2 PROJECT DESCRIPTION

Purpose and Objective of the Project

2.1 Stage 1 of HATS has brought about 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 Stage 1) 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.

2.2 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.

2.3 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 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.

Need for the Project

2.4 The following paragraphs summarise the EPD's beach water quality monitoring and ranking system, Government's present policy for beach closing, and the role the proposed ADF plays in facilitating re-opening of the affected beaches.

Beach Water Quality Monitoring and Ranking System

2.5 To protect public health and to assess whether the Water Quality Objective is met, a comprehensive beach monitoring programme has been implemented by the EPD. The Beach Monitoring Programme has the following six functions:

- to assess compliance with the Water Quality Objective;
- to detect any change in beach water quality;
- to identify polluted beaches that need remedial actions;
- to evaluate pollution abatement programmes;
- to decide on the opening of beaches; and
- to advise the public on the beach water quality status.

2.6 The monitoring of beach water quality is based on the measurement of E. coli density, which is the microbiological parameter stipulated in the WQO and is an internationally acceptable indicator.

2.7 The establishment of an annual ranking system facilitates the interpretation of long-term water quality changes at different beaches. The rank of a beach is determined by calculating the annual geometric mean E. coli density with all the data collected during the bathing season from 1 March to 31 October.

2.8 Under the annual ranking system, beaches are classified according to their annual geometric mean E. coli densities in the beach water. There are four categories for the annual ranking of beaches, viz. "Good", "Fair", "Poor" and "Very Poor", as shown in **Table 2.1**.

Table 2.1 Annual Ranking System for Beaches

Rank	E. coli per 100mL*	Minor illness rate** (cases per 1,000 swimmers)	WQO Compliance
Good	Less than or equal to 24	Undetectable	Complied
Fair	25 to 180	Less than or equal to 10	Complied
Poor	181 to 610	10 to 15	Not complied
Very Poor	More than 610	More than 15	Not complied

(Source: EPD web site)

* Geometric mean E. coli count calculated based on all the data collected during the bathing season.

** Gastrointestinal and skin complaints

2.9 The water quality of beaches in the first two categories i.e., "Good" and "Fair", meets the WQO for bathing beaches (which is 180 E. coli per 100mL). Beaches having annual geometric mean E. coli densities between 181 and 610 per 100mL are ranked "Poor". Beaches having annual geometric mean E. coli densities greater than 610 per 100mL are ranked "Very Poor". In this case, the beach management authority would consider closing these beaches for the next bathing season.

Policy on Beach Opening and Closing

2.10 The Leisure and Cultural Services Department (LCSD) is currently the "beach management authority", responsible for determining the opening and closing of gazetted beaches. The decision is made with reference to the advice provided by EPD on the suitability of beach water quality for bathing purposes and the consideration of all other factors. Generally, a beach will be closed if it is ranked "Very Poor" repeatedly.

2.11 The procedures for re-opening a beach will involve the following key steps:

- EPD informs LCSD of continued water quality improvement at the concerned beach and that the beach is suitable for swimming. In making this advice, EPD normally refers to beach water quality monitoring results that it has collected over a period of time.
- LCSD then clarifies the actual situation with EPD, and decides whether and when to re-open the affected beach.
- Once a decision on beach re-opening is made, LCSD will issue a press release and inform the relevant District Council.

Impact of HATS Stage 1 Discharges on Beach Water Quality

2.12 The long-term beach water-quality trends along the Tsuen Wan coast are presented in **Exhibit 2.1**. This shows that, with the exception of Ma Wan Tung Wan, water quality of all of the other seven beaches (Anglers', Approach, Casam, Gemini, Hoi Mei Wan, Lido, and Ting Kau) have been "poor" or "very poor" for many years. The major source of beach pollution up to late 2001 has been wastewater discharges from local unsewered villages or squatter areas in the upland areas. The water quality of Angler's, Approach, and Ting Kau beaches have been so unsatisfactory that these beaches have been closed since as early as 1997.

Exhibit 2.1 Tsuen Wan District - Annual Geometric Mean E. coli over 10 years

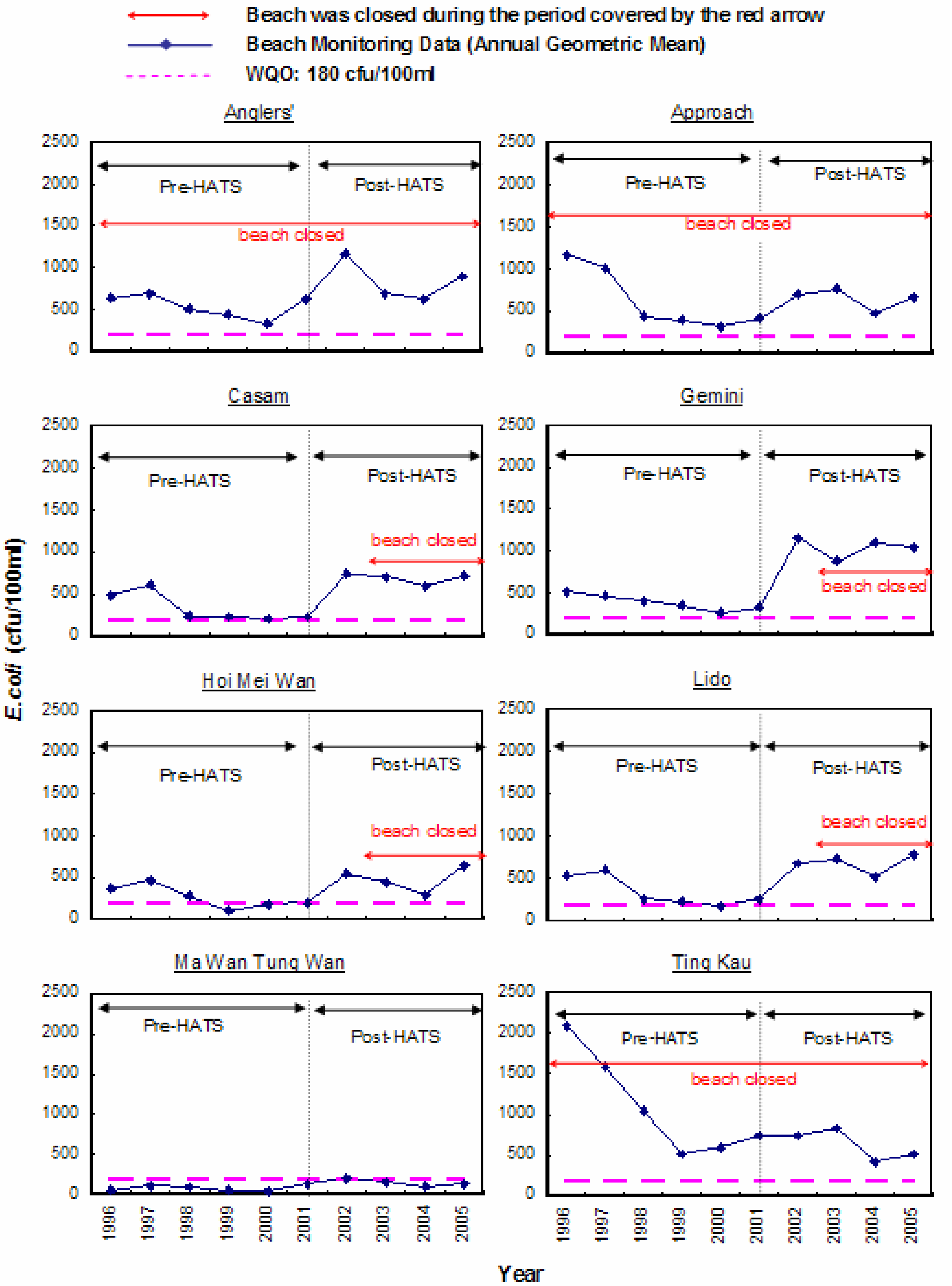
Beach	*E.coli* counts per 100 mL									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Anglers'	691	502	442	326	621	1,169	693	619	895	772
Approach	1,009	435	387	316	411	696	762	470	663	599
Casam	609	239	231	209	233	741	702	594	716	426
Gemini	458	399	350	258	323	1,155	875	1,102	1,042	853
Hoi Mei Wan	471	280	109	177	199	547	442	287	641	308
Lido	600	262	231	181	269	683	734	523	782	459
Ma Wan Tung Wan	110	92	51	39	133	201	159	101	132	171
Ting Kau	1,583	1,045	515	593	739	742	831	412	512	469

Note: Figure in red indicates that the beach was closed in that year

(Source: EPD web site)

2.13 Noting the unsatisfactory beach water quality in the Tsuen Wan area, the Government has been tackling local pollution sources by providing centralised sewerage service under several regional sewerage schemes (e.g., Ting Kau Sewerage Scheme, Sham Tseng Sewerage Scheme). These schemes have been effective in reducing E. coli levels at the Tsuen Wan beaches (in particular Anglers', Approach, and Ting Kau, as shown in **Exhibit 2.2**), until HATS Stage 1 was commissioned in December 2001. Since then, owing to the impact of the un-disinfected effluent plume from SCISTW, the Tsuen Wan beach water quality has begun again to deteriorate. Eventually, in 2003, Casam, Gemini, Hoi Mei Wan, and Lido were closed. To date, all seven beaches remain closed.

