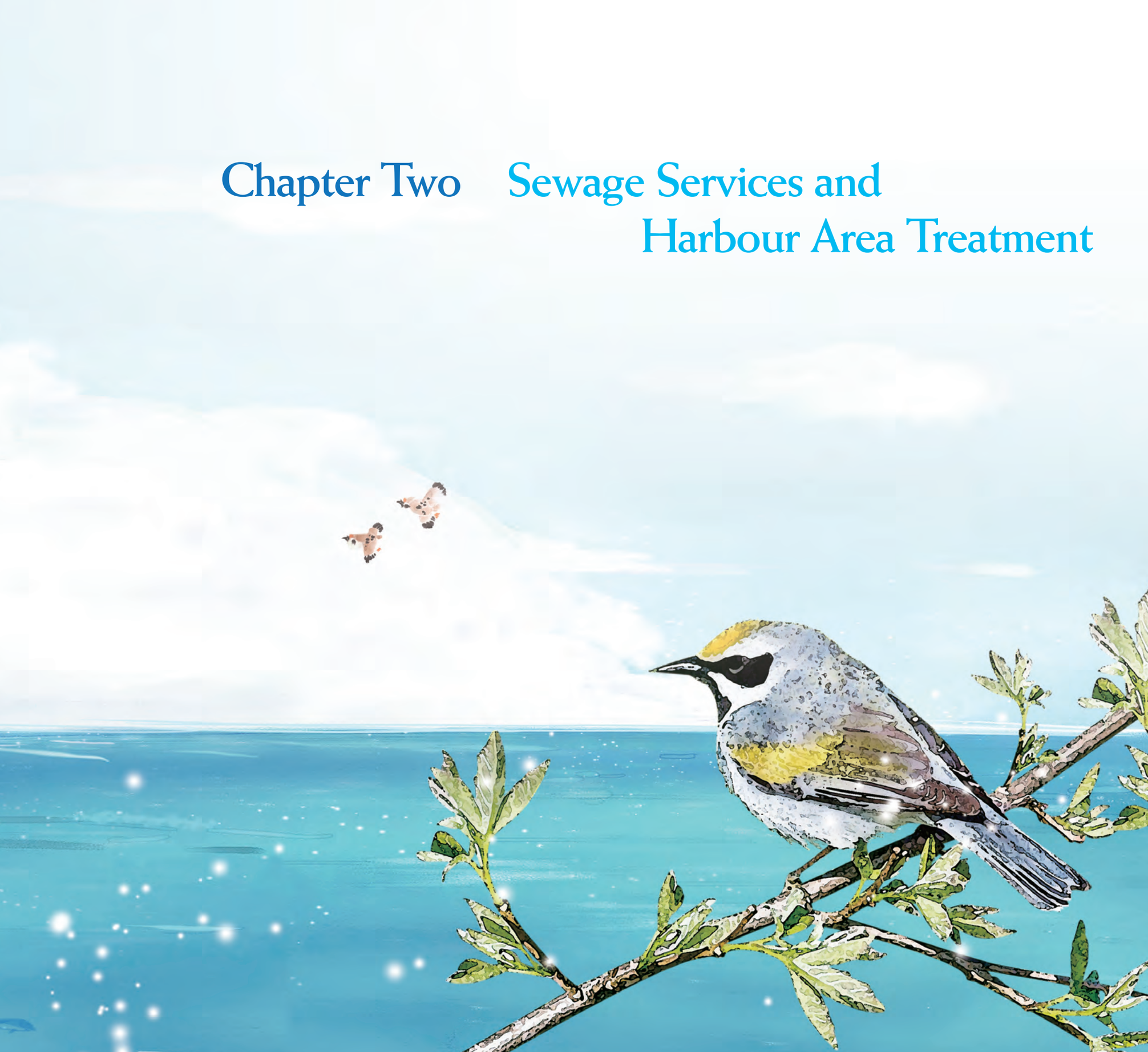
Chapter Two Sewage Services and Harbour Area Treatment



Chapter Two Sewage Services and Harbour Area Treatment

Hong Kong is in possession of a long coastline. The ocean has the natural self-purification capability to dilute and decompose pollutants in waters. However, to treat large amounts of sewage generated due to rapid population growth and industrial development, we need appropriate water quality control measures. The Government completed the Report on Marine Investigation into Sewage Discharges in the late 1960s and implemented the Water Pollution Control Ordinance and the Waste Disposal Ordinance. The Sewage Strategy Study was also conducted between 1988 and 1989 to establish a long term strategy for collection, treatment and disposal of wastewater for the territory. They included, inter alia, the formulation of the Strategic Sewage Disposal Scheme, construction of regional sewage collection facilities (such as the Village Sewerage Programme), setting of different sewage treatment levels, extension of sewage disposal systems (such as the Tolo Harbour Effluent Export Scheme) and the enforcement of odour management measures. Successive implementation of these projects helped continuously improve the water quality of our rivers and beaches. Moreover, with the commissioning of Stage 1 of the Strategic Sewage Disposal Scheme (now renamed as the Harbour Area Treatment Scheme) in late 2001, the water quality of Victoria Harbour improved substantially.

Water quality and functions of water bodies in Hong Kong

Hong Kong has unparalleled natural endowments and is blessed with a coastline of over 1 000 km long. Located between Hong Kong Island and the Kowloon Peninsula, Victoria Harbour is one of the busiest harbours in the world. At its south and north sides are hills serving as natural shelters, and at its east and west sides are Lei Yue Mun and Kap Shui Mun respectively. It is an ideal natural harbour deep enough for large vessels to navigate.

With a modest area of waters, Hong Kong sits at the estuary of Pearl River where the waters of sea and river mix. Hong Kong was once a rich fishing ground supporting the fishery development and contributing to our economy. In addition, the long coastline renders Hong Kong suitable for different activities such as mariculture operations, navigation and various water recreational and sports activities. As the water quality requirements of individual activities are different, we need to take them into consideration when adopting water quality control measures. In recent years, the water quality of the harbour has become a concern of the public. Endangered species such as green turtles, horseshoe crabs, Chinese white dolphins and finless porpoises have become symbols of harbour conservation.

As the self-purification capability of the ocean allows dilution or biological decomposition of pollutants in waters, minor water pollution usually has minimal impact on the marine environment. Since the 1950s, a great number of Mainlanders migrated to Hong Kong, stimulating rapid population growth and industrial development. The persistent increase in the quantities of domestic and industrial sewage and industrial discharge affected the water quality of rivers and the harbour. In the late 1960s, being aware of the gravity of the water pollution problem, the Government conducted a territory-wide investigation. In 1971, the Government published the Report on Marine Investigation into Sewage Discharges[1], which was the first blueprint for sewage disposal in Hong Kong. The report assessed the pollution situation in Victoria Harbour, Tolo Harbour and other water bodies, and proposed sewage discharge improvement measures. The Government established the Water Pollution Control Ordinance and the Waste Disposal Ordinance in the 1980s to regulate the disposal of trade effluents and livestock waste.

