4 *WATER QUALITY*

4.1 *INTRODUCTION*

The effluent from the Sha Tin and Tai Po STWs is currently collected by the Tolo Harbour Effluent Export Scheme (THEES) which pumps the treated sewage effluent to the Kai Tak Nullah via a tunnel sewer. The Kai Tak Nullah discharges into the Victoria Harbour at the landward end of the Kwun Tong Typhoon Shelter. The location of the existing THEES discharge point is presented in *Figure 4.1a*. The Sha Tin STW Stage III Extension (the Project) is being implemented to accommodate increased flows from the rising population in the catchment area and also to upgrade the standard of treatment to meet EPD's revised requirements. This will ultimately mean increased treated effluent loads to the Kai Tak Nullah. This section of the report assesses the impact of the Stage III Extension on the receiving water bodies.

The EPD has recently determined that more stringent effluent standards should be applied to the Sha Tin STW. Revised effluent standards will be applied to Biochemical Oxygen Demand (BOD), Suspended Solids (SS), Total Nitrogen (TN), Ammoniacal Nitrogen (NH_3-N), *E. coli* and Total Residual Chlorine (TRC). At present, standards are only applied to BOD, SS and TN. The standards are discussed in *Section 4.2.1* and presented in *Table 4.2b*.

Water quality impacts associated with the Sha Tin STW Stage III Extension have been examined with regard to both the construction and operation phases. Construction phase impacts were assessed with regard to impacts on the Shing Mun River and Tolo Harbour, while operation phase impacts primarily focus on impacts to Victoria Harbour. Consideration has also been given to possible impacts to Tolo Harbour during the operation phase in the event that the transfer of the flows of treated sewage effluent by the THEES is suspended for maintenance or other reasons.

4.2 *ENVIRONMENTAL LEGISLATION, POLICIES, STANDARDS AND CRITERIA*

The following relevant pieces of legislation and associated guidance are applicable to the evaluation of water quality impacts associated with the discharge of treated effluent from the Sha Tin STW Stage III Extension into Victoria Harbour via the THEES.

- *Environmental Impact Assessment Ordinance* (Cap. 499. S.16), Technical Memorandum on EIA Process (EIAO TM), Annexes 6 and 14;
- *Water Pollution Control Ordinance* (WPCO); and
- Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems Inland and Coastal Waters.

4.2.1 *Water Pollution Control Ordinance*

The *Water Pollution Control Ordinance* (WPCO) is the legislation for the control of water pollution and water quality in Hong Kong. Under the *WPCO*, Hong Kong waters are divided into 10 Water Control Zones (WCZs). Each WCZ has a designated set of statutory Water Quality Objectives (WQOs). The discharge from the THEES falls within the Victoria Harbour WCZ, which was declared in April 1996. The WQOs set limits for different parameters that should be achieved in order to maintain the water quality within the WCZs.

The WQOs for the Victoria Harbour WCZ, which are presented in *Table 4.2a*, are applicable as evaluation criteria for assessing compliance of the discharge of effluent from the Sha Tin Stage STW III Extension through the THEES. It should be noted that only those standards which refer to the marine waters part of the WCZ will be applicable to this assessment as the Kai Tak Nullah is considered principally as a storm drain and not an inland waterway or part of the marine waters.

Table 4.2a ***Water Quality Objectives for the Victoria Harbour WCZ***

		Water Quality Objective	Part or Parts of Zone
A.	AESTHETIC APPEARANCE		
	(a)	There should be no objectionable odours or discolouration of the water.	Whole zone
	(b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone
	(c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole zone
	(d)	There should be no recognisable sewage-derived debris.	Whole zone
	(e)	Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, should be absent.	Whole zone
	(f)	The water should not contain substances which settle to form objectionable deposits.	Whole zone
B.	BACTERIA		
	No level specified for Marine Waters		
C.	COLOUR		
	No specification for Marine Waters		
D.	DISSOLVED OXYGEN		
	(a)	The level of dissolved oxygen should not fall below 4 mg per litre for 90% of the sampling occasions during the whole year, values should be calculated as the annual water column average (see Note). In addition, the concentration of dissolved oxygen should not be less than 2 mg per litre within 2 m of the seabed for 90% of the sampling occasions during the whole year.	Marine waters
E.	pH		
	(a)	The pH of the water should be within the range of 6.5-8.5 units. In addition, human activity should not cause the natural pH range to be extended by more than 0.2 unit.	Marine waters

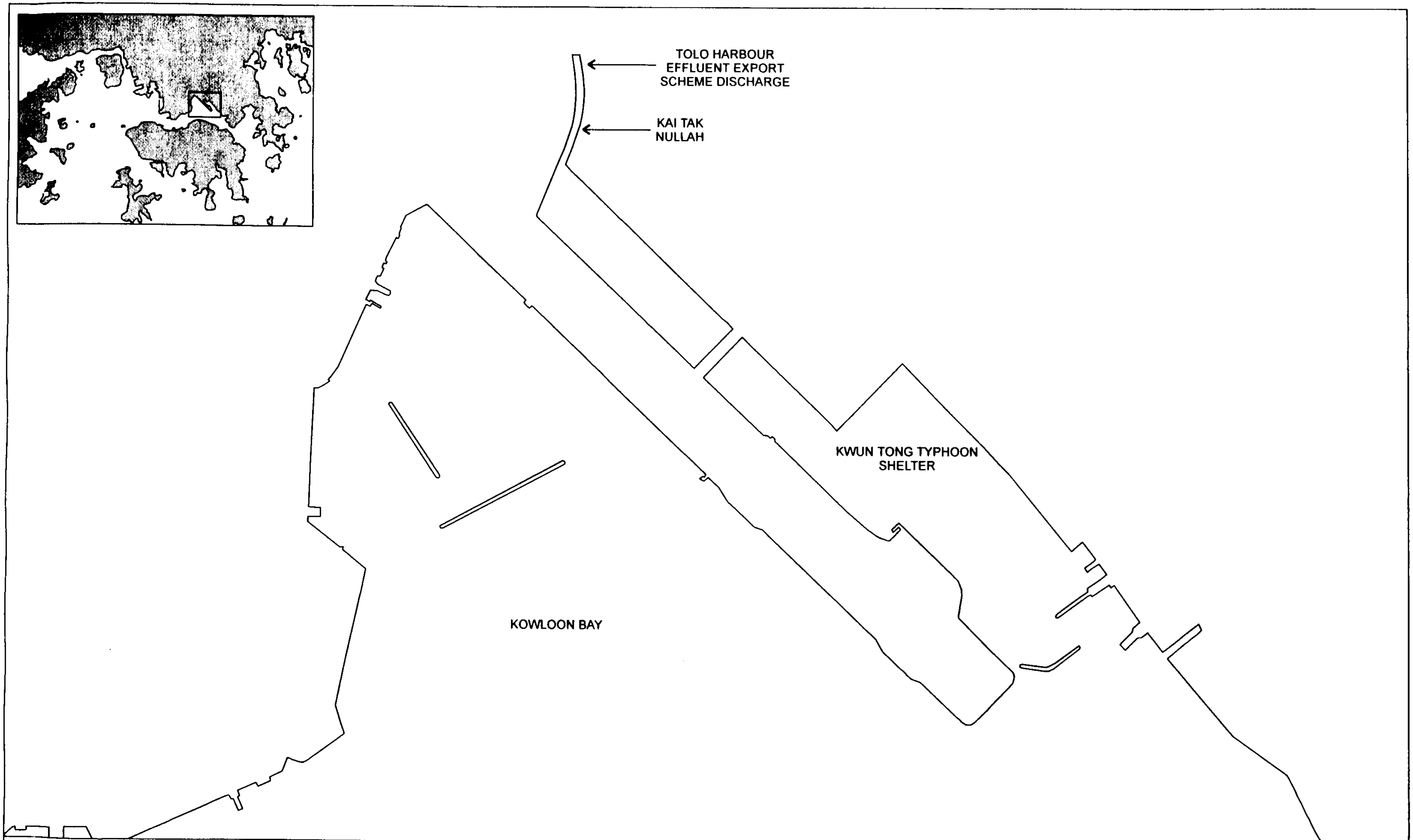

FIGURE 4.1a

PRESENT LOCATION OF TOLO HARBOUR EES DISCHARGE INTO KAI TAK NULLAH

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	Water Quality Objective		Part or Parts of Zone
F.	TEMPERATURE		
	Human activity should not cause the daily temperature range to change by more than 2.0°C.		Whole zone
G.	SALINITY		
	Human activity should not cause the salinity level to change by more than 10%.		Whole zone
H.	SUSPENDED SOLIDS		
	(a)	Human activity should neither cause the suspended solids concentration to be raised more than 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters
I.	AMMONIA		
	The un-ionized Ammoniacal nitrogen level should not be more than 0.021 mg per litre, calculated as the annual average (arithmetic mean).		Whole zone
J.	NUTRIENTS		
	(a)	Nutrients should not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters
	(b)	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.4 mg per litre, expressed as annual water column average (see Note).	Marine waters
K.	5-DAY BIOCHEMICAL OXYGEN DEMAND		
	No level specified for Marine Waters		
L.	CHEMICAL OXYGEN DEMAND		
	No level specified for Marine Waters		
M.	TOXIC SUBSTANCES		
	(a)	Toxic substances in the water should not attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to interactions of toxic substances with each other.	Whole zone
	(b)	Human activity should not cause a risk to any beneficial use of the aquatic environment.	Whole zone

Notes:
Expressed normally as the arithmetic mean of at least 3 measurements at 1 m below surface, mid depth and 1 m above the seabed. However in water of a depth of 5 m or less, the mean shall be that of 2 measurements (1 m below surface and 1 m above seabed), and in water of less than 3 m the 1 m below surface sample only shall apply.

4.2.2 *Technical Memorandum for Effluent Discharges*

All discharges during the operational phases of the Project are required to comply with the Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM) issued under Section 21 of the *WPCO*. The TM defines discharge limits to different types of receiving waters. Under the TM, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs are subject to pollutant concentration standards for particular discharge volumes. The TM acts as a guideline for setting discharge standards for the *WPCO* licence. The existing discharge standards for the Sha Tin STW are shown in *Table 4.2b*.

Table 4.2b *Existing Discharge Standards (95%tile) for Sha Tin Sewage Treatment Works*

Discharge Parameter	Existing Standard
Biochemical Oxygen Demand	20 mg L^{-1}
Suspended Solids	30 mg L^{-1}
Total Nitrogen	20 mg L^{-1}

Note:
Discharge standards are expressed as maximum values.

It is worth noting that there are currently no discharge standards for ammoniacal nitrogen and *E.coli*. These additional parameters may be included in future discharge licence conditions for the Sha Tin STW.

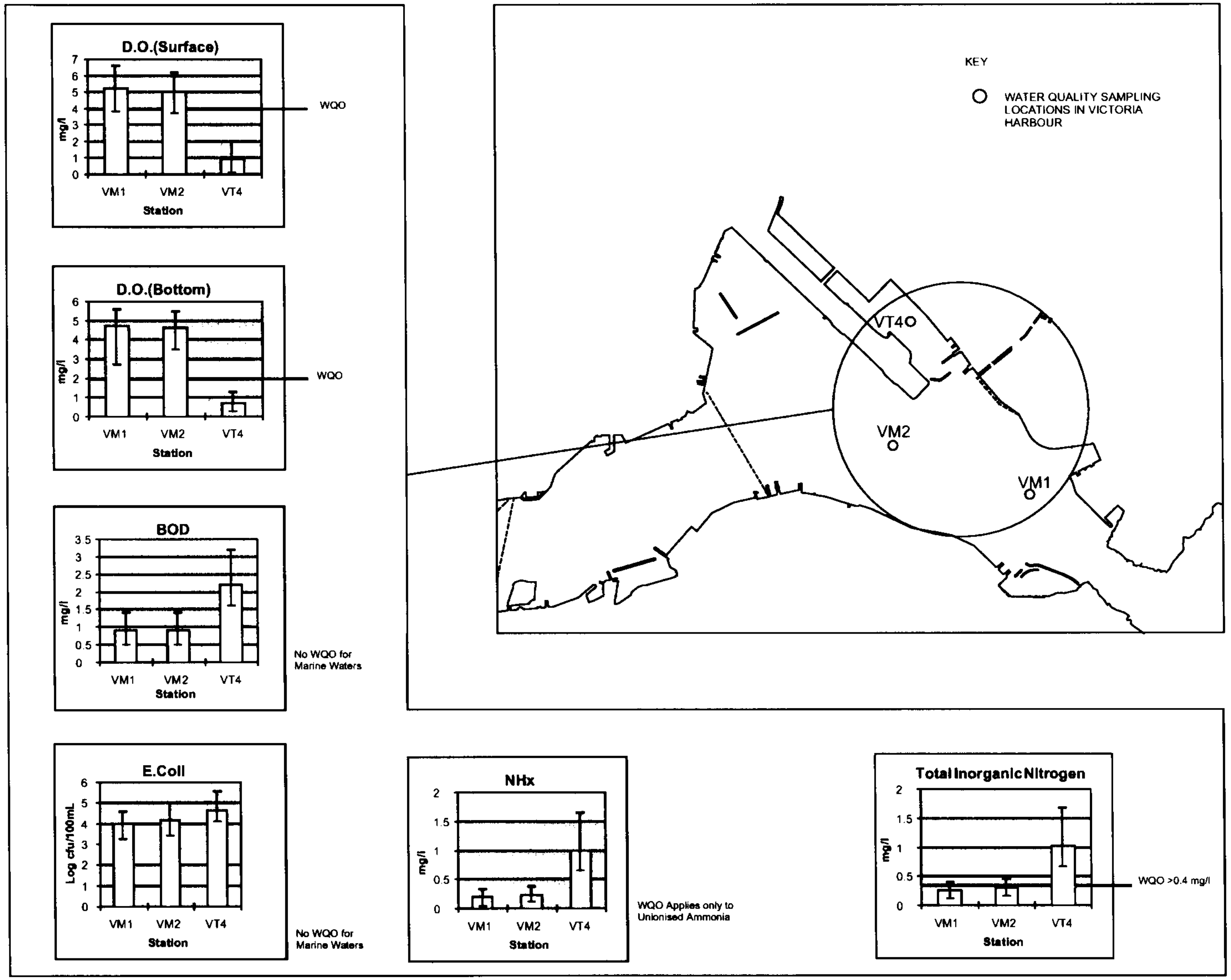
4.3 DESCRIPTION OF THE ENVIRONMENT

Existing water quality data for the Kwun Tong Typhoon Shelter and the surrounding waters in Victoria Harbour are reported by the EPD as part of their routine marine water quality monitoring programme. Selected data for the study area are presented in *Table 4.3a* and represent water quality in 1997[(19)]. The locations of the stations are shown in *Figure 4.3a*, which also contains a graphical representation of the data.

The data presented in *Table 4.3a* clearly show the poor water quality within the Kwun Tong Typhoon Shelter at Station VT4. Exceedences of the WQOs are reported for Dissolved Oxygen (DO), both for depth averaged and bottom samples, for Total Inorganic Nitrogen (TIN) and for Unionized Ammonia (NH_3-N). These exceedences are most probably due to the high level of polluting discharges, including sewage effluent, into the typhoon shelter and are not solely due to the discharges from the THEES. The presence of sewage discharges is also indicated by the high *E.coli* concentrations. Another factor causing the high observed levels is the fact that there is a very low tidal exchange within the typhoon shelter, which leads to a low rate of flushing and hence to long residence times.

Despite the poor water quality within the typhoon shelter the measurements at Stations VM1 and VM2 show much better values. This demonstrates that the relatively poor water quality within the typhoon shelter does not greatly impact upon Victoria Harbour. This may be attributed to the high degree of dispersion of pollutants migrating from the typhoon shelter by the tidal currents within the harbour.

(19) EPD 1998. Marine Water Quality in Hong Kong for 1997.



KEY

DO DISSOLVED OXYGEN

BOD 5 DAY BIOLOGICAL OXYGEN DEMAND

NH_x AMMONICAL NITROGEN

FIGURE 4.3a

EXISTING WATER QUALITY (1996) IN THE VICINITY OF THEES

Notes: charts presented here show average values, maxima and minima of the indicated parameters

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Table 4.3a ***Water Quality in Kwun Tong Typhoon Shelter and Victoria Harbour in 1997***

	Station VT4	Station VM1	Station VM2	WQO
DO ($mg\ L^{-1}$)	**2.1** (0.6-4.4)	5.0 (4.0-6.8)	4.6 (3.4-6.4)	>4[(c)]
DO Bottom ($mg\ L^{-1}$)	**1.8** (0.8-4.2)	4.7 (3.8-6.9)	4.3 (3.3-6.6)	>2[(d)]
SS ($mg\ L^{-1}$)	3.5 (1.9-6.1)	5.6 (2.6-10.8)	5.5 (2.2-10.4)	Ambient+30%
BOD ($mg\ L^{-1}$)	2.5 (1.3-4.4)	0.7 (0.4-1.7)	0.9 (0.5-2.4)	No WQO
TIN ($mg\ L^{-1}$)	**0.98** (0.75-1.27)	0.32 (0.14-0.47)	0.39 (0.24-0.54)	<0.4
Unionized ammonia ($mg\ L^{-1}$)	**0.021** (0.008-0.043)	0.009 (0.003-0.016)	0.010 (0.004-0.017)	<0.021
E. coli (cfu $100mL^{-1}$)	67,684 (7,500-393,333)	5,780 (1,433-40,000)	14,268 (3,000 - 110,667)	No WQO

Notes:
(a) All data presented in parentheses are maxima and minima. Other data are means.
(b) All data depth averaged, except where specified otherwise.
(c) For 90% of depth averaged samples.
(d) For 90% of samples.

Following the construction of the Sha Tin STW Stage III Extension the flows through the THEES will increase due to the greater population in the catchment area. Coupled with this increase in flows will be the development of the South East Kowloon Reclamation (SEKR) which will reclaim Kowloon Bay and the Kwun Tong Typhoon Shelter. As part of the SEKR, the Kai Tak Nullah will be diverted through the centre of the reclamation and discharge directly into Victoria Harbour, as shown in *Figure 4.3b*. This will mean that the flows from the Kai Tak Nullah will discharge into the faster moving water of Victoria Harbour and hence be more efficiently disposed. It is anticipated that this development has the potential to further reduce the impacts of the THEES. In addition, many of the discharges to the nullah, other than the THEES, will be removed as part of the ongoing implementation of Sewage Master Plans.

4.4 *SENSITIVE RECEIVERS*

The discharge of treated sewage effluent from the Sha Tin STW through the THEES will primarily have the potential to affect water quality within Victoria Harbour and, as such, the definition of sensitive receivers is based on this premise. There are a number of Water Supplies Department (WSD) seawater intakes along the coastline of Victoria Harbour which are deemed sensitive to changes in water quality. The locations of these water intakes are shown in *Figure 4.4a,* as are the locations of the 6 stations used for monitoring water quality.