Exhibit 2.2 Annual Trend of Geometric Mean E.coli Levels Measured at Tsuen Wan Beaches



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Conclusion on Need for the ADF

2.14 The monitoring data shows that both the HATS Stage 1 un-disinfected effluent discharge and local pollution sources are contributing to the poor or very poor beach water quality at the seven Tsuen Wan beaches. Before the beach management authority may consider re-opening any of these beaches, it is necessary to improve beach water quality to a level consistent with the present policy on beach management and community aspirations.

2.15 As demonstrated in Section 5 of this EIA Report, the proposed ADF will disinfect HATS effluent to bring beach water quality back to pre-HATS Stage 1 conditions. The ADF, together with reduction of localised un-treated wastewater discharges being implemented under the regional sewerage schemes, will be essential to improving the Tsuen Wan beach water quality and, consequently, re-opening of the beaches. From the historic records as shown in **Exhibit 2.2**, three beaches, namely Anglers', Ting Kau and Approach, on the Tsuen Wan coast had been closed due to strong influence of local pollution sources before the commissioning of HATS Stage 1. On top of the already poor water quality, un-disinfected effluent from HATS Stage 1 commissioned in late 2001 has caused four other beaches on the coast to close. They are, namely Lido, Casam, Hoi Mei Wan, and Gemini.

2.16 Based on the water quality modelling results given in Section 5, provision of disinfection facilities at SCISTW after implementation of ADF will keep the influence of the HATS effluent at the Tsuen Wan Beaches to a very low level (≤ 15 *E. coli* per 100 ml). With regard to the background (i.e., non-HATS) pollution sources, the government has been implementing the local sewerage works along Castle Peak Road for completion by 2009 in conjunction with the ADF to serve the unsewered villages and properties around Ting Kau, Sham Tseng and Tsing Lung Tau. As the outfalls of Kwai Chung, Tsing Yi and Northwest Kowloon PTWs (which should have an influence on the water quality of Tsuen Wan beaches at the pre-HATS stage) have been decommissioned since the commissioning of HATS Stage 1 in 2001, it is expected that the beach water quality after the operation of the ADF would be improved to a level that is better than the pre-HATS Stage 1 condition to facilitate early re-opening of the Tsuen Wan beaches.

2.17 Without disinfecting the HATS Stage 1 effluent, the Tsuen Wan beach water quality cannot be restored even with the completion of local sewerage works which can only arrest the local pollution problems. The proposed ADF, in conjunction with the local sewerage works being implemented, will bring about the necessary water quality improvements needed for the re-opening of Tsuen Wan beaches at the earliest possible moment. If the ADF were not implemented, the Tsuen Wan beach water quality would remain jeopardised by the un-disinfected HATS Stage 1 effluent, until the permanent disinfection facilities proposed under Stage 2A are commissioned. The current timetable for HATS Stage 2A is for substantial completion to be achieved by end 2014. This is about five years behind the target commissioning date of end 2009 for completing the ADF.

2.18 In conclusion, the provision of the proposed ADF is an integral part of the sewerage programme to restore the water quality of the Tsuen Wan beaches at the earliest possible moment. The *E. coli* levels at the Tsuen Wan beaches during the ADF stage have been quantified by using mathematical model. As the model input data such as the HATS flow rates and the background pollution loading tended to be conservative to provide a margin of tolerance (refer to **Section 5.65** and **Appendix 5.2** of this EIA report), it is likely that the actual *E. coli* levels at the beaches could be lower than that predicted in this EIA. This will be ascertained by monitoring of the actual beach water quality. Once the actual monitoring results confirm that the beach water quality has returned to an acceptable level for swimming, arrangements to re-open the beaches for public enjoyment will be instigated.

Consideration of Alternative Disinfection Methods and Selection of Preferred Disinfection Technology

2.19 Disinfection is the destruction, inactivation, or removal, to an appropriate level, of those microorganisms with the potential to cause infection (and therefore harm to people), and refers to the use of a technique designed specifically to reduce the number of viable infectious microorganisms in an effluent. In this context, conventional primary and/or secondary treatment are not considered as disinfection techniques, although these forms of treatment do reduce concentrations of microorganisms in sewage.

Project Specific Considerations

2.20 To achieve an optimal disinfection outcome for HATS (including the ADF), the selection of disinfection technology must take into accounts several project-specific conditions or requirements as well as the unique environmental setting of SCISTW.

Scale of Facility

2.21 The SCISTW is a mega-sized facility serving several million people. The quantity of effluent needing disinfection at SCISTW will range from about 1.7million m^3/day at 2009 (when the proposed ADF is commissioned) to possibly around 2.5million m^3/day under ultimate Stage 2A/B conditions. This very large capacity of SCISTW and its pivotal role in marine water quality protection means that any adopted disinfection technology must have been proven reliable for application at similar scales.

Phased Implementation of HATS Stage2

2.22 Owing to the phased nature of the HATS Stage2 implementation programme, two types of effluent are envisaged at different times. These are:

- *CEPT effluent*, which is being produced by SCISTW and will continue to be produced throughout Stage 2A
- *Biologically treated (secondary) effluent*, which will be produced by an upgraded SCISTW under HATS Stage 2B

2.23 CEPT and biologically treated effluents have different characteristics. For example, un-disinfected CEPT effluent typically has higher concentrations of microorganisms (including pathogens) and suspended solids, and lower UV light transmittance when compared to un-disinfected biologically treated effluent. Further, at present, ferric chloride is used as coagulant in the CEPT process, and this is known to interfere with the performance of UV radiation disinfection.

2.24 As performance and efficiency of disinfection are related to effluent characteristics or quality, different disinfection technologies may be optimal at different times of HATS. Therefore, flexibility to suit varying effluent quality will need to be considered when selecting the most appropriate disinfection scheme for HATS.

Early Improvement to Tsuen Wan Beach Water Quality

2.25 The discharge of un-disinfected sewage effluent from SCISTW is contributing to unsatisfactory beach water quality at the Tsuen Wan beaches. On this, the Report of the Public Accounts Committee (PAC) of the Legislative Council on the Director of Audit's Report No. 42 (2004) has requested the Administration to "*take into account the high bacteria level of the effluent discharged from the Stonecutters Island Sewage Treatment Works in planning the further stages of HATS, and in evaluating the options for providing a permanent disinfection facility in the long term*".

2.26 In response to this request and trusting that early restoration of the environmental quality should be pursued as far as possible, the Government is proposing to advance the provision of part of the permanent disinfection facilities under HATS Stage 2A at the earliest opportunity, rather than to wait until the completion of Stage 2A in late 2014. Therefore, the selected disinfection option for the ADF should be able to be implemented reasonably quickly (within two to three years).

Environmental Setting

2.27 Environmental setting is generally favourable for effluent dilution or dispersion from the existing SCISTW marine outfall. Key features of the SCI outfall include:

- Beneficial use of the water body off SCI is primarily "marine traffic", meaning that there are virtually no sensitive receivers in close proximity of the effluent discharge point
- The ecological value of the inner harbour waters is generally low
- Water sensitive receivers (e.g., beaches, fish farms, coral sites, marine parks, etc) are remote from the SCI outfall
- Water currents are relatively high at or near the SCI outfall, meaning that the effluent plume can be effectively diluted and dispersed before it reaches the sensitive receivers
- The receiving marine water facilitates die-off of infectious microorganisms by virtue of natural environmental and biological factors. These include temperature, solar radiation, salinity, natural mortality, and the presence of protozoan flagellates.

Approach to Option Evaluation

2.28 With the above project-specific considerations in mind, a comprehensive four-tier option evaluation has been conducted to select the most appropriate disinfection technology for HATS (and the ADF), considering environmental as well as non-environmental factors. The evaluation process included long-listing and short-listing of technology options, along with multi-criteria assessments with increasing levels of sophistication.

2.29 In parallel, a review of local and international disinfection practices was also conducted to provide general information for reference by the project team.

2.30 Details of the option evaluation and review of local and international practices are contained in **Appendix 2.1**. A summary of the key findings are presented in the following paragraphs.

