CHAPTER 7

THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

GENERAL REVENUE ACCOUNT

GOVERNMENT DEPARTMENT

Drainage Services Department

The Government's sewage treatment facilities

Audit Commission
Hong Kong
13 March 2001

THE GOVERNMENT'S SEWAGE TREATMENT FACILITIES

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Summary and key findings

A. **Introduction.** The Drainage Services Department (DSD) is responsible for the design, construction, operation and maintenance of sewage treatment facilities. These facilities include sewage treatment plants, sewage pumping stations and submarine outfalls. In 1999-2000, the recurrent expenditure for the operation and maintenance of such facilities was $565 million. In 1999-2000, 809 million cubic metres (m^3) of sewage and wastewater received treatment at the DSD's sewage treatment plants. Under the Water Pollution Control Ordinance (Cap. 358), the effluent discharged from sewage treatment plants is subject to control. The Environmental Protection Department (EPD) is responsible for licensing and controlling the discharge of effluent. Upon application by the DSD as the operator of the sewage treatment plants, for each plant the EPD grants a licence to the DSD for the discharge of the effluent. The licence specifies the terms and conditions which a sewage treatment plant has to comply with in its operations (paras. 1.1, 1.3 and 1.5 to 1.7).

B. **Audit review.** Audit has recently carried out a review to examine the economy, efficiency and effectiveness of the operation and maintenance of the sewage treatment facilities and to ascertain whether the treated effluent complies with the effluent standards specified in the licences (para. 1.10). The audit findings are summarised in paragraphs C to I below.

C. **Leakage of treated effluent into the Tolo Harbour.** The Tolo Harbour Effluent Export Scheme (THEES) was constructed to divert the discharge of the treated effluent of the Sha Tin sewage treatment works (STSTW) and the Tai Po sewage treatment works from the Tolo Harbour to the Victoria Harbour. However, after the THEES was commissioned on a full-scale basis in April 1998, part of the treated effluent leaked into the Tolo Harbour due to the deterioration of a temporary stop log constructed at the inlet chamber of the Sha Tin pumping station at the STSTW. The cofferdam constructed in March 2000 to replace the stop log also leaked. The leakage of treated effluent undermined the effectiveness of the THEES in reducing the quantity of pollutants entering the Tolo Harbour. Furthermore, the STSTW did not comply with the EPD's licensing condition that there should only be occasional discharge of treated effluent into the Tolo Harbour for the purposes of flushing/emergency operations. In response to Audit's enquiry, the DSD has said that in November 2000, the seam of the cofferdam was sealed up and, since then, the quantity of treated effluent leaked into the Tolo Harbour has been negligible (paras. 2.2, 2.9 and 2.11).

D. **Non-compliance with effluent standards.** The STSTW is the Government's largest secondary sewage treatment plant. Its construction consists of 3 stages. Stages 1 and 2 were completed in the 1980s. The construction of the stage 3 extension is scheduled to commence in 2001. In November 1991, the design capacity of the STSTW was reduced from 205,000 m^3/day to 150,000 m^3/day due to modification works carried out to increase the extent of removal of nitrogen in the treated effluent. In November 1994, a review carried out by the EPD concluded that there was imminent overloading of the STSTW as the incoming sewage flow exceeded the (already reduced)

design capacity, and that works to extend its capacity should be carried out immediately. In the event, funding for the STSTW stage 3 extension project was sought from the Finance Committee only in May 2000. From 1995 to October 2000, the STSTW failed to comply fully with the effluent standards specified in the licences. The non-compliance with the effluent standards specified in the licences contravened the Water Pollution Control (General) Regulations (paras. 3.2, 3.9 and 3.22).

E. **The need to improve the operation of the Cheung Chau sewage treatment works.** The Cheung Chau sewage treatment works (CCSTW), commissioned in December 1985, is the DSD's only primary sewage treatment plant. The sewage flowing into the CCSTW contained a high proportion of seawater. One reason for this was the inflow and infiltration of seawater into the sewerage system due to the defects and the damage to sewers and manholes. The DSD and the Territory Development Department had implemented measures to mitigate the problem. While the proportion of seawater had reportedly dropped since 1986, the DSD needs to continue to take positive action to resolve the problem. Audit also found that, from April 1998 to October 2000, the maximum flow rate of 12,000 m^3/day as specified in the licences of the CCSTW had been exceeded in 231 days. However, if the maximum flow rate (as specified in the Design Memorandum of the CCSTW) of 16,000 m^3/day had been allowed in the licences, the number of days of excess flow rate would have been reduced from 231 days to 23 days. It is necessary for the DSD to resolve the problem of non-compliance with the licensing condition as soon as possible (paras. 4.1, 4.6 and 4.13).

F. **Contracting-out opportunities.** The DSD is exploring the feasibility of outsourcing the operation and maintenance of its sewage treatment plants and of using the design, build and operate contract arrangement for the provision of some new treatment facilities. Audit welcomes the DSD's initiative. Audit considers that the DSD should also consider contracting out the operation and maintenance of some existing sewage treatment plants so as to assess the cost-effectiveness of contracting out (para. 5.4).

G. **The need to use a mobile team to achieve savings.** Ten sewage pumping stations of the central district of Kowloon were unmanned. However, there were six sewage pumping stations in the same district which were manned during daytime. Audit considers that the DSD should consider the use of a mobile team to patrol these six sewage pumping stations, instead of stationing staff there. Audit estimates that eight staff can be saved if a mobile team is used to patrol the six sewage pumping stations, with a potential saving of $1.4 million a year (para. 5.12).

H. **Maintenance management system not fully utilised.** In July 1996, the DSD installed a computerised job accounting and stores control system, called the Planned Engineering Maintenance and Stores Control System (PEMAC) at the STSTW. The DSD set up PEMAC for trial run at the STSTW with a view to extending PEMAC to other sewage treatment plants. However, PEMAC was not in full operation until April 2000. The DSD did not regularly produce management information from PEMAC to analyse the time spent by its staff on maintenance work and did not make estimates of the time required for the completion of work orders (paras. 6.3, 6.6 and 6.7).

I. **The need to conduct cost comparisons among sewage treatment plants.** Audit analysed and compared the recurrent cost per unit of sewage treated of three major secondary sewage treatment plants. Audit noted that there were significant differences in the unit treatment costs among the sewage

treatment plants. Audit considers that the DSD should ascertain the reasons for the variances in the unit treatment costs among the plants. Audit also noted that the DSD did not have readily available information on the recurrent cost of individual preliminary sewage treatment plants because there were no separate cost centres for each plant in the accounting system (paras. 6.13 to 6.16).

J. **Audit recommendations.** Audit has made the following main recommendations that the Director of Drainage Services should:

(a) take expeditious remedial measures to stop the leakage of treated effluent from the Sha Tin pumping station into the Tolo Harbour so as to reduce the quantity of pollutants entering the Tolo Harbour (para. 2.10);

(b) closely monitor the implementation of the phase 1 works of the STSTW stage 3 extension project to ensure that there is no slippage in the completion of the works (para. 3.23(a));

(c) continue to take positive action to address the problem of the inflow and infiltration of seawater into the sewerage system of Cheung Chau so as to enhance the CCSTW's efficiency in sewage treatment and to reduce the wear and tear of its equipment (para. 4.7);

(d) take action to ensure that the sewage treatment plants comply with the licensing conditions for effluent discharge (para. 4.14(a));

(e) consider contracting out the operation and maintenance of some sewage treatment plants so as to evaluate the cost-effectiveness of contracting out (para. 5.5(a));

(f) consider the possibility of using a mobile team to patrol those sewage pumping stations which are presently manned (such as the six sewage pumping stations in the central district of Kowloon) in order to achieve savings by not stationing staff there (para. 5.13);

(g) require staff to record fully the time spent on a work order for maintenance work, input promptly the time spent by staff on work orders into PEMAC and produce reports regularly from PEMAC on the time spent by staff on maintenance work for monitoring purposes (paras. 6.10(a), (b) and (d)); and

(h) create separate cost centres for the major preliminary sewage treatment plants so that regular comparisons of the unit treatment costs among them can be made (para. 6.17(a)).

K. **Response from the Administration.** The Director of Drainage Services has generally agreed with the audit recommendations (paras. 2.11, 3.24, 4.8, 4.15, 5.6, 5.14, 6.11 and 6.18).

PART 1: INTRODUCTION

Background

1.1 Domestic and non-domestic wastewater enter the sewerage system from the drains of residential, commercial and industrial buildings. The sewage flow is delivered to sewage treatment facilities either by sewage pumps or by gravitational flow from high to low levels. The treated effluent is discharged into the sea via submarine outfalls. The Drainage Services Department (DSD) is responsible for the design, construction, operation and maintenance of sewage treatment facilities. These facilities include sewage treatment plants, sewage pumping stations and submarine outfalls. In 1999-2000, the recurrent expenditure for the operation and maintenance of such facilities was $565 million.

1.2 ***Treatment plants.*** The DSD operates the following different types of sewage treatment plants:

(a) ***Preliminary treatment plant.*** The treatment process adopted by this type of treatment plant involves the screening of solids and the removal of grit. Settleable solids over 0.25 millimetres in diameter and suspended solids over 6 millimetres in diameter are segregated for disposal at designated landfills. The screened effluent is discharged into the sea via submarine outfalls. This treatment process is adopted in 24 preliminary sewage treatment plants. These plants are mainly in the urban areas and treat about 67% of the sewage (see paragraph 1.3 below for details);

(b) ***Primary treatment plant.*** The treatment process adopted by this type of treatment plant provides solid separation by sedimentation, in addition to screening. Sedimentation helps to remove over 50% of the suspended solids. The treated effluent is discharged into the sea. This treatment process is not common and is only used in one sewage treatment plant located in Cheung Chau;

(c) ***Chemically enhanced primary treatment plant.*** The treatment process adopted by this type of treatment plant enhances the primary treatment process through the addition of flocculating agents (Note 1) that enable quicker and better settlement. This method of treatment is capable of removing 80% of the suspended solids and 70% of the Biochemical Oxygen Demand (Note 2). This treatment process is adopted in one sewage

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Note 1: *A flocculating agent is a substance which promotes the agglomeration of small particles to larger ones.*

Note 2: *"Biochemical Oxygen Demand" is a measure of the organic pollutants level based on the amount of oxygen consumed by micro-organisms during a fixed period.*

treatment plant located on Stonecutters Island, which was constructed under the Strategic Sewage Disposal Scheme (SSDS — Note 3) Stage I; and

(d) ***Secondary treatment plant.*** The treatment process adopted by this type of treatment plant involves screening, primary sedimentation, biological treatment and final sedimentation of sewage prior to disposal. The core process is the biological treatment process that utilises aeration to facilitate the growth of micro-organisms to decompose organic matters. This treatment process is adopted in six major secondary sewage treatment plants mainly in the new towns in the New Territories (see paragraph 1.3 below for details — Note 4).

1.3 ***Sewage treated.*** In 1999-2000, 809 million cubic metres (m^3) of sewage and wastewater were collected by the public sewerage system and received treatment at the DSD's sewage treatment plants. Details are shown in Table 1 below.

Note 3: *The SSDS is a central sewerage network to intercept, treat and dispose of the sewage in an environmentally acceptable manner. The SSDS Stage I includes the construction of a deep tunnel system for collecting the sewage from the areas between Tsuen Wan and Tseung Kwan O, and between Chai Wan and Shau Kei Wan; a chemically enhanced primary sewage treatment plant on Stonecutters Island; and a submarine outfall off Stonecutters Island.*

Note 4: *In addition to the six major secondary sewage treatment plants, the DSD also operates 28 minor secondary sewage treatment plants. Of these 28 plants, 21 are owned by other government departments such as the Correctional Services Department. In 1999-2000, the volume of sewage treated by these 28 plants was insignificant (only 2 million m^3 or 0.2% of the total sewage treated by the DSD's plants).*

Table 1

DSD's sewage treatment plants

Sewage treatment plant			Volume of sewage treated in 1999-2000	
Type	**No.**	**Location**	**Million m^3**	**Percentage**
Preliminary	24	17 plants in the urban areas (Note A) 6 plants in the New Territories (Note B) 1 plant on Lantau Island	542 (Note A)	67%
Primary	1	Cheung Chau	4	0.5%
Chemically enhanced primary	1	Stonecutters Island (Note A)	117	14.5%
Secondary	6 (see Note 4 to paragraph 1.2(d) above)	Sha Tin, Tai Po, Shek Wu Hui, Yuen Long, Sai Kung and Stanley	146	18%
Total	**32**		**809**	**100%**

Source: DSD's records

Note A: Of the 17 preliminary sewage treatment plants in the urban areas:

(i) the treated effluent of 4 plants is conveyed to the chemically enhanced primary sewage treatment plant on Stonecutters Island for further treatment (2 plants in Sham Shui Po, 1 plant in Cheung Sha Wan and 1 plant in North West Kowloon). The volume of sewage treated of 542 million m^3 does not include the treated effluent of these 4 plants;

(ii) in 2001, the treated effluent of the 4 plants in Chai Wan, Shau Kei Wan, Kwun Tong and To Kwa Wan will be conveyed to the chemically enhanced primary sewage treatment plant for further treatment after the completion of the SSDS Stage I sewage tunnel system;

(iii) the treated effluent of the 8 plants in Aberdeen, Ap Lei Chau, Central, North Point, Sandy Bay, Wah Fu, Wan Chai East and Wan Chai West is expected to receive further treatment under future stages of the SSDS; and

(iv) the treated effluent of the plant in Shek O does not receive further treatment.