The WSD has a set of standards for the quality of abstracted seawater and these are presented in *Table 4.4a*. The WSD criteria will be assessed in addition to the WQOs for the Victoria Harbour WCZ, which are shown in *Table 4.2a*.

Table 4.4a ***WSD Water Quality Criteria for Abstracted Seawater***

Parameter	Criteria
Colour (HU)	<20
Turbidity (NTU)	<10
Threshold Odour No.	<100
Ammonical Nitrogen (mg L^{-1})	<1
Suspended Solids (mg L^{-1})	<10
Dissolved Oxygen (mg L^{-1})	>2
5-day Biochemical Oxygen Demand (mg L^{-1})	<10
Synthetic Detergents (mg L^{-1})	<5
E.coli (counts $100mL^{-1}$)	<20,000

Another sensitive receiver was identified to be the Fish Culture Zone (FCZ) at Tung Lung Chau. Although it is thought unlikely that there will be any impact from the treated sewage discharges from Sha Tin STW on this area, consideration has been given to the FCZ as a potential sensitive receiver.

4.5 CONSTRUCTION PHASE

4.5.1 *Assessment Methodology*

The assessment of the construction phase impacts on water quality was undertaken in a qualitative manner. Consideration has been given to controlling potentially harmful impacts from the site works and given to the use of 'best' practice measures to minimise the potentially for harmful discharges of pollutants to nearby receiving waters. The receiving waters were considered to be the Shing Mun River, which is adjacent to the site, and the Tolo Harbour.

4.5.2 *Potential Sources of Impacts*

During the construction of the Project the primary sources of potential impacts to the receiving waters will be from suspended sediments in site run-off, which may ultimately enter the receiving waters directly or enter the storm drain system which discharges into these waters. Suspended sediments may also enter the receiving waters if pumped groundwater is not adequately controlled.

Wastewater from temporary site facilities should be controlled to prevent direct discharge to the receiving waters of the Shing Mun River and Tolo Harbour. Such wastewater may include sewage from toilets and on-site kitchen facilities. Water from plant servicing facilities may be contaminated with oil and other petroleum products and have the potential to discharge to surface wasters if spillages are not contained.

4.5.3 *Prediction and Evaluation of Impacts*

The potential sources of impacts, described in *Section 4.5.2*, may be readily controlled by appropriate on-site measures to minimise potential impacts and, as such, no further prediction of impacts has been carried out.

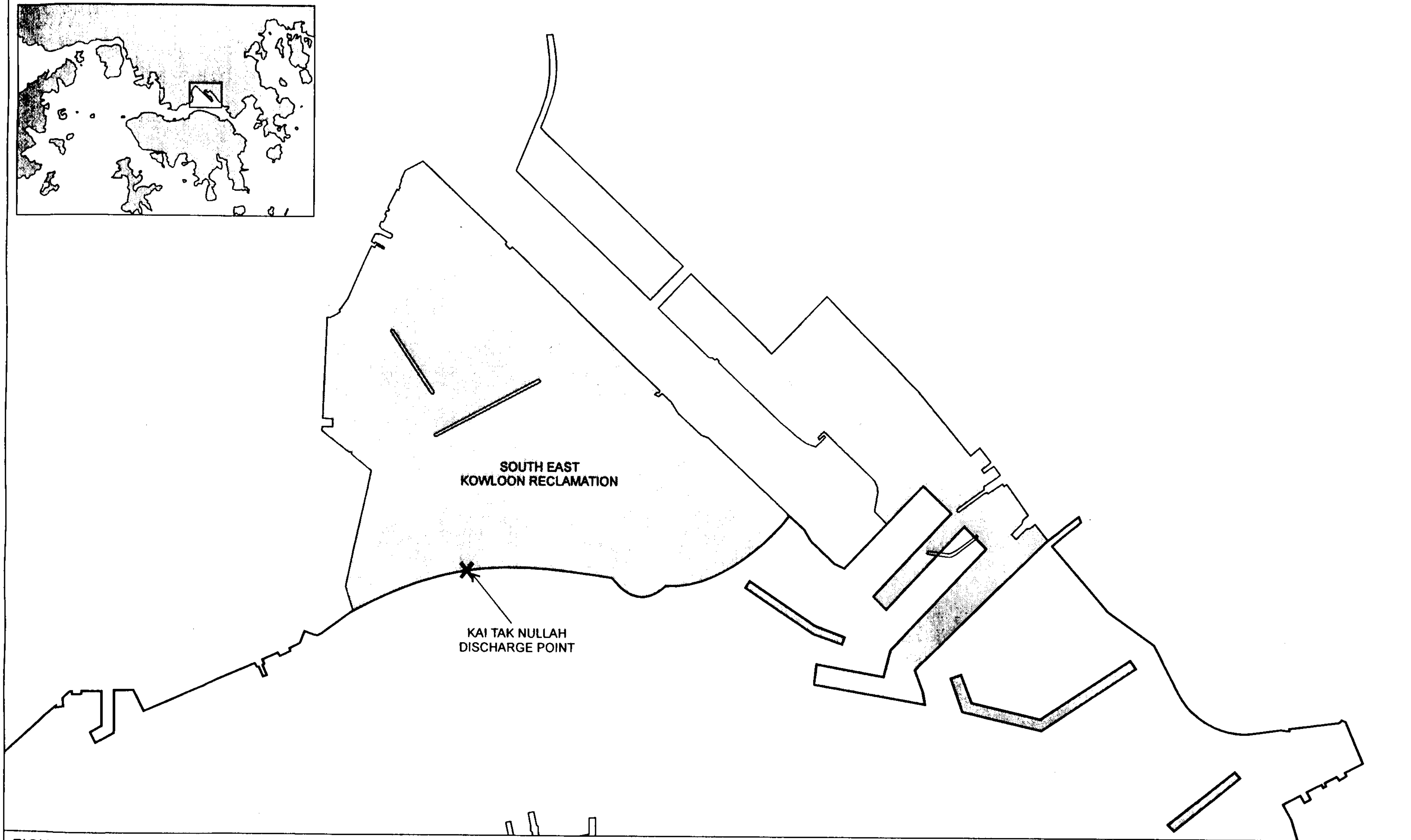

FIGURE 4.3b

LOCATION PLAN OF THE DISCHARGE POINT OF THE KAI TAK NULLAH FOLLOWING THE CONSTRUCTION OF THE SOUTH EAST KOWLOON RECLAMATION

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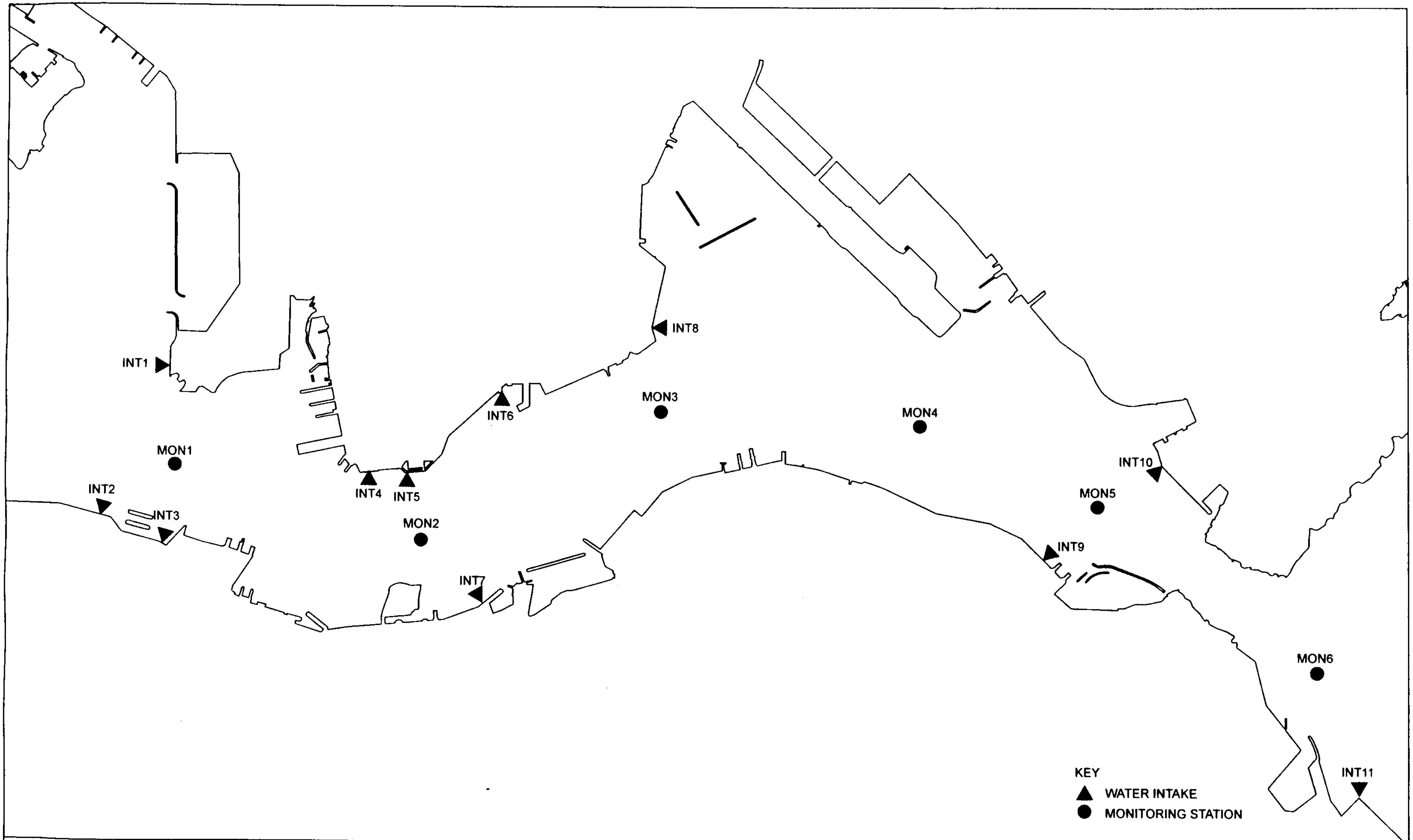

FIGURE 4.4a

LOCATIONS OF WATER INTAKES & EXISTING MONITORING STATIONS IN VICTORIA HARBOUR

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4.5.4 *Mitigation of Adverse Environmental Impacts*

Surface Run-Off

Surface run-off from the Sha Tin STW Stage III Extension construction site should be directed into storm drains via adequately designed sand/silt removal facilities such as sand traps, silt traps and sediment basins. Channels, earth bunds or sand bag barriers should be provided on site to properly direct stormwater to such silt removal facilities. Catchpits and perimeter channels should be constructed in advance of site formation works and earthworks.

Silt removal facilities, channels and manholes should be maintained and the deposited silt and grit should be removed regularly, at the onset of and after each rainstorm to ensure that these facilities are functioning properly at all times.

If excavation cannot be avoided during rainy seasons, temporarily exposed soil surfaces should be covered e.g. by tarpaulin, and temporary access roads should be protected by crushed stone or gravel, as excavation proceeds. Intercepting channels should be provided (e.g. along the crest/edge of the excavation) to prevent storm runoff from washing across exposed soil surfaces. Arrangements should always be in place to ensure that adequate surface protection measures can be safely carried out well before the arrival of a rainstorm.

Earthworks final surfaces should be well compacted and the subsequent permanent work or surface protection should be carried out as soon as practical after the final surfaces are formed to prevent erosion caused by rainstorms. Appropriate intercepting channels should be provided where necessary. Rainwater pumped out from trenches or foundation excavations should be discharged into storm drains via silt removal facilities.

Open stockpiles of construction materials (e.g. aggregates and sand) on site should be covered with tarpaulin or similar fabric during rainstorms. Measures should be taken to prevent the washing away of construction materials, soil, silt or debris into any drainage system.

Manholes (including any newly constructed ones) should always be adequately covered and temporarily sealed so as to prevent silt, construction materials or debris from getting into the drainage system, and to prevent storm run-off from getting into foul sewers. Discharges of surface run-off into foul sewers must always be prevented in order not to unduly overload the foul sewerage system.

Groundwater

Groundwater pumped out of wells, etc. for the lowering of ground water level in foundation construction, such as that required for new buildings, should be discharged into storm drains after the removal of silt in silt removal facilities.

Wheel Washing Water

All vehicles and plant should be cleaned before they leave the construction site to ensure that no earth, mud or debris is deposited by them on roads. A wheel washing bay should be provided at every site exit, if practicable, and wash-water should have sand and silt settled out or removed before being discharged into the storm drains. The section of construction road between the wheel washing bay and the public road should be paved with backfall to reduce vehicle tracking of soil and to prevent site run-off from entering public road drains.

Wastewater from Building Construction

Wastewater generated from concreting, plastering, internal decoration, cleaning work and other similar activities, should undergo large object removal by installing bar traps at the drain inlets. It is not considered necessary to carry out silt removal due to the small quantities of water involved. Similarly, pH adjustment of such water is not considered necessary due to the small quantities and the fact that the water is only likely to be mildly alkaline.

Wastewater From Site Facilities

Sewage from toilets, kitchens and similar facilities should be discharged into a foul sewer or chemical toilets should be provided. Wastewater collected from canteen kitchens, including that from basins, sinks and floor drains, should be discharged into foul sewers via grease traps.

Vehicle and plant servicing areas, vehicle wash bays and lubrication bays should, as far as possible, be located within roofed areas. The drainage in these covered areas should be connected to foul sewers via a petrol interceptor. Oil leakage or spillage should be contained and cleaned up immediately. Waste oil should be collected and stored for recycling or disposal, in accordance with the *Waste Disposal Ordinance*.

Storage and Handling of Oil, Other Petroleum Products and Chemicals

All fuel tanks and chemical storage areas should be provided with locks and be sited on sealed areas. The storage areas should be surrounded by bunds with a capacity equal to 110% of the storage capacity of the largest tank to prevent spilled oil, fuel and chemicals from reaching the receiving waters. The Contractors should prepare guidelines and procedures for immediate clean-up actions following any spillages of oil, fuel or chemicals.

4.6 OPERATION PHASE

4.6.1 *Assessment Methodology*

Impacts to Victoria Harbour

Impacts from the discharge of treated sewage effluent from the Sha Tin STW Stage III Extension to Victoria Harbour have been determined using a three-dimensional computer model. A local area model of tidal hydrodynamics and water quality has been constructed by Delft Hydraulics specifically for the simulation of treated effluent discharges for this Study. This local area model has been derived from the larger area Upgraded Model, which was set up for the Hong Kong SAR Government, Environmental Protection Department (EPD) and Civil Engineering Department (CED). The Upgraded Model has been calibrated and validated to approved standards and covers the whole of Hong Kong waters, the Pearl River Estuary, the Lema Channel and Mirs Bay. Within the model a local area refinement has been provided in the vicinity of the Kai Tak Nullah, so that the best representation of the discharge may be made. *Figure 4.6a* shows the

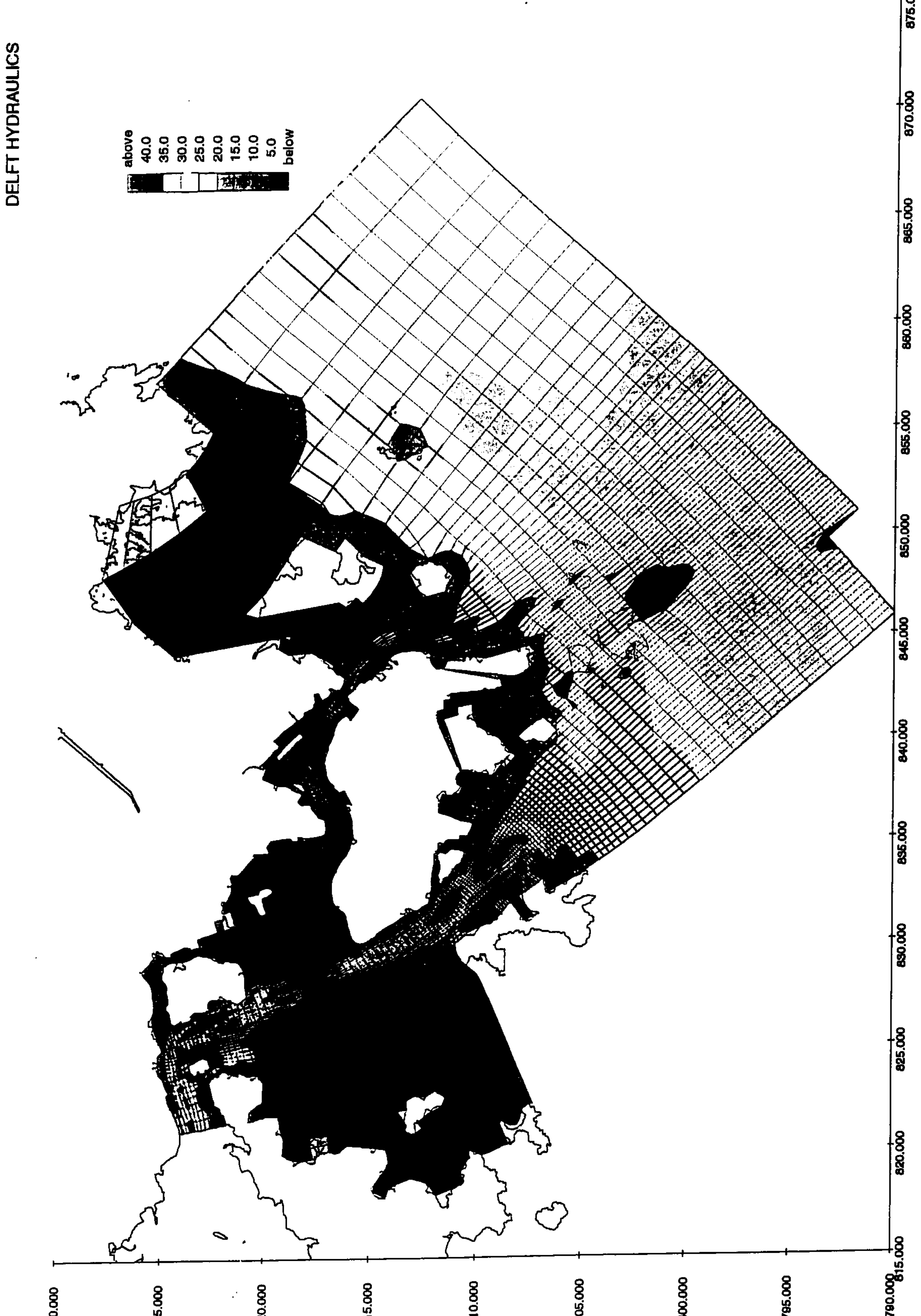

FIGURE 4.6a GRID LAYOUT AND BATHYMETRY SCHEMATISATION

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model grid and bathymetry. Boundary conditions for the local area model have been defined from the larger area Upgraded Model. This local model has been fully calibrated and validated as part of this study and a description of this exercise is presented in *Annex C*.