The Water Pollution Control Ordinance

The Water Pollution Control Ordinance divided Hong Kong waters into ten Water Control Zones and established a set of Water Quality Objectives (WQO) as a benchmark. The objective of the Ordinance is to protect the ocean environment so as to allow marine lives to continue to flourish and at the same time ensure that the water quality is kept to a level which allows sustainable use by the public. In order to improve the water quality, the Government constructs new sewers in different districts, enhances the existing public sewerage facilities, while progressively installs new public sewerage facilities in unsewered areas[2].

The Waste Disposal Ordinance

In the 1980s, the Government formulated the Waste Disposal Ordinance to comprehensively regulate the handling of waste. The Ordinance prohibits waste disposal at public and private places or government land. The Government further introduced legislation to regulate the pollution sources and extended the application of the Ordinance to cover livestock farming, chemical waste disposal, illegal dumping as well as import or export of waste[3].

The Government believed that a comprehensive plan was crucial to effectively tackle the sewage problem in Hong Kong. Between 1988 and 1989, the Government conducted the Sewage Strategy Study to develop a long-term strategy for collection, treatment and disposal of local sewage. The Study recommended two strategies on sewage treatment infrastructure, namely the Strategic Sewage Disposal Scheme and the Sewerage Master Plans (SMPs) at the regional/district level across the territory. The former aims to deal with the urban sewage problem at both sides of Victoria Harbour, whereas the latter is to formulate specific regional SMPs.

The SMPs aim to plan and construct sewage collection facilities, as well as to establish suitable sewage treatment levels and disposal systems based on the pollution characteristics and sensitivity of the waters in individual regions. For commissioning of the proposed facilities, DSD, after continuous assessment and review, completed the works in stages so as to provide Hong Kong with sustainable sewage treatment services and keep the normal functioning of water bodies of the territory.

Functions of water bodies

Marine waters offer various beneficial uses and platforms for activities related to recreation, mariculture, fishing, navigation and sand mining. Seawater can also be used for cooling and flushing. EPD has been monitoring local waters to ensure that the water quality meets the environmental protection requirements of the society.

In general, sanctuaries, mariculture areas, bathing beaches and habitats for important species (like Chinese white dolphin) are classified as waters with more sensitive uses (mostly found in the Eastern and Southern Hong Kong). More stringent Water Quality Objectives are set for these areas. On the other hand, the waters for navigation are classified as less sensitive with less stringent water quality requirements[4].

Sewage treatment services

Population growth entailed fast urbanisation in Hong Kong and generated large amounts of sewage, causing water pollution in our waters particularly in Victoria Harbour. To resolve the water pollution problem, DSD is dedicated to providing sewage treatment services which comprise three components: collection, treatment and disposal.

Sewage collection

The policy objective of developing sewage collection systems is to provide public sewage collection facilities for unsewered areas (including villages) in order to safeguard public health and enhance the nearby water environment to meet WQOs. Sewage collection systems are beneficial to the environment and conducive to reduction of public health risk posed by sewage, removal of pests and odour, and restoration of polluted water bodies back to a balanced ecosystem.

Sewerage Master Plans at the regional/district level across the territory

SMPs at regional/district level across the territory form the blueprint for sewage collection infrastructure of Hong Kong. To facilitate sewage collection, Hong Kong is divided into 16 regions with tailor-made SMPs designed according to the population density and geographical environment of individual regions. The aim is to collect and convey the sewage from the regions to the sewage treatment works for treatment.

Systematic assessments of sewage catchment areas to ascertain regional needs are essential for the planning for sewage collection systems and the mapping out of comprehensive SMPs. Priority regions under SMPs are areas: (1) with water bodies close to or exceeding their assimilative limits; (2) with a high conservation value; and (3) heavily polluted and categorised as an environmental blackspot. Each SMP recommends appropriate sewerage systems, sewage pumping stations and treatment facilities for proper collection, treatment and disposal of sewage from the catchments to cater for the development needs.

To ensure that the works proposed in SMPs could cope with Hong Kong's rapid development, growing population and rising environmental protection standards, the Government regrouped the 16 sewage catchments into eight in 1995 and completed a series of review studies on SMPs.

Village Sewerage Programme

Nowadays, DSD has constructed a sewerage network of about 1 683 km long, serving 93% of the local population. Yet, unlike concentrated settlements in urban areas, settlements in the New Territories are relatively scattered and hence their sewage collection and treatment system is different from that adopted in urban areas. Villages which do not have connections to public sewerage systems are still using septic tanks and soakaway systems for sewage treatment. These commonly used systems can only provide sewage treatment with minimum standard.

Sewage treated by septic tanks still contains a high level of nutrients, organics and micro-organisms. These substances can be naturally decomposed under a soakaway system provided that the ground condition is satisfactory and the development density is low. If the septic tanks and soakaway systems in village houses fail to operate satisfactorily, however, the environment will be polluted and the environmental hygiene jeopardised.

Septic tank system

A septic tank is basically a simple enclosed sewage treatment system constructed underground in front of a building, where the pollutants will be decomposed naturally in soil. Manual clearance of the tank will however be required if the waste is excessive. Space available for building of septic tanks is decreasing following growth in village population and high density of village houses. When the volume of sewage exceeds the natural purification capacity of the soil, the sewage will overflow onto the ground or even into nullahs outside the houses, affecting the environmental hygiene[5].

Operating principle of septic tanks

When sewage enters the septic tank, solid waste sinks to the bottom while grease and other lighter material float to the top and form a layer of scum. The remaining liquid further flows to the soakaway pit, and disperses into surrounding sand and soil which filter and decompose the pollutants.

In response to the need of village sewerage, DSD launched the Village Sewerage Programme to extend the public sewerage network to the vicinity of private land with village houses in order to facilitate connection between private and public sewers. The works resulted in remarkable improvement of the water quality of surrounding watercourses and betterment of the living environment for the villagers.