Note B: Of the 6 preliminary sewage treatment plants in the New Territories, the treated effluent of the 3 plants in Kwai Chung, Tseung Kwan O and Tsing Yi will be conveyed to the chemically enhanced primary sewage treatment plant for further treatment after the completion of the SSDS Stage I sewage tunnel system in 2001.

1.4 ***Sewage pumping stations.*** The DSD operates 123 sewage pumping stations to deliver sewage and wastewater to the treatment plants from their catchment areas. Most of the sewage pumping stations are located in the urban areas and in the North East New Territories.

Licensing system for effluent discharge

1.5 The Water Pollution Control Ordinance (WPCO — Cap. 358) provides the statutory framework for the declaration of water control zones in Hong Kong and the establishment of water quality objectives. The water quality objectives specify the water quality that should be achieved and maintained in order to promote the conservation and best use of the waters of Hong Kong. Within each water control zone, all effluent discharges are controlled by a licensing system. The Environmental Protection Department (EPD) is responsible for licensing and controlling the discharge of effluent (see paragraph 1.7 below).

1.6 ***Licensing of government sewage treatment plants.*** Under the WPCO, the effluent discharged from sewage treatment plants is subject to control. The operators of sewage treatment plants (including the DSD) are required to apply for a licence from the EPD and should comply with the terms and conditions stipulated in the licence.

1.7 ***Conditions of a licence.*** Upon application by an operator (including the DSD), the EPD grants a licence for a minimum period of two years to the operator for each sewage treatment plant for the discharge of effluent. The licence specifies the terms and conditions, such as the location of discharge, effluent standards, self-monitoring requirements and the maximum allowable quantity (maximum flow rate), which the sewage treatment plant has to comply with. By reference to a technical guide called the Technical Memorandum on Effluent Standards (Note 5), the EPD determines the effluent standards taking into consideration, among other things, the need to protect the receiving waters (Note 6). Various effluent standards are set for different types of sewage treatment plants. There are no effluent standards set for the preliminary sewage treatment plants because the treatment process only involves the screening of solids and the removal of grit. **For other types of sewage treatment plants, the determinants of effluent standards generally include Biochemical Oxygen Demand and total suspended solids. Nitrogen related**

Note 5: *The Technical Memorandum on Effluent Standards, issued under section 21 of the WPCO, is the EPD's guide for determining the effluent standards. It sets the effluent standards having regard to the flow rate, location, and type of wastewater/sewers. The standards set for sewage treatment plants with higher flow rates are normally more stringent than those with lower flow rates.*

Note 6: *Other than the need to protect the receiving waters, in determining the effluent standards, the EPD also takes into consideration the need to protect the drainage or sewerage system and the health and safety of the operation and maintenance staff.*

determinants, including total nitrogen (Note 7), are applicable to those sewage treatment plants equipped with nitrogen removal facilities.

1.8 ***Variation of licensing conditions and renewal of licence.*** If a licensee wishes to change any of the conditions of his licence, e.g. the maximum flow rate or quality of the effluent, he should apply to the EPD for a variation. Similarly, if the licensee wishes to renew his licence, he should apply to the EPD for renewal of the licence at least two months (and not more than four months) before the expiry date of the licence.

1.9 ***Offence for contravention of licensing conditions.*** According to the Water Pollution Control (General) Regulations, a subsidiary legislation enacted under the WPCO, a person who contravenes any of the provisions of a licence granted under the WPCO commits an offence. The WPCO stipulates the following enforcement actions:

(a) ***Private sector.*** If there is a contravention of the WPCO, the offending person/company may be prosecuted by the Director of Environmental Protection; and

(b) ***Government departments.*** If it appears to the Director of Environmental Protection that any discharge is being, or has been, made in contravention of the WPCO by any person in the course of carrying out his duties in the service of the Government, the Director will report the matter to the Chief Secretary for Administration if the contravention is not forthwith terminated to the Director's satisfaction. On receipt of the Director of Environmental Protection's report, the Chief Secretary for Administration will enquire into the circumstances and, if the enquiry shows that a contravention is continuing or likely to recur, the Chief Secretary for Administration will ensure that the best practicable steps are taken to terminate the contravention or avoid the recurrence.

Audit review

1.10 Audit has recently carried out a review of the Government's sewage treatment facilities. The objectives of the audit review are:

Note 7: *Total nitrogen is a measure of the level of nutrients in water. Excessive nutrients in various forms of nitrogen compound in the effluent may, under favourable conditions, lead to rapid algal growth in the receiving waters into which the treated effluent is discharged, sometimes resulting in visible blooms. Nitrogen related effluent standards are included as a licensing requirement for sewage treatment plants equipped with nitrogen removal facilities, such as the plants located in Sha Tin, Tai Po, Sai Kung and Stanley.*

(a) to examine the economy, efficiency and effectiveness of the operation and maintenance of the sewage treatment facilities;

(b) to ascertain whether the treated effluent complies with the effluent standards specified in the licences; and

(c) to ascertain whether there is room for improvement in the operation and maintenance of the sewage treatment facilities.

1.11 Audit selected eight major sewage treatment plants for review. Details are shown in Table 2 below.

Table 2

Eight sewage treatment plants selected for Audit review

Type of treatment plant	Location of treatment plant
Preliminary (4 plants)	Kwun Tong, To Kwa Wan, Aberdeen and North Point (Note A)
Primary (1 plant)	Cheung Chau (Note B)
Secondary (3 plants)	Sha Tin, Tai Po and Shek Wu Hui (Note C)

Source: DSD's records

Note A: The four plants selected are the major preliminary sewage treatment plants.

Note B: This is the DSD's only primary sewage treatment plant.

Note C: The total volume of sewage treated by these three plants represented 85% of the sewage receiving secondary treatment in 1999-2000.

Note D: The chemically enhanced primary sewage treatment plant located on Stonecutters Island was not selected for review because, up to October 2000, the plant had not yet been fully operational.

1.12 Audit also selected the sewage pumping stations in the central district of Kowloon for review. This district was selected because it was one of the areas with the highest number (19) of sewage pumping stations.

PART 2: LEAKAGE OF TREATED EFFLUENT INTO THE TOLO HARBOUR

2.1 This PART examines the problem of leakage of the treated effluent from the Sha Tin pumping station at the Sha Tin sewage treatment works (STSTW) into the Tolo Harbour. The audit has revealed that there was a delay of two years in resolving the leakage problem.

Tolo Harbour Effluent Export Scheme

2.2 In 1987, the Government formulated the Tolo Harbour Action Plan to reduce the quantity of pollutants entering the Tolo Harbour. As part of the Tolo Harbour Action Plan, the Tolo Harbour Effluent Export Scheme (THEES) was implemented to divert the discharge of the treated effluent of the STSTW and the Tai Po sewage treatment works (TPSTW) from the Tolo Harbour to the Victoria Harbour (via the Kai Tak Nullah). The THEES had the double benefits of cleaning up the Tolo Harbour and providing a flow of flushing water to the heavily polluted Kai Tak Nullah. The DSD was responsible for the THEES which was implemented in two stages (Note 8). The actual expenditure of the THEES up to October 2000 was $752 million. In the Director of Audit's Report No. 31 of October 1998, Audit reported on the delay in the commissioning of the THEES. From 1995 to 1997, only part of the treated effluent of the STSTW and TPSTW was exported to the Victoria Harbour due to problems encountered in operating the Sha Tin pumping station (Note 9).

2.3 ***Licence for discharge of effluent into the Tolo Harbour.*** In 1990, the EPD granted the DSD a licence for discharging the STSTW's treated effluent into the Tolo Harbour. The licence was subsequently renewed several times. In August 1997, after the commissioning of the THEES, the EPD changed the conditions of the licence so that the licence contained two parts. One part of the licence was for the normal discharge of the effluent into the Victoria Harbour (via the Kai Tak Nullah). **The other part of the licence was for the discharge of the effluent into the Tolo Harbour. The relevant licensing condition stated that the discharge of the effluent into the Tolo Harbour was restricted to occasional discharge for the purposes of flushing/emergency operations.** This licensing condition was made to provide for the need to discharge the effluent into the Tolo Harbour for specific purposes, such as during the flushing of the outfall or during the annual desilting of the Kai Tak Nullah.

Leakage of treated effluent into the Tolo Harbour

2.4 In April 1998, the Sha Tin pumping station started operation on a full-scale basis for the export of the treated effluent from the STSTW and the TPSTW to the Victoria Harbour. The Sha Tin pumping station diverted the discharge of the treated effluent from the STSTW and the TPSTW (exported to the Sha Tin pumping station under the THEES — see paragraph 2.2 above) via the Kai

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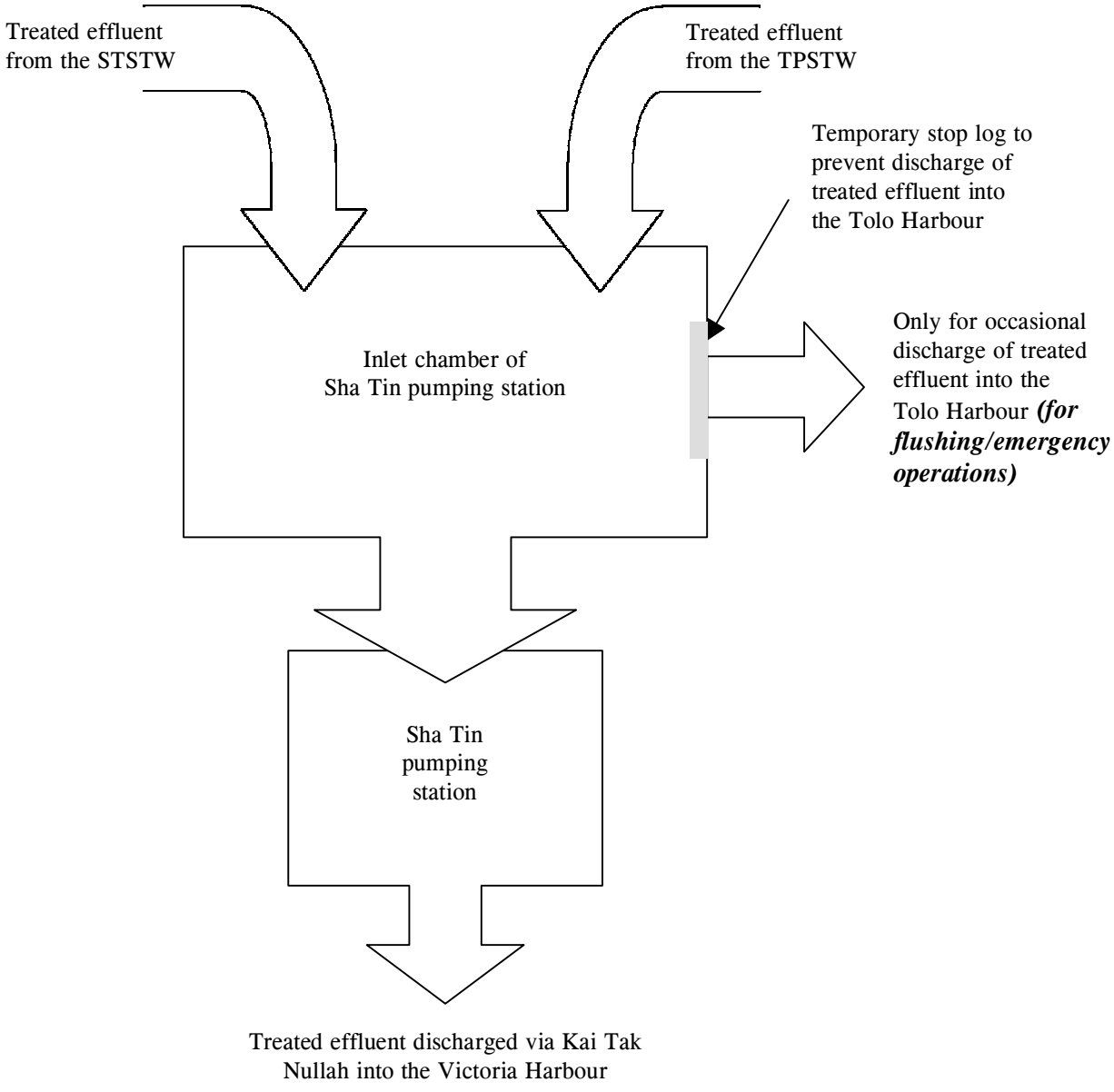
Note 8: *Stage 1 of the THEES was for the export of the treated effluent from the STSTW to the Kai Tak Nullah. Stage 2 of the THEES was for the export of the treated effluent from the TPSTW to the Sha Tin pumping station at the STSTW.*