The local model is capable of simulating a comprehensive range of water quality parameters, although attention has been paid to Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Nitrogen (TN), Ammoniacal Nitrogen (NH_3), *E.coli* and Suspended Solids (SS). The results from the water quality model have been produced in two formats which allow direct comparison with the relevant Water Quality Objectives (WQOs) and aid in the determination of the impacts of the flows from the Sha Tin STW Stage III Extension. Tables of predicted concentrations of water quality parameters have been produced for the sensitive receiver locations shown in *Figure 4.4a* to allow a determination of the level of compliance with the relevant WQOs. Contours of mean concentrations of each of the parameters have been produced for the inner part of the local model. These contour plots show any areas of non-compliance with the WQOs and display the discharge plume from the Kai Tak Nullah.

By comparing the results from each of the scenarios it is possible to determine the impacts of the increased discharges from the Sha Tin STW Stage III Extension on water quality within Victoria Harbour. The scenarios used in the modelling assessment are described in the following section.

An additional qualitative assessment of discharges in 2006 has been carried out. The background loading for this assessment would be representative of the SSDS Stage, I including the implementation of the Interim Outfall and the connection of Kowloon sewerage systems to Stonecutters Island. The loading from the Sha Tin STW Stage III Extension would be less than the ultimate design capacity. The South East Kowloon Reclamation will only be 50% complete by 2006, but the Kai Tak Nullah will have been diverted to the west of the Kai Tak runway following the reclamation of the Kwun Tong Typhoon Shelter. The location of the Kai Tak Nullah discharge in 2006 is shown in *Figure 4.6b*.

Tolo Harbour

The treated effluent from the Sha Tin and Tai Po STWs is currently collected and discharged via the THEES to the Kai Tak Nullah. Periodically the THEES is shut down for routine maintenance and desilting of the Kai Tak Nullah. During these periods the treated effluent from both the Sha Tin and Tai Po STWs is discharged to Tolo Harbour. The location of the discharge point is shown in *Figure 4.6c*. The assessment of the impacts has been based on records of the performance of the THEES received from the DSD and bi-weekly EPD water quality monitoring data in 1997 and 1998 at Stations TM2 and TM4, which are the closest water quality monitoring stations to the Sha Tin STW.

Data on the performance of the THEES together with records of the closure of the THEES were obtained from the DSD. The closure records of the THEES in 1997 and 1998 are as follows :

- 4 August 1997 to 12 September 1997, for checking and defect rectification;
- 9 February 1998 to 20 March 1998 for desilting and defect rectification; and
- 1 December 1998 to 29 December 1998 for desilting and defect rectification.

It was also noted that prior to 30 November 1997, only one pump was in operation for the THEES. This meant that, on average, only 50% of the treated effluent from the Sha Tin and Tai Po STWs was discharged to the Kai Tak Nullah via the THEES, with the remainder being discharged to Tolo Harbour.

Routine EPD water quality monitoring data for Stations TM2 and TM4, the locations of which are shown in *Figure 4.6c*, were obtained from EPD for the whole of 1997 and 1998. Stations TM2 and TM4 were selected because they are the closest of the Tolo Harbour stations to the Sha Tin STW. At these stations, water quality is monitored every two weeks. At Station TM2 monitoring is carried out for the surface and bed layers, while at Station TM4 monitoring data are available for the surface, middle and bed layers. Water quality data for dissolved oxygen (DO), biochemical oxygen demand (BOD), ammoniacal nitrogen (NH_4-N), total inorganic nitrogen (TIN) and chlorophyll-a (Chy) have been used in the analysis.

The analysis was carried out by comparing the water quality during periods of the complete closure of the THEES with that prior to and after closure. This analysis is expected to show whether there was any marked deterioration in water quality during the closure of the THEES, which could then be attributed to the discharge from the Sha Tin STW. Finally, likely future discharges were compared to the existing discharges to determine whether there would be any effects from such discharges in the future.

Consideration is also given to the potential for discharges to Tolo Harbour due to equipment failure, such as the pumps at the Sha Tin STW. Treated effluent is also discharged to Tolo Harbour due to the periodic flushing of the submarine outfall at the Sha Tin STW. The outfall is flushed monthly with treated effluent for periods of several hours to prevent any blockages forming. The impacts from this routine procedure were also assessed qualitatively.

Kai Tak Nullah

A qualitative assessment of the likely impacts on water quality in the Kai Tak Nullah from the operation the THEES following the implementation of the Sha Tin STW Stage III Extension has been made. The assessment has initially considered the existing water quality within the Kai Tak Nullah and compared the existing effluent load from the Sha Tin STW with that which is predicted to occur following the implementation of the Stage III Extension. The assessment focussed on *E.coli* and dissolved oxygen which would be the parameters of concern in the future operation of the Kai Tak Nullah. As it is planned to divert the Nullah through an open space amenity area in the centre of the proposed South East Kowloon Reclamation the bacteria concentration and potential for odour problems would be of most concern. It should be noted that the Kai Tak Nullah will, in future, continue to be a storm drain and as such there are no applicable WQOs.

Uncertainties in the Assessment Methodology

Uncertainties in the water quality modelling should be considered when making an evaluation of the predictions. Worst case conditions were adopted as model inputs in order to provide conservative predictions of impacts. It is therefore possible that the input data for the relevant parameters may cause an overestimation of the water quality impacts. Some examples of the conservative nature of the input parameters are given below:

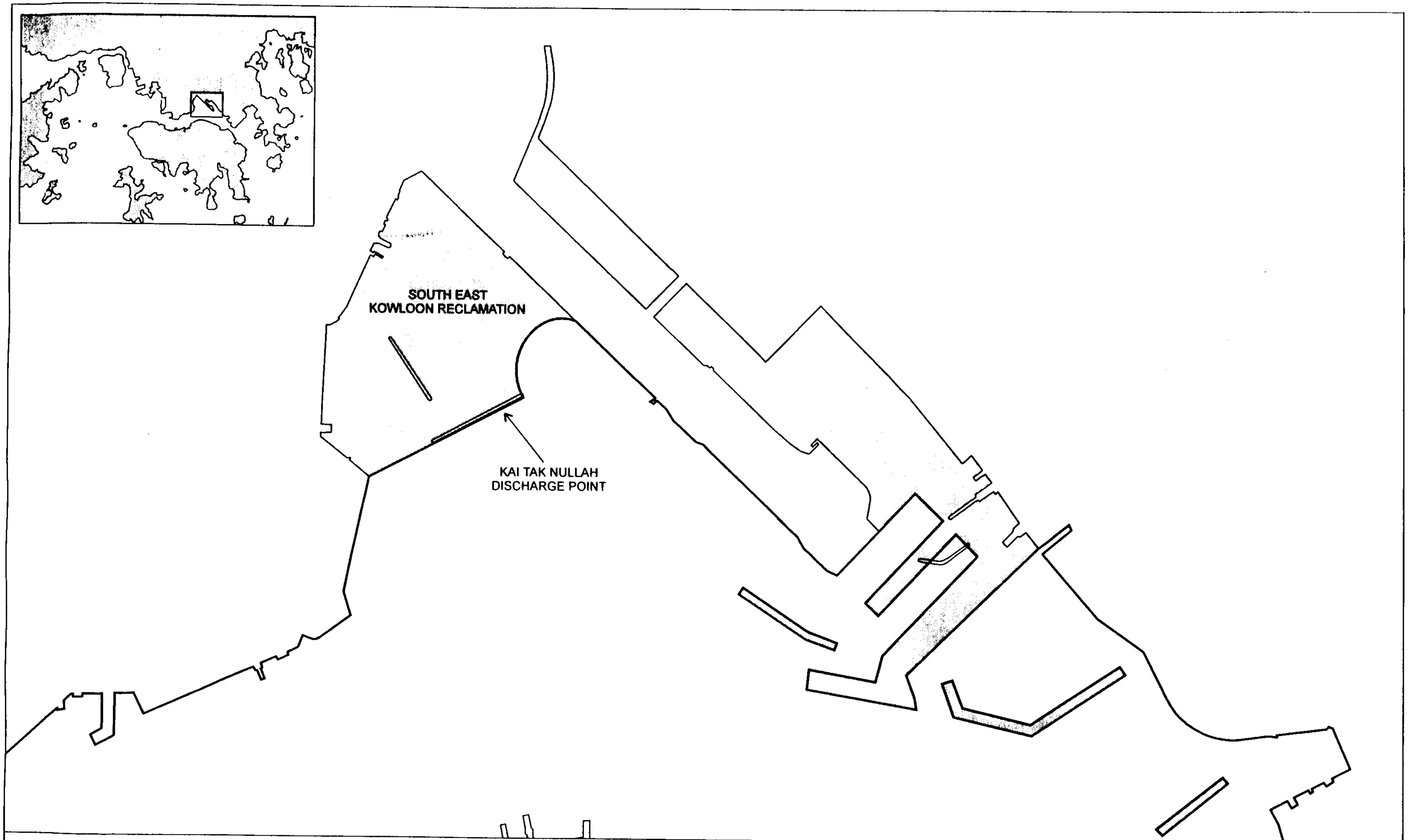

FIGURE 4.6b

LOCATION PLAN OF THE KAI TAK NULLAH DISCHARGE IN 2006

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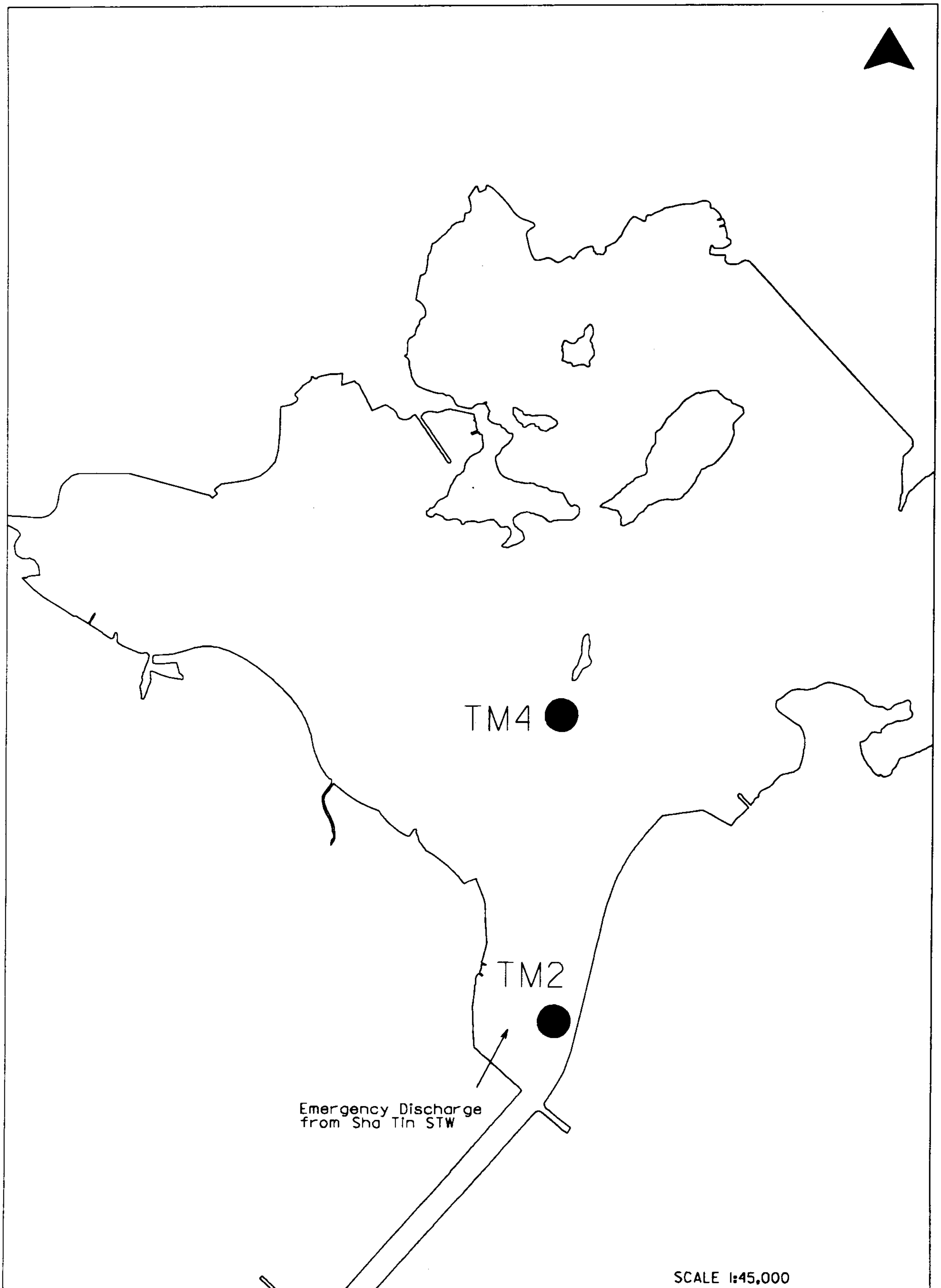

FIGURE 4.6c

LOCATIONS OF THE EPD ROUTINE WATER QUALITY MONITORING STATIONS TM2 AND TM4 AND THE EMERGENCY DISCHARGE FROMTHE SHA TIN STW

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- the highest design flow rates for the Sha Tin STW have been considered;
- background pollutant loads have been derived from conservative population estimates, and may therefore over-predict the loads;
- it is assumed that in 2011 10% of the sewage flow in the Kai Tak Nullah catchment enters the stormdrains[20].

4.6.2 *Potential Sources of Impacts*

Victoria Harbour

The water quality model has been used to simulate a total of 7 different flow and load combinations from the Sha Tin STW. The aim of the definition of the sensitivity tests was to specify a range of effluent flows and loads which could be tested by water quality modelling. The various effluent quality parameters which were varied corresponded to those for which discharge licence standards may be applied.

Stage I/II: The first simulation was representative of the existing Stages I & II of the Sha Tin STW, and provided an assessment of the current conditions against which the results of the sensitivity tests can be compared. Background pollution loads were representative of 1997.

Sensitivity Test 1: The first sensitivity test simulated the background water quality conditions in the design year for the Stage III Extension (2011), without any load from the Sha Tin STW. The results from this simulation enabled a direct comparison with the other sensitivity tests to show the impact of the Sha Tin STW on water quality. This was achieved by subtracting the results of this 'no load' scenario from the other tests. Background pollution loads were representative of 2011 which meant that the SSDS Stages I, II, III and IV, including the long sea outfall, were in operation, which in effect removes most of the polluting loads from Victoria Harbour and discharges them to the south of Lamma Island.

Sensitivity Test 2: The second sensitivity test simulated possible effluent quality following the construction of the Sha Tin STW Stage III Extension, as defined in *Table 4.2b*, in combination with the design flow rate for the Sha Tin STW Stage III Extension. Background pollution loads were representative of 2011.

Sensitivity Tests 3 and 4: The third and fourth sensitivity tests simulated an increased flow through the Sha Tin STW. This increased flow represented a potential alternate design for the Stage III Extension. Test 3 simulated the impacts of the same effluent quality as simulated in Test 3, except for the total nitrogen concentration which was reduced. Test 4 simulated a higher value of the ammonia concentration compared with Test 2, but kept the same effluent quality for other parameters. Background pollution loads were representative of 2011 when the SSDS Stages I, II, III and IV were assumed to be in operation.

Sensitivity Test 5: The fifth sensitivity test simulated the same pollutant loading from the Sha Tin STW as Test 4 but assuming that only SSDS Stage I and the associated Interim Outfall is operational. This scenario may be taken to be

[20] Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool. Preliminary Pollution Load Inventory Report (Draft). Agreement No CE42/97. Hyder Environmental and CES (Asia) Ltd. in Association with Delft Hydraulics, September 1998.

representative of 2006, before the construction of the SSDS Stage II long sea outfall, or, in the worst case, of the situation if the construction of the long sea outfall is delayed beyond the assumed date of 2006.

Sensitivity Test 6: The sixth sensitivity test simulated an increased total nitrogen load, in combination with the higher flow rates in Tests 3 and 4 and the increased ammonia concentration in Test 4. This test thus simulated the highest potential pollutant load from the Sha Tin STW. Background pollution loads were representative of 2011 when the SSDS Stages I, II, III and IV were assumed to be in operation.

For each of the sensitivity tests, the *E.coli* values were gradually increased to test whether a high level of disinfection using ultra-violet radiation would be necessary from the water quality perspective. This was possible because the behaviour of *E.coli* in the receiving waters is not dependant upon any of the other water quality parameters.

A definition of each of the tests is given in *Table 4.6a*.

Table 4.6a Pollution Loads for the Sha Tin Sewage Treatment Works

Test	Flow (m^3 day^{-1})	BOD (mg L^{-1})	COD (mg L^{-1})	DO (mg L^{-1})	SS (mg L^{-1})	NH3-N (mg L^{-1})	Org-N (mg L^{-1})	NO2-N (mg L^{-1})	NO3-N (mg L^{-1})	Total N (mg L^{-1})	Ortho-P (mg L^{-1})	Total P (mg L^{-1})	E. Coli (counts $100mL^{-1}$)
Stage I/II													
Wet Season	200,000	4.3	40.8	0.1	15.8	0.9	2.3	0.1	3.2	6.5	1.5	1.8	107,000
Dry Season	167,000	5.9	26.0	0.1	23.5	1.2	3.0	0.5	5.9	10.6	2.0	2.6	107,000
Sensitivity Tests													
1													
Wet Season	No Load												
Dry Season	No Load												
2													
Wet Season	295,000	20.0	40.8	0.1	30.0	5.0	4.4	0.5	15.1	25.0	1.5	1.8	1,000
Dry Season	263,000	20.0	26.0	0.1	30.0	5.0	3.8	1.3	14.9	25.0	2.0	2.6	1,000
3													
Wet Season	350,000	20.0	40.8	0.1	30.0	5.0	4.4	0.3	10.3	20.0	1.5	1.8	5,000
Dry Season	312,000	20.0	26.0	0.1	30.0	5.0	3.8	0.8	10.4	20.0	2.0	2.6	5,000
4													
Wet Season	350,000	20.0	40.8	0.1	30.0	10.0	4.4	0.3	10.3	25.0	1.5	1.8	15,000
Dry Season	312,000	20.0	26.0	0.1	30.0	10.0	3.8	0.8	10.4	25.0	2.0	2.6	15,000
5[(a)]													
Wet Season	350,000	20.0	40.8	0.1	30.0	10.0	4.4	0.3	10.3	25.0	1.5	1.8	100,000
Dry Season	312,000	20.0	26.0	0.1	30.0	10.0	3.8	0.8	10.4	25.0	2.0	2.6	100,000
6													
Wet Season	350,000	20.0	40.8	0.1	30.0	10.0	4.4	0.5	15.1	30.0	1.5	1.8	100,000
Dry Season	312,000	20.0	26.0	0.1	30.0	10.0	3.8	1.3	14.9	30.0	2.0	2.6	100,000

Note:
(a) Test 5 has been simulated with SSDS Stage I Interim Outfall only, the other tests will be simulated with the Stage II long sea outfall.