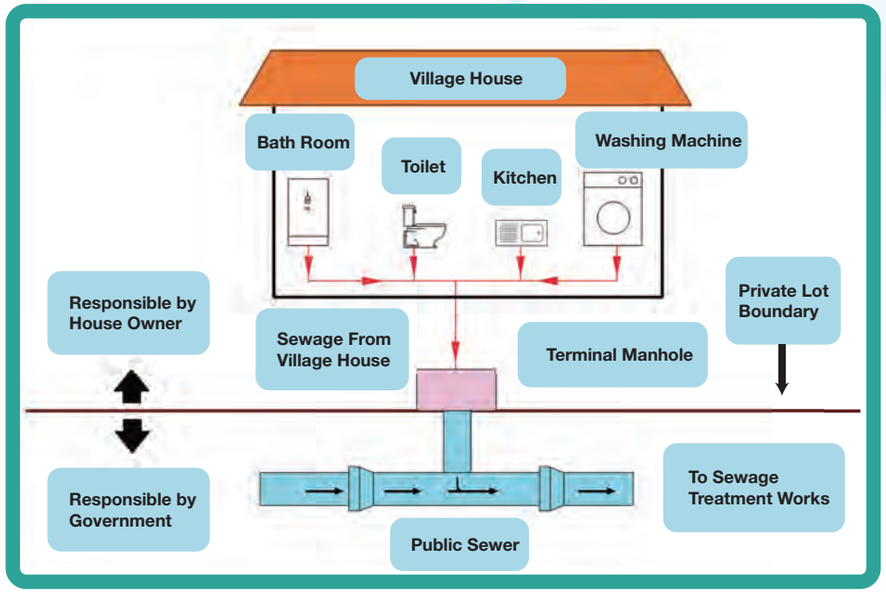


Illustration of village sewer connection

Construction of the sewerage network for villages in Yuen Long

Dilemma in construction stage

Mr Wong Tung-keung, village representative of Ma Tin Tsuen in Shap Pat Heung Yuen Long, New Territories, stated that underground septic tanks were usually installed in the front together with the construction of the houses. At times, however, the sewage seeped out and caused odour. Mr Wong believed that sewer connection to the public sewerage system would be the solution to the problem. Yet, since sewer laying works have to be carried out at the narrow and busy alleys in Ma Tin Tsuen which caused inconvenience to the villagers and affected their normal living. Coupled with the situation that not all households were willing to pay for connecting the private sewers to the public sewerage, the progress of sewer connection was slow.

Mr Wong also pointed out that with excessive sewage remaining in the soil, saturation would eventually occur and give rise to hygienic problems. In his view, the Village Sewerage Programme must be carried out for the long-term interests of Ma Tin Tsuen. Despite the controversy aroused during the programme promotion, Mr Wong still encouraged the villagers to support the programme with a view to enhancing the living environment of the village.

Ma Tin Tsuen, Shap Pat Heung, Yuen Long, the New Territories

Experience sharing on constructing village sewers

Ir Lee Wai-man, Raymond, a DSD Senior Engineer with over 20 years of work experience, shared the difficulties encountered in the implementation of the Village Sewerage Programme and it was not readily accepted by villagers. Sewers laying works in the narrow alleys between village houses could obstruct the access, and therefore a consensus among affected households had to be reached beforehand.

The villagers were also concerned that the works would affect the fengshui of their village or houses, and that they would have to bear the additional retrofitting costs and sewage charges afterwards. Due to these considerations, many villagers preferred to use septic tanks.

Ir Lee added that DSD had accorded high emphasis on communication with the villagers. Consultation meetings, briefings on works progress, etc, were organised for villagers to learn more about the project. Ir Lee also shared that more often than not, the villagers reflected their satisfaction to the project team after completion of the sewer connection works. They no longer needed to clear their septic tanks regularly to prevent sewage overflow. The pest and odour problems were also completely resolved. The understanding and support from the villagers was a big encouragement to the project team indeed.

Narrow village alleys

Experience sharing on sewer connections to the public sewerage system for Ping Kong Village, Sheung Shui

Ping Kong Village is located in Sheung Shui, the New Territories. The only access of the village is Ping Kong Road which is a single-lane road of about 500 m long. According to the original alignment design, the sewage from Ping Kong Village would flow via sewers underneath Ping Kong Road to the public sewerage system downstream. However, pre-construction condition surveys revealed an unexpected obstacle. If the original design was pursued, the sewers would have been laid at a deeper level, occupying more space on Ping Kong Road for the construction works and causing a greater impact on the traffic at Ping Kong Village. DSD, having carefully considered the views from the villagers, revised the sewer alignment to minimise the inconvenience to the villagers.

Since the commencement of the public sewerage works at Ping Kong Village, DSD had been closely liaising with the villagers to ensure that the project could proceed smoothly.

The demand for sewage treatment services grows correspondingly with continuous new town developments. Expansion of the public sewerage network is the future direction for sustainable development. As of March 2014, DSD has completed village sewerage projects for approximately 160 villages to connect private sewers with the public sewerage. At present, the sewerage works in about 90 villages are ongoing, while those for some 240 villages are under planning and design.

Dry weather flow interceptors

Some drainage channels or watercourses are prone to sewage inflow. During wet seasons, rainwater can usually flush away and dilute the sewage in the drains. This is however not the case during dry seasons where the sewage finds its way into the channel and is discharged directly into the sea and accumulates at the discharge points, eventually resulting in pollution at near-shore water bodies. In response to this, DSD constructs "dry weather flow interceptors" to intercept polluted dry weather flow into the public sewerage system so that it can be properly treated before being discharged into the sea.

Interception facilities at the Kowloon Bay stormwater box culvert

In the past, rainwater from Kowloon Bay, Ngau Tau Kok and Kowloon Peak areas was discharged directly into the Kai Tai Approach Channel through the Kowloon Bay stormwater box culvert. As the Kowloon Bay stormwater box culvert was frequently polluted by sewage, the water quality of the Kai Tak Approach Channel was impaired, causing an odour nuisance.

Dry weather flow observed at the Kowloon Bay stormwater box culvert before the provision of interception facilities

The Kowloon Bay stormwater box culvert (outfalls)

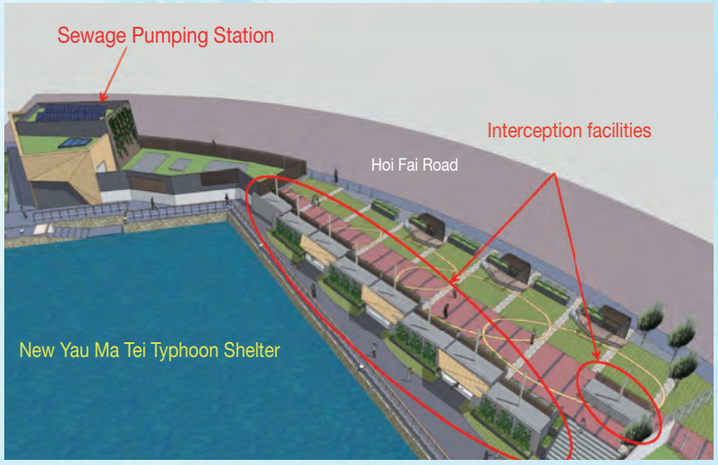
The Kowloon Bay Sewage Interception Station

In view of this, DSD has recently completed the Interception Facilities at the Kowloon Bay stormwater box culvert, so that polluted flow is intercepted at downstream and conveyed through rising main to the existing trunk sewers at Kai Fuk Road. The polluted flow is then treated at the Stonecutters Island Sewage Treatment Works before being discharged. This arrangement prevents polluted water collected from the urban area from being directly discharged into the Kai Tak Approach Channel through the Kowloon Bay stormwater box culvert, thus improving coastal water quality and alleviating the odour nuisance.