Note 9: *Stage 1 of the THEES, originally scheduled for completion by September 1993, only commenced operation on an interim basis (i.e. using only one of the four pumps) in April 1995 because of problems encountered in operating the Sha Tin pumping station. Stage 2 of the THEES came into service in March 1996 but was disrupted by the intermittent failure of the pumps. The THEES was commissioned on a full-scale basis in April 1998.*

Tak Nullah to the Victoria Harbour. **However, not all the treated effluent was diverted to the Victoria Harbour. Some of the treated effluent leaked into the Tolo Harbour due to the deterioration of a temporary stop log (Note 10) at the inlet chamber of the Sha Tin pumping station (see Figure 1 below).** Details are described in paragraphs 2.5 to 2.8 below.

Figure 1

Schematic diagram of the flow of treated effluent at the inlet chamber of the Sha Tin pumping station



Source: DSD's records

Note 10: *A stop log is a log or plank, or a beam or plate of concrete or steel, fitting between vertical grooves in walls or piers to close a water channel.*

Cause of leakage

2.5 ***Temporary stop log.*** In 1993, a temporary stop log was installed at the junction of the inlet chamber of the Sha Tin pumping station and the twin submarine outfalls to the Tolo Harbour. The purpose of the temporary stop log was to facilitate the flushing of the twin submarine outfalls. In the late 1990s, the DSD planned to replace the temporary stop log by penstocks in order to achieve better water-tightness.

2.6 In order to provide a dry working space for the installation of the penstocks, in March 2000, the DSD installed a steel cofferdam (Note 11) to replace the temporary stop log. However, according to the DSD, the steel cofferdam failed to achieve water-tightness because there was still a seam between the steel cofferdam and the concrete wall/base. The DSD attempted twice to seal up the seam completely, but was only partially successful. Up to October 2000, the leakage problem had not yet been resolved.

Extent of leakage

2.7 According to the DSD, around 2% to 3% of the treated effluent diverted to the inlet chamber of the Sha Tin pumping station leaked into the Tolo Harbour during the period April 1998 to October 2000. **In June 1998, at a meeting between the DSD and the EPD, the DSD agreed to resolve the leakage problem as soon as possible.**

DSD's explanation on the delay in resolving the leakage problem

2.8 In October 2000, Audit enquired the DSD why the leakage problem still existed. Audit suggested to the DSD that expeditious action should be taken to resolve the problem. In response, the DSD said that:

(a) the DSD was aware of the need to resolve the leakage problem promptly. Indeed the DSD had taken action to rectify the situation when the DSD found that the temporary stop log was deteriorating;

(b) the DSD expected that the leakage problem would be fixed shortly as another attempt would be made to seal up the seam completely with an alternative epoxy product; and

(c) the inlet chamber would become water-tight once the cofferdam had been properly sealed. A reasonably dry working space could then be provided for the installation of the penstocks.

Note 11: *A cofferdam is a water-tight enclosure placed or constructed in waterlogged soil or under water and pumped dry so that construction or repairs can proceed under normal conditions.*

Audit observations on the leakage problem

2.9 **As mentioned in paragraph 2.2 above, there was a delay in the commissioning of the THEES which was constructed at a cost of $752 million.** As a result, from 1995 to 1997, only part of the treated effluent was exported to the Victoria Harbour. **After the THEES was commissioned on a full-scale basis in April 1998, all the treated effluent should have been diverted to the Victoria Harbour.** However, part of the treated effluent leaked into the Tolo Harbour due to the deterioration of a temporary stop log constructed at the inlet chamber of the Sha Tin pumping station. **The leakage undermined the effectiveness of the THEES in reducing the quantity of pollutants entering the Tolo Harbour. Furthermore, the STSTW did not comply with the EPD's licensing condition that there should only be occasional discharge of treated effluent into the Tolo Harbour for the purposes of flushing/emergency operations. In June 1998, the DSD agreed with the EPD to fix the leakage problem as soon as possible. However, the cofferdam constructed in March 2000 to replace the stop log also leaked. Up to October 2000, the leakage problem had not yet been resolved.**

Audit recommendation on the leakage problem

2.10 **In October 2000, Audit *recommended* that the Director of Drainage Services should take expeditious remedial measures to stop the leakage of treated effluent from the Sha Tin pumping station into the Tolo Harbour so as to reduce the quantity of pollutants entering the Tolo Harbour and to ensure that the relevant licensing conditions are complied with.**

Response from the Administration

2.11 The **Director of Drainage Services** has said that:

(a) he agrees with the audit recommendation on the remedial measures to stop the leakage of treated effluent as mentioned in paragraph 2.10 above; and

(b) the seam of the cofferdam was sealed up on 9 November 2000. Since then, the quantity of the treated effluent leaked into the Tolo Harbour has been negligible. The actual leakage was measured on 1 February 2001 and was also found to be negligible, ranging from 348 m^3 a day to 683 m^3 a day (i.e. 0.13% to 0.26%, respectively, of the average daily flow of 270,000 m^3).

PART 3: NON-COMPLIANCE WITH EFFLUENT STANDARDS

3.1 This PART examines the issue of non-compliance with the effluent standards specified in the licences, with particular reference to the treated effluent of the DSD's secondary sewage treatment plants. The audit has revealed that, of the three major secondary sewage treatment plants selected for review (see paragraph 1.11 above), the TPSTW and the Shek Wu Hui sewage treatment works (SWHTW) generally complied with the effluent standards specified in the licences. However, between 1995 and October 2000, the STSTW failed to comply fully with the effluent standards specified in the licences.

STSTW

3.2 The STSTW is the Government's largest secondary sewage treatment plant. In 1999-2000, it treated 50% of the total sewage receiving secondary treatment. The construction of the STSTW consists of 3 stages. The construction of stages 1 and 2 were completed in the 1980s. The construction of stage 3 extension of the STSTW is scheduled to commence in 2001. A summary of the key planning parameters of the three stages is shown in Table 3 below.

Table 3

Summary of the key planning parameters of the three stages of the STSTW

Stage	Responsible department	Year of commissioning	Population to be served	Design capacity
				m^3/day
Stage 1	Territory Development Department (TDD)	1982	505,250	205,000 (reduced to 150,000 in November 1991 — Note A)
Stage 2	TDD	1986		
Stage 3 extension (Note B)	DSD	Construction to commence in 2001. Commissioning expected in 2007.	830,000	340,000

Source: *DSD's records*

Note A: *In November 1991, the design capacity was reduced to 150,000 m^3/day after the completion of the modification works to increase the extent of removal of nitrogen of the treated effluent (see paragraphs 3.7 and 3.8 below for details).*

Note B: *The project was upgraded to Category A of the Public Works Programme in June 2000 (see paragraphs 3.20 and 3.21 below for details).*

Effluent standards applicable to STSTW

3.3 As mentioned in paragraphs 1.5 to 1.7 above, within each water control zone, the EPD controls the effluent discharged from the sewage treatment plants by a licensing system. The EPD sets the effluent standards in the licences in order to protect the water quality of the water control zones. In 1990, the EPD granted a licence for the STSTW to discharge the treated effluent into the Tolo Harbour. The licence was subsequently renewed several times. In August 1997, after the commissioning of the THEES to export the effluent to the Victoria Harbour, the EPD changed the conditions of the licence. The licence contains two parts, as follows:

(a) ***Discharge of effluent into the Tolo Harbour.*** This part of the licence specifies that the discharge of the effluent into the Tolo Harbour is restricted to occasional discharge for the purposes of flushing/emergency operations (see paragraph 2.3 above); and

(b) ***Discharge of effluent into the Victoria Harbour.*** The other part of the licence is for the normal discharge of the effluent into the Victoria Harbour. The effluent standards are the same as those for the discharge of the effluent into the Tolo Harbour.

3.4 ***Maximum and percentile standards.*** According to the licences granted to the STSTW, effluent standards were set for three determinants (i.e. Biochemical Oxygen Demand, total suspended solids and total nitrogen — see Appendix A for details). In respect of each determinant, there are two effluent standards specified in the licences:

(a) ***Maximum standard.*** Prior to 6 August 1997, a maximum effluent standard was set in the licences. No samples taken from the effluent were allowed to exceed the maximum standard; and

(b) ***Percentile standard.*** From 6 August 1997 onwards, in addition to the maximum standard, a 95 percentile standard (which is more stringent than the maximum standard) was also set in the licences. Only up to 5% of the samples taken from the effluent may exceed the percentile standard (Note 12).

3.5 ***Assessment of compliance with percentile standard.*** According to the licences of the STSTW, the DSD should measure the daily flow rate and take samples to analyse the quality of the effluent. The minimum frequency of taking samples was two times a week (i.e. around 100 samples a year). Monthly, the DSD should summarise the results of the qualitative analysis and submit a report to the EPD for monitoring purposes. The assessment of compliance with the percentile standard is normally based on the data of a 12-month period and on a rolling basis. According to the licensing conditions, the maximum number of samples allowed to exceed the percentile standard is in Table 4 below.

Note 12: *According to the EPD, the 95 percentile standard means that up to 5% of the samples taken from the effluent may exceed the standard. As the STSTW was designed for 95 percentile compliance, the EPD considered that the introduction of the percentile standard was in line with the design philosophy of the STSTW.*

Table 4

Maximum number of samples allowed to exceed the percentile standard

Determinant	12-month period sample size	No. of samples allowed to exceed the percentile standard (Note A)
Biochemical Oxygen Demand (Note B)	96 — 110	9
Total suspended solids (Note C)	285 — 300	21
	301 — 317	22
Total nitrogen (Note B)	96 — 110	9

Source: *EPD's and DSD's records*

Note A: *According to the EPD, the number of samples allowed to exceed the percentile standard is based on a table adopted in the Council Directive of the European Communities Concerning Wastewater Treatment. In order to allow for sampling error, the number of samples allowed to exceed the percentile standard may slightly exceed 5% of the samples taken from the effluent.*

Note B: *The DSD took about 100 samples a year for analysing the effluent quality (i.e. the minimum number of samples required by the licences).*

Note C: *The DSD took about 300 samples a year for analysing the effluent quality.*

Extent of non-compliance with the EPD's effluent standards

3.6 As regards the above three determinants (namely Biochemical Oxygen Demand, total suspended solids and total nitrogen specified in the licences), Audit found that the treated effluent of the STSTW only complied with the effluent standards for Biochemical Oxygen Demand. However, as shown in Table 5 below, the treated effluent of the STSTW failed to comply with the effluent standards for total suspended solids and total nitrogen, as follows:

(a) ***Non-compliance with the effluent standards for total suspended solids.*** The STSTW had failed to comply with the maximum standard from 1995 to mid-1998. It has, since mid-1998, complied with the maximum standard. **However, the STSTW had failed to comply with the percentile standard from October 1997 to October 2000.** The non-compliance was mainly due to:

(i) overloading of the plant from 1993 onwards because the incoming sewage flow had exceeded the (already reduced) capacity of 150,000 m^3/day of the STSTW (see Appendix B for details); and

(ii) in Sha Tin, since mid-1995, seawater had been used for flushing, giving rise to bacterial foaming in the aeration tanks and high total suspended solids in the effluent; and

(b) ***Non-compliance with the effluent standards for total nitrogen.*** The STSTW failed to comply with the maximum standard in six samples taken in the first half of 1998. Since mid-1998, the STSTW has complied with the maximum standard. **However, the STSTW had failed to comply with the percentile standard from February 1998 to October 2000.** The non-compliance was due to the overloading of the plant as mentioned in paragraph 3.6(a)(i) above.