Multi-tiered, Multi-criteria Option Evaluation

Technology Long-listing

2.31 Drawing on established practices, input from the public consultation sessions, and considering new or emerging disinfection technologies, five groups of potential disinfection technologies (some with sub-options) have been evaluated for SCISTW :

- Chemical-based technologies:
  - Chlorination (and chlorine-based technologies)
  - Ozonation
  - Other non-chlorine based disinfection chemicals, including mainly oxidants such as potassium permanganate, potassium ferrate, hydrogen peroxide, peracetic acid, etc, and combinations of chemicals, such as "ozone/hydrogen peroxide"
- UV radiation
- Membrane technologies
- Artificial reefs
- Extension of SCISTW outfall to enhance mixing and dispersion of the effluent

Tier 1 Evaluation – Technical Feasibility

2.32 These initial options were evaluated against feasibility requirements, in terms of functionality and proven-ness. In summary, the Tier 1 evaluation showed that:

- Chlorination and UV radiation[1] are feasible, though they have different degrees of proven-ness

[1] UV radiation was taken forward to the next stage of evaluation despite its current limited operating experience for primary/CEPT effluent in terms of (a) size and (b) track record. With respect to size, the existing UV system capacity (of less than 20,000m^3/d) is much smaller than the 2,500,000m^3/d for HATS. With respect to track record, it is noted that there are increasing number of UV installations with increasing sizes, e.g. Sand Island STW, Hawaii, Siu Ho Wan STW, HK, Halifax STW, Canada, all for CEPT effluent. Hence,

for application to a mega-scale project like HATS.
- No other disinfection options are feasible for HATS. It is acknowledged that some of these alternative technologies are feasible for small-scale applications, but they are either unworkable or unproven at the scale contemplated for HATS.

2.33 In conclusion, it was proposed to carry forward both chlorination and UV radiation to the next stage of the evaluation.

Tier 2 - Confirmation of Environmental Acceptability

2.34 Before chlorination and UV radiation were short-listed for further evaluation in Tier 3, an assessment of the fundamental acceptability of the technologies was conducted with respect to the key aspects of marine water quality and human/ecological health. The short-listed technology will not be selected for further evaluation if its environmental acceptability cannot be confirmed in this tier of evaluation.

2.35 With respect to chlorination, the combined effect of source control measures (e.g., de-chlorination), effective initial dilution/far field mixing, and absence of water sensitive receivers or uses in the near field is that there should be no or negligible risk to human health or aquatic lives. This has been confirmed by human health and ecological risk assessments (see Sections 6 and 7), which have been based on precautionary principle by adopting conservative approaches and assumptions, including:
- Carry out laboratory analyses and include in risk assessments of all the (9) chlorination by-products (CBPs) regulated under US *Drinking Water Standards* plus all (25) chloro-organic compounds in the priority pollutant list regulated under US National Pollutant Discharge Standards, although these priority pollutants are not regulated due to the concern of generation during chlorination process.
- Adopt maximum effluent and background contaminant concentrations (instead of mean values) to calculate chemical of concern (COC) concentrations at exposure points (also see Section 6.37, 7.53 and 7.54)
- Neglect the effect of possible chemical degradation, volatilization and other mechanisms (also see Section 6.37, 7.53 and 7.54)
- Adopt conservative incidental water ingestion rate during swimming activities and seafood consumption rate (also see Section 6.37)
- Include exposure scenarios of dropping into the harbour once per year and frequent swimming at the edge of mixing zone, which are unlikely to happen (also see Section 6.37)
- Assume that aquatic organisms live their entire lives at the mixing zone (also see Section 7.53)
- Adopt conservative area use factors for marine mammals (also see Section 7.54)

2.36 In addition, precautionary principle is followed through by conducting Whole Effluent Toxicity Test (WETT) using chlorinated/dechlorinated effluent at a higher chlorine dosage. The results of the WETT provide assessment on combined effects of all the chemical species present in the chlorinated/dechlorinated effluent including the possible additive/synergistic/antagonistic interactive effects onto representative local marine biota and fisheries (also see Section 7.18).

2.37 The findings of the human health and ecological risk assessments are as follows:
- Risks to human health and ecological resources are low and within acceptable limits
- No adverse impact on aquatic lives due to acute and chronic toxicity
- Chlorination disinfection is an environmentally acceptable option for HATS, with respect to water quality, human and ecological health risks

2.38 With respect to UV radiation:
- Disinfection of sewage effluent by UV radiation is generally considered environmentally benign. Aldehydes and other oxidation by-products were found to exhibit a UV-dose response increase in previous pilot studies using both low- and high-intensity UV systems, although the elevated levels

operating experience is improving. Also, modular design of UV disinfection facilities could allow installation of larger capacity UV plants, although a scale-up factor of more than 100 times for HATS needs to be carefully addressed.

were found to be within the acceptable limits[2]. UV pilot tests conducted at SCISTW also indicated that there was no significant increase of any of the tested compounds.

- For the purpose of this assessment, it has been considered that no or insignificant level of potentially toxic DBPs from UV radiation would enter the receiving water body. Therefore, the risk on human or ecological health due to UV radiation of effluent is insignificant or negligible.

2.39 Overall, both chlorination and UV disinfection are environmentally acceptable options for HATS, with respect to water quality, human and ecological health risks.

Tier 3 Evaluation – Environmental Considerations

2.40 Subsequently, the two short listed options were further developed. For chlorination, it was concluded that purchase of sodium hypochlorite solution would be the most appropriate way of effecting chlorination. For UV radiation, either low- or medium-pressure high intensity UV lamps would be suitable for application at SCISTW.

2.41 In the Tier 3 evaluation, both options were assessed against a comprehensive range of environmental criteria, including fisheries, air quality, noise, landscape and visual impacts, waste management implications, hazards to public, in addition to water quality, human health, and marine ecology.

2.42 The analysis suggested that both disinfection options would be environmentally acceptable. The relative performances of each disinfection option against the environmental criteria are elaborated below.

- With respect to *water quality improvement (pathogen reduction*), chlorination (purchase of sodium hypochlorite) would be preferred to UV radiation. This is because the chlorination system could be implemented much sooner than the UV system, with the potential to bring about earlier improvement to water quality (reduction of pathogens) at the Tsuen Wan beaches.

- On *human health, marine ecology, and fisheries,* the key concerns of chlorination are toxicity generated by total residual chlorine (TRC) and formation of chlorination by-products (CBPs) (which are mainly chlorinated organic compounds). It is noted that:

  - TRC can be removed from the effluent by de-chlorination such that it would not pose a significant concern to human health, marine ecology, or fisheries.
  - The formation of CBPs is related to the strength of the sewage and the dosage of chlorine added to the wastewater. In the case of HATS, chemical tests have confirmed that there are few CBPs in the HATS effluents, and that the detected CBPs are of relatively low concentrations, and found to be well within acceptable limits.
  - Further, hydrodynamic conditions are favourable to effective mixing and dilution of the discharged effluent from SCISTW, while the SCI outfall is located well away from human receivers, sensitive marine resources, and fisheries resources.
  - The project-specific human and ecological health risk assessments (based on conservative approaches) conducted as part of the EIA study have demonstrated that the risks are low and are well within acceptable criteria.
  - In conclusion, in the context of HATS, effluent disinfection by chlorination poses low and therefore acceptable risk to human health, marine ecology, and fisheries with the proposed dechlorination system, precautionary design measures and accepted good operation practice.

- Two groups of contaminants of concerns are associated with UV radiation: mercury from the UV

[2] Soroushian F, Kwan A, Abramson C., Ferris M., Archer J;, and Mohammed A (1997). Pilot-Scale Studies of High Intensity UV Disinfection Byproducts. Disinfection Digest WEF pp 505 – 510.
Awad J., Gerba C. and Magnuson, G (1993). Ultraviolet Disinfection for Water Reuse. Proceedings of WEF Specialty Conference Disinfection Systems. Whippany, New Jersey. Pp 1 -12.

lamps and disinfection by-products (DBPs) from the UV radiation process.

- With respect to mercury, this could be released into the effluent if the UV lamps break during operation and maintenance activities. This is unlikely, however, given that proper procedures will be in place.
- Regarding DBPs from UV radiation of sewage, there is relatively little information, as this subject is being researched. Aldehydes and other oxidation by-products were found to exhibit a UV-dose response increase in previous pilot studies using both low- and high-intensity UV systems, although the elevated levels were within the acceptable limits[3]. UV pilot tests conducted at SCISTW also indicated there was no significant increase of any of the tested compounds. This means that any health risks due potential DBPs associated with UV radiation would be low.
- Nevertheless, hydrodynamic conditions are favourable to effective mixing and dilution of the discharged effluent from SCISTW, while the SCI outfall is located well away from human receivers, sensitive marine resources, and fisheries resources.
- Again, in the context of HATS, effluent disinfection by UV radiation is considered to pose low and therefore acceptable risk to human health, marine ecology, and fisheries with precautionary design measures or generally accepted good operation practice (e.g., storage and handling of UV lamps etc).

• With respect to *air quality* and *noise*, neither disinfection option would generate any significant air and noise emissions during operation. Therefore, either option is considered to have no material air quality or noise impact.