Data on pollution sources, other than from Sha Tin STW, were provided from a pollution inventory which has been prepared during an ongoing study on cumulative water quality impacts[21]. These other pollution sources included the discharge from the Tai Po STW, which also passes through the THEES. The loads derived from the pollution inventory include the years 1997 and 2012 which may be taken as being representative, for the purposes of this study, of existing and 2011 (ultimate design condition) for the Sha Tin STW. Full details of the pollution load inventory are included in *Annex D*, which presents the flows and loads used in the simulations together with a description of all pollution sources included in the estimates. The SSDS Stage I Interim Outfall is given the designation NWE, while the SSDS Long Sea Outfall is given the designation of NWF. For all of the sensitivity tests the assumed coastline was representative of 2012, which included the South East Kowloon Reclamation and the diversion of the Kai Tak Nullah. For the test of the Sha Tin STW Stage I/II discharges, the model coastline was representative of the current situation.

Flow and performance data for Stages I and II for 1995 from Appendix D of the Sha Tin STW Stage III Project Review Report[22] were used in the analysis. This report contains monthly analytical data and was used because it included complete flow and load data for the whole year, not just those effluent parameters for which discharge licence standards had been set. The data were analysed to provide mean flow and load values in the wet and dry seasons. The *E.coli* values are assumed to be the same for both the wet and dry seasons. Data on *E.coli* concentrations in the effluent were only available for October, November and December (in the dry season). This is a conservative assumption because the increased flows in the wet season would result in greater dilution of the *E.coli* load and hence lower concentrations, as can be seen for the other parameters.

Flow rates for Sensitivity Test 2 are the wet and dry season design values[23]. An alternate design for the Stage III Extension would result in higher flow rates. This higher flow rate has been used for the wet season in Sensitivity Tests 3, 4, 5 and 6. The dry season flow rate for these scenarios has been defined by considering the ratio of wet and dry season flows in Sensitivity Test 2.

For those pollution parameters for which no discharge licence standard has been specified or is likely to be specified, the 1995 measured data have been used as the basis for the values used in the analysis. For organic nitrogen (Org-N) the ratio of suspended solids (SS) to Org-N has been used. The same ratio of nitrate (NO_2-N) to nitrite (NO_3-N) has been used, whilst assuming that the Total Nitrogen concentration would remain at the EPD standard. The values for Ortho-P and COD have been assumed to remain the same as in 1995. These assumptions are not unreasonable because the treatment process in the Stage III Extension will be the same as in Stages I and II, with the exception that ultraviolet disinfection will be provided as part of the Project.

The Dissolved Oxygen (DO) concentration has been set to 0.1 mg L^{-1} for all of the scenarios reflecting the expected low value in the treated sewage. It should be noted that DO levels in the receiving waters of the Kai Tak Nullah are

(21) Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool. Preliminary Pollution Load Inventory Report (Draft). Agreement No CE 42/97. Hyder Environmental and CES (Asia) Ltd in Association with Delft Hydraulics, September 1998.
(22) Montgomery Watson 1996. Sha Tin Sewage Treatment Works Stages 3 : Project Review. Final Report
(23) DSD 1998. PWP Item 4276DS. Sha Tin Sewage Treatment Works, Stage 3. Preliminary Design Report (Final)

considerably higher and show that significant re-aeration is occurring with in the Nullah.

DSD has indicated that the ammonia concentrations in the treated effluent would be a critical factor in the treatment process design. The sensitivity tests have been designed to investigate the effects on water quality of various Ammonia and Total Nitrogen concentrations in the treated effluent, whilst protecting water quality and achieving the WQOs.

For each of the sensitivity tests, with the exception Test 1 where there will be no load from the Project, a conservative tracer has been introduced into the model. The concentrations of this tracer may represent the dilution of any conservative substance, such as dissolved metals, in the treated effluent. Based on the TM for effluents discharged into Victoria Harbour individual toxic metals have any allowable concentration of 0.1 mg L^{-1}. If it is assumed that the discharge from the Sha Tin STW complies with this standard then it will be possible to calculate the resulting concentrations of individual toxic metals in the receiving waters by using the dilution factors calculated from the conservative tracer simulations. It should be noted that there is no currently WQO for metals in any of the WCZs.

Tolo Harbour

Treated effluent from the Sha Tin STW Stage III Extension will be discharged to the Tolo Harbour during routine maintenance of the THEES system, in the unlikely event of an equipment malfunction and during routine flushing of the submarine outfall from the existing STW. It should be noted that during any closure of the THEES treated effluent from the Tai Po STW would also be discharged to the Tolo Harbour.

Potential concerns arising from such discharges would be an increase in the nutrient loadings, eutrophication, leading to rapid algal growth and the formation of algal blooms. Another concern would be the increase in biochemical oxygen demand load, leading to a possible reduction in dissolved oxygen levels.

Kai Tak Nullah

The THEES currently discharges into the upper reaches of the Kai Tak Nullah, which then discharges to the Kwun Tong Typhoon Shelter. There are also a number of storm drains with expedient connections which discharge into the Nullah. As part of the future developments for the South East Kowloon Reclamation, the Kai Tak Nullah will be diverted to the western side of the old Kai Tak Airport runway and will flow through the middle of the reclamation. The Nullah will become a water feature of a proposed urban park in the centre of the South East Kowloon Reclamation. It will therefore be necessary to protect the water quality in the Kai Tak Nullah so that its amenity value may be maintained. The THEES will continue to discharge to the Kai Tak Nullah but a number of the expedient connections will have been removed from the storm drains, although it is not possible that they will all have been removed. The key parameters in terms of the amenity value of the Nullah will be odour and *E.coli* concentrations.

4.6.3 *Prediction and Evaluation of Impacts*

Victoria Harbour

Model Set Up: The flows and loads for each of the seven tests, as described in *Section 4.6.2*, were converted into model input data and added to the loads from the other pollution sources, which included the Tai Po STW. The resulting total load data for the Kai Tak Nullah are presented in *Table 4.6b*.

A number of differences are shown in *Table 4.6b* compared with *Table 4.6a*, which are due to approximations to accommodate the operation of the Delft water quality model:

- all loadings are presented in g s^{-1}, while *E.coli* is presented as counts s^{-1}, which are a function of flow rate and concentration;
- no nitrate or nitrite loading is given in the pollution load inventory report and so no distinction can be made for the Sha Tin STW load. Nitrate and nitrite are assumed to be discharged as ammonia;
- dissolved oxygen is not modelled as being present in the discharge, the omission of which has very little influence on the model predictions and results in a more conservative simulation;
- two values are given for phosphorous in the pollution load inventory report, Total-P and PO_4-P. The water quality model has Organic-P and Inorganic Adsorbed P (AAP) as model substances. The differences between Total-P and PO_4-P have been distributed equally between Organic-P and AAP;
- a concentration of 18 mg L^{-1} for Si has been used in the pollution load inventory and the same value has been applied for all of the simulations in this Study; and
- changes in the *E.coli* concentrations are not obviously reflected by the loadings because the Sha Tin STW Stage III load is much smaller than the total Kai Tak Nullah loading.

Table 4.6b *Total Pollution Loads to the Kai Tak Nullah*

Test	BOD ($g\ s^{-1}$)	SS ($g\ s^{-1}$)	NH4 ($g\ s^{-1}$)	Org-N ($g\ s^{-1}$)	PO_4 ($g\ s^{-1}$)	Org-P ($g\ s^{-1}$)	AAP ($g\ s^{-1}$)	E. Coli (counts s^{-1})	Si ($g\ s^{-1}$)	Tracer ($g\ s^{-1}$)
Stage I/II										
Wet Season	929.7	1196.0	53.8	211.2	30.3	9.7	9.7	2.11×10^{12}	194.6	2.00×10^{8}
Dry Season	183.1	213.0	17.1	35.2	10.9	2.3	2.3	5.08×10^{11}	56.2	1.67×10^{8}
Sensitivity Tests										
1										
Wet Season	394.4	614.0	60.2	163.7	10.75	3.83	3.83	2.018×10^{12}	110.3	0
Dry Season	146.7	173.4	6.6	69.5	1.83	0.694	0.694	2.018×10^{11}	10.6	0
2										
Wet Season	457.7	716.4	133.9	178.7	15.87	4.34	4.34	2.018×10^{12}	171.8	2.95×10^{8}
Dry Season	207.6	264.7	67.3	81.0	7.92	1.61	1.61	5.449×10^{11}	72.1	2.63×10^{8}
3										
Wet Season	470.4	735.5	126.8	181.5	16.82	4.433	4.433	2.018×10^{12}	183.2	3.50×10^{8}
Dry Season	218.9	281.7	61.3	83.2	9.05	1.778	1.778	5.451×10^{11}	82.3	3.12×10^{8}
4										
Wet Season	470.4	735.5	147.0	181.5	16.82	4.433	4.433	2.019×10^{12}	183.2	3.50×10^{8}
Dry Season	218.9	281.7	79.3	83.2	9.05	1.778	1.778	5.455×10^{11}	82.3	3.12×10^{8}
5[(a)]										
Wet Season	470.4	735.5	147.0	181.5	16.82	4.433	4.433	2.022×10^{12}	183.2	3.50×10^{8}
Dry Season	218.9	281.7	79.3	83.2	9.05	1.778	1.778	5.485×10^{11}	82.3	3.12×10^{8}
6										
Wet Season	470.4	725.5	167.3	181.5	16.82	4.433	4.433	2.022×10^{12}	183.2	3.50×10^{8}
Dry Season	218.9	281.7	97.4	83.2	9.05	1.778	1.778	5.485×10^{11}	82.3	3.12×10^{8}

Note:
(a) Test 5 has been simulated with SSDS Stage I outfall only, the other tests have been simulated with the Stage II long sea outfall.

The load data for the Tai Po STW is presented in *Table 4.6c* and the load data for the storm drains with expedient connections is shown in *Table 4.6d*. These values were calculated from data given in the preliminary pollution load inventory. For the Tai Po STW the values represent the expected flows in 2012, without increased capacity at the STW, which is the subject of an ongoing study. It should be noted that the pollutant loadings in *Table 4.6b* show that the wet season loads are much higher than those for the dry season which reflects the greater flows through storm drains with expedient connections. This is most evident for the Stage I/II simulation because of the reduced implementation of Sewage Master Plans, compared with the 2012 simulations. *Table 4.6d* shows that the storm drains contribute the greatest proportion of the BOD, SS, OrgN and *E.coli* in the wet season. Although the Sha Tin STW contributes the greatest proportion of the ammonia load, 66% for Test 6 in the wet season, the storm drains contribute the majority of the total nitrogen load, 62% for Test 6 in the wet season.

Table 4.6c ***Tai Po STW Loading to THEES in 2012***

Parameter	Load (g s^{-1})
BOD	7.8
SS	13.4
NH4	3.5
Org-N	2.1
PO_4	1.2
Org-P	0.3
AAP	0.3
E.coli	$1.17x10^{11}$(counts s^{-1})
Si	6.8

Table 4.6d ***Storm Drain Loading to Kai Tak Nullah in 2012***

Parameter	Wet Season Load (g s^{-1})	Dry Season Load (g s^{-1})
BOD	386.6	138.9
SS	600.6	160.0
NH4	56.7	3.1
Org-N	160.2	67.4
PO_4	9.55	0.63
Org-P	3.53	0.394
AAP	3.53	0.394
E.coli	$1.901x10^{12}$ (counts s^{-1})	$8.48x10^{10}$ (counts s^{-1})
Si	103.5	3.8

The model was set up to simulate 15 day spring-neap tidal cycles in the wet and dry seasons. The model was run for a 'spin-up' period of two full spring-neap periods prior to the commencement of the 15 day spring-neap cycle simulation period. This was the same approach as was used in the model calibration, as described in *Annex C*.

Presentation of Results: The results from the computer modelling exercise have been presented as summary tables of predicted water quality values at the sensitive receivers. The tables contain the following information:

- minimum depth averaged dissolved oxygen concentrations;
- minimum bed layer dissolved oxygen concentrations;
- mean depth averaged biochemical oxygen demand concentrations;
- mean depth averaged total inorganic nitrogen concentrations;
- mean depth averaged ammonia concentrations;
- geometric mean depth averaged *E.coli* concentrations; and
- maximum depth averaged suspended solids concentrations.

The complete set of model results is presented in *Annex E*. It should be noted that the WQO for dissolved oxygen is specified as a 90th percentile value, while the model results have been output as minimum values. This will mean that an assessment of the modelling results for DO relative to the WQO will be somewhat conservative.

Contour plots of water quality parameters have also been prepared for the wet and dry seasons to present the following information:

- mean depth averaged dissolved oxygen concentrations;

- minimum surface and bed layer dissolved oxygen concentrations;

- mean depth averaged concentrations of biochemical oxygen demand, total inorganic nitrogen, ammonia, suspended solids, chlorophyll-a and the conservative tracer; and

- geometric mean surface and bed layer *E.coli* concentrations.

Additionally for the wet season, contour plots were generated to show mean surface and bed layer concentrations of biochemical oxygen demand, total inorganic nitrogen, ammonia, suspended solids, and the conservative tracer.

The contour plots are contained within *Annexes F* and *G* for the wet and dry seasons respectively.

Stage I/II Test Results: This test simulated the existing conditions, in terms of the discharge from the Sha Tin STW and the background pollutant loads. Summaries of the water quality modelling predictions are given in *Tables 4.6e* and *4.6f* for the wet and dry seasons respectively.

Table 4.6e ***Water Quality Model Results at Sensitive Receivers - Stage I/II, Wet Season***

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1})
Intake 1	**2.1**	2.1	3.1	**0.73**	**0.029**	2,000	18.8
Intake 2	**3.5**	3.5	2.1	**0.48**	0.015	51	18.5
Intake 3	**3.5**	3.5	2.1	**0.48**	0.015	51	18.5
Intake 4	**3.1**	3.1	2.7	**0.60**	0.021	3,300	17.9
Intake 5	**3.2**	3.2	2.8	**0.60**	**0.022**	5,500	16.3
Intake 6	**3.5**	3.5	3.1	**0.63**	**0.023**	14,000	27.2
Intake 7	**3.3**	3.3	3.2	**0.59**	**0.022**	12,000	16.9
Intake 8	**3.3**	3.3	2.6	**0.60**	**0.022**	450	15.1
Intake 9	**3.7**	3.8	2.4	**0.51**	0.018	1	15.9
Intake 10	4.0	4.0	3.6	**0.73**	**0.030**	5,200	16.1
Intake 11	4.0	4.1	2.2	**0.47**	0.016	1,000	14.0
Mon 1	**3.3**	3.3	2.4	**0.54**	0.018	520	18.3
Mon 2	**3.5**	3.5	2.5	**0.55**	0.019	590	16.2
Mon 3	**3.6**	3.6	2.5	**0.55**	0.019	2,500	14.2
Mon 4	**3.7**	3.7	2.5	**0.54**	0.019	24	18.5
Mon 5	**3.8**	3.8	2.2	**0.51**	0.017	94	13.3
Mon 6	**3.9**	4.2	1.6	**0.41**	0.013	1	12.2

Notes:

(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6f ***Water Quality Model Results at Sensitive Receivers - Stage I/II, Dry Season***

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1})
Intake 1	**3.4**	3.4	2.1	**0.91**	0.020	5,300	13.9
Intake 2	**3.6**	3.6	2.0	**0.73**	0.016	5,500	15.9
Intake 3	**3.6**	3.6	2.0	**0.73**	0.016	5,500	15.9
Intake 4	**3.5**	3.5	2.3	**0.84**	0.018	7,400	13.6
Intake 5	**3.5**	3.5	2.3	**0.84**	0.019	7,900	13.4
Intake 6	**3.5**	3.5	2.3	**0.82**	0.018	8,800	14.4
Intake 7	**3.6**	3.6	2.6	**0.84**	0.019	22,000	12.9
Intake 8	**3.5**	3.5	2.2	**0.78**	0.017	7,600	12.2
Intake 9	4.0	4.0	1.9	**0.68**	0.015	7,200	10.5
Intake 10	4.0	4.0	1.7	**0.62**	0.013	1,300	12.7
Intake 11	4.6	4.6	1.5	**0.50**	0.010	7,700	8.8
Mon 1	**3.6**	3.6	2.2	**0.78**	0.017	6,000	15.0
Mon 2	**3.6**	3.6	2.2	**0.78**	0.017	8,300	13.9
Mon 3	**3.7**	3.8	2.2	**0.74**	0.016	8,800	13.0
Mon 4	**3.8**	3.8	2.1	**0.68**	0.015	8,100	13.8
Mon 5	**3.9**	3.9	1.9	**0.61**	0.013	6,400	11.8
Mon 6	4.3	4.3	1.2	**0.46**	0.009	1,700	9.7

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

The above tables show that, in general, water quality is better in the dry season than the wet season with the exception of TIN. The primary reason for this is increased flows through the storm drains in the wet season which increase the pollutant load. *Tables 4.6e* and *4.6f* show that at many of the stations the WQO for dissolved oxygen is not achieved for the depth averaged conditions, although it is predicted to be met in the bed layer. The concentrations are less than 1 mg L^{-1} below the WQO, except at Intake 1 which is in the vicinity of the Yau Ma Tei Typhoon Shelter. In the inner harbour, the WQO for ammonia is breached in the wet season. Non-compliance with the WQO for total inorganic nitrogen is predicted in both the wet and dry seasons at all stations, but the values are all less than 1 mg L^{-1}. The *E.coli* values indicate that it is most probably the presence of sewage discharges that leads to the predicted water quality impacts, particularly dissolved oxygen which is depleted by the relatively high biochemical oxygen demand.

The contour plots for a range of water quality parameters are shown in *Figures 1* to *6* in *Annex G* for the dry season and in *Figures 1* to *11* in *Annex F* for the wet season. The contour plots clearly show the poor water quality which is found in the Kwun Tong Typhoon Shelter. In particular, low dissolved oxygen concentrations of below 1 mg L^{-1} in the surface and bed layers are shown in both the wet and dry seasons. In the wet season the low dissolved oxygen content of water in the typhoon shelter is shown having an influence on dissolved oxygen concentrations in Victoria Harbour in the vicinity of the mouth of the typhoon shelter, along to Yau Tong Bay. Areas of low dissolved oxygen concentration are shown around the West Kowloon Reclamation. The contours show high pollutant loadings, with BOD concentrations exceeding 2.5 mg L^{-1}, in much of the harbour area during the wet season. The results for both wet and dry seasons show much better water quality to the south of Lei Yue Mun. In particular, at the Tung Lung Chau FCZ compliance with all WQOs is achieved. A degree of stratification is found in the wet season, which is not present in the dry season. It is for this reason that depth averaged values have been produced for the dry season, while additional plots for the surface and bed layers have been produced for the wet season.