Table 5

Non-compliance with effluent standards specified in the licences of the STSTW

Year	Total suspended solids		Total nitrogen	
	Non-compliance with maximum standard (Note A)	**Non-compliance with percentile standard (Note B)**	**Non-compliance with maximum standard (Note A)**	**Non-compliance with percentile standard (Note B)**
	No. of samples	**No. of periods**	**No. of samples**	**No. of periods**
1995	59 (Note C)	N.A.	1	N.A.
1996	98	N.A.	0	N.A.
1997	68	3	1	0
1998	11	12	6 (Note D)	11
1999	0	12	0	12
2000 (up to October)	0	10	0	10

Source: EPD's and DSD's records

Note A: This means the number of samples which failed to meet the maximum standard.

Note B: This means the number of 12-month periods in which the samples failed to comply with the percentile standard. The percentile standard was first introduced in August 1997. The assessment of compliance with the percentile standard was normally based on the data of a 12-month period and on a rolling basis.

Note C: The non-compliance occurred from 1995 to mid-1998.

Note D: The non-compliance occurred during the first half of 1998.

Plant capacity reduced after completion of modification works in November 1991

3.7 ***Modification works to increase the extent of removal of nitrogen.*** As mentioned in paragraph 2.2 above, in 1987, the Government formulated the Tolo Harbour Action Plan to reduce the quantity of pollutants entering the Tolo Harbour. Included in the Action Plan were measures to modify the sewage treatment process of the STSTW. The measures would increase the extent of removal of nitrogen by the STSTW so as to reduce the level of residual nitrogen in the effluent discharged into the Tolo Harbour. It was an interim measure aimed at providing a much-needed temporary relief to the pollution of the Tolo Harbour.

3.8 ***Capacity reduced after completion of modification works.*** In November 1988, the TDD (Note 13) completed a consultancy study to determine the modification of the sewage treatment process for increasing the extent of removal of nitrogen of the treated effluent of the STSTW, from 70% to a target of 90%. The consultancy study indicated that, after the completion of the modification works (Note 14), the sewage being treated would need to remain longer (from 8 hours to 11 hours) in the aeration tanks. As a result, the capacity of the STSTW would have to be reduced significantly. **In November 1991, the modification works were completed and the capacity of the STSTW was reduced from 205,000 m^3/day to 150,000 m^3/day.**

Review of STSTW's capacity to tackle the overloading problem

3.9 As shown in Appendix B, in the wet season of 1993 and 1994, the incoming sewage flow of the STSTW was 188,000 m^3/day and 209,000 m^3/day respectively, which exceeded the reduced capacity of 150,000 m^3/day. The EPD, the DSD and the TDD agreed that there was an urgent need to determine whether an increase of the capacity of the STSTW was required. (This led to the planning work of the stage 3 extension works — see Note 15).

3.10 ***EPD's preliminary review on capacity of STSTW.*** In November 1994, the EPD completed a preliminary review of the capacity of the STSTW. The review concluded that:

(a) works to extend the capacity of the STSTW would be required. The extension works of the STSTW should be carried out in two phases. In view of the imminent overloading

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Note 13: *The TDD was the vote controller for funding the modifications works, and was responsible for the construction works.*

Note 14: *The works included the modification of the existing aeration tanks and the provision of equipment for mixed liquor recirculation; the facilities for lime storage; and the provision of methanol storage and dosing facilities.*

Note 15: *The EPD initiated and planned the stage 3 extension works. The TDD was responsible for the implementation of the stage 3 extension works. From 1 April 1996, the DSD took over this responsibility from the TDD.*

situation, implementation of the phase 1 extension works should be carried out immediately for commissioning in 1998. The requirement of the phase 2 extension works could be reviewed and confirmed later; and

(b) the capacity of the STSTW could be reverted back to 205,000 m^3/day on the assumption that no more treatment processing would be required to increase the extent of removal of nitrogen after the commissioning of the THEES.

3.11 ***TDD's study of STSTW stage 3 extension works.*** Subsequent to the preliminary review carried out by the EPD, in May 1995, the TDD commissioned a consultancy study on the design of the STSTW stage 3 extension works. The consultancy report of April 1996:

(a) **found that the STSTW did not comply with the effluent standard for total suspended solids in 1995. Improvement to the existing sewage treatment process would be required in order to consistently achieve the effluent standard; and**

(b) recommended that the stage 3 extension works would be required. However, as the EPD was then carrying out monitoring work on the water quality of the Victoria Harbour to ascertain whether the effluent standard for total nitrogen could be relaxed (Note 16), no decision could be expected until the end of 1996. It was therefore inappropriate to proceed with the stage 3 extension works at that time.

3.12 In April 1997, the DSD completed an adoptive review to examine the findings of the TDD's consultancy study on the design of the STSTW stage 3 extension works. The adoptive review concluded that further studies and site investigations should be carried out to facilitate the subsequent design work.

Relaxation of the nitrogen standard

3.13 In December 1996, the EPD advised the DSD on the effluent standards for the stage 3 extension works. The EPD relaxed the effluent standard for total nitrogen from 20 milligrammes per litre to 25 milligrammes per litre. The EPD also agreed to relax the effluent standard for total nitrogen specified in the licence of the STSTW. In June 1999, the DSD submitted an application for renewing the licence of the STSTW. Following discussions between the DSD and the EPD, the effluent standards for total nitrogen were finalised and included in the licence of the STSTW issued in December 1999.

Note 16: *The monitoring work was required because the EPD wanted to assess the impact on the water quality of the Victoria Harbour after the commissioning of the THEES.*

Modification works to increase STSTW's capacity

3.14 In November 1997, the DSD and the EPD discussed the scope of the stage 3 extension works. Both parties agreed that the scope of works under the stage 3 extension should be increased to provide an additional capacity of 95,000 m^3/day. Both parties also expected that, upon completion of the modification works of the STSTW, its capacity could be reverted back to the original capacity of 205,000 m^3/day, and that, upon completion of the stage 3 extension, its total capacity would be increased to 300,000 m^3/day.

3.15 In April 1998, the DSD informed the EPD that the process of removing total nitrogen was not a major factor that affected the treatment process in the STSTW. The removal of total suspended solids was more likely to be the major factor. The relaxation of the requirements of total nitrogen could not increase the treatment capacity of the STSTW. The modification of the STSTW was the most pragmatic approach to addressing the overloading problem. After noting the DSD's response, the EPD considered that the treatment capacity of the STSTW had long been overloaded and the non-compliance with effluent standards was expected to continue due to the continuous overloading situation.

Non-compliance with effluent standards reported to the Chief Secretary for Administration

3.16 Pursuant to the requirement of the WPCO as mentioned in paragraph 1.9(b) above, in December 1998, the Director of Environmental Protection reported the STSTW's non-compliance with the effluent standards specified in the licence to the Lands, Works, Transport, Housing and Environmental Protection Policy Group of the Chief Secretary for Administration's Committee through the then Secretary for Planning, Environment and Lands. The Committee, which was chaired by the Chief Secretary for Administration, was informed that:

(a) the effluent discharged from the STSTW was substandard and contravened the Water Pollution Control (General) Regulations. There was non-compliance with the effluent standards for total suspended solids and total nitrogen. The non-compliance was mainly due to overloading of the STSTW; and

(b) the DSD had adopted short-term measures to reduce foaming and adjust balancing of flow during peak flow periods. As a long-term measure, upgrading of the STSTW would be necessary. The works were planned to commence in 1999 for completion in 2001.

3.17 The Chief Secretary for Administration was subsequently kept informed of the plan and progress of the upgrading works, as follows:

Date of report	Plan and progress of upgrading works
March 1999	The upgrading works of the existing STSTW were planned to commence in September 2000 for completion in 2003 or early 2004 (the upgrading works were later incorporated into the stage 3 extension works).
December 1999	Phase 1 and phase 2 of the stage 3 extension works would be completed in 2004 and 2009 respectively. On the commissioning of the phase 1 works in 2004, there would be a substantial increase in the capacity of the STSTW. The quality of the effluent would comply with the effluent standards.
March 2000	The stage 3 extension works had been split into phases for overall completion in 2007. The quality of the effluent would gradually be improved to comply with the effluent standards.
August 2000	Phase 1 and phase 2 of the stage 3 extension works would be completed in 2004 and 2007 respectively. After the completion of the phase 1 works in 2004, the quality of the effluent would gradually be improved to comply with the effluent standards.

STSTW stage 3 extension project

3.18 ***Concerns of Members of the Legislative Council.*** In May 2000, at a meeting of the Legislative Council Panel on Environmental Affairs, Members' support was sought for a proposal to seek the Finance Committee (FC)'s approval to upgrade the project "STSTW stage 3 extension" to Category A (Note 17) of the Public Works Programme. At the meeting, some Members of the Panel:

(a) expressed concerns over the adverse impact of the substandard effluent of the STSTW on the Victoria Harbour; and

(b) enquired why the effluent from the STSTW was not discharged into the sewage tunnels of the SSDS Stage I so that it could be treated collectively at the chemically enhanced primary sewage treatment plant on Stonecutters Island.

Note 17: *Public works projects are classified into several categories under the Public Works Programme. Category A projects are projects which are ready in all aspects for tenders to be invited and for construction works to proceed, and which have approved project estimates.*

3.19 ***DSD's response.*** In response, the DSD's representative advised the Panel that:

(a) the loading of total suspended solids and total nitrogen of the treated effluent discharged from the STSTW only represented 2% and 7% respectively of the total loading of each pollutant going into the Victoria Harbour. The treated effluent discharged from the STSTW was of high quality with little pollutants. Therefore, it had no adverse effect on the water quality of the Victoria Harbour; and

(b) it would not be cost-effective to discharge the effluent from the STSTW into the sewage tunnels of the SSDS Stage I because the STSTW adopted a much higher sewage treatment standard. It would defeat the purpose if the treated effluent from the STSTW was to be mixed with untreated sewage for treatment again at the sewage treatment plant on Stonecutters Island.

3.20 ***Funding approval.*** In May 2000, the Government sought funding approval for the STSTW stage 3 extension project from the FC. In June 2000, the FC approved the upgrading of the project to Category A of the Public Works Programme at an estimated cost of $2,425 million in money-of-the-day prices.

3.21 The FC was also informed that the stage 3 extension project would increase the capacity of the STSTW to 340,000 m^3/day, taking into account an expected increase of the population in the Sha Tin and Ma On Shan areas to 830,000 by 2011 (Note 18). The stage 3 extension works are scheduled to start in March 2001. The phase 1 and the phase 2 works of the stage 3 extension project are scheduled to be completed in 2004 and 2007 respectively. The scope of the project includes:

(a) the construction of sedimentation and aeration tanks and other facilities;

(b) the modification of 12 existing aeration tanks (Note 19); and

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Note 18: *According to the EPD, the scope of the project was substantially revised and expanded to cope with the targeted population increase. It was forecast that the targeted population in the Sha Tin and Ma On Shan areas would increase to 830,000 by 2011, as compared with the earlier forecasts (made in 1996 and 1997) of about 600,000 under the TDD's study and the DSD's adoptive review of the STSTW stage 3 extension works.*

Note 19: *Of the 12 aeration tanks, two tanks are expected to be completed in 2003, another two in 2004 and the remaining eight in 2007.*

(c) interim measure, such as temporary modification works to the existing aeration tanks, to improve the treatment process prior to the commissioning of the phase 1 works.