• Concerning *landscape and visual impacts*, given the industrial setting of the area and the scale of disinfection plant (either chlorination or UV radiation) relative to the SCISTW, it is considered that either option would be acceptable without mitigation measures over and above generally accepted good practice (e.g., sympathetic architectural treatment).

• Regarding *waste management implications*, chlorination is preferred to UV radiation. This is because:
  - Application of UV radiation to CEPT effluent (Stage 2A) would require switching the coagulant to alum (from ferric chloride) in the CEPT process. This, in turn, would lead to about 10% extra sludge each day (about 100 to 130 wet tpd) requiring disposal at landfills.
  - The capacity available for co-disposing sewage sludge (with other solid wastes) at landfills is depleting rapidly. The extra 10% of alum sludge is not a significant amount. To overcome this problem, it may be necessary to pre-process the sludge to a condition that is suitable for direct disposal at landfills.
  - UV lamps contain mercury, and spent UV lamps are hazardous wastes requiring special disposal practice or re-processing by the manufacturer. It has been estimated that on average thousands of spent UV lamps would be generated each year under Stage 2A.
  - For Stage 2B, where biologically treated effluent is involved, no extra sludge would be generated (as there would be no need to use alum in the upstream CEPT process). However, spent UV lamps will continue to be managed or disposed of as a hazardous waste.

• With respect to *hazards to public*:
  - The chlorination option would involve sodium hypochlorite and sodium bisulphite solutions. Given the nature of the chemicals (neither substance is explosive or flammable), and the

[3] Soroushian F, Kwan A, Abramson C., Ferris M., Archer J;, and Mohammed A (1997). Pilot-Scale Studies of High Intensity UV Disinfection Byproducts. Disinfection Digest WEF pp 505 – 510.
Awad J., Gerba C. and Magnuson, G (1993). Ultraviolet Disinfection for Water Reuse. Proceedings of WEF Specialty Conference Disinfection Systems. Whippany, New Jersey. Pp 1 -12.

location of SCISTW (which is isolated and remote from population centres), storage and handling of these chemicals in SCISTW are not expected to pose any material hazards to the public. Transportation of these substances to SCISTW will be by purpose-built marine vessel or road tankers, and will follow standard HK Fire Services Department requirements. Overall, it is expected that the hazard posed to public during transportation of these substances would be low with adoption of relevant Fire Services Department codes of practices.

- The UV option would also pose a certain degree of hazard to the public during transportation of spent UV lamps (which contain mercury, a hazardous waste) from the disinfection plant to the disposal site (e.g., the Chemical Waste Treatment Facility at south Tsing Yi). Nevertheless, risks are considered acceptable with standard precautionary measures.

2.43 Overall, both chlorination and UV radiation would comply with relevant environmental assessment criteria. Therefore, both are considered preferred from an environmental perspective, as neither option would lead to unacceptable or adverse environmental impacts (effects). This also means that adoption of either chlorination or UV radiation will avoid adverse environmental effects to the maximum practicable extent.

2.44 Nevertheless, neither disinfection option is superior to the other on all of the environmental aspects considered in the Tier 3 evaluation. Each option has environmental benefits and disbenefits relative to existing (i.e. baseline) conditions, as highlighted in **Table 2.2**.

Table 2.2 Summary of Environmental Benefits and Disbenefits of the Disinfection Options

DISINFECTION Option	benefits	disbenefits
Chlorination	▪ Reduction of pathogen discharge from un-disinfected effluent and the associated potential heath and safety problems ▪ Improvement to beach water quality ▪ Can be installed at the earliest opportunity (i.e. before end 2009)	▪ Potential discharge of chlorine residual, which is toxic to aquatic life, but the residual can be controlled by the proposed dechlorination system to meet the TRC discharge limits (0.2 mg/l at 95 percentile and 0.4 mg/l at maximum) as proposed in Section 5). ▪ Formation of potentially harmful chlorinated organic compounds, but the short- and long-term residual risks to human and ecological health have been found to be well within acceptable limits ▪ Potential hazard to life due to handling and storage of disinfection chemicals, but this can be eliminated/minimized upfront with precautionary design measures and the residual risk level is well within acceptable criteria
UV radiation	▪ Reduction of pathogen discharge from un-disinfected effluent and the associated potential heath and safety problems ▪ Improvement to beach water quality	▪ Generation of spent UV lamps which contain mercury (which is a hazardous waste), but this will be controlled by recycle and re-processing by the UV equipment suppliers ▪ Possible mercury release into the effluent when UV lamps break during operation and maintenance

DISINFECTION Option	benefits	disbenefits
		activities, but this is unlikely given proper operation procedures will be in place ▪ Formation of potentially harmful compounds (e.g., aldehydes and other oxidation by-products) , but the residual risks to human and ecological health have been found to be well within acceptable limits ▪ Generation of additional waste sludge from the CEPT process due to the need to use alum instead of ferric chloride as coagulant but the increase in sludge volume is slight (about 100 wet tpd).

2.45 To select a disinfection option for HATS, it was necessary to proceed to Tier 4 evaluation, which has considered a broader range of criteria (other than environmental aspects).

Tier 4 Evaluation- Consideration of Non-environmental Factors

2.46 The two short listed options were further evaluated in Tier 4 against four non-environmental criteria:

- *Cost*, i.e., lifecycle cost, covering both capital, and operating and maintenance components. The option with the lower the total lifecycle cost is preferred.
- *Flexibility* of the disinfection system to cater for project risks or uncertainties, including, for example, sewage flow and quality variations, delay to overall HATS programme, etc. The more flexible option would be preferred.
- *Implementation issues*, in terms of impact on existing SCISTW operations, and time required to build and commission the disinfection facility.
- *Scale-Up Factor* is the capacity of the HATS disinfection plant relative to that of the largest known and established plant using the same disinfection technology. It may be regarded as an indirect measurement of the level of proven-ness of the disinfection technology for application to HATS. The option with a smaller scale up factor would be preferred, as the technical risks and operational challenges to be managed or overcome would be smaller. As HATS Stage 2 will be implemented in phases, the scale up factor is most critical for disinfecting the type of effluent encountered at the initial stage of HATS, i.e., CEPT effluent under the ADF and Stage 2A.

2.47 In essence, the Tier 4 evaluation has concluded that:

- Chlorination would be *less costly* than UV radiation on a total lifecycle cost basis. This is because while the operation and maintenance (O&M) costs of the chlorination and UV radiation systems would be similar, the former would have a much lower capital cost, as shown in **Appendix 2.1**. Note that:
  - The major capital cost item for the chlorination/dechlorination system would be storage tanks and a dosing system, which would be much lower than the cost of constructing a UV radiation plant of equivalent capacity.
  - The major O&M cost item for chlorination would be chemicals while for UV radiation it would be energy (electricity). For HATS, these are comparable.
- Chlorination would be more *flexible* to deal with project risks such as lower (than expected) population (sewage) growth, delay to project implementation due to socio-political factors, variable effluent quality, etc. Specifically,

- The quantity of sodium hypochlorite to be purchased can be adjusted relatively easily to deal with these uncertainties. That is, more or less sodium hypochlorite may be purchased to suit actual sewage quantity and quality at any point in time.
- On the other hand, the UV radiation plant will have to be built to the largest anticipated capacity to deal with a CEPT-type effluent under Stage 2A. Yet, about half of the UV plant capacity will become redundant as Stage 2B is implemented, as the quality of secondary effluent is much better than CEPT effluent and will require a lower UV radiation dose.

• Chlorination would be *quicker* and *easier* than UV radiation to implement at SCISTW, due to its relatively simple construction (essentially only tanks and a dosing system). If a UV radiation plant were to be implemented, an additional electrical substation would be required to power the UV plant, and additional land (that is currently not available) would need to be secured to accommodate the UV plant. The time taken to provide these would be several years, meaning that improvement to marine water quality will be delayed compared to applying chlorination at SCISTW.

• For HATS, developing a chlorination plant at SCISTW would involve a smaller scale-up factor than UV radiation for the critical case of disinfecting the CEPT effluent under the ADF and Stage 2A. This is elaborated below:
- There is some experience[4] with applying UV radiation to disinfect CEPT effluent at several STWs in Hong Kong, e.g., Siu Ho Wan Phase 1 (96,000m^3/d), Cyberport (10,800m^3/d), and Sham Tseng (16,850m^3/d).
- Internationally, the largest known CEPT plant using UV radiation disinfection is the Sand Island STW, Honolulu, USA (320,000$m^{3/}$d), which is being commissioned at the moment.
- The proposed ADF or Stage 2A CEPT disinfection plant at SCISTW (up to 2.5million m^3/d) would be one to two orders of magnitude larger than these local or overseas CEPT STWs. Therefore, applying UV radiation to HATS CEPT effluent would involve scaling up the UV system by the corresponding orders of magnitude to deal with the challenges of the local situation (e.g., effluent UV transmittance profile[5]).
- On the other hand, chlorination has been applied to treat CEPT effluent at many large STWs, e.g., Deer Island[6] STW, Boston, USA (1.8million m^3/d) and Newtown Creek[7] STW, New York, USA (1.2million m^3/d). This scale of application of chlorination (to CEPT effluent) is of the same order of magnitude as HATS.
- Overall, on a comparative basis, chlorination would involve a much lower scale up factor. Hence, it is a relatively more proven technology than UV radiation for disinfecting CEPT effluent for HATS.