Sensitivity Test 1 Results: This test simulated the 2011 situation, in terms of both the pollutant loading and coastline configuration. Specifically it included the SSDS Stages I, II, III and IV and the completed South East Kowloon Reclamation. There was assumed to be no load input from the Sha Tin STW. Summaries of the water quality modelling results are presented in *Tables 4.6g* and *4.6h* for the wet and dry seasons respectively.

Table 4.6g ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 1, Wet Season***

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts $100mL^{-1}$)	SS[f] (mg L^{-1})
Intake 1	**3.6**	3.6	1.3	0.33	0.008	360	17.6
Intake 2	4.8	4.8	1.2	0.30	0.006	29	16.6
Intake 3	4.8	4.8	1.2	0.31	0.006	16	17.8
Intake 4	4.6	4.6	1.2	0.32	0.007	1,100	18.3
Intake 5	4.8	4.8	1.3	0.32	0.007	1,800	15.8
Intake 6	4.8	4.8	1.4	0.33	0.008	8,000	28.7
Intake 7	4.6	4.6	1.5	0.33	0.008	100	13.3
Intake 8	4.9	4.9	1.5	0.36	0.010	6,300	18.6
Intake 9	4.6	4.8	1.1	0.30	0.007	110	10.8
Intake 10	4.8	4.8	1.0	0.31	0.007	1,600	9.5
Intake 11	4.6	4.6	1.1	0.29	0.007	510	17.8
Mon 1	4.8	4.8	1.2	0.31	0.006	270	16.4
Mon 2	4.8	4.8	1.2	0.31	0.007	380	13.7
Mon 3	4.8	4.8	1.2	0.31	0.007	920	12.7
Mon 4	4.8	4.8	1.1	0.31	0.007	3,600	11.8
Mon 5	4.7	4.7	1.0	0.29	0.007	940	11.2
Mon 6	4.7	4.7	0.8	0.26	0.006	280	10.2

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6h ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 1, Dry Season***

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1})
Intake 1	6.3	6.3	0.6	0.29	0.004	1,100	10.1
Intake 2	6.4	6.4	0.6	0.26	0.004	1,700	12.0
Intake 3	6.4	6.4	0.6	0.26	0.004	1,700	12.0
Intake 4	6.3	6.3	0.6	0.26	0.004	3,000	9.8
Intake 5	6.3	6.3	0.6	0.26	0.004	3,800	9.6
Intake 6	6.3	6.3	0.6	0.25	0.004	6,700	8.9
Intake 7	6.2	6.2	0.8	0.28	0.005	6,400	7.8
Intake 8	6.3	6.3	0.6	0.23	0.003	820	8.4
Intake 9	6.3	6.3	0.5	0.22	0.003	2,400	6.7
Intake 10	6.2	6.2	0.4	0.20	0.003	410	6.1
Intake 11	6.4	6.4	0.5	0.19	0.003	4,100	6.6
Mon 1	6.4	6.4	0.6	0.26	0.004	1,900	11.1
Mon 2	6.4	6.4	0.6	0.25	0.004	1,900	9.9
Mon 3	6.4	6.4	0.5	0.23	0.003	1,800	8.6
Mon 4	6.4	6.4	0.5	0.22	0.003	3,200	7.5
Mon 5	6.4	6.4	0.5	0.20	0.003	1,500	7.0
Mon 6	6.4	6.4	0.3	0.18	0.003	350	7.8

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

These tables clearly show much improved water quality compared with the Stage I/II simulation. This is attributed to the reduction in polluting discharges to Victoria Harbour following the implementation of the SSDS Stages I, II, III and IV, which will discharge treated effluent via a long sea outfall to the southeast of Lamma Island. Compliance is achieved for all parameters and stations, except for dissolved oxygen at Intake 1 during the wet season. This may be due to the proximity of the Yau Ma Tei Typhoon Shelter, from which water with a low dissolved oxygen content may be transported to Intake 1.

The improvement in water quality is graphically demonstrated in the contour plots which are *Figures 7* to *12* in *Annex G* for the dry season and *Figures 12* to *22* in *Annex F* for the wet season. The contour plots also show the changes in the coastline which have occurred between 1997 and 2012, most notably the South

East Kowloon Reclamation, the Central-Wan Chai Reclamation and the Green Island Development.

This scenario included all of the loads for 2012 except for the Sha Tin STW. The results from Sensitivity Tests 2, 3, 4 and 6 may be compared with the results from this scenario to determine the impacts of different flow and load combinations from the Sha Tin STW following the construction of the Stage III Extension.

Sensitivity Test 2 Results: In this test, the design flow rate for the Sha Tin STW in 2011 was simulated together with a set of assumed treated effluent quality concentrations. The background pollutant loads were representative of conditions in 2011 which included the SSDS Stages I, II, III and IV. The only difference between this test and Sensitivity Test 1 was the inclusion of the Sha Tin STW load. Summaries of the water quality modelling results are given in *Tables 4.6i* and *4.6j* for the wet and dry seasons respectively.

Table 4.6i ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 2, Wet Season***

Station[(A)]	Parameter						
	DO[(B)] (mg L^{-1})	DO Bed[(C)] (mg L^{-1})	BOD_5[(d)] (mg L^{-1})	TIN[(d)] (mg L^{-1})	NH_3-N[(d)] (mg L^{-1})	*E.coli*[(e)] (counts 100mL^{-1})	SS[(f)] (mg L^{-1}) 17.7
Intake 1	**3.5**	3.5	1.3	0.35	0.008	360	17.7
Intake 2	4.8	4.8	1.2	0.32	0.007	29	16.7
Intake 3	4.8	4.8	1.2	0.33	0.007	16	17.9
Intake 4	4.5	4.5	1.3	0.34	0.008	1,100	18.4
Intake 5	4.7	4.7	1.3	0.35	0.008	1,800	15.9
Intake 6	4.8	4.8	1.4	0.37	0.01	8,000	28.9
Intake 7	4.5	4.5	1.5	0.36	0.009	100	13.4
Intake 8	4.8	4.8	1.5	**0.46**	0.016	6,200	20.4
Intake 9	4.6	4.8	1.1	0.33	0.008	110	10.8
Intake 10	4.7	4.7	1.1	0.35	0.009	1,600	9.6
Intake 11	4.6	4.6	1.1	0.31	0.008	510	17.9
Mon 1	4.8	4.8	1.2	0.33	0.008	270	16.5
Mon 2	4.8	4.8	1.2	0.33	0.008	380	13.8
Mon 3	4.8	4.8	1.2	0.34	0.008	920	12.8
Mon 4	4.8	4.8	1.2	0.35	0.010	3,600	11.9
Mon 5	4.7	4.7	1.0	0.32	0.008	940	11.3
Mon 6	4.7	4.7	0.9	0.28	0.006	290	10.2

Notes:

(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6j ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 2, Dry Season***

Station[a]	Parameter						
	DO[B] (mg L^{-1})	DO Bed[C] (mg L^{-1})	BOD_5[B] (mg L^{-1})	TIN[B] (mg L^{-1})	NH_3-N[B] (mg L^{-1})	*E.coli*[B] (counts 100mL^{-1})	SS[B] (mg L^{-1})
Intake 1	6.2	6.2	0.6	0.36	0.006	1,100	10.2
Intake 2	6.3	6.3	0.6	0.33	0.005	1,100	12.1
Intake 3	6.3	6.3	0.6	0.33	0.005	1,400	12.1
Intake 4	6.3	6.3	0.6	0.34	0.006	3,000	9.9
Intake 5	6.2	6.2	0.7	0.34	0.006	3,800	9.7
Intake 6	6.2	6.2	0.7	0.34	0.006	6,700	9.0
Intake 7	6.1	6.1	0.9	0.36	0.007	6,400	7.9
Intake 8	6.2	6.2	0.7	0.33	0.006	820	8.8
Intake 9	6.3	6.3	0.6	0.29	0.005	2,400	6.8
Intake 10	6.1	6.1	0.5	0.25	0.004	410	6.2
Intake 11	6.4	6.4	0.6	0.23	0.004	4,100	6.7
Mon 1	6.3	6.3	0.6	0.33	0.006	1,900	11.2
Mon 2	6.3	6.3	0.6	0.32	0.005	1,900	10.0
Mon 3	6.3	6.3	0.6	0.30	0.005	1,800	8.7
Mon 4	6.3	6.3	0.6	0.29	0.005	3,200	7.6
Mon 5	6.3	6.3	0.5	0.26	0.005	1,500	7.0
Mon 6	6.3	6.3	0.5	0.21	0.004	350	7.8

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

These data show that there are only two predicted exceedences of the WQOs at the sensitive receivers, which are dissolved oxygen at Intake 1 and total inorganic nitrogen at Intake 8 during the wet season. There are small decreases in the order of 0.1 mg L^{-1} shown for dissolved oxygen concentrations at the intakes on the northern side of Victoria Harbour[24], which shows that the effluent plume from the Kai Tak Nullah remains along this side of the harbour. The exceedence of the WQO for dissolved oxygen at Intake 1 was also predicted in Sensitivity Test 1, which shows that this is not a result of the additional discharge from the Sha Tin STW. The total inorganic nitrogen at Intake 8 is shown to increase by 0.1 mg L^{-1}, which is sufficient to cause a breach of the WQO level in the wet season. However, when the yearly average is considered the resulting concentration is 0.40 mg L^{-1} which is in compliance with the WQO. The

(24) Intakes 1, 4, 5, 6 and 8.

unionized ammonia concentrations are also shown to increase but all of the values remain within the WQO. Changes in suspended solids concentrations are less than 1 mg L^{-1}. The *E. coli* concentrations are predicted to remain largely unchanged, which shows that the contribution of the Sha Tin STW to the total *E.coli* load is small.

The contour plots for the dry season simulation are shown in *Figures 11* to *15* in *Annex G* and are shown in *Figures 23* to *33* of *Annex F* for the wet season. In comparison with Sensitivity Test 1 there are no differences shown for dissolved oxygen, suspended solids and *E.coli* in both seasons. In the wet season there is an area of low bottom dissolved oxygen concentrations, less than 2 mg L^{-1}, in the northern part of the West Kowloon Reclamation. This area was present in Sensitivity Test 1 and is beyond the zone of influence of the THEES. In the dry season there are small areas of BOD increases in the immediate vicinity of the Kai Tak Nullah discharge. Both ammonia and total inorganic nitrogen are shown to increase throughout the western portion of Victoria Harbour. The increases are most noticeable around the discharge point for the Kai Tak Nullah. The predicted concentrations are shown to be above the WQO for total inorganic nitrogen in the immediate vicinity of the Kai Tak Nullah discharge point and along the coastline of the South East Kowloon Reclamation during the wet season. However, if the dry season results are included and the yearly average calculated, the area of exceedence of the WQO reduces to be only in the immediate vicinity of the Kai Tak Nullah discharge point. This area would be termed the 'mixing zone'[(25)]. The unionized ammonia concentrations are shown to be within the WQO in the areas impacted by the THEES discharge. The increased nutrient concentrations are not sufficient to stimulate algal growth, as can be seen from the contour plots of chlorophyll-a (*Figure 32* in *Annex G* and *Figure 15* in *Annex F*). To the east of Lei Yue Mun there are no differences relative to Sensitivity Test 1 for all water quality parameters. This demonstrates that the discharge from the Sha Tin STW does not affect water quality at Tung Lung Chau. The contours of tracer concentrations for the dry season show that there is a small initial mixing zone adjacent to the discharge point. Within Victoria Harbour mixing to at least a factor of 400 is predicted, which equates to a metals concentration of 0.25 μg L^{-1}[(26)]. Beyond the inner harbour mixing to at least a factor of 800, which gives a metals concentration of 0.13 μg L^{-1}, is expected on the western side of Tung Lung Chau. In the wet season the results show mixing to a factor of 400, which gives a metals concentration of 0.25 μg L^{-1}, in the harbour in both the surface and bed layers. At Tung Lung Chau a mixing factor of 400, which again gives a metals concentration of 0.25 μg L^{-1}, is predicted in the surface layer and a factor of 1,500, giving a metals concentration of 0.07 μg L^{-1}, is predicted in the lower layer. These results show good dispersion of any trace elements or conservative pollutants which may be present in the treated effluent discharge. In the case of metals this would give concentrations below any level of concern.

The results from Sensitivity Test 2 show that the discharge from the Sha Tin STW used for this simulation only results in changes in water quality in Victoria Harbour sufficient to breach the WQO for total inorganic nitrogen during the wet season. The area of exceedence is shown to be in the immediate vicinity of the Kai Tak Nullah discharge point and along the face of the South East Kowloon Reclamation. The predicted total inorganic nitrogen concentrations would be

(25) A mixing zone is a term contained within the *Technical Memorandum on Environmental Impact Assessment Process* and is defined as '*a region of a water body where initial dilution of a pollution input takes place and where water quality criteria can be exceeded*'.

(26) Calculated from the assumed discharge concentration of 0.1 mg L^{-1} diluted by a factor of 400.

within the WQO when the yearly average is considered, except in the immediate vicinity of the Kai Tak Nullah discharge point and this area would be defined as the 'mixing zone'. The other breach of the WQOs is for dissolved oxygen at Intake 1 in the wet season, which was breached without the Sha Tin STW load, as demonstrated in Sensitivity Test 1. The reduction in the dissolved oxygen concentration caused by the Sha Tin STW discharge at this location is 0.1 mg L^{-1}, which is very small and represents 1.7% of the WQO. The results show that good dilution, greater than a factor of 400, would occur for any trace conservative pollutants discharged from the Sha Tin STW.

In summary, it is concluded that the discharge from the Sha Tin STW addressed in this test would be acceptable in terms of water quality impacts in Victoria Harbour. The only localised breaches of the WQO attributable to the Sha Tin STW discharge would be for total inorganic nitrogen in the vicinity of the Kai Tak Nullah discharge point. This would be within the 'mixing zone' of the discharge point and is considered acceptable. Water quality at Tung Lung Chau would not be effected.

Sensitivity Test 3: In this test an increased flow rate from the Sha Tin STW was simulated, which represented an alternate design for the Stage III Extension. The Total Nitrogen concentration was reduced from Sensitivity Test 2. Summaries of the water quality predictions are contained in *Tables 4.6k* and *4.6l* for the wet and dry seasons respectively.

Table 4.6k ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 3, Wet Season***

Station[a]	Parameter						
	DO[B] (mg L^{-1})	DO Bed[C] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1})
Intake 1	**3.5**	3.5	1.3	0.35	0.008	360	17.7
Intake 2	4.8	4.8	1.2	0.32	0.007	29	16.7
Intake 3	4.8	4.8	1.2	0.32	0.007	16	17.9
Intake 4	4.5	4.5	1.3	0.34	0.008	1,100	18.4
Intake 5	4.7	4.7	1.3	0.34	0.008	1,800	15.9
Intake 6	4.8	4.8	1.4	0.37	0.010	8,000	28.9
Intake 7	4.5	4.5	1.5	0.36	0.009	100	13.4
Intake 8	4.8	4.8	1.6	**0.45**	0.015	6,300	20.8
Intake 9	4.6	4.8	1.1	0.33	0.008	110	10.8
Intake 10	4.7	4.7	1.1	0.35	0.009	1,600	9.6
Intake 11	4.6	4.6	1.1	0.30	0.008	510	17.9
Mon 1	4.8	4.8	1.2	0.33	0.007	270	16.5
Mon 2	4.8	4.8	1.2	0.33	0.008	380	13.8
Mon 3	4.8	4.8	1.2	0.34	0.008	920	12.8
Mon 4	4.8	4.8	1.2	0.35	0.009	3,600	11.9
Mon 5	4.7	4.7	1.0	0.32	0.008	940	11.3
Mon 6	4.7	4.7	0.9	0.28	0.006	290	10.3

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6l ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 3, Dry Season***

Station[(a)]	Parameter						
	DO[(B)] (mg L^{-1})	DO Bed[(C)] (mg L^{-1})	BOD_5[(d)] (mg L^{-1})	TIN[(d)] (mg L^{-1})	NH_3-N[(d)] (mg L^{-1})	*E.coli*[(e)] (counts 100mL^{-1})	SS[(f)] (mg L^{-1})
Intake 1	6.2	6.2	0.6	0.36	0.006	1,100	10.2
Intake 2	6.3	6.3	0.6	0.32	0.005	1,700	12.1
Intake 3	6.3	6.3	0.6	0.32	0.005	1,700	12.1
Intake 4	6.3	6.3	0.6	0.33	0.006	3,000	9.9
Intake 5	6.3	6.3	0.7	0.33	0.006	3,900	9.7
Intake 6	6.2	6.2	0.7	0.33	0.006	6,700	9.0
Intake 7	6.1	6.1	0.9	0.35	0.006	6,400	7.9
Intake 8	6.2	6.2	0.7	0.32	0.006	830	9.0
Intake 9	6.3	6.3	0.6	0.28	0.005	2,400	6.9
Intake 10	6.1	6.1	0.5	0.25	0.004	410	6.2
Intake 11	6.4	6.4	0.6	0.22	0.004	4,100	6.7
Mon 1	6.3	6.3	0.6	0.33	0.005	1,900	11.2
Mon 2	6.3	6.3	0.6	0.32	0.005	1,900	10.0
Mon 3	6.3	6.3	0.6	0.30	0.005	1,800	8.8
Mon 4	6.3	6.3	0.6	0.28	0.005	3,200	7.7
Mon 5	6.3	6.3	0.5	0.26	0.004	1,500	7.1
Mon 6	6.3	6.3	0.5	0.21	0.003	350	7.8

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

The above tables show that the only breaches of the WQOs are at Intake 1 in the wet season for dissolved oxygen and total inorganic nitrogen. The same prediction was made in Sensitivity Tests 1 and 2 and for total inorganic nitrogen the WQO would be satisfied based on an annual average basis. It should be noted that a reduction in the total nitrogen load of 5 mg L^{-1} has only resulted in a decrease in the TIN concentration at Intake 8 of 0.1 mg L^{-1}, compared with the results from Test 2. This shows the dominant influence of the storm drain loadings which constitute the largest proportion of the total nitrogen load. In this test an increased effluent flow rate and *E.coli* concentration and a reduced total nitrogen concentration were simulated. Despite the increased flow rates, there were predicted to be no changes in the dissolved oxygen levels, which is reflected by the almost unchanged biochemical oxygen demand concentrations, compared with Sensitivity Test 2. Slight decreases in total nitrogen and ammonia concentrations are predicted at Intake 8, which is closest to the discharge point, compared with Sensitivity Test 2. The *E.coli* and suspended sediment concentrations remain unchanged from Sensitivity Test 2.