Construction site of the "Provision of Interception Facilities at Kowloon Bay stormwater box culvert"

Construction of a dry weather flow interceptor at the Cherry Street stormwater box culvert

The Cherry Street stormwater box culvert collects rainwater primarily from Western Kowloon and upper reaches amounting to a catchment area of about 5.3 km^2 for discharge into New Yau Ma Tei Typhoon Shelter. The box culvert has always been conveying polluted water which has been either illegally or improperly connected to the box culvert. This has affected the water quality in New Yau Ma Tei Typhoon Shelter and created odour nuisance as well as hygiene problems.



The construction of a dry weather flow interceptor at the Cherry Street helps intercept the sewage flowing into New Yau Ma Tei Typhoon Shelter via the box culvert

DSD is planning to construct interception facilities at downstream of the Cherry Street stormwater box culvert in Tai Kok Tsui, to collect sewage from the drains and deliver it to the Stonecutters Island Sewage Treatment Works for treatment and disposal. After completion of the work on interceping the polluted flow, water quality in New Yau Ma Tei Typhoon Shelter is expected to be greatly improved and the associated odour nuisance will be alleviated.

Maintenance of sewage collection facilities

Regular inspection, cleansing and maintenance of sewerage facilities are essential for effective collection, treatment and disposal of sewage. Otherwise, prolonged accumulation of grease or other sediments in the sewers will lead to blockage and improper disposal of corrosive chemicals (like detergent), and damage the sewers. To ensure proper functioning of the extensive sewerage system, DSD implemented a preventive maintenance programme. In 2013, DSD inspected over 1 200 km of sewers, and 660 km of which were cleansed.

Application of inner surface protective measures after laying of the trunk sewer

DSD applies targeted inspection methods for each type of drain. For instance, closed-circuit television (CCTV) surveys are used for drains in general, while sonar surveys are deployed for submerged drains. Submarine outfall is monitored using dye tests, in which the coloured dye is introduced at the upstream end of the outfall; any dye found at locations other than the outlet of the outfall indicates the outfall may be damaged and need to be repaired. In addition, DSD provides comprehensive preventive maintenance for submarine outfalls, including regular underwater inspections, hydrographic sonar surveys and cleansing of outfalls to ensure proper flow.

Closed-circuit television survey

Sonar survey

Dye test

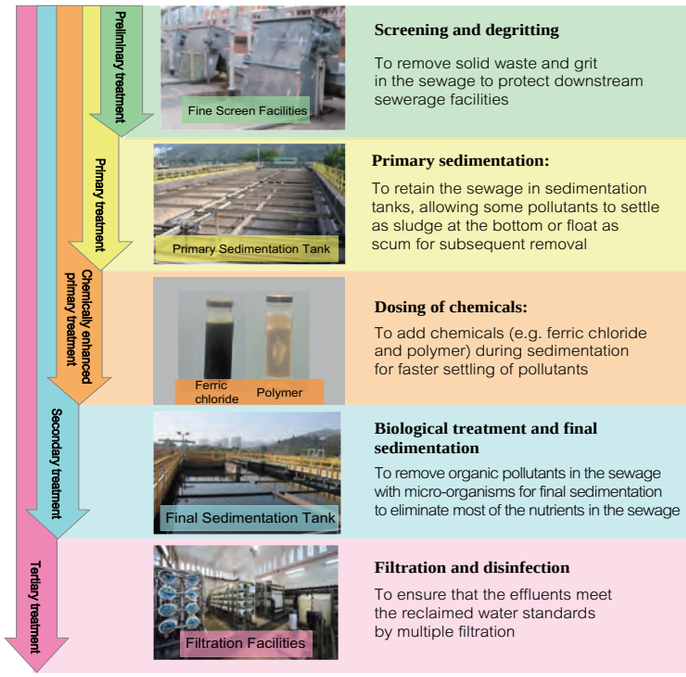
Sewage treatment

Map showing location of Hong Kong Sewage Treatment Plants, 2013

Sewage treatment is one of the major services of DSD. With the use of different sewage treatment procedures and advanced technologies, most pollutants, toxic substances and bacteria in the sewage are removed to ensure that the effluent quality meets the environmental protection standards. Currently, DSD has 293 sewage treatment facilities (including 68 sewage treatment works and 225 sewage pumping stations) to treat the sewage (with an average daily volume of about 2.8 million m^3) collected through the sewerage network.

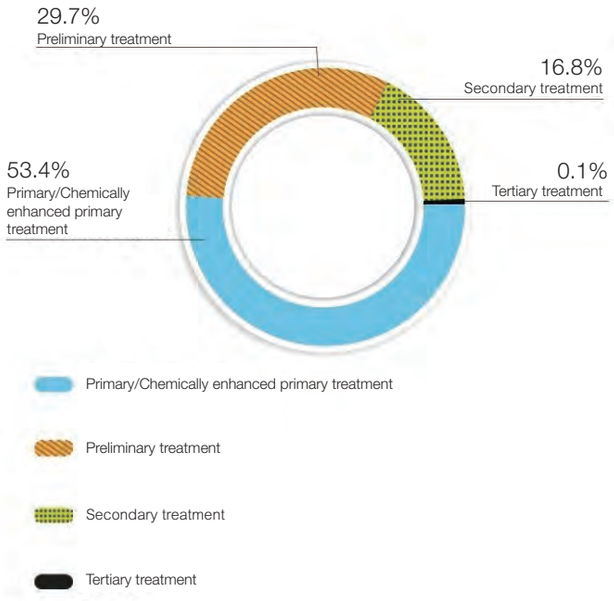
Sewage treatment facilities and levels

At present, local sewage treatment facilities are broadly categorised into five treatment levels, viz. preliminary treatment, primary treatment, chemically enhanced primary treatment, secondary treatment and tertiary treatment (see pictures on the right). For disinfection of treated sewage, chlorination/dechlorination or ultraviolet radiation is usually used to reduce the bacterial level in the effluents.



