- Western Buffer WCZ and western Victoria Harbour WCZ does not support high catch of fisheries.

14.33 As there would be no adverse fisheries impact from the proposed disinfection, no mitigation measure would be required.

Waste Management Implications

14.34 Waste types generated by the construction activities are likely to include C&D material from excavation works, general refuse from the workforce, and chemical waste from the maintenance of construction plant and equipment. Provided that these wastes are handled, transported and disposed of using approved methods and that the recommended good site practices are strictly followed, adverse environmental impacts are not expected during the construction phase.

14.35 In the event that minor chemical wastes are produced during operation and maintenance of the Project, the relevant mitigation and control requirements for chemical wastes should be observed. Provided that the handling, storage and disposal of chemical wastes are in

accordance with the requirements, adverse environmental impacts are not expected to result during the operation phase.

Hazard to Life

14.36 Hazard to life impact associated with the proposed disinfection facilities at SCISTW was quantitatively assessed, with consideration of identified precautionary measures / operation procedures that minimize the risks associated with the chemicals related operations. The individual risk and societal risk associated with the chemicals related operations were found to be acceptable in accordance with the risk guidelines stipulated in the Annex 4 of the EIAO TM. Hence, the hazard to life impact due to the Project is considered to be low and acceptable.

Impact on Human Health and Man-made Environment

14.37 Impact of atmospheric TRC and CBPs deposits on human health and man-made environment up to date is not an issue of concern as revealed in the findings of the desktop study with literature review. In addition, based on the evaluation of TRC and CBPs concentration levels in the effluent discharged from SCISTW estimated from the water quality assessment and physical properties of the contaminants, concentrations of TRC and CBPs in air would be insignificant and therefore, it is unlikely to have any potential human health and man-made environmental effects caused by atmospheric TRC and CBPs deposits.

Overall Conclusion

14.38 The findings of this EIA Study have determined the likely nature and extent of environmental impacts predicted to arise from the construction and operation phases of the Project. Where appropriate, the EIA has identified mitigation measures to ensure compliance with environmental legislation and standards. The feasibility, practicability, programming and effectiveness of the mitigation measures have been assessed and determined.

14.39 Overall, the EIA Study for the proposed ADF has predicted that the Project, with the implementation of the proposed mitigation measures for construction and operation phases, would comply with all applicable environmental standards and legislation. This EIA has also demonstrated the acceptability of the residual impacts from the Project and the protection of the population and environmentally sensitive resources. **Table 14.2** summarises the environmental outcomes/benefits from the implementation of the Project. Environmental monitoring and audit mechanisms have been recommended, where necessary, to verify the accuracy of the EIA predictions and the effectiveness of recommended mitigation measures.

Table 14.2 Summary of Key Environmental Outcomes / Benefits

Area/Issue	Environmental Outcomes / Benefits
Selection of Preferred Disinfection Technology	As part of the multi-tiered, multi-criteria disinfection technology evaluation, the environmental implications of alternative chlorination agents (i.e., chlorine gas, sodium hypochlorite solution, solid calcium hypochlorite, and chlorine dioxide) have been considered. The assessment found that use of sodium hypochlorite solution would be environmentally preferred, as it would have the lowest level of health, safety, and hazard to life concerns amongst the chlorination options. On sodium hypochlorite, the options were “on-site generation by electro-chlorination (i.e., electrolysis of seawater)” or “purchase of sodium hypochlorite solution that is manufactured by off-site suppliers”. The assessment found that for HATS the alternative of purchase of sodium hypochlorite would have a higher degree of flexibility, lesser operation and maintenance efforts, lesser land/space requirements, and shorter timeframe for implementation. With respect to adoption of chlorination (direct purchase option) in

Area/Issue	Environmental Outcomes / Benefits
	preference to UV radiation disinfection, the key environmental benefit would be a lesser degree of waste management concerns. This is because, if UV radiation were adopted: ▪ It would be necessary to use alum (instead of ferric chloride) as coagulant in the CEPT process to enhance the UV transmittance efficiency. However, compared to using ferric chloride (as at present on SCISTW), use of alum would increase the quantity of sludge generated from the CEPT process by up to about 10% each day. ▪ Spent UV lamps, which contain mercury, are classified as a hazardous waste, and these will need to be disposed of as such, requiring special waste management procedures.
Water Quality Impact	In the course of the water quality impact assessment, design features or response procedures of the ADF were identified to minimize chlorine dosage and the formation of chlorination by-products (CBPs): • A better mixing environment would result in better disinfection efficacy and thus reducing the required chlorine dose. To achieve complete mixing, sodium hypochlorite from the day tank will combine with carrier water (effluent) and dose to the flow distribution chamber through a diffuser installed below effluent surface to enhance the mixing efficiency between chlorine and water. • Accurate dosing of optimal amounts of hypochlorite will minimize the generation of chlorination by-products. To this end, a closely monitored and controlled operation system has been designed to minimize chemical consumption. • A slight overdose of sodium bisulphite has been recommended to ensure complete elimination of TRC in effluent. In addition, the dosing system has been so designed such that in the event of power failure, dosing of sodium bisulphite will continue from a storage tank for at least half an hour. This will allow ample time for the chlorination system to shut down so that the possibility of discharge of non de-chlorinated effluent is avoided. • Comprehensive laboratory test on dechlorination reaction time has been conducted to support the design of the ADF chemical dosing system. This will be further supplemented by a dechlorination simulation loop to be installed at Chamber 15 to monitor the actual de-chlorinated effluent TRC and bisulphite level, and to confirm TRC level in discharge is within limits. • Response procedures were established for the response to chlorination / dechlorination plant failure
Hazard to Life	In the course of the hazard to life assessment, a package of precautionary measures was identified to avoid the occurrence of hazardous scenarios as far as practicable. Precautionary measures include: <u>Measures to avoid mixing of incompatible chemicals in case of chemical spillage</u> • Provide as much separation as practicable chemicals between the chemical storage areas • Protection and separation of chemical delivery pipelines

Area/Issue	Environmental Outcomes / Benefits
	Measures to avoid chemical unloading error • Dedicated chemical delivery route and road signs • Provide security of chemical loading points • Adopt unique colour and size of pipelines and hose coupling for different chemicals • Develop operation procedures and safety measures to avoid chemical unloading error • Adopt special provisions in the chemical supply contracts As a result, the location of sodium hypochlorite tank farm was relocated from the north-eastern part of SCISTW to the south-eastern part of SCISTW to increase the separation between the, existing ferric chloride and sodium hypochlorite solution from the respective tank farms.