The contour plots for the dry season simulation are shown in *Figures 19* to *24* in *Annex G* and in *Figures 34* to *44* in *Annex F* for the wet season. In the dry season the contours plots are very similar to those for Sensitivity Test 2, the only exceptions being small reductions in the total nitrogen and ammonia concentrations. In the wet season the same small differences are observed as in the dry season plots. No differences are shown in either the wet season or dry season to the east of Lei Yue Mun. The concentrations of the conservative tracer are the same as in Sensitivity Test 2, despite the increased flow rate from the Sha Tin STW and so similarly low metals concentrations would be found.

The conclusions from Sensitivity Test 3 are the same as those for Sensitivity Test 2. This scenario is also environmentally acceptable and would only create breaches of the WQO for total inorganic nitrogen in the immediate vicinity of the Kai Tak Nullah discharge point and at Intake 1 for dissolved oxygen. The latter has been demonstrated to be only minimally impacted by the Sha Tin STW discharges. The increased flows simulated in this scenario have not caused unacceptable impacts nor have they created a predictable deterioration in water quality relative to Sensitivity Test 2.

Sensitivity Test 4 Results: In this test the same flow rate as in Sensitivity Test 3 was simulated, but the ammonia concentration was increased from 5 mg L^{-1} to 10 mg L^{-1}. Summaries of the water quality modelling results are presented in *Tables 4.6m* and *4.6n* for the wet and dry seasons respectively.

Table 4.6m ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 4, Wet Season***

Station[a]	Parameter						
	DO[B] (mg L^{-1})	DO Bed[C] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1}) 17.7
Intake 1	**3.5**	3.5	1.3	0.35	0.008	360	17.7
Intake 2	4.8	4.8	1.2	0.32	0.007	29	16.7
Intake 3	4.8	4.8	1.2	0.33	0.007	16	17.9
Intake 4	4.5	4.5	1.2	0.35	0.008	1,100	18.4
Intake 5	4.7	4.7	1.3	0.35	0.009	1,800	15.9
Intake 6	4.8	4.8	1.4	0.38	0.011	8,000	28.9
Intake 7	4.5	4.5	1.5	0.36	0.009	100	13.4
Intake 8	4.8	4.8	1.6	**0.47**	0.017	6,300	20.8
Intake 9	4.6	4.7	1.1	0.33	0.008	110	10.8
Intake 10	4.7	4.7	1.1	0.36	0.010	1,600	9.6
Intake 11	4.6	4.6	1.1	0.31	0.008	510	17.9
Mon 1	4.8	4.8	1.2	0.34	0.008	270	16.5
Mon 2	4.8	4.8	1.2	0.34	0.008	380	13.8
Mon 3	4.8	4.8	1.2	0.35	0.009	920	12.8
Mon 4	4.7	4.7	1.2	0.36	0.010	3,600	11.9
Mon 5	4.7	4.7	1.0	0.33	0.009	940	11.3
Mon 6	4.7	4.7	0.9	0.28	0.007	290	10.3

Notes:

(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6n ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 4, Dry Season***

Station[a]	Parameter						
	DO[B] (mg L^{-1})	DO Bed[C] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts $100mL^{-1}$)	SS[f] (mg L^{-1})
Intake 1	6.2	6.2	0.6	0.38	0.006	1,100	10.2
Intake 2	6.3	6.3	0.6	0.34	0.006	1,700	12.1
Intake 3	6.3	6.3	0.6	0.34	0.006	1,700	12.1
Intake 4	6.2	6.2	0.6	0.36	0.006	3,000	9.9
Intake 5	6.2	6.2	0.7	0.36	0.006	3,900	9.7
Intake 6	6.2	6.2	0.7	0.35	0.007	6,700	9.0
Intake 7	6.2	6.2	0.9	0.37	0.007	6,400	7.9
Intake 8	6.2	6.2	0.7	0.35	0.005	830	9.0
Intake 9	6.2	6.2	0.6	0.30	0.005	2,400	6.9
Intake 10	6.1	6.1	0.5	0.26	0.005	410	6.2
Intake 11	6.4	6.4	0.6	0.23	0.004	4,100	6.7
Mon 1	6.3	6.3	0.6	0.35	0.006	1,900	11.2
Mon 2	6.3	6.3	0.6	0.34	0.006	1,900	10.0
Mon 3	6.3	6.3	0.6	0.32	0.006	1,800	8.8
Mon 4	6.3	6.3	0.6	0.30	0.006	3,200	7.7
Mon 5	6.3	6.3	0.5	0.27	0.005	1,500	7.1
Mon 6	6.3	6.3	0.5	0.22	0.004	350	7.8

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Sensitivity Test 4 simulated an increased flow rate compared with Sensitivity Test 2, increased ammonia and total nitrogen concentrations and increased *E.coli* concentrations. The above tables demonstrate that, despite these increased flows and loads, the WQOs are satisfied, except in the wet season at Intake 8 for total inorganic nitrogen and at Intake 1 for dissolved oxygen, where for the latter the breach is not attributable to the discharge from the Sha Tin STW. Only small increases in total inorganic nitrogen and ammonia concentrations are predicted compared with Sensitivity Test 2. As for Sensitivity Test 2, the breach in the total inorganic nitrogen for the wet season would not occur once the yearly average is considered. It should be noted that the increase in the ammonia and total nitrogen loads, compared with Test 3, has only increased the wet season TIN at Intake 8 by 0.02 mg L^{-1}, which demonstrates the dominant influence of the storm drain loadings on water quality at this location. The other water quality parameters remain unchanged.

The contour plots for the dry season simulation are shown in *Figures 25* to *30* in *Annex G* and in *Figures 45* to *55* in *Annex F* for the wet season. The contour plots for the dry season are essentially the same as those for Sensitivity Test 2. The only discernable differences are found in the total inorganic nitrogen and ammonia plots where a single model grid cell shows increased concentrations of these two parameters. In the wet season the only differences compared with Scenario 2 are also for total inorganic nitrogen and ammonia. For total inorganic nitrogen there has been very little increase in the size of the region with concentrations greater than 0.4 mg L^{-1} but within this region the size of the area at a concentration greater than 0.5 mg L^{-1} has increased. This means that the total area which breaches the WQO for total inorganic nitrogen on an annual average basis will be increased from Scenario 2 but will still be generally localised to within the vicinity of the Kai Tak Nullah discharge point. There are no differences in predicted water quality to the east of Lei Yue Mun. The contours of the conservative tracer concentrations show no differences from Sensitivity Test 2.

The conclusions from Sensitivity Test 4 are the same as those for Sensitivity Test 2 and show that the discharge simulated in this scenario is environmentally acceptable. The only breaches of the WQO on a yearly basis will be for total inorganic nitrogen in the vicinity of the discharge point of the Kai Tak Nullah which will form a 'mixing zone'. The same breach of the WQO at Intake 1 for dissolved oxygen during the wet season is shown but this is not attributed to the discharge from the Sha Tin STW. This means that the increased ammonia concentration in combination with the higher flow rate does not result in unacceptable impacts.

Sensitivity Test 5 Results: In this test the same flows and loads from the Sha Tin STW were simulated as in Sensitivity Test 4. However, the background load was set to be representative of the SSDS Stage I in 2011, assuming that the Stage I Interim Outfall is still operating and treated sewage effluent from the SSDS is discharged into the Western Harbour. This means that the background flows and loads to Victoria Harbour were much higher than in the previous sensitivity tests. Summaries of the water quality modelling results are contained in *Tables 4.6o* and *4.6p* for the wet and dry seasons respectively.

Table 4.6o ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 5, Wet Season***

Station[a]	Parameter						
	DO[B] (mg L^{-1})	DO Bed[C] (mg L^{-1})	BOD_5[B] (mg L^{-1})	TIN[B] (mg L^{-1})	NH_3-N[B] (mg L^{-1})	*E.coli*[B] (counts 100mL^{-1})	SS[B] (mg L^{-1}) 17.7
Intake 1	**2.0**	2.0	2.3	**0.51**	0.016	690	21.0
Intake 2	**3.2**	3.3	2.8	**0.47**	0.015	76	19.7
Intake 3	**3.0**	3.4	2.8	**0.48**	0.015	24	20.7
Intake 4	**3.3**	3.3	2.2	**0.48**	0.015	1,900	21.3
Intake 5	**3.5**	3.5	2.3	**0.48**	0.015	3,100	18.4
Intake 6	4.1	4.1	2.3	**0.51**	0.017	13,000	32.1
Intake 7	**3.6**	3.6	2.8	**0.52**	0.018	180	15.1
Intake 8	4.3	4.3	2.3	**0.58**	**0.022**	8,500	22.3
Intake 9	4.1	4.3	1.7	**0.43**	0.013	110	12.1
Intake 10	4.4	4.4	1.5	**0.46**	0.014	2,000	10.7
Intake 11	4.4	4.4	1.6	0.38	0.011	740	18.8
Mon 1	**3.2**	3.3	2.5	**0.47**	0.015	530	19.6
Mon 2	**3.6**	3.6	2.3	**0.47**	0.015	610	16.1
Mon 3	**3.9**	3.9	2.0	**0.46**	0.014	1,600	14.7
Mon 4	4.2	4.2	1.8	**0.45**	0.014	4,100	13.4
Mon 5	4.3	4.3	1.4	0.40	0.012	1,100	12.6
Mon 6	4.3	4.5	1.1	0.33	0.009	330	11.3

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6p ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 5, Dry Season***

Station[a]	**Parameter**						
	DO[b] **($mg\ L^{-1}$)**	**DO Bed**[c] **($mg\ L^{-1}$)**	**BOD_5**[d] **($mg\ L^{-1}$)**	**TIN**[d] **($mg\ L^{-1}$)**	**NH_3-N**[d] **($mg\ L^{-1}$)**	***E.coli***[e] **(counts $100mL^{-1}$)**	**SS**[f] **($mg\ L^{-1}$) 17.7**
Intake 1	4.0	4.0	1.6	**0.65**	0.013	2,100	12.9
Intake 2	4.1	4.1	2.1	**0.58**	0.012	4,600	15.6
Intake 3	4.1	4.1	2.1	**0.58**	0.012	4,600	15.6
Intake 4	4.2	4.2	1.4	**0.57**	0.011	4,500	12.5
Intake 5	4.3	4.3	1.4	**0.57**	0.011	5,500	12.1
Intake 6	4.4	4.4	1.3	**0.53**	0.011	9,300	11.2
Intake 7	4.4	4.4	1.8	**0.60**	0.013	12,000	10.1
Intake 8	4.6	4.7	1.1	**0.50**	0.010	1,000	10.5
Intake 9	5.1	5.1	0.9	**0.43**	0.008	4,100	8.3
Intake 10	5.3	5.3	0.6	0.36	0.007	480	6.9
Intake 11	5.7	5.7	0.7	0.31	0.006	6,100	7.1
Mon 1	4.2	4.2	1.7	**0.57**	0.011	4,200	14.2
Mon 2	4.3	4.3	1.4	**0.53**	0.011	3,400	12.6
Mon 3	4.6	4.6	1.1	**0.48**	0.009	2,700	10.9
Mon 4	4.8	4.8	0.9	**0.43**	0.008	3,600	9.4
Mon 5	5.1	5.2	0.8	0.38	0.007	1,700	8.2
Mon 6	5.4	5.5	0.6	0.29	0.005	410	8.1

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

The results from this test are very different from those of the other tests. This is because the short interim outfall from Stonecutters Island STW was assumed to be discharging into the Western Harbour and that there were sewage outfalls discharging preliminary treated effluent from the northern shore of the Hong Kong Island. This results in the overall pollution load into Victoria Harbour being significantly greater than that assumed in the other model scenarios.

Table 4.6m shows breaches of the dissolved oxygen WQO at the western stations in the wet season. These locations are, however, outside of the zone of influence of the effluent discharges from the Sha Tin STW. It may be concluded that the breaches of the WQO for dissolved oxygen are as a direct result of the SSDS Stage I Interim Outfall discharge from the Stonecutters Island STW. This conclusion is supported by the increase in biochemical oxygen demand at these stations. The WQO for total inorganic nitrogen is also breached at the western stations and the WQO for ammonia is exceeded at Intake 8 for the wet season but would be satisfied once the yearly average is considered. The exceedence for ammonia, however, is only 0.001 mg L^{-1} and the majority of the ammonia at this location is from the background loads. This is shown by a comparison of the results of Sensitivity Tests 1 and 2.

The contour plots for the dry season simulation are shown in *Figures 31* to *36* in *Annex G* and in *Figures 56* to *66* in *Annex F* for the wet season. The contour plots for the dry season show lower dissolved oxygen concentrations throughout Victoria Harbour than are predicted in the other tests. There are predicted breaches of the WQO for dissolved oxygen in the Western Harbour and the container terminals at Kwai Chung. These breaches may be directly attributable to the discharge from the SSDS Stage I Interim Outfall, rather than the Sha Tin STW. In the wet season, breaches of the dissolved oxygen WQO are shown at the southern entrance to the Rambler Channel, in the Western Harbour and along the face of the West Kowloon Reclamation. Again these breaches may be attributed to the SSDS Stage I Interim Outfall. As might be expected from the dissolved oxygen results, the biochemical oxygen demand plots show higher values than previously predicted, particularly in the Western Harbour in the vicinity of the SSDS Stage I Interim Outfall.

In both the wet and dry seasons there are exceedences of the WQO for ammonia in the vicinity of the Kai Tak Nullah discharge. However, these exceedences are localised and do not extend into the main flow channel. In the wet season, total inorganic nitrogen is shown to exceed the WQO for much of Victoria Harbour, while in the dry season the exceedences are confined to the area around the West Kowloon Reclamation. Once the yearly average is considered, the areas of exceedence will be principally limited to the West Kowloon Reclamation and the vicinity of the Kai Tak Nullah discharge. The total inorganic nitrogen concentrations in the vicinity of the Kai Tak Nullah discharge are over 0.5 mg L^{-1}, higher than any of the previous scenarios, which may be explained by the increased background concentrations. Furthermore, the Sha Tin STW does not contribute the majority of the nitrogen loads. Any reductions in the Sha Tin STW load would not cause a significant reduction in the total inorganic nitrogen concentrations, as demonstrated by comparing the results of Tests 2, 3, and 4.

In both the wet and dry seasons, the highest suspended sediment concentrations are found in the vicinity of the SSDS Stage I Interim Outfall. Elevated *E.coli* concentrations are also found in this area. Despite the increased nutrient concentrations, particularly in the wet season, there is not predicted to be significantly increased algal growth, as shown on the chlorophyll-a contour plots, compared with the previous tests.

To the east of Lei Yue Mun the water quality is shown to be much better than that in the harbour. At the Tung Lung Chau FCZ there are no predicted exceedences of the WQOs.

In summary, Sensitivity Test 5 has shown a number of breaches of the WQOs, for dissolved oxygen, ammonia and total inorganic nitrogen, which may largely be attributed to the increased background concentrations, which include the SSDS Stage I Interim Outfall and sewage outfalls on Hong Kong Island which discharge preliminary treated effluent. The only exceedences of the WQOs which may be partly attributed to the Kai Tak Nullah discharge, are those for ammonia and total inorganic nitrogen. An area along the waterfront of the South East Kowloon Reclamation is predicted to experience concentrations in excess of the ammonia and total inorganic nitrogen WQOs. However, reductions in the Sha Tin STW nitrogen loads would not cause the ammonia and total inorganic concentrations to be reduced below the WQO as the majority of the impacts are likely caused by the storm drains which discharge into the Kai Tak Nullah.

Sensitivity Test 6 Results: In Sensitivity Test 6 the higher discharge rate of Sensitivity Tests 3, 4 and 5 was combined with increased ammonia and total nitrogen loads. The highest *E.coli* concentration was also simulated in this test. Background pollutant concentrations were representative of the operation of the SSDS Stages I, II, III, and IV in 2011. Summaries of the water quality modelling results are presented in *Tables 4.6q* and *4.6r* for the wet and dry seasons respectively.

Table 4.6q ***Water Quality Model Results at Sensitive Receivers - Sensitivity Test 6, Wet Season***

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts $100mL^{-1}$)	SS[f] (mg L^{-1})
Intake 1	**3.5**	3.5	1.3	0.35	0.008	360	17.7
Intake 2	4.8	4.8	1.2	0.33	0.007	29	16.7
Intake 3	4.8	4.8	1.2	0.33	0.008	16	17.9
Intake 4	4.5	4.5	1.3	0.36	0.009	1,100	18.4
Intake 5	4.7	4.7	1.3	0.36	0.009	1,800	15.9
Intake 6	4.8	4.8	1.4	0.39	0.011	8,100	28.9
Intake 7	4.5	4.5	1.5	0.37	0.010	100	13.4
Intake 8	4.8	4.8	1.6	**0.50**	0.018	6,300	20.8
Intake 9	4.6	4.7	1.1	0.34	0.009	110	10.8
Intake 10	4.7	4.7	1.1	0.37	0.010	1,600	9.6
Intake 11	4.6	4.6	1.1	0.32	0.008	510	17.9
Mon 1	4.7	4.7	1.2	0.34	0.008	270	16.5
Mon 2	4.8	4.8	1.2	0.35	0.008	380	13.8
Mon 3	4.8	4.8	1.2	0.36	0.009	920	12.8
Mon 4	4.7	4.7	1.2	0.37	0.010	3,600	11.9
Mon 5	4.7	4.7	1.0	0.34	0.009	940	11.3
Mon 6	4.7	4.7	0.9	0.29	0.007	290	10.3

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

Table 4.6r *Water Quality Model Results at Sensitive Receivers - Sensitivity Test 6, Dry Season*

Station[a]	Parameter						
	DO[b] (mg L^{-1})	DO Bed[c] (mg L^{-1})	BOD_5[d] (mg L^{-1})	TIN[d] (mg L^{-1})	NH_3-N[d] (mg L^{-1})	*E.coli*[e] (counts 100mL^{-1})	SS[f] (mg L^{-1})
Intake 1	6.2	6.2	0.6	0.40	0.007	1,200	10.2
Intake 2	6.2	6.2	0.6	0.36	0.006	1,700	12.1
Intake 3	6.2	6.2	0.6	0.36	0.006	1,700	12.1
Intake 4	6.2	6.2	0.6	0.38	0.007	3,000	9.9
Intake 5	6.2	6.2	0.7	0.38	0.007	3,900	9.7
Intake 6	6.2	6.2	0.7	0.38	0.007	6,700	9.0
Intake 7	6.0	6.0	0.9	0.39	0.007	6,400	7.9
Intake 8	6.2	6.2	0.7	0.38	0.008	830	9.0
Intake 9	6.2	6.2	0.6	0.32	0.006	2,500	6.9
Intake 10	6.1	6.1	0.5	0.28	0.005	420	6.2
Intake 11	6.4	6.4	0.6	0.25	0.004	4,100	6.7
Mon 1	6.2	6.2	0.6	0.37	0.006	1,900	11.2
Mon 2	6.2	6.2	0.6	0.36	0.006	1,900	10.0
Mon 3	6.2	6.2	0.6	0.34	0.006	1,800	8.8
Mon 4	6.2	6.2	0.6	0.33	0.006	3,200	7.7
Mon 5	6.2	6.2	0.5	0.29	0.005	1,500	7.1
Mon 6	6.3	6.3	0.5	0.23	0.004	350	7.8

Notes:
(a) Refer to *Figure 4.4a* for locations.
(b) Minimum depth averaged concentration.
(c) Minimum bed layer concentration.
(d) Mean depth averaged concentration.
(e) Depth averaged geometric mean concentration.
(f) Maximum depth averaged concentration.
(g) Non-compliance with WQOs is shown in bold.