Audit observations on STSTW's non-compliance with effluent standards

3.22 In November 1991, the design capacity of the STSTW was reduced from 205,000 m^3/day to 150,000 m^3/day. In November 1994, the EPD's preliminary review concluded that there was an imminent overloading situation and that works to extend the capacity of the STSTW should be carried out immediately. In the event, funding for the stage 3 extension project was sought from the FC only in May 2000. From 1995 to October 2000, the STSTW had failed to comply with the effluent standards specified in the licences for total suspended solids. From 1998 to October 2000, the STSTW had also failed to comply with the effluent standards specified in the licences for total nitrogen. **The non-compliance with the effluent standards specified in the licences contravened the Water Pollution Control (General) Regulations. After a lapse of about six years since 1995, the problem of overloading of the STSTW has not been resolved. The Government expects that the phase 1 and the phase 2 works of the stage 3 extension project will be completed in 2004 and 2007 respectively, and that the quality of the effluent will comply with the effluent standards upon completion of the phase 1 works in 2004.**

Audit recommendations on STSTW's non-compliance with effluent standards

3.23 **Audit has *recommended* that the Director of Drainage Services should:**

(a) **closely monitor the implementation of the phase 1 works of the STSTW stage 3 extension project to ensure that there is no slippage in the completion of the works; and**

(b) **in future, if it is necessary to implement a new sewage treatment process (for example, for further increasing the level of nitrogen to be removed), critically evaluate whether the new process will have any adverse impact on the operation of the existing sewage treatment plant, and, if adverse impact is expected, take early action to address any consequent problems.**

Response from the Administration

3.24 The **Director of Drainage Services** has said that he agrees with the audit recommendations on the issue of the STSTW's non-compliance with effluent standards as mentioned in paragraph 3.23 above.

PART 4: PRIMARY SEWAGE TREATMENT PLANT

Cheung Chau sewage treatment works

4.1 This PART examines the operation of the Cheung Chau sewage treatment works (CCSTW). As mentioned in paragraph 1.11 above, the CCSTW is the DSD's only primary treatment plant. It was commissioned in December 1985. In 1999-2000, the CCSTW treated four million m^3 of sewage. The audit has revealed that the sewage flowing into the CCSTW contained a high proportion of seawater due to the inflow and infiltration of seawater into the sewerage system (see paragraphs 4.2 to 4.7 below for details), and that the maximum flow rate as specified in the licences of the CCSTW had been exceeded (see paragraphs 4.10 to 4.14 below for details).

Inflow and infiltration of seawater into the sewerage system of Cheung Chau

4.2 The sewerage system of Cheung Chau is a combined system (i.e. a mix of sewerage and stormwater drainage system). The sewage collected is routed to the CCSTW for treatment. From April 1998 to October 2000, the actual average flow rate of sewage of the CCSTW was 10,349 m^3/day (Note 20). This flow rate substantially exceeded the design dry weather flow (Note 21) of 4,000 m^3/day for the CCSTW. One of the reasons for the excess of the actual average flow rate over the design dry weather flow rate was the inflow and infiltration of seawater into the sewerage system due to defects and damage to the sewers and manholes (Note 22). **The inflow and**

Note 20: *As the sewerage system of Cheung Chau is a combined system, the actual average flow rate of 10,349 m^3/day included the foul sewage, stormwater, and the inflow and infiltration of seawater into the sewerage system. The flow rate of the CCSTW is measured at the flume which is located at the plant where the sewage has been screened but before sedimentation. The measured flow rate is also regarded as the discharge rate of the CCSTW.*

Note 21: *The design dry weather flow is defined as the average flow of sewage to a treatment plant without the influence of stormwater infiltration.*

Note 22: *According to the DSD, on Cheung Chau, the reasons for the increase in the actual average flow rate over the design dry weather flow rate included:*

(a) the flow of stormwater into the sewerage system. The period from April 1998 to October 2000 included three wet seasons and there would have been stormwater received into the combined system. When averaged out on a daily basis, this would account for a part of the difference between the actual average flow rate of 10,349 m^3/day and the design dry weather flow rate of 4,000 m^3/day;

(b) the discharge of seawater from the premises of seafood merchants along the Cheung Chau waterfront and within the market area into the sewerage system. The seafood merchants had installed pumps along the seawall for continually providing running seawater which overflowed from the fish tanks into the drainage system; and

(c) the backflow of seawater into the sewerage system. During short periods of high tide, seawater might flow over the baffle walls (walls for deflecting the flow of water) in stormwater overflow chambers/manholes near the seawall. In designing the combined sewerage system, in order to strike a proper balance, the baffle walls could not be designed at too high a level so as to ensure that excessive stormwater could flow over into the sea. This design prevents flooding during heavy rain.

infiltration of seawater into the sewerage system lowered the efficiency of treating of the sewage, and resulted in excessive pumping operations at the CCSTW. Seawater also accelerated the wear and tear, and corrosion of the equipment of the CCSTW.

4.3 The problem of inflow and infiltration of seawater into the sewerage system of Cheung Chau was noted as early as 1986. The following is a summary of how the problem was identified and what had been done to deal with it:

Date	Events
Early 1986	An investigation carried out by the Electrical and Mechanical Services Department (Note 23) revealed that **the sewage entering into the CCSTW contained a high proportion of seawater.**
Late 1994	The Outlying Islands Sewerage Master Plan study revealed that the inflow and infiltration of seawater into the sewerage system of Cheung Chau was still excessive. Seawater strained the treatment capacity of the CCSTW. Effluent standards were only achieved by dilution. There were major defects in the sewerage system due to cracks and other forms of deterioration. The study recommended that structural improvement works to the sewerage system should be carried out.
Mid-2000	The Interim Report of the Outlying Islands Sewerage Master Plan Stage 2 Review study stated that **the inflow and infiltration of seawater into the sewerage system of Cheung Chau remained a significant problem.** The seawater entered the trunk sewer at manholes and through the seawall outfall during high tide. The study proposed to eliminate the inflow of seawater urgently and to monitor the change in total flow of the CCSTW.

DSD's explanation

4.4 In response to Audit's enquiry about the inflow and infiltration of seawater into the sewerage system, in November 2000, the DSD said that:

(a) the presence of seawater would accelerate the wear, deterioration and corrosion of the plant equipment. However, during the last 15 years since the CCSTW had been commissioned, the DSD considered that the maintenance carried out was comparable to the maintenance of equipment at plants serving other sewage catchment areas in which seawater was used for flushing (Note 24);

Note 23: *Prior to the establishment of the DSD in September 1989, the Electrical and Mechanical Services Department was responsible for the day-to-day operation of the CCSTW.*

Note 24: *Fresh water, instead of seawater, is used for flushing in Cheung Chau.*

(b) the problem of the substantial inflow and infiltration of seawater into the sewerage system of Cheung Chau was recognised in 1985-86 soon after the commissioning of the system. To mitigate the problem:

(i) baffle walls were constructed in each stormwater overflow chamber to minimise the inflow of seawater into the sewerage system (see also Note 22 to paragraph 4.2 above); and

(ii) the DSD relaid partly the trunk sewer along the west coast of Cheung Chau; and

(c) the problem of inflow and infiltration of seawater could be reduced but not eliminated because of the nature of the sewerage system of Cheung Chau. However, so far the quality of treatment had not been adversely affected. The CCSTW had complied with the two effluent standards, namely Biochemical Oxygen Demand and total suspended solids, specified in the EPD's licences for effluent discharge.

Measures implemented by the TDD to mitigate the problem

4.5 According to the TDD, it had also implemented the following measures to mitigate the problem of inflow and infiltration of seawater into the sewerage system of Cheung Chau:

(a) the TDD had constructed six stormwater overflow chambers as part of the improvement works to provide a separate sewerage system at Cheung Chau Old Town under a works contract which commenced in April 1997. Baffle walls were provided in three stormwater overflow chambers to prevent backflow of seawater into the sewerage system of Cheung Chau; and

(b) the TDD had reconstructed about 100 metres of sewers at Tai Hing Tai Road on Cheung Chau.

Audit observations on inflow and infiltration of seawater into the sewerage system of Cheung Chau

4.6 The sewage flowing into the CCSTW contained a high proportion of seawater. A reason for this was the inflow and infiltration of seawater into the sewerage system due to the defects and the damage to sewers and manholes. **The DSD and the TDD had implemented measures to mitigate the problem. While the proportion of seawater had reportedly dropped since 1986, the DSD needs to continue to take positive action to resolve the problem.**

Audit recommendation on inflow and infiltration of seawater into the sewerage system of Cheung Chau

4.7 **Having regard to the fact the problem of inflow and infiltration of seawater into the sewerage system has existed for about 15 years, Audit has *recommended* that the Director of Drainage Services should continue to take positive action to address the problem so as to enhance the CCSTW's efficiency in sewage treatment and to reduce the wear and tear of its equipment.**

Response from the Administration

4.8 The **Director of Drainage Services** has said that:

(a) he fully agrees with the audit recommendation on the issue of the inflow and infiltration of seawater into the sewerage system as mentioned in paragraph 4.7 above;

(b) the DSD acknowledged that, at certain times during the past 15 years, there have been cases of inflow and infiltration of seawater into the sewerage system due to the defects and the damage to sewers and manholes. The sewers and manholes, particularly those near the seawall, have been susceptible to ground movement which has caused a higher than normal incidence of defects and damage; and

(c) the particular problems (mentioned in paragraph 4.3 above) were identified in 1986 and 1994 and were dealt with at the time. The problems identified in 2000 were not the same as those which had previously been identified in 1994 or 1986, but have also been rectified.

4.9 The **Secretary for the Treasury** has said that, with regard to the inflow and infiltration of seawater into the sewerage system of Cheung Chau, the DSD/the EPD should perhaps examine the feasibility and financial implications of providing separate sewerage and drainage systems in the context of the on-going Outlying Islands Sewerage Master Plan study.

Maximum capacity of CCSTW

4.10 ***Maximum flow rate specified in the licence.*** In March 1991, the EPD granted to the CCSTW a licence for the discharge of the effluent. According to the licence, which was renewable every two years, the DSD had to measure the daily flow rate of treated effluent from the CCSTW and report on a monthly basis to the EPD for monitoring purposes. The maximum flow rate specified in the licences of the CCSTW was 12,000 m^3/day.

4.11 Based on the monthly report submitted to the EPD, Audit noted that during the period April 1998 to October 2000, the maximum flow rate (as specified in the licences) had been exceeded in 231 days. Audit also noted that, according to the Design Memorandum of the CCSTW, the maximum capacity of the plant was a flow rate of 16,000 m^3/day. If this maximum flow rate had been applied for and had been granted by the EPD in the licences, the number of days of excess flow rate would have been reduced from 231 days to 23 days.

4.12 ***DSD's explanation.*** In response to Audit's enquiry about which maximum flow rate should have been used in the licences, the DSD said that:

(a) in order to cater for the inflow of polluted stormwater into the combined sewerage system, the maximum capacity of the CCSTW specified in the Design Memorandum was 16,000 m^3/day. The flow rate of 12,000 m^3/day applied for in the licences was based on the sedimentation capacity of the CCSTW; and

(b) it would be difficult to set a realistic maximum flow rate figure for a combined sewerage system. This was because besides the sedimentation capacity, the treatment plant had to handle all the sewage flow entering it, including seawater.

Audit observations on the maximum capacity of CCSTW

4.13 **As mentioned in paragraph 4.11 above, from April 1998 to October 2000, the maximum flow rate of 12,000 m^3/day as specified in the licences of the CCSTW had been exceeded in 231 days. This constituted a contravention of the Water Pollution Control (General) Regulations. However, if the maximum flow rate (as specified in the Design Memorandum of the CCSTW) of 16,000 m^3/day had been allowed in the licences, the number of days of excess flow rate would have been reduced from 231 days to 23 days. Audit considers that the DSD needs to evaluate the optimal maximum flow rate of the CCSTW and, where appropriate, apply to the EPD for a revised maximum flow rate to be specified in the licence. This would affect the assessment of whether or not, and to what extent, the CCSTW had complied with the licensing condition. It is necessary for the DSD to resolve the problem of non-compliance with the licensing condition as soon as possible.**

Audit recommendations on the maximum capacity of CCSTW

4.14 **Audit has *recommended* that the Director of Drainage Services should:**

(a) **take action to ensure that the sewage treatment plants comply with the licensing conditions for effluent discharge;**

(b) **ascertain the most appropriate licensing conditions for the discharge of effluent from a particular sewage treatment plant, and ensure that such conditions are stated in the licence application to be submitted to the EPD; and**

(c) **where a change in licensing conditions is considered necessary, such as the maximum flow rate of a sewage treatment plant, apply to the EPD for a variation of the licensing conditions as soon as possible.**

Response from the Administration

4.15 The **Director of Drainage Services** has said that:

(a) he agrees with the audit recommendation that, where a change in licensing conditions is considered necessary, the DSD should apply to the EPD for a variation as soon as possible;

(b) the DSD will continue to work closely with the EPD to ascertain the most appropriate licensing conditions for the discharge of effluent from the sewage treatment plants to be operated and maintained by the DSD; and

(c) the last time the DSD applied for the renewal of the licence of the CCSTW was in May 1999. At that time, the flow rate during the dry season was generally within the licensing conditions. There was no strong justification for the DSD to apply for a maximum flow rate higher than 12,000 m^3/day. The DSD will discuss with the EPD the possibility of revising the maximum flow rate specified in the licence prior to the next renewal of the licence.