Pictures showing different sewage treatment levels

The collected sewage is conveyed to sewage treatment works for treatment. In 2013–2014, DSD handled in total about 1 billion m^3 of sewage, of which 29.7% underwent preliminary treatment, 53.4% primary or chemically enhanced primary treatment, 16.8% secondary treatment and the remaining 0.1% tertiary treatment.



Volumes of sewage treated with different treatment levels in 2013–2014 (% of total volume)

UV disinfection system

Apart from the chlorination and dechlorination disinfection process, DSD has lately introduced the UV disinfection system in sewage treatment. Sha Tin Sewage Treatment Works, Tai Po Sewage Treatment Works and Siu Ho Wan Sewage Treatment Works, etc. have been installed with such system. Compared with disinfection by chemicals, UV is more effective (especially against viruses). Besides, UV disinfection can save time and space, but it requires a higher cost.

The UV disinfection system in Shek Wu Hui Sewage Treatment Works

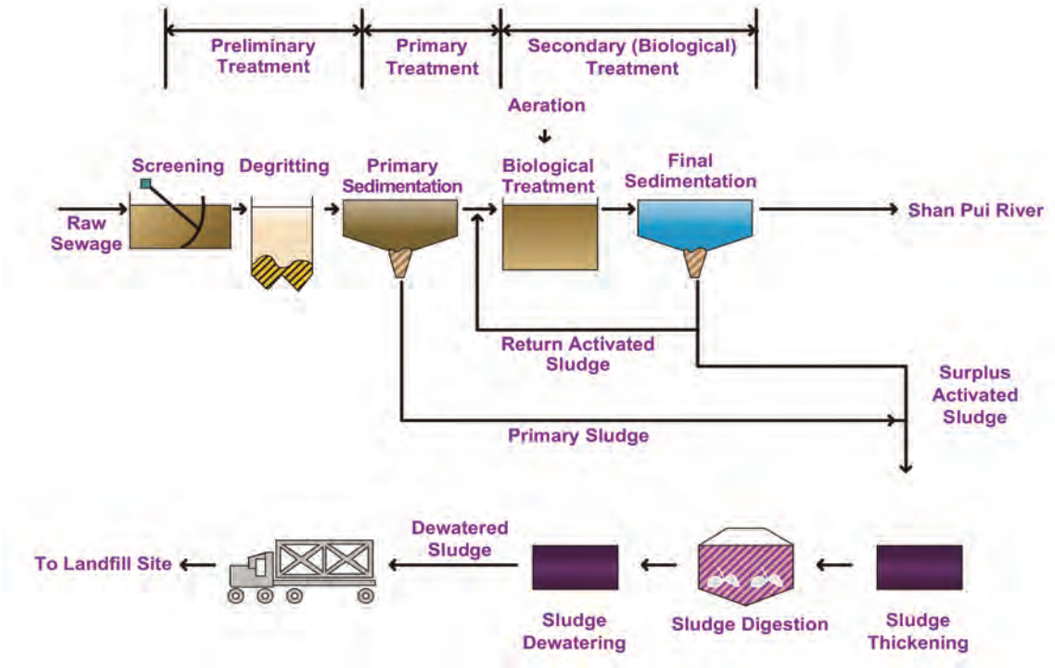
Principles of UV disinfection

The UV light used in disinfection is emitted from a special UV lamp. As UV light contains much higher energy than visible light, it can destroy the genetic structures of micro-organisms to inhibit their replication and growth in the sewage, thereby achieving disinfection.

Sludge treatment

Currently, sludge needs to be removed during the sewage treatment process. There are two main types of sludge: (1) primary sludge produced by settling of pollutants in the primary sedimentation tank. With its higher solids content, it can be conveyed directly to the sludge digestion tank for anaerobic digestion; (2) surplus activated sludge, i.e. the surplus micro-organisms deposited in the final sedimentation tank of the secondary biological treatment. Given its higher water content, it has to undergo sludge thickening for volume reduction before entering the sludge digestion tank for anaerobic digestion.

After anaerobic digestion, both the primary sludge and surplus activated sludge need to be further dewatered. Their solids contents should reach 30% or above before they are delivered to landfills for disposal. During 2013 to 2014, DSD treated a total of some 300 000 tonnes of sludge.



Sewage and Sludge Treatment Flowchart
(Showing Sewage treatment process at Yuen Long Sewage Treatment Works)

The process of sludge dewatering

Dewatering centrifuge

Screw conveyor of the dewatering centrifuge

Dewatered sludge cake

Improvement works for sewage treatment facilities

To keep in pace with Hong Kong's development, DSD has been committed to enhancing the sewage treatment facilities over the years. Apart from upgrading and expanding the existing sewage treatment works, DSD has been actively planning and designing new sewage treatment facilities to meet the future needs.

Expansion of Shek Wu Hui Sewage Treatment Works

The existing Shek Wu Hui Sewage Treatment Works (SWHSTW) has been put into operation since 1984 to provide secondary sewage treatment services for Sheung Shui, Fanling and nearby areas. In the coming years, the volume of sewage to be treated by SWHSTW will exceed its design capacity of 93 000 m^3 per day. To provide quality sewage treatment services for Sheung Shui, Fanling and new development areas, DSD is planning to progressively raise the sewage treatment capacity of SWHSTW in phases and upgrade its treatment level from secondary to tertiary. In December 2012, DSD commenced an investigation study for the further expansion of SWHSTW, which included the sewage and sludge treatment process design, various impact assessments, site investigations, preliminary project design, landscape and greening plans, implementation strategies and programme, as well as public engagement activities for public consultation.

Shek Wu Hui Sewage Treatment Works

New sewage treatment facilities on Lamma Island

With a growing number of residents and tourists in recent years, the existing sewage treatment facilities on Lamma Island have been overloaded. In 2010, DSD commenced the construction of a sewage treatment works at Yung Shue Wan and another at Sok Kwu Wan to enhance the sewage treatment capacity to cater for the increasing sewage flow. The construction works are in full swing, with Yung Shue Wan Sewage Treatment Works under testing for commissioning soon.

Location of Yung Shue Wan Sewage Treatment Works

Location of Sok Kwu Wan Sewage Treatment Works

Owing to space constraint, the two sewage treatment works on Lamma Island adopt a highly efficient and space-saving technique – submerged membrane biological reactor (SMBR). The treated effluent will be discharged through submarine outfalls into deep waters for protecting inshore fish culture zones and maintaining the quality of nearby waters.