2.48 Overall, chlorination (purchase of sodium hypochlorite solution) is preferred to UV radiation against the Tier 4 evaluation criteria.

Conclusions on Disinfection Alternatives

2.49 As concluded from the Tier 1 evaluation, the feasible sewage disinfection options for HATS are chlorination and UV radiation.

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4 In Cyberport STW, there were initial equipment problems on UV transmittance online analysers and control systems. At SHW STW, problems related to UVT of the CEPT effluent were encountered, and an investigation into the CEPT profile is being made.

5 Uncertainties in the local CEPT UVT profile pose challenges in the design of the UV disinfection system. Uncertainties may be overcome by a conservative design approach (i.e., addressing the worst case UVT condition), but this could lead to over-design resulting in excessive capital works that will be underutilised. It will also occupy more land/space than necessary, resulting in inefficient use of this resource.

6 Deer Island STW was previously a primary treatment works using chlorination for disinfection. It was upgraded to a secondary treatment plant in 1999. Disinfection method continues to be by chlorination.

7 Newtown Creek STW is a primary treatment works using chlorination disinfection. It is now being upgrade to a secondary plant, and it will continue to use chlorination disinfection.

2.50 Based on the outcome of Tier 2 evaluation, it is concluded that both chlorination (purchase of sodium hypochlorite) and UV radiation are environmentally acceptable for HATS. Water quality and ecological impacts can be controlled to well within established criteria (contained in the Technical Memorandum of EIA Process).

2.51 A comparison of the relative environmental performance of chlorination (purchase of sodium hypochlorite) and UV radiation has been made in the Tier 3 evaluation. It is concluded that:

- Neither chlorination nor UV radiation is superior to the other on all of the environmental aspects. Nevertheless, neither option would result in adverse environmental effects (or impacts exceeding the relevant criteria in the TM).
- Therefore, both chlorination (purchase of sodium hypochlorite) and UV radiation are preferred from an environmental perspective.

2.52 For chlorination,

- The environmental benefit is that it will bring about significant reduction of pathogen discharge from un-disinfected effluent and the associated potential heath and safety problems; and consequently improvement to the Tsuen Wan beach water quality at the earliest opportunity (by end 2009)
- The environmental disbenefits are:
  - Potential discharge of chlorine residual, which is toxic to aquatic life, but the residual can be controlled by the proposed dechlorination system to meet the TRC discharge limits (0.2 mg/l at 95 percentile and 0.4 mg/l at maximum) as proposed in Section 5).
  - Formation of potentially harmful chlorinated organic compounds, but the short- and long-term residual risks to human and ecological health have been assessed to be well within acceptable limits
  - Potential hazard to life due to handling and storage of disinfection chemicals, but this can be eliminated upfront with precautionary design measures and the residual risk level is well within acceptable criteria

2.53 For UV radiation,

- The environmental benefit is that it will also bring about significant reduction of pathogen discharge from un-disinfected effluent and the associated potential heath and safety problems; and consequently improvement to the Tsuen Wan beach water quality
- The environmental disbenefits are:
  - Generation of spent UV lamps which contain mercury (which is a hazardous waste), but this will be controlled by recycle and re-processing by the UV equipment suppliers
  - Possible mercury release into the effluent when UV lamps break during operation and maintenance activities, but this is unlikely given proper operation procedures will be in place
  - Formation of potentially harmful compounds (e.g., aldehydes and other oxidation by-products), but the residual risks to human and ecological health have been found to be well within acceptable limits
  - Generation of additional waste sludge from the CEPT process due to the need to use alum instead of ferric chloride as coagulant but the increase in sludge volume is slight (about 100 wet tpd)

<u>Preferred Option</u>

2.54 As discussed earlier, a multi-tier multi-criteria option evaluation has been conducted to recommend a preferred disinfection technology for HATS. The Tier 1 evaluation was a screening test, and served to identify only those disinfection options that would be technically feasible for HATS.

2.55 Environmental considerations have played a key part in the technology selection process for HATS. These included:

- In Tier 2 evaluation, the environmental acceptability of both technically feasible options (UV radiation and chlorination) in terms of water quality, human health, and ecological health was confirmed before these were taken forward to the next stage of the evaluation.

- In Tier 3 evaluation, both UV radiation and chlorination were assessed against nine environmental criteria, i.e., fisheries, air quality, noise, landscape and visual impacts, waste management implications, hazards to public, in addition to water quality improvement (pathogen reduction), human health, and marine ecology.

2.56 The Tier 3 evaluation has concluded that, from an environmental perspective, both chlorination (purchase of sodium hypochlorite) and UV radiation would be preferred. Neither option would result in any adverse environmental effects.

2.57 Adoption of either option will avoid adverse environmental effects to the maximum practicable extent, as either option will comply with all relevant environmental criteria.

2.58 Nevertheless, neither disinfection option would be superior to the other on all of the nine environmental criteria. There were relative environmental benefits and disbenefits, depending on the criteria under consideration, as elaborated above.

2.59 On "non-environmental" considerations, chlorination does have advantages over UV radiation in the context of HATS (including the ADF), in terms of a lower total lifecycle cost8, a higher level of flexibility to deal with uncertainties and project risks, easier and speedier implementation at SCISTW, and lower technology scale-up factors and hence more proven application in large-scale STWs. These "non-environmental" advantages of chlorination also bring about significant environmental benefits. In particular,

- Adoption of UV radiation for the ADF (and Stage 2A), where CEPT effluent is involved, will result in substantial abortive works (hence capital investment and wastage of resources) at Stage 2B when biological treatment is implemented.
- Early commissioning of the disinfection plant at SCISTW would bring about water quality improvement (pathogen reduction) at the earliest opportunity.
- Further, given the mega-size of SCISTW (2.5million m^3/d), and its pivotal role in marine water quality protection, it would be prudent to minimise the technical risks and operational challenges associated with system scale up.

2.60 Therefore, it is recommended that chlorination (purchase of sodium hypochlorite solution) should be adopted as the disinfection technology for HATS in preference to UV radiation.

2.61 In arriving at the above conclusion, environmental factors have played a significant role, as manifested in the conduct of Tiers 2 and 3 evaluations.

Review of Local and International Disinfection Practices

2.62 As elaborated above, selection of sewage disinfection technology is necessarily a project-specific exercise that must consider a wide range of technical and non-technical constraints and issues unique to the situation at hand. With this in mind, the objective of the review of local and international disinfection practices was to provide supplementary information for general reference by the project team. **Appendix 2.1** contains the review, which is summarised below.

Local Review

2.63 In Hong Kong, there are over 260 sewerage facilities. Eleven of these are municipal STWs employing primary, secondary, or tertiary treatment. Most of these municipal STWs are less than 100,000m^3/day, with the exception of SCISTW (1.7million m^3/d) and Shatin STW (340,000m^3/d).

2.64 Disinfection of secondary effluent by either chlorination or UV radiation has been practised for some time in Hong Kong. These include UV disinfection at Shek Wu Hui STW (80,000m^3/d) and Sai Kung

[8] Due to reduced UV disinfection efficiencies at low UV transmittance and high suspended solids for CEPT effluent, and high UV equipment costs for mega-scale HATS systems because of linear relationship between UV lamp requirements and flow rates

STW (22,000m^3/d), both employing secondary treatment. At Stanley STW (11,600m^3/d), the secondary effluent is disinfected using chlorination.

2.65 For CEPT effluent, there is some recent experience with UV radiation disinfection at several STWs, including Siu Ho Wan CEPT Plant Phase 1 (96,000m^3/day), Sham Tseng CEPT Plant (16,850m^3/day), and Cyberport CEPT Plant (10,800m^3/day).

2.66 To sum up, both chlorination and UV radiation have been adopted at local STWs for either CEPT or secondary effluent, though all these are at a scale much smaller than that anticipated for HATS (up to 2.5million m^3/d). This point has been considered in the option evaluation process, as mentioned previously.

International Review

2.67 The objective of the international survey was to gather information on disinfection practices, being or likely to be adopted in the near future, in coastal cities that discharge their treated effluents in marine waters. It is cautioned that the conditions that led to the adoption of a particular disinfection scheme or technology by an overseas sewage treatment plant could be complex and might include a multitude of technical and non-technical (e.g., social, political, etc) considerations. As such, the review is to provide a general reference, and it should not be taken as a definitive account of overseas trends or practices.