PART 5: CONTRACTING-OUT OPPORTUNITIES AND THE USE OF A MOBILE TEAM

5.1 This PART examines the contracting-out opportunities for the operation and maintenance of the sewage treatment plants, and the possibility of using mobile teams to patrol the sewage pumping stations, instead of using staff who are stationed at the sewage pumping stations. The audit has revealed that there are contracting-out opportunities which the DSD could explore (see paragraphs 5.2 to 5.5 below for details), and that the DSD should explore the possibility of using mobile teams to patrol the sewage pumping stations (see paragraphs 5.7 to 5.13 below for details).

Contracting-out opportunities

5.2 In 1998, the Government launched the Enhanced Productivity Programme. The aim of the programme is to improve productivity and efficiency across the Government with a view to releasing resources from the baseline to fund new initiatives. Under the programme, departments are required to identify savings through a variety of measures. One of the measures is to contract out work where it is more cost-effective to do so.

5.3 The operation and maintenance of the sewage treatment plants is being partly carried out by the in-house staff of the DSD. In addition to the disposal of sludge, a considerable amount of maintenance work has been contracted out. In the next few years, a number of new sewage treatment facilities will be commissioned and additional staff will be required to operate and maintain these facilities. However, the DSD does not intend to increase its staff establishment. Concerning the new staffing needs, in October 2000, the DSD informed the Civil Service Bureau that it was exploring the feasibility of:

(a) meeting all new staffing needs by employing non-civil service contract staff in the short term and by other means of outsourcing in the long term; and

(b) adopting a design, build and operate contract arrangement for the provision of some new sewage treatment facilities so that the completed facilities will be managed by the contractors who design and build them.

Audit observations on contracting-out opportunities

5.4 The DSD is exploring the feasibility of outsourcing the operation and maintenance of its sewage treatment plants and of using the design, build and operate contract arrangement for the provision of some new treatment facilities. Audit welcomes the DSD's initiative. **Audit considers that the DSD should also consider contracting out the operation and maintenance of some existing sewage treatment plants so as to assess the cost-effectiveness of contracting out and to gain experience in managing the contractor's staff.**

Audit recommendations on contracting-out opportunities

5.5 **Audit has *recommended* that the Director of Drainage Services should:**

(a) **consider contracting out the operation and maintenance of some sewage treatment plants so as to evaluate the cost-effectiveness of contracting out; and**

(b) **assess the cost-effectiveness of adopting the design, build and operate contract arrangement with a view to adopting such an arrangement for the provision of new sewage treatment facilities at an earlier date.**

Response from the Administration

5.6 The **Director of Drainage Services** has said that the DSD is actively pursuing the feasibility of contracting out the operation and maintenance of sewage treatment plants. Over the next few years, the DSD will contract out the operation and maintenance of a number of plants. The design, build and operate contract arrangement will also be considered and implemented as appropriate.

Possibility of using mobile teams to patrol the sewage pumping stations

5.7 As mentioned in paragraph 1.12 above, Audit selected the sewage pumping stations in the central district of Kowloon (Note 25) for review. This district was selected because it was one of the areas with the highest number (19) of sewage pumping stations.

5.8 As at October 2000, of the 19 sewage pumping stations, 17 stations were in operation. Two sewage pumping stations were temporarily closed (Note 26). Of the 17 sewage pumping stations:

(a) 1 sewage pumping station (i.e. the Hung Hom Bay sewage pumping station) was manned on a 24-hour and three-shift basis. This station was the control centre of the district and it monitored the operation of all the 17 sewage pumping stations;

(b) 6 sewage pumping stations were manned during daytime (i.e. with staff in attendance); and

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Note 25: *The central district of Kowloon means the east, south and central areas of Kowloon (i.e. Yau Tong, Kwun Tong, Ngau Tau Kok, Kowloon Bay, San Po Kong, Ma Tau Kok, Hung Hom and Lai Chi Kok).*

Note 26: *Kai Tak Airport No. 1 and No. 2 sewage pumping chambers were temporarily closed.*

(c) 10 sewage pumping stations were unmanned (Note 27).

5.9 As at October 2000, the 17 sewage pumping stations were operated and maintained by 31 staff (see Appendix C for details). The deployment of the 31 staff was as follows:

(a) 2 supervisory staff supervised the overall operation and maintenance of the 17 sewage pumping stations;

(b) 11 staff were stationed at the Hung Hom Bay sewage pumping station;

(c) 10 staff were stationed during daytime at the 6 sewage pumping stations mentioned in paragraph 5.8(b) above (see also Appendix C);

(d) a 2-member team consisting of 1 Works Supervisor and 1 Artisan patrolled 5 of the 10 unmanned sewage pumping stations (see paragraph 5.8(c) above). The other 5 unmanned sewage pumping stations were patrolled by staff who manned the sewage pumping stations in the vicinity (see Appendix D for details); and

(e) a team consisting of 6 staff carried out major maintenance work of all 17 sewage pumping stations.

5.10 ***Patrolling of unmanned sewage pumping stations.*** According to Part 2 (Pumping Stations and Rising Mains) of the DSD's Sewerage Manual, all unmanned sewage pumping stations should be patrolled at least once a day. The duty of patrolling the 10 unmanned sewage pumping stations was carried out by the staff of the mobile team, and the staff who manned the sewage pumping stations in the vicinity (see paragraph 5.9(d) above). The staff were responsible for inspecting the equipment, carrying out minor maintenance work and reporting faults to the district control centre. Major maintenance work was carried out by the maintenance team (see paragraph 5.9(e) above).

5.11 ***Remote-monitored devices installed in manned sewage pumping stations.*** Similar to the 10 unmanned sewage pumping stations, the 6 manned ones had also been equipped with remote-monitored devices and could therefore also be monitored by the staff at the Hung Hom Bay sewage pumping station.

Note 27: *The 10 unmanned sewage pumping stations are equipped with telemetry systems and/or auto-diallers (i.e. remote-monitored devices). Telemetry systems are used to relay signals from the unmanned sewage pumping stations to the manned sewage pumping stations for monitoring operation. The fault signals of the telemetry systems and the auto-diallers of these 10 unmanned sewage pumping stations are relayed to the Hung Hom Bay sewage pumping station for monitoring purposes.*

Audit observations on the possibility of using a mobile team

5.12 As mentioned in paragraph 5.8(c) above, ten sewage pumping stations of the central district of Kowloon were unmanned. However, six sewage pumping stations were manned during daytime. These six sewage pumping stations are within reasonable travelling distances in the central district of Kowloon and their operation can be monitored at the Hung Hom Bay sewage pumping station. Audit considers that these six sewage pumping stations, especially the Kai Tak No. 2 and No. 4 sewage pumping stations which receive low sewage flow, do not need to be manned during daytime. **In Audit's view, the DSD should consider the use of a mobile team to patrol these six sewage pumping stations instead of stationing staff there during daytime. Audit estimates that eight staff (i.e. 26% of all the staff responsible for overseeing the sewage pumping stations of the central district of Kowloon) can be saved if a mobile team is used to patrol the six sewage pumping stations which are presently manned, with a potential saving of $1.4 million a year (see Appendix E). The surplus staff can be gainfully deployed to fill vacancies elsewhere, such as those in the new sewage treatment plants. Regarding the five unmanned sewage pumping stations (which were patrolled by staff of the presently manned sewage pumping stations — see paragraph 5.9(d) above), they could also be patrolled by the existing mobile team, and/or by a new mobile team to be formed. Based on Audit's discussion with the DSD, the DSD supports Audit's proposal of exploring the possibility of using a mobile team to patrol the six sewage pumping stations which are presently manned during daytime.**

Audit recommendation on the possibility of using a mobile team

5.13 **Audit has *recommended* that the Director of Drainage Services should consider the possibility of using a mobile team to patrol those sewage pumping stations which are presently manned (such as the six sewage pumping stations in the central district of Kowloon) in order to achieve savings by not stationing staff there.**

Response from the Administration

5.14 The **Director of Drainage Services** has said that:

(a) he agrees with the audit recommendation on the possibility of using a mobile team as mentioned in paragraph 5.13 above; and

(b) the DSD has been using mobile teams to patrol unmanned facilities for quite some time. The DSD will continue to increase the use of mobile teams, taking into consideration the location and complexity of the equipment, and the need to maintain the integrity of the plants.

PART 6: MAINTENANCE MANAGEMENT SYSTEM AND COST COMPARISON OF SEWAGE TREATMENT PLANTS

6.1 This PART examines the maintenance management system and the comparison of cost of operating and maintaining different sewage treatment plants. The audit has revealed that there is room for improvement in the maintenance management system of the sewage treatment plants (see paragraphs 6.2 to 6.10 below). The audit has also revealed that there were significant cost variances among different sewage treatment plants (see paragraphs 6.13 to 6.17 below).

6.2 As mentioned in paragraph 1.11 above, Audit selected the STSTW for review. As at April 2000, there were 113 staff in the STSTW. Audit conducted a review of the STSTW's maintenance management system which is used for capturing the time spent by staff on maintenance work.

Planned Engineering Maintenance and Stores Control System

6.3 In July 1996, the DSD installed a computerised job accounting and stores control system, called the Planned Engineering Maintenance and Stores Control System (PEMAC) at the STSTW. PEMAC was set up for trial run at the STSTW with a view to extending PEMAC to other sewage treatment plants if the trial run was successful.

6.4 Under PEMAC, the officer-in-charge (usually a Senior Mechanical Inspector) issued maintenance work orders to the Artisan and Workman grade staff on a daily basis. In general, the work orders were issued to 33 Artisan and Workman grade staff (Note 28) to perform electrical and mechanical maintenance work. They were required to record on the work orders, among other things, the commencement and the completion dates of the work and the time taken to complete the work. However, no estimates of the time required for the completion of the work orders were made. Upon the completion of a work order, the officer-in-charge checked the work order to satisfy himself that the work had been satisfactorily completed. A Works Supervisor was also required to check and sign on the work orders. The data in the work orders were then input into PEMAC.

Audit's analysis of time spent by staff on maintenance work

6.5 PEMAC is capable of producing regularly management reports on the time spent by the staff on the maintenance work. However, no management reports had been produced. Audit therefore requested the DSD to produce special reports from PEMAC for the year 1999-2000 and for the period 1 April 2000 to 31 October 2000. Based on these special reports, Audit analysed the time spent by the 33 Artisan and Workman grade staff on the maintenance work. The results of the analysis (see Appendix F for details) are as follows:

Note 28: *The 33 staff comprised 8 Senior Artisans, 13 Artisans, 9 Workmen I and 3 Workmen II.*

(a) ***For 1999-2000.*** The time spent by the staff on the maintenance work captured by PEMAC was only 20% (or 14,177 hours) of the total conditioned hours of the 33 Artisan and Workman grade staff concerned (Note 29). Thus, 80% (or 57,862 hours) of their time was not captured by PEMAC. The DSD explained that PEMAC was not in full operation until April 2000. Hence, the percentage of work captured by PEMAC was low. Of the work captured by PEMAC, 91% was unplanned and only 9% was planned; and

(b) ***From 1 April 2000 to 31 October 2000.*** The time spent by the staff on the maintenance work captured by PEMAC was only 53% (or 22,249 hours) of the total conditioned hours of all the staff concerned. Thus, 47% (or 19,774 hours) of their time was not captured by PEMAC. Of the work captured by PEMAC, 77% was unplanned and only 23% was planned.