Submerged Membrane biological reactor

SMBR makes use of membrane modules in biological reaction tanks for sewage treatment. It allows the screened sewage to pass through the membrane modules with a mere 0.4 micron pore size to screen out suspended solids and E. coli. This new technology improves the effluent quality and obviates the need for final sedimentation. Moreover, it requires a smaller footprint than the traditional secondary sewage treatment system.

Besides the above mentioned examples, DSD is now carrying out various upgrading works for sewage treatment facilities, such as the Harbour Area Treatment Scheme (HATS) Stage 2A which comprises the upgrading of Stonecutters Island Sewage Treatment Works and provision of additional disinfection facilities for enhancement of its sewage treatment capacity. At the same time, we are upgrading eight preliminary treatment works on Hong Kong Island to prevent any grit from entering and settling in the deep sewage conveyance tunnels or damaging the downstream treatment facilities.

Maintenance of sewage treatment facilities

DSD carries out from time to time suitable maintenance and repair works for our sewage treatment facilities to ensure their efficiency, and takes the following measures to improve their operational performance and treatment standards.

- Gradual replacement of aged and obsolete facilities;
- Regular maintenance of sewage treatment facilities to avoid possible breakdowns;
- Formulation and implementation of contingency plans for all facilities.

Striving for more effective management of the sewage treatment facilities, DSD has introduced various computer systems including the Computerised Maintenance Management System (CMMS), Supervisory Control and Data Acquisition System (SCADA) and Sewage Treatment Operation and Maintenance Management Information System (STOMMIS).

Monitoring and data collection

Through these systems, DSD staff at designated control centres (e.g. the Sha Tin Sewage Treatment Works and Yuen Long Sewage Treatment Works) are able to remotely monitor and control unmanned treatment facilities, as well as to collect and transmit real-time monitoring data to the central computer for further processing, fault analysis, report preparation and formulating maintenance programme for mechanical and electrical equipment. The systems are equipped with an automatic alarm system which allows real-time alerts through mobile phone in case of system failures for the emergency inspection teams to take prompt actions.

The implementation of these computer systems has brought about higher efficiency in the operation of the sewage treatment facilities and flexibility in staff deployment, enabling us to provide more cost-effective and better quality sewage treatment services.

Sewage Services Charging Scheme

At present, the public sewerage system serves around 93% of Hong Kong's population and millions of cubic metres of sewage have to be treated every day. In the early days, the public regarded sewage collection and treatment costs as mere accounting figures of the Government, with no knowledge of the scope and cost of sewage treatment services. The incentive to reduce water pollution was little.

For sustainable development of our living environment and recovery of the operating costs in sewage treatment services, DSD implemented the Sewage Services Charging Scheme on 1 April 1995 based on the Polluter Pays Principle. Under the scheme, polluters are obliged to share the responsibility for sewage treatment, i.e. to pay a partial cost of the sewage treatment services according to the volume and pollution level of their discharge. The scheme has encouraged the public to save water and promoted the awareness of water pollution control.

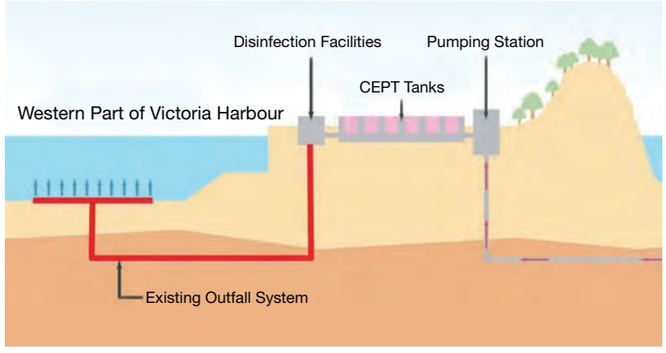
The Sewage Services Charging Scheme comprises two charges, namely:

- **Sewage Charge** to recover the cost of collecting and treating wastewater at or below a pollution strength equivalent to that of domestic sewage; and
- **Trade Effluent Surcharge** to recover the extra cost of treating effluent with a pollution strength exceeding that of domestic sewage.

Discharge of treated effluent

Discharge plan

Sewage from every district is collected through the public sewerage system and then conveyed to sewage treatment works for processing. DSD provides different levels of sewage treatment for each area, taking into account the quantity of sewage collected and the ability of the water body in receiving the effluent.



Schematic diagram of the outfall system at Victoria Harbour

In a water body with deep and fast flow, pollutants are quickly diluted and dispersed and thus the ability of the water body in receiving pollutants would hence be higher. Under such condition, chemically enhanced primary treatment plus disinfection would provide adequate treatment for discharge through a submarine outfall. However, in partially enclosed waters, such as inner harbours or shallow bays, the ability for the water body to receive pollutants is lower due to slow current. Moreover, the Water Quality Objectives are also more stringent in these areas. Therefore, higher levels of sewage treatment are needed for the discharge. It may even be necessary to consider discharging to a different water body.

Effluent assessment system

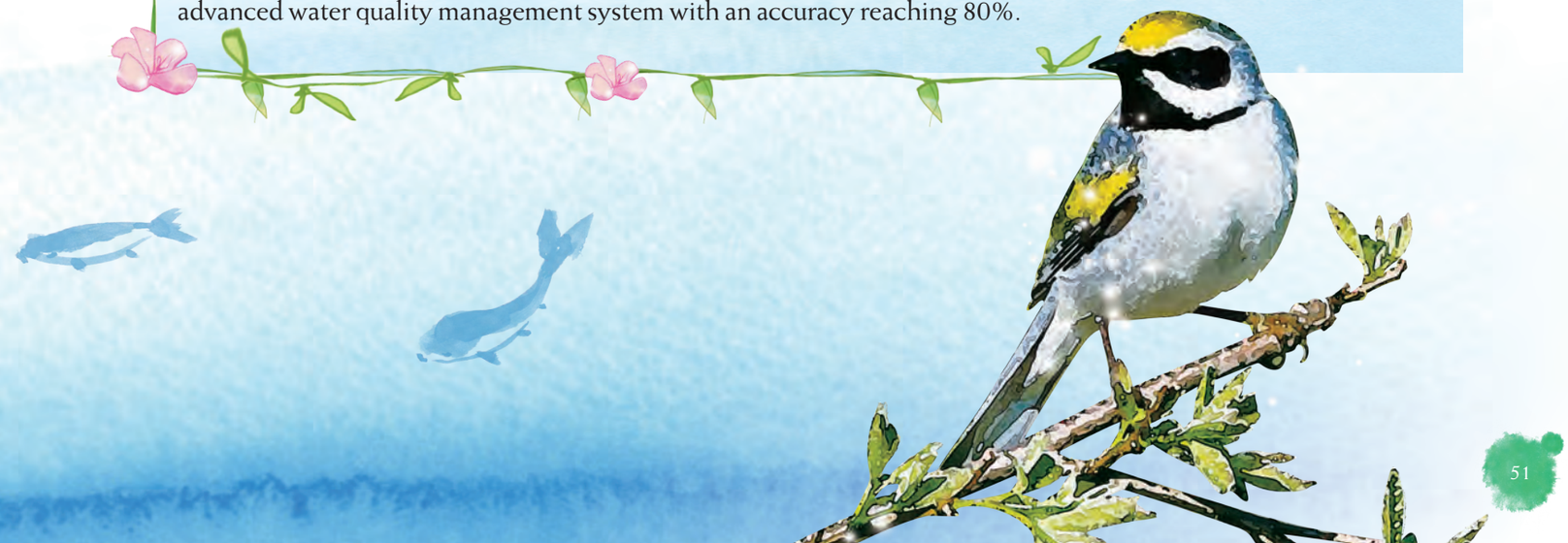
To assess the effluent conditions, DSD has been endeavouring to identify suitable discharge systems. Effluent discharge scenario is stimulated to predict its impacts on the surrounding marine environment and put forward improvement proposals to be used as reference for betterment of the sewage treatment services