The above tables show that the only exceedences of the WQOs occur at Intake 1 for depth averaged dissolved oxygen and total inorganic nitrogen at Intake 8 in the wet season. At Intake 8 the total inorganic nitrogen would not be within the WQO once the yearly average is considered and so a breach of the WQO is predicted to occur. However, even though the total inorganic nitrogen load is the highest in this test it is still with the WSD criterion of 1 mg L^{-1} for ammoniacal nitrogen which is only one of the constituents of total inorganic nitrogen, the others being nitrite and nitrate. At the other stations only small changes in dissolved oxygen are shown. The highest ammonia concentration is predicted at Intake 8 but the predicted value is less than the WQO and so would be deemed acceptable. There is no change to the *E.coli* concentrations compared with Sensitivity Test 1, which demonstrates the small contribution made by the Sha Tin STW to the total *E.coli* concentrations from the Sha Tin STW, even at the highest load used in this test.

The contour plots for the dry season simulation are shown in *Figures 37* to *42* in *Annex G* and in *Figures 67* to *77* in *Annex F* for the wet season. The dry season contour plots show no discernable differences from those shown in Sensitivity Test 2, with the exception of total inorganic nitrogen and ammonia. Concentrations of total inorganic nitrogen are shown to increase in the area to the east of the discharge point, and with an area of greater increases in the immediate vicinity of the discharge. Similar changes are shown for the predicted ammonia concentrations. In the wet season the area of non-compliance with the WQO for total inorganic nitrogen is shown to increase compared with Sensitivity Test 4 and this area now includes one of the sensitive receivers, Intake 8. However, when the yearly average concentrations of ammonia and total inorganic nitrogen are considered the areas of exceedences are reduced to be confined to the vicinity of the Kai Tak Nullah discharge. These areas may be considered mixing zones. A reduction in the Sha Tin STW total nitrogen load would not cause the areas of WQO exceedences to be reduced significantly, as discussed previously. The increases in nutrient concentrations are not predicted to cause any increased algal growth, as shown by the contour plots for chlorophyll-a. It should be noted that there is no effect from the Sha Tin STW on water quality conditions at the Tung Lung Chau FCZ. This is demonstrated by comparing the results of Sensitivity Tests 6 and 1.

In summary, the results from Sensitivity Test 6 show that there will be areas of exceedence of the WQOs for ammonia and total nitrogen in the vicinity of the Kai Tak Nullah discharge. There is predicted to be an exceedence of the WQO at Intake 8 but the water quality at this location is predicted to be within the WSD criteria for sea water intakes. The areas of exceedence of the WQO would be termed a "mixing zone" and thus the results from this scenario are deemed to be environmentally acceptable.

Qualitative Assessment of 2006: The background water quality in Victoria Harbour in 2006 will be very similar to that which was predicted in Sensitivity Test 5 because this year assumes the operation of the SSDS Stage I Interim Outfall which has demonstrably been the major influencing factor. The background water quality would be slightly better due to the lower overall loads. The discharge from the Sha Tin STW would also be lower because the population in the catchment area would not be as high as that in 2011.

Overall, it would still be expected that there would be breaches of the WQOs in the western part of Victoria Harbour due to the SSDS Stage I Interim Outfall discharges, as was the case for Sensitivity Test 5, but that the magnitude and number of breaches would be reduced. In the vicinity of the Kai Tak Nullah discharge there would still be an area in which the cumulative effects of the discharges from the SSDS Stage I Interim Outfall and Kai Tak Nullah would cause localised breaches of the WQOs. This would also be likely because of the sheltering effect of the disused Kai Tak runway on the flood tide, causing a portion of the discharge to be retained. It is therefore possible that there will be areas in the vicinity of the Kai Tak Nullah which will experience poor water quality. However, as the construction of the South East Kowloon Reclamation proceeds, the area of poor water quality will diminish as the area sheltered by the disused Kai Tak runway will be reduced.

In summary, it is concluded that there would be localised breaches of the WQOs in the vicinity of the Kai Tak Nullah discharges in 2006 but that these areas of exceedence would probably be smaller than those predicted in Sensitivity Test 5. This would be because of the lower flows and loads included in the background and from the Kai Tak Nullah, particularly the Sha Tin STW Stage III Extension. However, there are likely to be instances of degraded water quality during some phases of the South East Kowloon Reclamation construction.

Tolo Harbour

The water quality data for Stations TM2 and TM4 have been plotted on a series of graphs, which are presented in *Annex J*, each of the water quality parameters shown on a separate graph. Data for the surface, middle and bed layers have been plotted on separate graphs. On each of the graphs the percentage of the total flows from the Sha Tin and Tai Po STWs which is pumped to Kai Tak Nullah via the THEES is included as the percentage operation of the THEES. Zero percentage operation shows that the THEES was shut down and hence that all of the treated effluent was discharged directly to the Tolo Harbour.

The water quality data show that there is no marked decrease in DO for either Stations TM2 (*Figures 2* and *7* in *Annex J*) or TM4 (*Figures 12, 17* and *22* in *Annex J*) during periods of closure of the THEES, which demonstrates that there is no correlation between DO levels and the discharges from the Sha Tin STW. This conclusion is supported by the fact that there is no marked increase in BOD for either Stations TM2 (*Figures 1* and *6* in *Annex J*) or TM4 (*Figures 11, 16* and *21* in *Annex J*)

For both TIN and NH_4-N at Stations TM2 (*Figures 3, 4, 8* and *9* in *Annex J*) and TM4 (*Figures 13, 14, 18, 19, 23* and *24* in *Annex J*) there are marked increases in concentrations during the second and third periods of closure of the THEES, between 9 February 1998 and 20 March 1998 and 1 December 1998 to 29 December 1998. This shows that the discharge from the Sha Tin STW may be responsible for the increase of TIN and NH_4-N concentrations, although closure of the THEES in August 1997 did not induce the same response. This may have been caused by greater quantities of nitrogen compounds being discharged during these two periods compared with the other closure period. At Station TM4 there is a period of marked algal growth immediately following the end of the second shutdown period, which would suggest that the increase in nutrients has triggered an algal bloom. There are, however, no discernible effects on algal growth at Station TM2 (*Figures 5* and *10* in *Annex J*), which indicates that the rapid increase in nutrient concentrations has not triggered an algal bloom at this location. This may be attributed to a number of factors, but the discharge from the Sha Tin STW could still be the main factor in the observed algal bloom at Station TM4 (*Figures 15, 20* and *25* in *Annex J*).

It should be noted that since the first half of 1997, when the THEES was only operating at an average of 50%, there has been a gradual improvement in water quality in Tolo Harbour. Nutrient concentrations have been decreasing and the concentrations of chlorophyll-a also decreasing. The high dissolved oxygen concentration in the first half of 1997 is likely to be a result of algal growth causing super-saturation and the reductions in dissolved oxygen in 1998 reflect the decreased algal concentrations.

The purpose of the analysis of the THEES closure events and water quality in Tolo Harbour has been to determine whether there is the potential for water quality impacts to Tolo Harbour from such events during the future operation of the Sha Tin STW, following the commissioning of the Stage III Extension. It will therefore be necessary to consider the future loadings from the Sha Tin STW compared with the present loadings.

The data on the effluent loadings for BOD and Total Nitrogen (TN) during the three closure events and the predicted future loadings during closure events are presented in *Table 4.6s*. In the future the closure of the THEES will be limited to either two 10 day periods or one 14 day period each year, both of these possibilities have been considered and the data are presented in the table.

Table 4.6s *Loading from the Sha Tin STW to Tolo Harbour During Periods of Closure of the THEES*

Closure Period	Total Flow (m^3)	BOD Load (kg)	TN Load (kg)
4-8-97 to 12-9-97	8,136,024	33,358	60,207
9-2-98 to 20-3-98	6,545,177	70,688	244,135
1-12-98 to 31-12-98	5,636,716	29,874	150,500
10 days future closure	3,500,000	70,000	105,000
14 days future closure	4,900,000	98,000	147,000

The assessment of TN loads has been based on average observed concentrations of TN in the treated effluent during the periods of closure of the THEES for the existing discharges and 30 mg L^{-1} for the future (post operation of the Stage III Extension) conditions during periods of closure of the THEES. The analysis shows that, provided the period of the discharge is limited to a maximum of 14 days, the TN load will be well below that of the existing situation. The existing load has been shown to be within the assimilative capacity of Tolo Harbour, except for the one occasion when increased algal growth was detected at one of the monitoring stations.

The analysis of BOD loads was based on average concentrations of BOD in the treated effluent during the periods of closure of the THEES for the existing discharges and 20 mg L^{-1} for the future conditions. The analysis has shown that for a period of discharge of less than 10 days, the total quantity of BOD discharged will be less than that which occurred during the second closure period and which has been found not to cause impacts on dissolved oxygen concentrations. The total BOD likely to be discharged during a 14 day closure period will be higher than any of the closure periods which have occurred previously. If the concentration of BOD is limited to 14 mg L^{-1} then a closure period of 14 days would reduce the concentrations to below that which occurred during the second closure period. However, it should be noted that the calculation of the total loads for the future conditions was based on the maximum flow rate and the predicted acceptable effluent quality concentration from the Sensitivity Tests. In practice the Sha Tin STW is likely to be producing better quality effluent than these assumed concentrations for BOD and TN.

Another way of specifying the acceptable BOD load during closure of the THEES could be in terms of total mass discharged during the closure period. It could be specified that the total load should be less than approximately 71,000 kg, which corresponds to the load during the second closure period. The same approach may also be applied to the TN load. For TN the maximum mass discharged during closure of the THEES should be limited to 150,500 kg, which corresponds to the third closure period. This load is chosen, rather than the higher load during the second closure period, because this was the highest load at which no observed increase in algal growth was observed. In order to determine compliance with this alternative concept of total acceptable load it will be necessary to monitor flow rate, BOD concentration and TN concentration of the treated effluent during closure of the THEES.

Another factor to consider is the timing of the discharges which may be critical in terms of the potential for algal growth. The peak periods for algal growth and the formation of harmful blooms within Tolo Harbour have been found to be March to June and September to November[27]. This may explain the rapid algal growth following the second assessed period of discharge, from 9 February 1998 to 20 March 1998, which fell within one of the critical periods. In future the regular periods of closure of the THEES for maintenance purposes should be strictly regulated to be outside of the periods with a high potential for algal growth.

The existing Sha Tin STW has been found to be extremely reliable with no emergency discharges to Tolo Harbour due to equipment breakdown within the STW being recorded. It would be likely that the Stage III Extension would be at least as reliable as the existing STW, as it will be based on more up to date technology. It is therefore assessed that the possibility of any discharges to Tolo Harbour due to failure of the Sha Tin STW Stage III Extension will be remote.

Another mechanism whereby treated effluent is discharged to Tolo Harbour is during flushing of the existing submarine outfall from the Sha Tin STW, which had been used for discharge of treated effluent to Tolo Harbour prior to the operation of the THEES and continues to be used during periods of closure of the THEES. The outfall is flushed with treated effluent from the STW on a monthly basic to prevent siltation blocking any part of the outfall. No detailed information on the duration of such discharges is available but it has been indicated that the duration is typically several hours. Given the short duration of these discharges it is thought unlikely that there would be any adverse effects on water quality in Tolo Harbour.

Kai Tak Nullah

The THEES currently discharges into the upper reaches of the Kai Tak Nullah, which then discharges to the Kwun Tong Typhoon Shelter. There are a number storm drains with expedient connections which discharge into the nullah. Based on EPD routine water quality monitoring data[28], the water quality in the upper reaches of the Nullah is generally fairly good, with high dissolved oxygen concentrations, low BOD concentrations and low nutrient levels. However, geometric *E.coli* concentrations exceed 80,000 counts $100mL^{-1}$. In the lower reaches of the Nullah water quality gradually deteriorates, with decreasing dissolved oxygen concentration and increasing nutrient, BOD and *E.coli* levels. This is likely to be due to the discharges from stormwater drains and the influence of the very poor water quality in the Kwun Tong Typhoon Shelter. In 1997, a decrease in water quality in the upper reaches of the Kai Tak Nullah was observed, with decreased dissolved oxygen and increased nutrient and *E.coli* concentrations. The 1997 EPD river water quality report states that the increase was thought to have been due to increased flows from the THEES.

As part of the future developments for the South East Kowloon Reclamation the Kai Tak Nullah will be diverted to the western side of the old Kai Tak Airport runway and will flow through the middle of the reclamation. The Nullah will

(27) Balfours International (Asia) 1988. *Sha Tin to Kai Tak Effluent Export Scheme*. Final Report. Volume 2.
(28) EPD 1998. *River Water Quality in Hong Kong in 1997*.

become a water feature of a proposed urban park in the centre of the South East Kowloon Reclamation. It will therefore be necessary to protect the water quality in the Kai Tak Nullah so that its amenity value may be maintained. The key parameters in terms of the amenity value of the Nullah will be odour and *E.coli* concentrations.

The current monitoring data show that high levels of *E.coli* care found in the upper reaches of the Kai Tak Nullah, in the vicinity of the THEES discharge. Further downstream *E.coli* concentrations increase due to other discharges into the Nullah. In the future it is likely that many of these polluting discharges will have been removed but the exact level of removal is uncertain. If the current levels of *E.coli* from the THEES are maintained with no other polluting loads to the Kai Tak Nullah then the concentrations of *E.coli* would probably be unacceptable for an open stream through a public park. While there is no applicable Water Quality Objective for *E.coli* concentrations in the Kai Tak Nullah, it is recommended as a precautionary measure that disinfection be installed at the Sha Tin STW so that the *E.coli* concentrations are reduced as far as practicable.

Odour problems are usually caused by the formation of sulphide compounds in low dissolved oxygen environments. At present the upper reaches of the Kai Tak Nullah do not suffer from odour problems. For the lower reaches in the vicinity of the Kwun Tong Typhoon Shelter odour has been reported to be a particular problem. The controlling factors are likely to be the BOD to the Nullah and the rates at which it flushes. The future BOD loads are likely to reduced from those which occur at present due to the removal of other polluting discharges. However, a precautionary measure would be to limit the concentrations of BOD compounds in the THEES discharge to ensure a good protection against odour problems.

4.6.4 *Mitigation of Adverse Environmental Impacts*

Victoria Harbour

During operation of the Sha Tin STW, the water quality evaluation has predicted that there would be breaches of the WQO for total inorganic nitrogen and ammonia as a result of the discharges of treated sewage effluent in the vicinity of the Kai Tak Nullah discharge point. These impacts were found to be of limited extent and to not include any sensitive receivers, except for Sensitivity Test 6. However, for Test 6 the breach of the WQO was at a WSD sea water intake and the specific standards for the intake were not predicted to be breached. The exceedences of the WQOs predicted for Sensitivity Tests 2, 3, 4 and 6 were found to environmentally acceptable because the area of exceedence was very limited in content and could be defined as the "mixing zone". This meant that the highest acceptable total nitrogen and ammonia loads would be those found in Sensitivity Test 6 and were equivalent to effluent concentrations of 10 mg L^{-1} and 30 mg L^{-1} respectively. These predictions were based on the assumption that the SSDS Stages I, II, III and IV, including the long sea outfall, are in operation. No further mitigation measures are necessary for this case. It should be noted that reductions in the nitrogen loads from the Sha Tin STW would not significantly reduce the predicted ammonia and total inorganic nitrogen concentrations because of the large contribution from storm drains discharging into the Kai Tak Nullah. Mitigation of these contributions would be the responsibility of other projects.

An assessment was also made of the operation of the Sha Tin STW at the same time as the SSDS Stage I Interim Outfall. The modelling results for this scenario showed that the majority of the breaches of the WQOs would be as a result of the SSDS Stage I Interim Outfall, with only the area in the vicinity of the Kai Tak Nullah discharge being subject to predicted exceedences of the total inorganic nitrogen and ammonia WQOs resulting from the pollution load from the Kai Tak Nullah. However, the impacts would be defined as a mixing zone and would be deemed environmentally acceptable. No further mitigation measures are required.

A qualitative assessment of the discharges in 2006 was made, which assumed that the SSDS Stage I Interim Outfall was in operation and that the South East Kowloon Reclamation was only 50% complete. It was predicted that adverse water quality conditions in the vicinity of the discharge would be likely due to the sheltering effect of the disused Kai Tak runway. However, these adverse water quality conditions would not persist as the ongoing construction of the South East Kowloon Reclamation would mean that the discharge point for the Kai Tak Nullah would be gradually pushed further offshore. No mitigation is suggested due to the limited duration of for the occurrence of adverse water quality conditions.

Tolo Harbour

The analysis of likely future conditions has shown that provided the periods of closure are limited to less than 14 days and the mean concentration of Total Nitrogen is less than 30 mg L^{-1} then the total load to Tolo Harbour will be less than that which has been discharged during previous closure events. If the BOD concentration is 20 mg L^{-1} then the maximum period should be 10 days and if the time of closure were to be 14 days then the BOD concentrations should be limited 14 mg L^{-1}. Alternatively, the allowable TN and BOD loads may be specified in terms of total mass discharged during closure periods. This was found to be 150,500 kg for TN and 71,000 kg for BOD. If this alternative specification is adopted then the effluent flow rate and concentrations of TN and BOD should be monitored during closure periods to ensure that the total masses of TN and BOD discharged are below the limits specified above. In the case of BOD this will be sufficient to prevent decreases in dissolved oxygen concentrations, as the analysis of previous closure events have shown no correlation between BOD discharges and dissolved oxygen concentrations for the quantities of previously discharged BOD. However, in the case of Total Nitrogen this may not necessarily be sufficient to prevent the stimulation of excessive algal growth. It will also be necessary to prevent discharges to Tolo Harbour during the periods March to June and September to November which are considered most sensitive to higher nutrient loadings.