Audit observations on PEMAC

6.6 ***PEMAC not fully utilised to provide management information.*** **Notwithstanding that PEMAC had been installed at the STSTW for trial run since July 1996, it was not in full operation until April 2000. The work orders completed prior to April 2000 were not fully captured by PEMAC.** The DSD did not regularly produce management information from PEMAC to analyse the time spent by its staff on maintenance work. Audit's analysis of the special report produced by PEMAC for the period April 2000 to October 2000 (i.e. after PEMAC had been in full operation) revealed that 47% of the conditioned hours of the STSTW's staff was still not captured by PEMAC. **Audit considers that there is room for improvement in using PEMAC for producing management information. The time spent by the STSTW's staff on maintenance work should be fully captured.**

6.7 ***No estimate of the time required for completion of a work order.*** Audit noted that the DSD did not make estimates of the time required for the completion of work orders. The supervisory staff mainly relied on their experience and judgement to monitor the progress of work. **Audit considers that it is a good management practice to set an estimated time required for the completion of a work order for monitoring purposes.**

6.8 ***Substantial unplanned maintenance work.*** Audit's analysis also revealed that unplanned maintenance work accounted for about 77% for the total maintenance work captured by PEMAC for the period April 2000 to October 2000. **In Audit's view, PEMAC should be used to facilitate the planning of future maintenance work.**

Note 29: *According to the Civil Service Regulations, "conditioned hours" means hours of duty which salary is calculated to cover. Conditioned hours may be expressed as gross (i.e. including lunch breaks) or net (i.e. excluding lunch breaks). The 33 Artisan and Workman grade staff's conditioned hours were 45 hours net per week (i.e. net annual working hours of 2,183).*

6.9 ***Audit's enquiry about the utilisation of PEMAC.*** In response to Audit's enquiry concerning the utilisation of PEMAC as mentioned in paragraphs 6.6 to 6.8 above, the DSD said that:

(a) not all the time spent by its staff on a work order had been recorded, especially when the staff concerned were working on more than one work orders; and

(b) the supervisors had been encouraged to record more accurately the time spent by staff on each work order. This should be reflected in the figures for the recent months.

Audit recommendations on PEMAC

6.10 **Audit has *recommended* that the Director of Drainage Services should:**

(a) **require staff to record fully the time spent on a work order for maintenance work;**

(b) **input promptly the time spent by staff on work orders into PEMAC;**

(c) **make use of PEMAC to facilitate the planning of future maintenance work;**

(d) **produce reports regularly from PEMAC on the time spent by staff on maintenance work for management information and monitoring purposes;**

(e) **estimate the time required for the completion of a maintenance work order so as to effectively monitor the progress of the maintenance work;**

(f) **critically consider whether it is practicable and cost-effective to increase the proportion of planned maintenance work; and**

(g) **consider setting up a computerised management information system, such as PEMAC, at other major sewage treatment plants so as to record the time spent by staff on maintenance work and to monitor the progress.**

Response from the Administration

6.11 The **Director of Drainage Services** has said that:

(a) he generally agrees with the audit recommendations on PEMAC as mentioned in paragraph 6.10 above. The DSD will investigate the feasibility of producing regular reports on the time spent by staff on maintenance work from PEMAC;

(b) the delay in implementing PEMAC was mainly due to the time taken in the development and the implementation of the application programs, including the Chinese input/output forms, by in-house staff; and

(c) the proportion of unplanned maintenance work for the STSTW has been higher in recent years mainly due to the overloading of the plant (see Part 3, paragraph 3.6(a)(i) above). In general, it is the DSD's objective to carry out preventive maintenance work in accordance with the manufacturer's recommendations, modified as necessary based upon the DSD's experience.

6.12 The **Secretary for the Treasury** has said that she fully concurs with the audit recommendation that reports should be produced regularly from PEMAC on the time spent by staff on maintenance work for management information and monitoring purposes.

Comparison of cost of operating and maintaining different sewage treatment plants

6.13 As mentioned in paragraph 1.11 above, Audit selected three major secondary sewage treatment plants (i.e. the STSTW, the TPSTW and the SWHTW) for review. Based on the information in the Ledger Accounting and Financial Information System (LAFIS) of the Treasury and sewage flow records of the DSD, Audit analysed and compared the recurrent cost per unit of sewage treated (hereinafter referred to as the unit treatment cost) of the three major secondary sewage treatment plants (see Appendix G for the calculation of the unit treatment cost). For the two years 1998-99 and 1999-2000, the results of the cost comparison:

(a) of the unit treatment cost of the plants are shown in Table 6 below; and

(b) of these two years are shown in Table 7 below.

Table 6

Comparison of unit treatment cost among the plants

(A) Unit treatment cost

	STSTW	TPSTW (Note A)	SWHTW
1998-99 (Note B)	$1.17/m^3	$1.62/m^3	$1.35/m^3
1999-2000 (Note B)	$1.13/m^3	$1.81/m^3	$1.32/m^3

(B) Comparison of unit treatment cost between TPSTW and the other two plants

	1998-99		1999-2000	
Unit treatment cost of TPSTW higher than that of STSTW by (Note C)	$0.45/m^3	38%	$0.68/m^3	**60%**
Unit treatment cost of TPSTW higher than that of SWHTW by (Note D)	$0.27/m^3	20%	$0.49/m^3	**37%**

Source: *Audit's analysis based on the DSD's records*

Note A: *The TPSTW had the highest unit treatment cost among the three sewage treatment plants.*

Note B: *The calculation of unit treatment cost is at Appendix G.*

Note C: *The higher unit treatment costs of $\$0.45/m^3$ and $\$0.68/m^3$ are equal to $\$1.62/m^3$ - $\$1.17/m^3$ and $\$1.81/m^3$ - $\$1.13/m^3$ respectively. The increases in percentage of 38% and 60% are equal to $\$0.45/m^3 \div \$1.17/m^3 \times 100\%$ and $\$0.68/m^3 \div \$1.13/m^3 \times 100\%$ respectively.*

Note D: *The higher unit treatment costs of $\$0.27/m^3$ and $\$0.49/m^3$ are equal to $\$1.62/m^3$ - $\$1.35/m^3$ and $\$1.81/m^3$ - $\$1.32/m^3$ respectively. The increases in percentage of 20% and 37% are equal to $\$0.27/m^3 \div \$1.35/m^3 \times 100\%$ and $\$0.49/m^3 \div \$1.32/m^3 \times 100\%$ respectively.*

Table 7

Comparison of unit treatment cost between 1998-99 and 1999-2000

Treatment plant	Unit treatment cost		1999-2000 cost more (or less) than 1998-99 cost	
	1998-99	1999-2000	Cost	Percentage
	(a)	(b)	(c) = (b) - (a)	(d) = (c) ÷ (a) × 100%
STSTW	$1.17/m^3	$1.13/m^3	($0.04/m^3)	(3%)
TPSTW	$1.62/m^3	$1.81/m^3	$0.19/m^3	12%
SWHTW	$1.35/m^3	$1.32/m^3	($0.03/m^3)	(2%)

Source: Audit's analysis based on the DSD's record

Audit observations on cost comparison

6.14 As shown in Table 6 and Table 7 in paragraph 6.13 above:

(a) ***Comparison among the plants***. The unit treatment costs were different among the three sewage treatment plants. **There were significant differences in the unit treatment costs of the TPSTW and the other two sewage treatment plants. In both 1998-99 and 1999-2000, the unit treatment costs of the TPSTW were higher than those of the STSTW and the SWHTW.** In particular, in 1999-2000, the unit treatment cost of the TPSTW was higher than that of the STSTW and that of the SWHTW by 60% and 37% respectively; and

(b) ***Comparison between 1998-99 and 1999-2000.*** **The unit treatment cost of the TPSTW for 1999-2000 was 12% higher than that of 1998-99.** On the other hand, the unit treatment costs of the STSTW and the SWHTW for 1999-2000 were lower than those of 1998-99.

6.15 Audit considers that cost comparisons provide useful information to the senior management of the DSD in highlighting areas for further investigation. **Based on Audit's discussion with the DSD, the DSD agrees to ascertain the reasons for the variances in the unit treatment costs among the plants. The DSD also agrees to perform cost comparisons among the secondary sewage treatment plants on a regular basis.**

6.16 Audit noted that the DSD did not have readily available information on the recurrent cost of individual preliminary sewage treatment plants because there were no separate cost centres for each plant in LAFIS. Therefore, the DSD could not readily compare the unit treatment costs among the preliminary sewage treatment plants. **Based on Audit's discussion with the DSD, the DSD agrees to consider creating separate cost centres for the major preliminary sewage treatment plants.**

Audit recommendations on cost comparison

6.17 **Audit has *recommended* that the Director of Drainage Services should:**

(a) **create separate cost centres for the major preliminary sewage treatment plants so that regular comparisons of the unit treatment costs among them can be made; and**

(b) **compare regularly the unit treatment costs of sewage treatment plants and analyse the reasons for any significant variances in order to provide a useful management tool for monitoring their costs.**

Response from the Administration

6.18 The **Director of Drainage Services** has said that:

(a) he agrees with the audit recommendations on cost comparison as mentioned in paragraph 6.17 above; and

(b) one of the reasons that the unit treatment costs of the TPSTW were higher than those of the STSTW and the SWHTW is that the TPSTW consists of two separate treatment streams. One treatment stream receives sewage flow from the Tai Po Industrial Estate and the Tai Po old town, and the other receives sewage flow from the Tai Po new town. The only sewage treatment process common to both the streams is the sludge dewatering process. While the total volume of sewage being treated at the TPSTW is comparatively low, the number of sewage treatment units is similar to that at the STSTW. As a result, the TPSTW has relatively higher maintenance and operation costs per m^3 of sewage treated.

6.19 The **Secretary for the Treasury** has said that she fully supports the audit recommendation that separate cost centres should be created for the major preliminary sewage treatment plants so that comparisons of the unit treatment costs among them can be made.

Appendix A
(paragraph 3.4 refers)

Effluent standards specified in the licences of the STSTW

	Period	Biochemical Oxygen Demand		Total suspended solids		Total nitrogen	
		Maximum standard (mg/l)	Percentile standard (mg/l)	Maximum standard (mg/l)	Percentile standard (mg/l)	Maximum standard (mg/l)	Percentile standard (mg/l)
(a)	30.11.1990 – 21.4.1993	20	N.A.	30	N.A.	20	N.A.
(b)	22.4.1993 – 27.3.1995	20	N.A.	30	N.A.	20	N.A.
(c)	28.3.1995 – 5.8.1997	20	N.A.	30	N.A.	20	N.A.
(d)	6.8.1997 – 27.12.1999	40	20	60	30	40	20
(e)	28.12.1999 – 31.12.2001	40	20	60	30	50	25

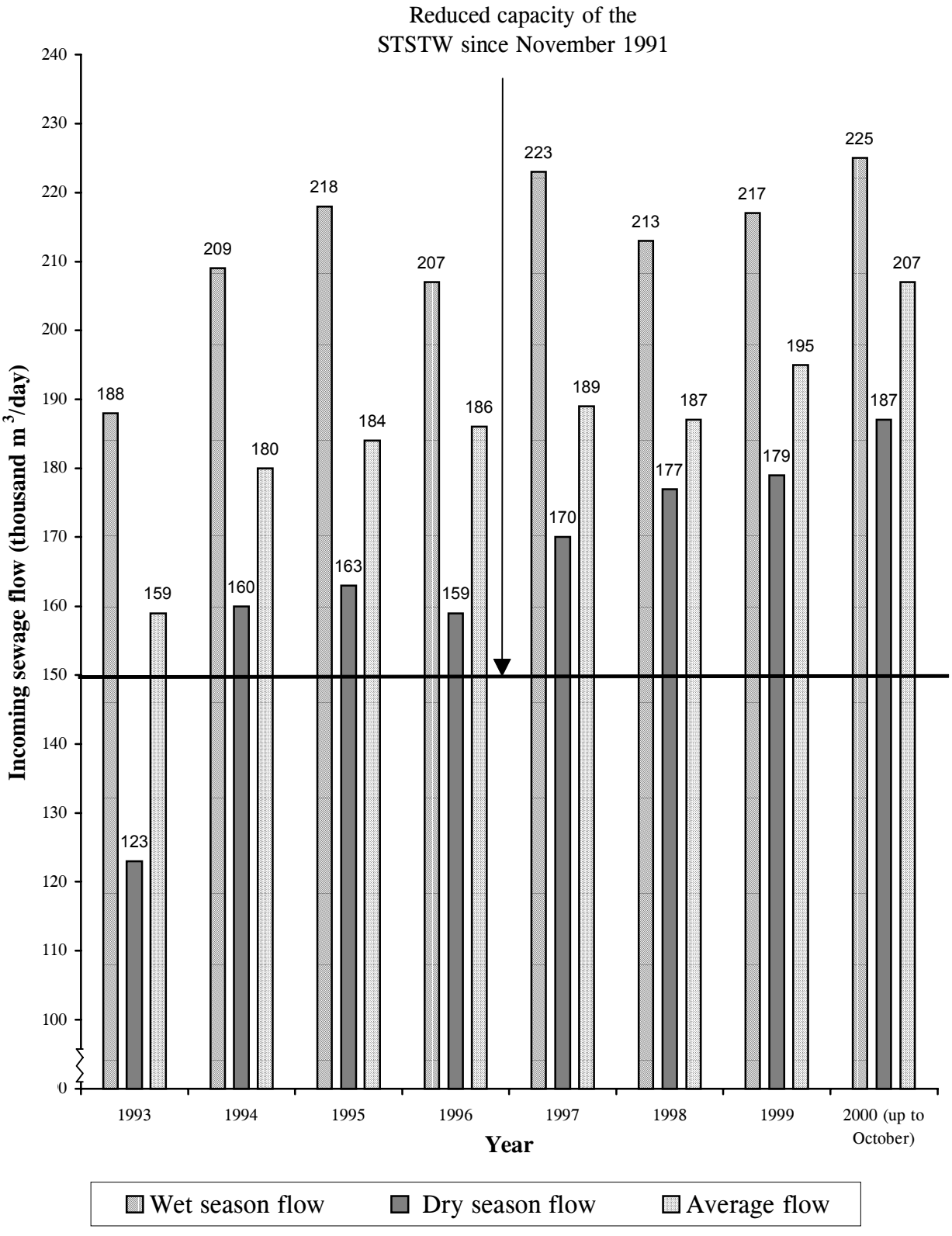
Legend: mg/l stands for milligrammes per litre

Source: Licences of the STSTW

Note: The current maximum flow rate specified in the licence in item (e) above is 450,000 m^3/day. The maximum flow rate specified in licences in items (a) to (d) above was 620,000 m^3/day.