In 2012, DSD collaborated with Professor Lee Hun-wei, Joseph, an internationally renowned expert on hydraulics, to give a visual analysis of the dynamics of pollutants in the seabed by using the 3D Environmental Impact Assessment System developed in his Project WATERMAN. The analysis helped DSD adjust the dose of disinfectant (chlorine) involved in HATS. As a result, we are able to save energy and operating costs and minimise the disinfectant entering the marine environment[6]. The 3D model of the System can also be used to formulate solutions to incidents of marine pollution.

3D Environmental Impact Assessment System of the Project WATERMAN

The Project WATERMAN is an innovative environmental knowledge-based system for marine water quality management in Hong Kong. It helps identify and quantify environmental pollution problems, facilitate water quality management, project design and proposal selection, as well as disaster risk management. The system also assists users in choosing the most sustainable and economical measures to prevent, reduce and mitigate the impacts of water pollution.

The 3D Environmental Impact Assessment System of WATERMAN is the pioneering visualisation system which uses the "near-field buoyant jet model" for quantitative evaluation of the impacts of effluent on the marine environment. The system serves to design cost-effective effluent diffusion plans and adjust the dose of disinfectant in sewage treatment for the objectives of reducing energy consumption, saving operating costs and lessening environmental impact of disinfectant. By scientific verification with the massive consolidated observations and experimental data, the assessment system provides information on water quality and water currents of coastal areas, and helps forecast red tides and predict the water quality of beaches. This visualisation assessment system is an advanced water quality management system with an accuracy reaching 80%.



Special discharge plan: Tolo Harbour Effluent Export Scheme

Tolo Harbour is one of the largest inner harbours in Hong Kong. Surrounded on three sides by land, the Harbour has limitation in terms of water circulation and natural purification. It is difficult to dilute pollutants by water current. The new town development in Sha Tin and Tai Po during the period from 1986 to 2001 almost doubled the population of the Tolo Harbour catchment from 500 000 to 900 000. The population boom contributed to a sharp increase in sewage to be treated by the Sha Tin and Tai Po Sewage Treatment Works in the Tolo Harbour area. Although most sewage had undergone secondary treatment, given the upsurge in effluent, there was a sharp increase in the level of nutrients which posed a great challenge to the purification capacity of Tolo Harbour. Red tides (or algal blooms) were common in Tolo Harbour in the 1980s and 1990s. In particular, over 40 red tide outbreaks were recorded in 1988. The toxin released by red tides are harmful to marine species, upsetting the fish supply in the harbour and causing economic loss to fish farmers[7].

In 1987, the Government developed a Tolo Harbour Action Plan to reduce discharge of pollutants into Tolo Harbour. One major measure was to launch the Tolo Harbour Effluent Export Scheme which diverted the effluent from the Sha Tin and Tai Po Sewage Treatment Works, via Kai Tak Nullah, to Victoria Harbour instead of to Tolo Harbour. This scheme had dual benefits: it helped reduce the pollutants in Tolo Harbour on the one hand and flush away the polluted flow in Kai Tak Nullah on the other.

The Tolo Harbour Effluent Export Scheme was implemented in two stages. The first stage was to divert the effluent from Sha Tin Sewage Treatment Works to Kai Tak Nullah, and the second stage to divert the effluent from Tai Po Sewage Treatment Works to the sewage pumping station at Sha Tin Sewage Treatment Works. The scheme commenced in 1995 and came into full operation in 1998.

Sha Tin Sewage Treatment Works

Tai Po Sewage Treatment Works

Kai Tak Nullah

Professional laboratory services: sewage and effluent testing

The professional laboratory of DSD regularly carried out water and sewage sampling and testing to determine the pollutant loads from sewage treatment facilities and monitor the sewage treatment efficiency to make sure that the effluent quality meets the stringent discharge standards. Their major laboratory services include the following:

- To provide sampling and testing services for effluent and sludge according to the effluent standards set by EPD;
- To provide testing results for monitoring and evaluating the effectiveness of the sewage treatment process on a regular basis;
- To assist the operators in selecting the most cost-effective sewage treatment process;
- To help identify the problems in chemical and biological sewage treatment, and provide professional advice and solutions;
- To procure chemicals for use in sewage treatment works and recommend on the appropriate dosages; and
- To monitor and manage the odour emission during the sewage treatment process.

Professional laboratory services

Professional laboratory services include taking samples during the sewage and sludge treatment process for physical, chemical and microbiological tests to ensure that the solids content of the treated effluent and sludge meets the discharge licence conditions. The tests also serve to provide accurate data for water quality control. Since 1999, the Shatin Central Laboratory has been accredited under the Hong Kong Laboratory Accreditation Scheme operated by the Hong Kong Accreditation Service of the Innovation and Technology Commission. This means that the Laboratory complies with the requirements for conducting 20 kinds of accredited tests.