2.68 Based on a set of criteria (e.g., population, treatment requirements, level of infrastructure development, etc), 24 coastal cities were selected for the survey, including eight (8) in North America, nine (9) in Asia/Australia/New Zealand and seven (7) in Europe.

2.69 In these 24 cities, 132 sewage treatment works (total capacity 38,688,000m^3/day) were surveyed. Of the total effluent, 36% of it is discharged into receiving waters without disinfection, 58% uses chlorination, 5% uses UV disinfection, and less than 1% uses other technologies.

2.70 Of these 132 STWs, 13 were primary or CEPT STWs, collectively treating about 6.8million m^3 of effluent each day. Of the surveyed primary STWs, the majority (69.4%, by volume) of the effluent is discharged to receiving waters (mostly marine waters except two were rivers) without disinfection. About 30.3% (by volume) of the effluent is disinfected by chlorination, with the capacity of the largest STW at about 1.2million m3/day. One small CEPT plant (capacity of 0.024million m^3/day) uses UV radiation, accounting for about 0.4% of the amount of effluent treated.

2.71 With respect to the 119 surveyed secondary or tertiary STWs (totalling 31.9million m^3 of effluent each day), about 29% (by volume) of the treated secondary/tertiary effluent is discharged to receiving waters without disinfection. The majority (65%, by volume) of the effluent is disinfected by chlorination, with the capacity of the largest STW (which is in Deer Island, Boston, USA) at 1.8million m^3/day. UV radiation is used to disinfect about 5% (by volume) of the effluent, with the capacity of the largest plant (which is Ringsend STW, Dublin, Ireland) at 0.64million m3/day. One plant in Japan (capacity 0.3million m^3/day) uses a combined chlorination and ozonation process to disinfect the treated effluent, prior to discharging it to the upstream of water gathering catchments.

2.72 The statistics may also be presented in terms of STW size. Of the 132 surveyed STWs, 48 were considered “large” (i.e., having a treatment capacity higher than 100,000m^3/day). Collectively, these 48 large STWs treat about 36.6million m^3 of effluent each day. The disinfection practices adopted in these large STWs are summarised below:

- About 36% (by volume) of the effluent is discharged to receiving waters without disinfection.
- Chlorination is used to disinfect about 60% (by volume) of the effluent, with the capacity of the largest STW (which is a secondary STW in the USA) at 1.8million m3/day.
- UV radiation is used to disinfect about 3% (by volume) of the effluent, with the capacity of the largest plant (which is a secondary/tertiary STW in Ireland) at 0.64million m^3/day

2.73 In conclusion, the review has found that effluent disinfection is not practised at all of the surveyed STWs. Where disinfection is employed, chlorination is the major technology (in terms of volume of effluent treated) for either primary/CEPT, secondary, or tertiary effluent. UV radiation is the next major disinfection technology after chlorination. The review shows that it is applied more to secondary/tertiary effluent than to primary/CEPT effluent.

2.74 With respect to disinfection practices being applied currently or to be applied in the coming years, it was found that:

- Of the disinfection facilities commissioned in the surveyed cities in the last 10 years, some 75% of the installed capacities use chlorination/dechlorination, whilst the remaining 25% use UV radiation for disinfecting mostly secondary or tertiary effluents.
- For those facilities to be commissioned in the coming five years, the total flow capacity of the new UV radiation installations is similar with that of new chlorination facilities.
- Most of the UV facilities installed/to be installed are for disinfection of secondary/tertiary effluents.

2.75 To sum up, overseas STWs are required to meet effluent quality standards and/or comply with receiving water quality objectives. Both chlorination (essentially sodium hypochlorite) and UV radiation continue to be the preferred mainstream disinfection technologies for municipal STWs.

2.76 Overall, there is not a simple, clear trend on disinfection technology being adopted in future STWs. It would appear that adoption of disinfection technologies is specific to local conditions and requirements. This is consistent with the project-specific approach to disinfection technology selection for HATS, as outlined in the preceding sections

Project Elements

2.77 Key elements of the proposed ADF include:

- Chlorination system - provision of a sodium hypochlorite solution storage plant and associated dosing system, including:
  - Six (4 duty and 2 standby) sodium hypochlorite storage tanks (8m in diameter, 12.5m in height)
  - One day tank for sodium hypochlorite storage (capacity of about 100m3)
  - Pipes in pipe trenches
  - Switch room
  - Chemical feeding and transfer system
  - Bund wall (2m in height)
  - ISO tank unloading area
  - Sodium hypochlorite barge unloading facility

- Dechlorination system - provision of a sodium bisulphite solution tank farm and associated dosing system, including:
  - Two sodium bisulphite storage tanks (6m in diameter, 6.2m in height)
  - Chemical feeding and transfer system
  - Bund wall (1.5m in height)
  - ISO tank unloading area
  - Security fence and gate

2.78 A location plan of the proposed disinfection facilities at SCISTW is shown in **Figure 2.1**.

Construction Method

2.79 The Project would involve the following major construction activities:

- Site formation & site establishment
- Piling
- Excavation and backfilling
- Erection of formwork and reinforcement
- Concreting
- Fabrication of steelwork & installation of E&M equipment
- Testing and commissioning

Operation of the Disinfection Facilities

2.80 Under the recommended option of purchasing sodium hypochlorite solution for the ADF, the existing effluent culvert system will be used as the chlorine contact basin. Sodium hypochlorite solution (w/v 10%-12%) as the disinfection agent will be purchased and delivered to SCISTW by a specially designed delivery barge and unloaded at the berthing facility at an interval of 2 to 3 times a week (by vehicles when weather or other conditions do not allow chemicals delivery by sea). Sodium hypochlorite solution will be transferred to the storage tanks in the chlorination plant through a designated and isolated piping system laid within pipe trench. Then the chemical will be pumped from the storage tanks to a day tank next to the flow distribution chamber. The sodium hypochlorite solution from the day tank will then combine with carrier water (effluent) and dose to the flow distribution chamber through a diffuser installed below effluent surface (see **Figure 2.1**). The maximum storage amount for sodium hypochlorite solution on-site for the ADF operation is estimated to be about 1,800,000L.

2.81 Sodium bisulphite solution (w/v 38%) will be used as the dechlorination agent and dosed at the existing Chamber 15 prior to the outfall discharge (see **Figures 2.1** and **2.2**). It will be purchased and delivered to SCISTW at an interval of 1 to 2 time(s) a week only by road tankers and then unloaded to the storage tanks. The chemical storage tanks for sodium hypochlorite solution will be rubber-lined steel tanks and that for sodium bisulphite solution will be fibreglass reinforced plastic tanks, and both will be located inside bund walls (see **Figures 2.3** and **2.2**). The proposed sodium hypochlorite, proposed sodium bisulphite, and existing ferric chloride tank farms are physically separated from each other to prevent mixing of the chemicals in case of failure of the storage tanks.

2.82 When designing a chlorination system, the key objective is to minimize the use of chlorine and hence cost, as well as to minimize the formation of chlorination by-products (CBPs). There are two ways to achieve this objective: providing complete initial mixing between water and chlorine; and controlling chlorine dosage by monitoring the residual chlorine in the effluent.

2.83 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. A better mixing environment would result in better disinfection efficacy and thus reducing the required chlorine dose.

2.84 For the control of chemical dosages, two operation modes, namely Manual Operation Mode and Automatic Operation Mode are developed. The control philosophy of two operation modes is basically the same:

- Sodium hypochlorite is used to disinfect CEPT effluent, and its dosage is adjusted to maintain TRC levels at Chamber 15 (i.e. outlet of disinfection system) of 2 – 4 mg/L
- Sodium bisulphite is dosed to remove TRC before discharge, and its dosage is adjusted to maintain zero TRC in discharge
- Both hypochlorite and bisulphite dosing rates are adjusted based on sewage flow rate and TRC level measured at Chamber 15
- While laboratory tests have demonstrated that dechlorination will occur within 15 seconds of adding of the bisulphite solution to the chlorinated effluent, a dechlorination simulation loop will be installed at Chamber 15 to monitor the de-chlorinated effluent TRC and bisulphite level, and to confirm zero TRC level in discharge
- Regular TRC measurement to ensure the reliability of control

2.85 The difference between two operation modes is the TRC measurement methods at Chamber 15, thereby the system's response time (chemical dosages adjustment) to the fluctuation of sewage characteristics then TRC levels.