Appendix B
(paragraphs 3.6 and 3.9 refer)

Incoming sewage flow of the STSTW from 1993 to 2000



Source: DSD's records

Appendix C
(paragraph 5.9 refers)

Distribution of staff responsible for operating and maintaining the sewage pumping stations in the central district of Kowloon

	Assistant Inspector/ Works Supervisor I	Works Supervisor II	Senior Artisan	Artisan	Workman I	Workman II	Total	
	(a)	(b)	(c)	(d)	(e)	(f)	(g) = (a) + (b) + (c) + (d) + (e) + (f)	
(a) Officer-in-charge	2 (Note)						2	
(b) District control centre at Hung Hom Bay sewage pumping station		1	1	3	2	4	11	
(c) **6 manned sewage pumping stations**								
(i) Kai Tak No. 2 sewage pumping station						1	1	10
(ii) Kai Tak No. 4 sewage pumping station					1		1	
(iii) Kowloon East Dry Weather Flow Interception sewage pumping station				1			1	
(iv) Kwun Tong intermediate sewage pumping station		1	1			2	4	
(v) Yau Tong sewage pumping station						1	1	
(vi) Whampoa Garden sewage pumping station					1	1	2	
(d) Mobile team		1		1			2	
(e) Maintenance team			1	4	1		6	
Total	2	3	3	9	5	9	**31**	

Source: DSD's records

Note: Two staff (Assistant Inspector and Works Supervisor I) were the officers-in-charge of the sewage pumping stations of the central district of Kowloon. They were stationed in the Kowloon East Dry Weather Flow Interception sewage pumping station.

Appendix D
(paragraph 5.9 refers)

Patrol of unmanned sewage pumping stations in the central district of Kowloon

	Unmanned sewage pumping station	Patrolled by
1.	Kai Tak No. 1 sewage pumping station	Mobile team
2.	Kai Tak No. 3 sewage pumping station	Mobile team
3.	Kau Wah Keng sewage pumping station	Mobile team
4.	San Po Kong sewage pumping chamber	Staff of the Kowloon East Dry Weather Flow Interception sewage pumping station
5.	Tai Hum Chuen sewage pumping chamber	Staff of the Kai Tak No. 2 sewage pumping station
6.	Kowloon Bay sewage pumping chamber	Mobile team
7.	Ngau Tau Kok sewage pumping chamber	Mobile team
8.	Sam Ka Tsuen sewage pumping chamber	Staff of the Yau Tong sewage pumping station
9.	Wan Hoi Street sewage pumping chamber	Staff of the Whampoa Garden sewage pumping station
10.	Winslow Street sewage pumping station	Staff of the Whampoa Garden sewage pumping station

Source: DSD's records

Appendix E
(paragraph 5.12 refers)

Potential saving if a mobile team is used to patrol the six sewage pumping stations

Rank	No. of staff stationed during daytime in the six sewage pumping stations	No. of staff in the mobile team	No. of staff saved	Annual staff cost (Note)	Potential saving a year
	(a)	(b)	(c) = (a) - (b)	(d)	(e) = (c) × (d)
Works Supervisor II	1	1	—	$287,376	—
Senior Artisan	1	—	1	$247,416	$247,416
Artisan	1	1	—	$216,828	—
Workman I	2	—	2	$176,496	$352,992
Workman II	5	—	5	$159,840	$799,200
Total	**10**	**2**	**8**		**$1,399,608**
					(say $1.4 million)

Source: Audit's analysis

Note: The annual staff cost is based on the Government's Staff Cost Ready Reckoner of 2000-2001.

Appendix F
(paragraph 6.5 refers)

Audit analysis of time spent on maintenance work captured by PEMAC

	Time captured by PEMAC			Time not captured by PEMAC
	Planned work	**Unplanned work**	**Total**	
	(a)	**(b)**	**(c) = (a) + (b)**	**(d)**
	(hours)	**(hours)**	**(hours)**	**(hours)**
(A) 1999-2000				
	1,272	12,905	14,177	57,862 (Note 1)
Percentage of planned work	9%			
Percentage of unplanned work		91%		
Percentage of time captured			20% (Note 2)	
Percentage of time not captured				80%
(B) 1 April 2000 to 31 October 2000				
	5,104	17,145	22,249	19,774 (Note 1)
Percentage of planned work	23%			
Percentage of unplanned work		77%		
Percentage of time captured			53%	
Percentage of time not captured				47%

Source: *PEMAC*

Note 1: *The total conditioned hours is equal to the 2,183 conditioned hours for each staff × 33 staff (see paragraph 6.5(a) above), i.e. 72,039 hours. The time which was not captured by PEMAC is calculated as follows:*

(a) 1999-2000 = 72,039 hours - 14,177 hours = 57,862 hours; and
(b) 1 April 2000 to 31 October 2000 = 72,039 hours × 7 ¸ 12 - 22,249 hours = 19,774 hours.

Note 2: *Upon Audit's enquiry concerning the low percentage of time captured by PEMAC for 1999-2000, the DSD explained that PEMAC was not in full operation until 1 April 2000.*

Appendix G
(paragraph 6.13 refers)

Calculation of unit treatment cost

		STSTW	**TPSTW**	**SWHTW**
	1998-99			
(a)	Recurrent cost ($'000)	80,483	46,545	30,399
(b)	Volume of sewage treated (thousand m^3)	68,589	28,712	22,513
(c) = (a) ÷ (b)	**Unit treatment cost ($/m^3)**	**1.17**	**1.62**	**1.35**
	1999-2000			
(d)	Recurrent cost ($'000)	81,831	52,208	30,847
(e)	Volume of sewage treated (thousand m^3)	72,111	28,821	23,327
(f) = (d) ÷ (e)	**Unit treatment cost ($/m^3)**	**1.13**	**1.81**	**1.32**

Source: Audit's calculation based on the DSD's records

Chronology of key events

Leakage of treated effluent into the Tolo Harbour

1990	The EPD granted the DSD a licence for discharging the STSTW's treated effluent into the Tolo Harbour.
1993	The DSD installed a temporary stop log at the inlet chamber of the Sha Tin pumping station.
August 1997	The EPD changed the conditions of the licence so that the licence contained two parts. One part of the licence was for the normal discharge of the effluent into the Victoria Harbour. The other part of the licence was for the discharge of the effluent into the Tolo Harbour, which was restricted to occasional discharge for the purposes of flushing/emergency operations.
April 1998	The THEES was commissioned on a full-scale basis.
March 2000	The DSD installed a steel cofferdam to replace the temporary stop log.

Non-compliance with effluent standards

1982	Stage 1 of the STSTW was commissioned.
1986	Stage 2 of the STSTW was commissioned. The combined design capacity of stages 1 and 2 of the STSTW was 205,000 m^3/day.
1987	The Government formulated the Tolo Harbour Action Plan which included measures to modify the sewage treatment process of the STSTW in order to increase the extent of removal of nitrogen.
November 1988	The TDD completed a consultancy study to determine the modification of the sewage treatment process that would be required to increase the extent of removal of nitrogen in the treated effluent of the STSTW, from 70% to a target of 90%.
1990	The EPD granted a licence to the STSTW for the discharge of the effluent into the Tolo Harbour.

November 1991	Modification works of the STSTW to increase the extent of removal of nitrogen were completed. The capacity of the STSTW was reduced from 205,000 m^3/day to 150,000 m^3/day.
1993	The average incoming sewage flow of the STSTW started to exceed the reduced capacity of 150,000 m^3/day.
November 1994	The EPD completed a preliminary review on the capacity of the STSTW. The review concluded that there was an imminent overloading situation and that works to extend the capacity of the STSTW should be carried out immediately.
April 1996	The DSD took over from the TDD the implementation of the stage 3 extension works.
April 1996	The TDD's study found that the stage 3 extension works would be required. As the EPD was then carrying out monitoring work on the water quality of the Victoria Harbour, it was therefore inappropriate to proceed with the stage 3 extension works at that time.
December 1996	The EPD advised the DSD on the effluent standards for the stage 3 extension works.
April 1997	The DSD completed an adoptive review to examine the findings of the TDD's consultancy study on the design of the STSTW stage 3 extension works.
August 1997	The EPD changed the conditions of the licence of the STSTW so that the effluent should normally be discharged into the Victoria Harbour. In addition to the maximum standard, a 95 percentile standard was also set in the licence.
November 1997	The DSD and the EPD agreed that the stage 3 extension works would provide an additional capacity of 95,000 m^3/day to give a total capacity of 300,000 m^3/day, assuming that modification of the STSTW could revert its capacity back to the original capacity of 205,000 m^3/day.
April 1998	The DSD informed the EPD that the process of removing total nitrogen was not a major factor that affected the treatment process in the STSTW. The removal of total suspended solids was more likely to be the major factor.

December 1998	The Director of Environmental Protection reported the STSTW's non-compliance with effluent standards specified in the licence to the Lands, Works, Transport, Housing and Environmental Protection Policy Group of the Chief Secretary for Administration's Committee.
December 1999	The EPD relaxed the effluent standards for total nitrogen specified in the licence of the STSTW.
May 2000	The Government sought funding approval for the STSTW stage 3 extension project from the FC.
June 2000	The FC approved the upgrading of the STSTW stage 3 extension project to Category A of the Public Works Programme at an estimated cost of $2,425 million in money-of-the-day prices.
August 2000	The Chief Secretary for Administration was informed that the quality of the effluent of the STSTW would gradually be improved to comply with the effluent standards after the completion of the phase 1 works of the STSTW stage 3 extension project in 2004.

Primary sewage treatment plant

December 1985	The CCSTW was commissioned.
Early 1986	An investigation carried out by the Electrical and Mechanical Services Department revealed that the sewage entering into the CCSTW contained a high proportion of seawater.
March 1991	The EPD granted to the CCSTW a licence for the discharge of the effluent.
Late 1994	The Outlying Islands Sewerage Master Plan study revealed that the inflow and infiltration of seawater into the sewerage system of Cheung Chau was still excessive.
Mid-2000	The Interim Report of Outlying Islands Sewerage Master Plan Stage 2 Review study stated that the inflow and infiltration of seawater into the sewerage system of Cheung Chau remained a significant problem.

Appendix I

Acronyms and abbreviations

CCSTW	Cheung Chau sewage treatment works
DSD	Drainage Services Department
EPD	Environmental Protection Department
FC	Finance Committee
LAFIS	The Ledger Accounting and Financial Information System
m^3	Cubic metres
PEMAC	The Planned Engineering Maintenance and Stores Control System
SSDS	Strategic Sewage Disposal Scheme
STSTW	Sha Tin sewage treatment works
SWHTW	Shek Wu Hui sewage treatment works
TDD	Territory Development Department
THEES	Tolo Harbour Effluent Export Scheme
TPSTW	Tai Po sewage treatment works
WPCO	Water Pollution Control Ordinance