It is suggested that the periods of closure of the THEES for routine maintenance of the THEES, and desilting of the Kai Tak Nullah should be limited to not more than 14 days in order to ensure the load being discharged to Tolo Harbour be kept to a minimum. During periods of closure of the THEES, the existing outfall will also be flushed as the treated effluent will be discharged through the outfall. The existing outfall is flushed on a monthly basis with treated effluent. The period of flushing is limited to a few hours and it was assessed that there would be no adverse impacts on water quality due to the short duration of these discharges. No mitigation measures will therefore be necessary.

Although it is considered a remote possibility that equipment failure will lead to the discharge of treated effluent to Tolo Harbour some measures should be considered in such an event. It should be noted that a backup pump has been provided for the THEES which reduces further the likelihood of total failure of the pumping system If equipment failure occurs, every effort should be made to facilitate repairs to limit the period of closure to as short a duration as possible.

Kai Tak Nullah

In order to reduce the potential for odour problems within the Kai Tak Nullah. It is recommended, as a precautionary measure, that the BOD concentrations from the Sha Tin STW be reduced as far as practicable. Further mitigation measures in terms of the reduction of untreated effluent inflows to the Kai Tak Nullah from storm drains with expedient connections will be dealt with under the South East Kowloon Reclamation project. It is recommended as a precautionary measure that disinfection be installed at the Sha Tin STW so that the *E.coli* concentrations are reduced as far as practicable.

4.7 DEFINITION AND EVALUATION OF RESIDUAL ENVIRONMENTAL IMPACTS

4.7.1 *Construction Phase*

No residual environmental impacts were predicted to occur during the construction phase, provided that the standard site construction practices, as described in *Section 4.6.4*, are followed.

4.7.2 *Operation Phase*

Victoria Harbour

Assuming that SSDS Stages I, II, III and IV were in operation, the only residual impacts to water quality in Victoria Harbour due to the discharge of treated effluent from the Sha Tin STW were predicted for total inorganic nitrogen and ammonia. There was predicted to be a mixing zone for these parameters in the vicinity of the discharge point from the Kai Tak Nullah. However, provided the total inorganic nitrogen load is below 30 mg L^{-1} and the ammonia concentration below 10 mg L^{-1}, then the mixing zone will be relatively small and would not cause unacceptable impacts to any sensitive receivers. The predicted impacts would thus be environmentally acceptable. All other Water Quality Objectives were predicted to be achieved. When the discharge from the THEES was combined with the SSDS Stage I Interim Outfall it was predicted that breaches of the WQOs would occur. The majority of these breaches were found to be as a result of the discharges from the SSDS Stage I Interim Outfall, effluent discharges from Hong Kong Island and the storm drain loadings to the Kai Tak Nullah. In the vicinity of the Kai Tak Nullah discharge point exceedences of the WQOs for total inorganic nitrogen and ammonia were predicted. However, further mitigation of the Sha Tin STW effluent loads would not significantly reduce the size of the mixing zone due to the influence of the SSDS Stage I Interim Outfall, effluent discharges from Hong Kong Island and the storm drain loadings to the Kai Tak Nullah.

During the intermediate phase of construction of the South East Kowloon Reclamation in 2006 it was found that there could be the potential for adverse water quality conditions in the vicinity of the Kai Tak Nullah discharge. The residual impacts are likely to be localised to the vicinity of the reclamation and only last for the duration of the construction of the South East Kowloon Reclamation and so are not considered unacceptable.

Tolo Harbour

An assessment of the potential impacts to Tolo Harbour during the closure of the THEES has found that, provided certain mitigation measures are employed, the impacts to water quality are unlikely to be unacceptable. No unacceptable residual impacts associated with discharges to Tolo Harbour during closure of the THEES are anticipated.

Kai Tak Nullah

An assessment of the potential impacts to the Kai Tak Nullah from the increased flows to the Nullah from the THEES due to the Sha Tin STW Stage III Extension has been carried out. The assessment found that provided that both BOD and *E.coli* concentrations are reduced as far as practicable, then the amenity value of the Nullah is likely to be protected. This means that there are unlikely to be any residual impacts.

4.8 ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENT

4.8.1 Construction Phase

No monitoring of water quality would be required during the construction phase. It is recommended that audit be carried out to confirm that compliance with the "best practice" site procedures, as defined in *Section 4.6.4*, are being undertaken. Full details of the audit requirements will be presented in the *EM&A Manual.*

4.8.2 Operation Phase

Victoria Harbour

Routine monitoring of effluent quality from the Sha Tin STW will be continued to satisfy EPD's licensing conditions. This requirement will be no different from that which is currently carried out by DSD for the existing STW, except that additional parameters would be monitored. Monitoring would cover the following parameters: Biochemical Oxygen Demand, Suspended Solids, Ammoniacal Nitrogen, Total Nitrogen and *E.coli.*

The treated sewage from the existing and the Stage III Extension of the Sha Tin STW will continue to be discharged via the THEES and therefore shall be subject to a comprehensive performance verification programme to confirm the predictions made in this report. The performance verification programme will comprise one year baseline monitoring in both wet and dry seasons before commissioning and one year operational monitoring in both dry and wet seasons following commissioning of Stage III Extension of the Sha Tin STW. The need of the baseline monitoring would depend on the prevailing environmental conditions at the time before commissioning of Stage III Extension. This programme will follow similar requirements of Agreement No. CE 1/98 with elements such as monitoring of effluent quality, effluent dispersion plume, marine water quality, etc as bounded by the EIA report. Details of the programme will be subject to EPD's endorsement.

Tolo Harbour

The prescription of monitoring arrangements to assess water quality within Tolo Harbour during discharges from the THEES is beyond the scope of this study. DSD is planning to cover this issue as part of a forthcoming review of the THEES. As stated elsewhere, these issues arise from the existing infrastructure and will not be exacerbated by the Project.

4.9 *CONCLUSIONS AND RECOMMENDATIONS*

The impacts to water quality from the construction and operation of the Sha Tin STW Stage III Extension have been considered in this EIA Study. The key findings and recommendations are summarised in this section.

4.9.1 *Construction Phase*

The impacts to water quality in the Shing Mun River and Tolo Harbour during the construction phase were assessed in a qualitative manner. It was determined that the majority of potential impacts to water quality would occur as a result of polluted site run-off and the uncontrolled discharge of waste to storm drains. A series of "best practice" site working procedures was specified to prevent any adverse impacts to water quality.

No monitoring of water quality during construction was recommended, although an auditing programme is proposed to ensure that 'best practice' site working procedures are implemented.

4.9.2 *Operation Phase*

The assessment of the impacts to water quality during the operation of the Sha Tin STW Stage III Extension was divided into three components, impacts to Victoria Harbour, Tolo Harbour and Kai Tak Nullah.

Victoria Harbour

The treated effluent from the Sha Tin and Tai Po STWs is currently collected by the THEES and discharged into Kai Tak Nullah which drains into the Kwun Tong Typhoon Shelter and ultimately into the Victoria Harbour. The treated effluent from the Sha Tin Stage III Extension will also be collected by the THEES. Following the completion of the Sha Tin STW Stage III Extension, the Kai Tak Nullah will be diverted as part of the South East Kowloon Reclamation project. This will result in the Nullah discharging directly into Victoria Harbour, to the west of the Kai Tak runway.

Computer modelling of water quality was carried out to simulate various background conditions in Victoria Harbour and alternative flows and loads. A number of tests were carried out and these are summarised below.

- Existing conditions, which consisted of the current Kai Tak Nullah discharge, including the existing Sha Tin STW effluent, to the Kwun Tong Typhoon Shelter and all other polluting discharges to Victoria Harbour.

- Future conditions (no load), which simulated the Kai Tak Nullah discharge minus the Sha Tin STW but with all other polluting discharges to Victoria Harbour in place. The ultimate design year of 2011 for the Stage III Extension was simulated which meant that the completed South East Kowloon Reclamation was included and the SSDS Stages I, II, III and IV were assumed to be in operation.

- Future conditions, which simulated the Kai Tak Nullah discharge including the Sha Tin STW load. The ultimate design year of 2011 was also used for this scenario, so the reclamations and background loads were the same as the 'Future conditions (no load)' test. A range of flows and pollutant loads for the Sha Tin STW Stage III were used for this scenario to determine the sensitivity of water quality in Victoria Harbour to changes in the Sha Tin STW load. The range of flows and loads from the Sha Tin STW represented maximum possible design flows and varying concentrations of pollutants which tested possible effluent qualities for the Sha Tin STW.

- Future conditions (SSDS Stage I), which simulated the 2011 discharge from the Kai Tak Nullah and the same reclamations as the other 'Future conditions' tests. The background polluting loads represented the operation of the SSDS Stage I Interim Outfall in 2011. This case would be the worst in terms of future polluting loads to Victoria Harbour because the Hong Kong Island preliminary treatment works outfalls would still be in operation and effluent from SSDS Stage I would impact on the western portion of Victoria Harbour.

The results from the existing conditions test showed that water quality within the Kwun Tong Typhoon Shelter was extremely poor. However, once the water exited the typhoon shelter there was good mixing with the waters in Victoria Harbour where the water quality was better. Breaches of the WQOs were predicted. These results are presented in *Figures 1* to *11* in *Annex F* for the wet season and *Figures 1* to *5* in *Annex G* for the dry season.

The results from the future conditions (no load) test, as described above, showed that water quality in the whole of Victoria Harbour was much better than the existing situation which reflected the expected improvement following the implementation of the SSDS Stages I, II, III and IV. The results from the future conditions sensitivity tests were compared with the results from the future conditions (no load) test to determine the impact of the Sha Tin STW flows following the construction of the Stage III Extension.

For all of the tests it was found that there was a breach of the WQOs for dissolved oxygen at the westernmost monitoring station in Victoria Harbour. This breach was not caused by the Sha Tin STW discharge and was attributed to other sources. For all of the sensitivity tests which included the discharge from the Sha Tin STW there were only found to be breaches of the WQOs for total inorganic nitrogen and for some of the tests there were predicted to be breaches of the ammonia WQO. These breaches were predicted to lead to the formation of a 'mixing zone'[29] in the vicinity of the Kai Tak Nullah discharge point. The

(29) A 'mixing zone' is defined in the *Technical Memorandum on Environmental Impact Assessment Process* as being *'a region of a water body where initial dilution of a pollution input takes place and where water quality criteria can be exceeded'*.

extent of the mixing zone was not predicted to include any sensitive receivers, with the exception of Test 6 where a WSD Intake was predicted to experience total inorganic nitrogen concentrations in exceedence of the WQO. However, the concentrations at this location would be within WSD's standards for sea water intakes. In all of the sensitivity tests, there were no predicted impacts to water quality at the Tung Lung Chau FCZ that could be attributed to the discharge from the Sha Tin STW. The modelling work has shown that the maximum design flows in combination with ammonia, total nitrogen and *E.coli* concentrations shown in *Table 4.9a*, which correspond to Sensitivity Test 6 for all parameters, would be acceptable in terms of their water quality impacts. However, in assessing the acceptability of certain water quality parameters (e.g. *E.coli.*), due consideration should also be made to the *Technical Memorandum - Effluent Discharge into Drainage and Sewerage Systems, Inland and Coastal Waters.*

Table 4.9a ***Highest Acceptable Pollution Flows and Loads for Victoria Harbour Based on the Results of the Water Quality Modelling in this Study (when SSDS Stages I, II, III and IV are in Operation)***

Flow (m^3 day^{-1})	**BOD (mg L^{-1})**	**SS (mg L^{-1})**	**NH_3-N (mg L^{-1})**	**Total N (mg L^{-1})**	***E.coli* (counts 100mL^{-1})**
350,000	20.0	30.0	10.0	30.0	100,000

The results from the test which assumed that the SSDS Stage I Interim Outfall discharged into the Western Harbour showed that water quality conditions within Victoria Harbour would not comply with the WQOs. The majority of the deterioration would be due to the background loads into Victoria Harbour and not the THEES discharges. Only in the vicinity of the Kai Tak Nullah outfall, along the face of the South East Kowloon Reclamation, was it predicted that breaches of the WQO for ammonia and total inorganic nitrogen would occur as a result of the cumulative impact of the SSDS Stage I Interim Outfall and the Kai Tak Nullah discharges. However, these breaches would form a mixing zone and could therefore be deemed to be environmentally acceptable. It should be noted that the majority of the nitrogen loads to the Kai Tak Nullah are from the storm drains which discharge into the Nullah. The sensitivity tests showed only small changes in the water quality impacts when the Sha Tin STW loads were varied, which indicates the significant influence of the storm drains on water quality. In the 2011 scenarios it was assumed that 10% of the sewage flows in the Kai Tak Nullah would still enter storm drains. Even if this percentage were to be halved the storm drains would still constitute the greatest proportion of the polluting lead to the Kai Tak Nullah.

A qualitative assessment of likely water quality conditions was carried out for 2006 coinciding with the partial completion of the South East Kowloon reclamation. It was concluded that the water quality conditions during the construction of the South East Kowloon Reclamation would be similar to those for Sensitivity Test 5, except that there would probably be fewer breaches of the WQOs in Victoria Harbour and the size of the mixing zone around the Kai Tak Nullah would be reduced. At some point in the construction phasing for the South East Kowloon Reclamation there would be an area of low tidal flushing formed in the water body to which the Kai Tak Nullah will discharge. Poor water quality would be likely to occur in this area. This area of poor water quality was found to be only present for a period during the construction of the South East Kowloon Reclamation and as the construction progressed would gradually reduce in size. Due to the relatively short duration of these impacts it was determined that water quality impacts would not be unacceptable.

The conclusion from the assessment of the impacts to Victoria Harbour of the discharges from the Sha Tin STW is that the flows and loads shown in *Table 4.9a* would give rise to acceptable impacts and that the discharges from the Sha Tin STW are not the dominant factor effecting water quality in Victoria Harbour.

Routine monitoring of the effluent quality of the Sha Tin STW is recommended to determine compliance with EPD licensing standards. Performance monitoring of the impacts of the Kai Tak Nullah discharges on water quality in Victoria Harbour is recommended at intervals during the operation of the Sha Tin STW Stage III Extension.

Tolo Harbour

During routine maintenance or breakdown of the THEES, treated effluent from both the Sha Tin STW and Tai Po STW would be discharged into the Tolo Harbour. Treated effluent is also discharged to Tolo Harbour during flushing of the existing outfall from the STW. A qualitative assessment of the impacts of such discharges was made based on observed water quality at EPD routine water quality monitoring stations in the vicinity of the discharge point during the periods of such discharges.

The assessment has shown that there was one instance of a distinct increase in nutrients during one of the periods of closure of the THEES and that this appeared to trigger the development of an algal bloom at Station TM4, but not at Station TM2 which is closest to the Sha Tin STW emergency discharge point. On a precautionary basis, it has been assumed that this increase in chlorophyll concentrations was attributable to discharges from the Sha Tin STW. Two other complete closures of the THEES did not produce the same effect; however, this may have been because they did not coincide with the peak periods for algal growth within Tolo Harbour. There was no impact on DO levels during the periods of closure.

The analysis of likely future conditions has shown that provided the periods of closure are limited to less than 14 days and the mean concentration of Total Nitrogen is less than 30 mg L^{-1}, then the total nitrogen loads to Tolo Harbour will be less than those which have been discharged previously. For BOD the closure period should be limited to 10 days if the effluent concentration is 20 mg L^{-1}, but if the effluent concentrations is 14 mg L^{-1} then the closure period could be extended to 14 days. An alternate definition of the acceptable BOD and Total Nitrogen loads is in terms of the total masses discharged during the closure of the THEES. These have been assessed as being 71,000 kg of BOD and 150,500 kg of total nitrogen. Determination of compliance with this alternative would require monitoring of flow rate and effluent quality during the closure period. In the case of BOD this will be sufficient to prevent decreases in dissolved oxygen concentrations, as the analysis of previous closure events have shown no correlation between BOD discharges and dissolved oxygen concentrations. However, in the case of Total Nitrogen this may not necessarily be sufficient to prevent the stimulation of excessive algal growth. It will also be necessary to prevent discharges to Tolo Harbour during the periods March to June and September to November, which are considered most sensitive to higher nutrient loadings. A further mitigation measure was specified and that was to ensure that desilting of the Kai Tak Nullah, routine maintenance of the THEES and flushing of the Sha Tin STW outfall should be programmed to coincide, so that periods of discharge to Tolo Harbour could be minimised.

Kai Tak Nullah

A qualitative assessment of the likely impacts on water quality in the Kai Tak Nullah from the operation the THEES following the implementation of the Sha Tin STW Stage III Extension has been made. The assessment has initially considered the existing water quality within the Kai Tak Nullah and compared the existing effluent load from the Sha Tin STW with that which is predicted to occur following the implementation of the Stage III Extension. The assessment focussed on *E.coli* and dissolved oxygen which would be the parameters of concern in the future operation of the Kai Tak Nullah. This is because it is planned to divert the Nullah through an open space amenity area in the centre of the proposed South East Kowloon Reclamation and the bacteria concentration and potential for odour problems would be of most concern. It should be noted that the Kai Tak Nullah will, in future, continue to be a storm drain and as such there are no applicable WQOs.

The assessment for *E.coli* concluded that if the current levels of *E.coli* from the THEES are maintained then the resulting concentrations in the Kai Tak Nullah would be likely to be unacceptable for an open stream through a public park. It was recommended as a precautionary measure that disinfection be installed at the Sha Tin STW so that *E.coli* concentrations will be reduced as far as practicable. The assessment for BOD concluded that in order to minimise the potential for odour problems that the discharge of BOD from the Sha Tin STW should be minimised as far as would be practicable to ensure that dissolved oxygen levels were maintained above a level at which odours could occur.

4.9.3 *Overall Conclusion*

Based on the assessments of water quality impacts to Victoria Harbour, Tolo Harbour and Kai Tak Nullah the following maximum flows and loads for the Sha Tin STW are predicted to be sufficient to protect the water quality in the three receiving water bodies.

Table 4.9b ***Predicted Acceptable Flows and Loads for the Sha Tin STW following the Implementation of the Stage III Extension in Terms of the Impacts to Water Quality Assessed in this Study***

Flow (m^3 day^{-1})	BOD (mg L^{-1})	SS (mg L^{-1})	NH_3-N (mg L^{-1})	Total N (mg L^{-1})	*E.coli* (counts 100mL^{-1})
350,000[a]	20.0 or 14.0[b]	30.0	10	30[c]	1,000[d]

Notes :

(a) The maximum design flow rate.

(b) During the closure of THEES, if the closure period of the THEES is 10 days then an effluent concentration of 20 mg L^{-1} will be acceptable, but if the closure period is 14 days then a concentration of 14 mg L^{-1} will be acceptable. Alternatively, the total mass during closure of the THEES may be specified, and this should be limited to 71,000 kg of BOD. This is a function of flow rate and BOD concentration.

(c) During the closure of THEES, the acceptable load may also be taken to be representative of the total mass discharged during closure of the THEES, which has been found to be 150,500 kg. This is a function of flow rate and Total N concentration.

(d) Defined on the basis of the use of disinfection.