2.86 Under Automatic Operation Mode, chemical dosages will be adjusted based on sewage flow rate and online TRC measurement at Chamber 15. Dual TRC analyzers will be installed at Chamber 15 to monitor the TRC value in chlorinated effluent after travelling through the effluent culvert and to provide continuous measurement e.g. 15-min interval. Signals from TRC analyzer and the flow data will be transmitted to the control system for adjusting chlorine dosages in order to maintain the TRC of 2 – 4 mg/L at Chamber 15, and for adjusting bisulphite dosages to ensure zero TRC discharge. Set point alarms will be established to notify the operator in case the TRC level at Chamber 15 drifting outside of the desired ranges immediately. Upon notification of the alarm, the operator should adjust the chlorine dosage to restore the TRC at Chamber 15 within the design range. In this way, dechlorination chemical can be adjusted based on the TRC data every 15 minutes. In addition, dual TRC analyzers and sodium bisulphite analyzers are provided at the outlet of dechlorination simulation loop to confirm zero TRC in discharge.

2.87 Under Manual Operation Mode, chemical dosages will be adjusted based on sewage flow rate and manual TRC measurement at Chamber 15. Regular TRC measurements will be conducted and dechlorination chemical will be adjusted based on the measured TRC data. The operator should adjust the hypochlorite dosage when the TRC measurement shifts outside the design range. A higher dosage of dechlorination chemical would be provided to ensure zero TRC in discharge during the Manual Operation Mode. This has allowed sufficient safety margin to offset the potential fluctuation of TRC between the hourly measurements. In addition, regular TRC and bisulphite measurements will be conducted at the discharge of bisulphite simulation loop to ensure the compliance of TRC discharge standards.

2.88 A schematic diagram of the control strategy is shown in **Figure 2.4**.

Project Location

2.89 The proposed chlorination system of the disinfection facilities would be located within the site boundary of the existing SCISTW (**Figure 2.1** refers). The proposed dechlorination plant would be located adjacent to the existing chamber no. 15 (**Figure 2.1** refers) at the western end of Container Port Road South. The land use to the north of the SCISTW is industrial in nature and comprises Container Terminal no. 8, the COSCO HIT Terminal Building, bus depot, shipyards and storage areas. Adjacent to the south-eastern boundary of the SCISTW is the Government Dockyard. The Ngong Shuen Chau Barracks is located at the south of Stonecutters Island. Route 8, which is under construction, is located adjacent to the proposed dechlorination plant.

2.90 The discharge point of the existing SCISTW outfall location was chosen at an area with low ecological and fisheries value to avoid adverse impacts on key ecological and fisheries resources. The outfall location is not at an area of high marine traffic usage.

Continuous Public Involvement

2.91 Public consultations have been conducted for the Project since an early stage of the EIA process. During December 2005, public consultation meetings were conducted with green groups and academics and professional institutions to introduce the EIA Study, brief the latest progress, present the EIA findings and solicit their views and comments on the EIA Study so that they could be considered in the EIA Study.

2.92 The list of green groups, professional bodies and academics institutions that were invited to the consultation exercises is presented in **Table 2.3** while the consultation meetings conducted are summarized in **Table 2.4**.

Table 2.3 Green Groups, Professional Bodies and Academics Institutions Invited for Consultation Exercises

Green Groups	Academics Bodies / Professional Institutions
World Wide Fund for Nature Hong Kong	Hong Kong Institution of Engineers
Conservancy Association	Hong Kong Institution of Environmental Impact Assessment
Green Power	Chartered Institution of Water and Environmental Management
Hong Kong Marine Conservation Society	University of Hong Kong
Friends of the Earth (HK)	Chinese University of Hong Kong
Earthcare	Hong Kong University of Science and Technology
Hong Kong Dolphin Conservation Society	City University of Hong Kong
Green Student Council	Open University of Hong Kong
	Hong Kong Polytechnic University
	Hong Kong Baptist University
	Marine Biological Association of Hong Kong
	Hong Kong Institute of Planners
	Hong Kong Institute of Architects
	Hong Kong Institute of Surveyors
	Association of Engineering Professionals in Society Ltd
	Hong Kong Project Management Exchange Centre

Table 2.4 Summary of Key Continuous Public Involvement

Date	Subject
1 December 2005	Public consultation discussion forum with academics and professional institutions. Attended by following parties: Hong Kong Institution of Engineers Hong Kong Institute of Environmental Impact Assessment Chartered Institution of Water and Environmental Management University of Hong Kong Hong Kong University of Science and Technology Hong Kong Institute of Vocational Education Marine Biological Association of Hong Kong
5 December 2005	Public consultation meeting with Green Peace
5 December 2005	Public consultation meeting with Hong Kong Marine Conservation Society
5 December 2005	Public consultation meeting with Worldwide Fund for Nature Hong Kong
7 December 2005	Public consultation meeting with Green Power
15 December 2005	Public consultation meeting with Hong Kong Conservancy Association
2 March 2006	Public consultation discussion forum with academics and professional institutions. Attended by following parties: Hong Kong Institution of Engineers Hong Kong Institute of Environmental Impact Assessment Chartered Institution of Water and Environmental Management University of Hong Kong Hong Kong University of Science and Technology
2 March 2006	Public consultation discussion forum with non-government organizations. Attended by following parties: Green Power Worldwide Fund for Nature Hong Kong
11 May 2006	Public consultation meeting with Earthcare
25 July 2006	Public consultation meeting with Hong Kong Marine Conservation Society
12 October 2006	Public consultation discussion forum with green groups, academics and professional institutions. Attended by the following parties:

	Hong Kong Institution of Engineers Hong Kong Institute of Environmental Impact Assessment Hong Kong Project Management Exchange Centre Limited Chartered Institution of Water and Environmental Management University of Hong Kong Conservancy Association Green Power World Wide Fund for Nature Hong Kong

2.93 Key comments and views received from the public consultation forum held on 1 December 2005 are summarized in **Table 2.5**.

Table 2.5 Summary of Key Comments/Views from the Public – December 2005

Concerned Parties	Key Comments / Views	Consultant's Response
Green Groups	1. Choice of disinfection technologies:- • Alternative methods of disinfection should be considered e.g. biofilters combined with artificial reef • Consider environmental considerations i.e. concerns on disinfection by-products of chlorination • Consider cost-effectiveness of different technologies • Consider alternative outfall options	• Disinfection technology options evaluation to address biofilters • Assessed in the EIA (Sections 5 to 9 and 12) • Cost-effectiveness of different disinfection methods to be assessed and provided • EIA to address alternative outfall options
	2. Environmental concerns on disinfection:- • Potential adverse impact on marine environment • Long term adverse effects of disinfection facilities on marine environment • Potential change in benthic community near outfall	• Assessed in the EIA (Sections 5, 7 to 9) • EIA to address potential long term effects (Sections 5, 7 to 9) • Assessed in the EIA (Section 8) and confirmed by Post Project Monitoring
	3. Other concerns on disinfection:- • Public health and safety during delivery of chemicals or disposal of UV lamps • Determine optimum chemical dosage	• Assessed in the EIA (Tables 6.3 and 6.10 of Appendix 2.1, Section 11) • Chlorine dosage determined in the EIA (Table 5.18)
	• Address cumulative impacts in water quality modeling	• Cumulative impacts from all point sources and non point sources to be included in the water quality model for cumulative assessment

Concerned Parties	Key Comments / Views	Consultant's Response
	• Interface between different stages of HATS	• Assessed in the EIA (water quality impact as well as human health and ecological risk impact were assessed in Sections 5 to 7)
Academics and Professional Institutions	1. Need for disinfection:- • Implement biological treatment first and review need for disinfection	• The purpose of ADF is to reduce the bacteria level of the HATS discharge so as to enable re-opening of the beaches in Tsuen Wan before completion of Stage 2A. The government has plans to implement Stage 2B (biological treatment), but current predictions indicate that the existing level of treatment is sufficient till the end of the next decade. Hence, the timing for the implementation Stage 2B is subject to a review to be conducted in 2010/11. Given the lengthy time frame for various stages of HATS and the outcome of the public consultation for HATS Stage 2, the public would like to see the re-opening of the Tsuen Wan beaches as early as possible, and would not welcome the proposal of delaying the implementation of ADF.
	2. Choice of disinfection technologies:- • Alternative methods of disinfection should be considered e.g. UV treatment, and their cost-effectiveness	• Cost effectiveness of different disinfection methods to be assessed and provided

Concerned Parties	Key Comments / Views	Consultant's Response
	• Consider environmental considerations i.e. concerns on disinfection by-products of chlorination	• The EIA study has included the following 5 tasks to address the CBP issue: 1) Review literature on formation of CBP during the disinfection process 2) CBP testing – chlorination / dechlorination process 3) Water quality modeling – based on levels of CBP determined during laboratory tests and would determine the size of the mixing zone 4) Whole Effluent Toxicity Testing (WETT) – results would indicate the acute toxicity using 5 local species 5) Ecological and human health risk assessment – results would indicate the chronic toxicity
	• Secondary treatment with higher removal of bacteria and other pathogens preferred	• EIA Study (Section 3 of Appendix 2.1) addressed the effectiveness of disinfection technologies in killing virus based on existing information
	1. Other concerns on disinfection:- • Address cumulative impacts i.e. effluent discharges from other STW • Expected chlorine dosage	• Assessed in the EIA • (S6.26 to 6.28 for cumulative human risk impact and S7.41 to 7.43 for cumulative ecological risk impact) • The EIA Study (Table 5.18) to establish chlorine dosage rate and contact time

2.94 A second round of public consultation was held on 2 March 2006 with the green groups and academics/professional institutions to present the initial findings of the evaluation and selection of disinfection technologies under the Project and to seek their views on the initial findings. Key comments and views received from the public from March to July 2006 are summarized in **Table 2.6**.

Table 2.6 Summary of Key Comments/Views from the Public – March to July 2006

Concerned Parties	Key Comments / Views	Consultant's Response
Green Groups	1. Need of disinfection • The need for disinfection is acknowledged	• Noted.
	2. Disinfection Technology Selection • Is chlorination the holistic approach that provides the best interest to the public? (adopt secondary treatment earlier may be a better option)	• Secondary treatment is the ultimate goal for HATS • Chemically Enhanced Primary Treatment (CEPT) is still an environmentally acceptable option at present, which utilizes the limited financial resources of the community more effectively • Chlorination is a more effective disinfection option for CEPT effluent
	3. Environmental Impact of Chlorination • Reduced diatom population may increase other species (e.g. algae responsible for red tide)	• No-Observable-Effect-Concentration (NOEC) for diatom is 27.2% of Chlorinated/Dechlorinated effluent, at least 29x dilution at edge of Zone of Initial Dilution (i.e. effluent conc. is < 27.2% in marine environment). Therefore, there would be no significant impact on diatom population in the receiving waters
	• Whole Effluent Toxicity Test only considered the effect to single species, the interaction between different species was not considered	• The acute/chronic toxicity of the most sensitive species was used to derive acute/chronic toxicity unit • This approach is used in local and overseas authorities
	4. Other Concerns • The potential environmental cost of purchasing sodium hypochlorite from China (i.e. pollution produced during the generation process)	• Electrochlorination/UV disinfection has high power consumption, which also contributes to the air pollution in Hong Kong • Can consider requiring the chemical supplier to meet ISO 14000 standard
	• The Government should aim at reducing the chemical additions to the marine waters	• The operation of the disinfection facilities will aim to reduce the dosage of chemicals as far as practicable

Concerned Parties	Key Comments / Views	Consultant's Response
Academics and Professional Institutions	1. Disinfection Technology Selection and Operation	
	• SCISTW was originally not designed to include disinfection in the treatment process - whether the bench scale test findings can be achieved in real SCISTW operation?	• There are potential hydraulic issue i.e. short circuiting or flow imbalance of using the existing effluent box culvert as chlorine contact chamber, as they are not originally designed for disinfection facilities. Numerical modelling (Computerized Fluid Dynamics modelling) has been carried out to ensure that the possible differences between ideal laboratory and actual conditions can be assessed and considered in the design
	• Is disinfection at SCISTW needed to ensure Water Quality Objective at Tsuen Wan beaches are met? - Do other sources largely contribute to the E-coli conc. at the beaches?	• It was investigated in details in the EIA Study (Section 5)
	• Is year-round disinfection needed because there would be lower "infection risk" in winter time	• We need to ensure that the beach can be opened in whole year so that swimmer can use the beaches in both summer and winter
	• Any information concerning the effectiveness of various disinfection technology to remove pathogens?	• Some studies on virus and *Cryptosporidium* oocysts & *Giardia* cysts (C&G), the effectiveness of chlorination and UV disinfection is similar
	2. Environmental Impact of Chlorination	
	• What will be the risk at the emergency scenario (e.g. chlorination system failure, dechlorination system failure?)	• Interlock system would be designed, the chlorination process will stop if dechlorination failure occurs • The acute risk from total residual chlorine would be investigated in the EIA Study (Section 5)

2.95 A third round of public consultation was held on 12 October 2006 with the green groups and academics/professional institutions to present the findings of the EIA Study and to seek their views on the findings. Key comments and views received from the public are summarized in **Table 2.7**.

Table 2.7 Summary of Key Comments/Views from the Public – October 2006

Concerned Parties	Key Comments / Views	Consultant's Response
Green Groups	1. Need of Project: • Was the closure of Tsuen Wan beaches caused by the background E. coli level rather than the un-disinfected HATS treated effluent?	• Un-disinfected HATS treated effluent contributed to additional E-coli level and caused the deterioration of water quality at Tsuen Wan beaches. • To restore the healthy state of the Victoria Harbour, both sources of E. coli at Tsuen Wan beaches, un-disinfected HATS effluent and sewage from local discharges need to be addressed by implementing disinfection facility at the SCISTW and local sewerage project respectively.
	2. Concern on selected disinfection option: • How can the cost of sodium hypochlorite be controlled? What would be the projection and fluctuation of the cost of the chemical?	• Sodium hypochlorite solution to be used for the disinfection process is a rather common chemical. There are many suppliers that are able to supply such chemical and therefore there would be competition in the market. The price of the chemical would be self-regulated by the competition among suppliers.
	• Part of the disinfection facility would be redundant when HATS Stage 2B commences	• The selected disinfection technology (i.e. direct purchase of sodium hypochlorite solution) would be the most flexible approach that is applicable to the conditions of HATS. • The proposed technology does not involve very capital intensive facilities (only chemicals storage, dosing and monitoring facilities to be constructed for the initial years). • When HATS Stage 2B is in operation, it only needs to decrease the chemical dosage and idling of facility would be minimal, which minimizes abortive capital investment that would not be utilized in HATS Stage 2B.

Concerned Parties	Key Comments / Views	Consultant's Response
	3. Implementation of HATS Stage 2B: • Any plan of earlier implementation of Stage 2B	• There are uncertainties in population and sewage flow build-ups as well as many other factors affecting the implementation of Stage 2B. The programme of Stage 2B implementation would be reviewed at 2010/11, when more updated data can be gathered.
Academics and Professional Institutions	1. Need of Project: • Hong Kong can take the lead in disinfection technology for the sewage effluent to improve water quality at the Region • What would be the cost of implementing the disinfection project, and is it worth to spend that amount of money to achieve the water quality objective (E coli. level) at the beaches?	• Agreed to adopt appropriate disinfection technology to minimize the bacterial content in the sewage effluent. • Based on the findings of the disinfection option evaluation, chlorination was founded to be an appropriate, reliable, flexible and a more cost-effective option for the disinfection of HATS CEPT effluent. The recurrent cost of the disinfection facility was estimated to be about HKD$80m in the initial years.
	2. Concern on selected disinfection option: • The selected option of using a large amount of sodium hypochlorite for effluent disinfection is unique in the world and it may not be an economically sustainable solution. • Adopting chlorination as the disinfection technology for HATS would be a unique project in the world in terms of its size and such project is considered not providing best value for the money spent.	• The problem to be solved is also a unique problem: need to disinfect the sewage generated from the huge population around the Victoria Harbour, which would be more than 2 million m^3 of effluent per day. A lot of effort has been put to investigate and develop an appropriate solution to tackle the problem. • Various project scenarios and the life cycle costs have been considered in the disinfection option selection exercise. It was found that among the applicable disinfection technologies to HATS, chlorination would be the most flexible and cost-effective technology (i.e. best value for money).

Concerned Parties	Key Comments / Views	Consultant's Response
	• Careful consideration of the design and control of the dosing system of sodium hypochlorite and sodium bisulphite needs to be given.	• The operation and control plan of the chemical dosing facility has been prepared, with reference to a sewage treatment works at Boston, US which has similar scale as SCISTW and uses chlorination (with dechlorination) for disinfection
	3. Other comment / concern • Disinfection cannot substantially improve other water quality parameters, but secondary treatment can serve this purpose.	• Addition of disinfection treatment process will provide the necessary mitigation to address the E. coli problem in the western part of Victoria Harbour. The Government has planned to review the programme of HATS Stage 2B based on the trends of water quality, population and sewage flow build-ups in 2010/11.

Project Programme

2.96 It is intended that the construction works for the Project will be packaged under one single contract and are tentatively scheduled to commence in March 2008 for completion in September 2009. The tentative construction programme is given in **Figure 2.5**. The major construction activities for the Project would comprise site formation, excavation and backfilling, piling works, erection of formwork and reinforcement, concreting, fabrication of steelwork, and testing and commissioning. Construction works would take place at two locations for the chlorination system and dechlorination plant.

Interactions with Other Projects

2.97 The planned diving rescue and diving training centre for the Fire Services Department (FSD) would be located adjacent to the eastern site boundary of the SCISTW. The general location plan of the FSD diving rescue and diving training centre is shown on **Figure 2.6**. The construction works for the FSD diving rescue and training centre are scheduled to start in December 2006 and with works completion in March 2009. By February 2009, the construction activity involved for the proposed disinfection facilities at SCISTW under the Project would be testing and commissioning, utility laying and other minor works.