20 kinds of accredited tests	
Total Suspended Solids	Escherichia Coli
Biochemical Oxygen Demand	Conductivity
Chemical Oxygen Demand	Total Dissolved Solids
Ammonia Nitrogen	Total Hardness
Nitrite Nitrogen	Turbidity
Nitrate and Nitrite Nitrogen	Colour
Total Kjeldahl Nitrogen	Anionic Surfactants
Total Solids	Non-ionic Surfactants
pH	Chloride
Oil and grease	Sulphate

Odour management

Hong Kong is now the only city in the world with extensive use of seawater for toilet flushing, with some 80% of our population using seawater for flushing. While seawater flushing can help save a lot of fresh water resources, it does pose extra challenges to the sewage treatment. As seawater is highly saline, when it is exposed to an anaerobic environment, the sulphate in seawater will be converted into hydrogen sulphide which is a major substance causing sewage odour.

Seawater flushing and sewage odour

As early as in the 1960s, in order to ease the water shortage crisis, the Government established independent seawater supply systems in both urban areas and new towns. Seawater has since been widely adopted for toilet flushing in Hong Kong.

Today, over 80% of local population is supplied with seawater for flushing. In 2013, the average daily volume of seawater used for flushing was over 760 000 m^3, equivalent to the total capacity of 300 standard swimming pools[8].

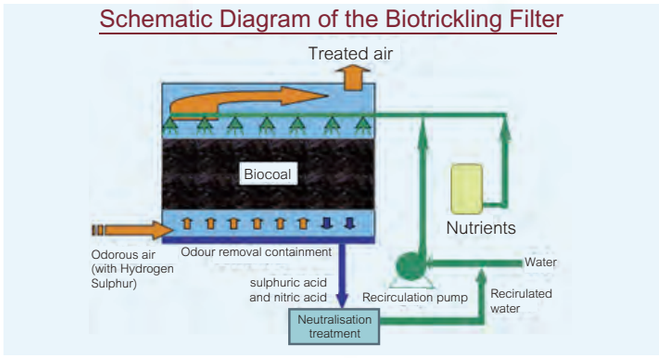
With the continuous development of new towns, sewage treatment facilities have been gradually surrounded by new residential areas and there is a growing public concern on the odour generating from these facilities. DSD has implemented three effective measures to mitigate the odour nuisance of our sewage treatment works, including:

- Adequate dosing of chemicals (such as calcium nitrate, ferric chloride and other deodorants) and oxygenation of sewage to reduce the odour generated under septic conditions;
- Covering potential odourous facilities (such as drains and sewage tanks) to prevent the spread of odour; and
- Installing deodorisation systems such as activated carbon systems, chemical scrubbers and biofilters at appropriate locations for odour reduction to an acceptable level before discharge. At present, our practice is to install one or a combination of different odour removal devices at pumping stations and sewage treatment works according to the odour level and type.

To properly implement odour mitigation measures, staff must be trained to master the technology for odour test. Currently, Hong Kong, like many other countries, uses analysers to measure hydrogen sulphide levels as a proxy for overall odour levels. In abnormal situations, staff are swiftly assigned to adjust the operation mode, such as by adding chemicals, increasing or changing deodorising materials in the odour removal unit, and if needed, implementing other necessary improvement.

In addition, DSD is continuing the trial of new deodorisation systems. For example, in 2010, we introduced the superoxygenation system at the Tung Chung Sewage Pumping Station, whereby a large amount of oxygen is dissolved in the sewage to keep the sewage under aerobic condition to prevent odour generation.

The covered sedimentation tanks in Stonecutters Island Sewage Treatment Works



The biotrickling filter (left) in Sha Tin Sewage Treatment Works and its operating principles (right)

Effectiveness of sewage purification

DSD is responsible for Hong Kong's sewage collection, treatment and disposal, with satisfactory results. Over the last 20 years, water pollution has been greatly improved, with continuous improvement in water quality of inland rivers and beaches and marked reduction of red tide.

Improving water quality of watercourses

To improve water quality of rivers, DSD has relied on the enforcement of various pollution control ordinances relating to the River Water Quality Objectives, and implemented different SMPs. Also, DSD has launched the Village Sewerage Programme to extend the public sewerage system to the rural areas all over Hong Kong, allowing more village households to connect their sewers to the public sewerage network. This helped substantially reduce the volume of sewage flowing into rivers. Notwithstanding the overall improvement in the river water quality in Hong Kong, the E. Coli level in certain rivers remains high. Therefore, DSD is now extending this Programme to benefit more villages in remote areas and further enhance the overall river water quality in Hong Kong.

Improving beach water quality

The E. Coli level in beaches directly reflects the effectiveness of the implementation of the sewage treatment master plan. In beaches suitable for swimming, the amount of E. Coli in every 100 mL of seawater should not exceed 180 counts. According to the Hong Kong Government Gazette published from the 1980s to 2010s, the annual water quality index of beaches has shown a continuous improvement. Since 1986, the number of beaches suitable for swimming has been increasing. In 2012, the water quality of all gazetted beaches met the standards suitable for swimming. From 2012 to 2013, over 10 million people have enjoyed swimming at the 41 gazetted beaches. These figures showed that the water quality of Hong Kong beaches was highly satisfactory.

World's ten best city beaches: Stanley Main Beach

Since the commissioning of the Stanley Sewage Treatment Works which is housed in a cavern in the Southern District, the seawater quality in the vicinity of Stanley has been improved. From 1999 to 2009, the water quality of Stanley Main Beach was rated as Grade 1. On 8 June 2013, the Beach was further selected as one of the top ten city beaches around the world by an international travel website.

Stanley Main Beach

Solving the red tide problem

Repeated incidents of red tides prevailed in Tolo Harbour in the 1980s. In response, DSD expanded the sewage treatment works in Sha Tin and Tai Po, and introduced the Tolo Harbour Effluent Export Scheme under which the effluent after secondary treatment is conveyed to Kai Tak Nullah for subsequent discharge into Victoria Harbour which has higher purification capability. Since then, there is no further record of red tide incident in Tolo Harbour.

A novel system for water quality monitoring

To ensure water quality improvement, constant monitoring of changes in water quality is necessary. As the previous monitoring systems had failed to accurately predict the trend of changes in water quality, DSD has instead adopted the 3D hydrodynamic model system since 2012 to monitor the water quality. The data so collected enabled us to suitably adjust the disinfectant dosage in Stonecutters Island Sewage Treatment Works.

Water quality improvement of beaches in Tsuen Wan

Since the commissioning of HATS Stage 1, the sewage from Kowloon, Tseung Kwan O, Kwai Tsing and the Northeastern Hong Kong Island was conveyed through a 23.6 km long deep tunnel to Stonecutters Island Sewage Treatment Works for centralised treatment. Owing to inadequate disinfection at that time, the bacteria level in the discharge remained high, leading to consistently poor water quality of beaches in Tseun Wan District which was only 8 km away from the outfall of Stonecutters Island Sewage Treatment Works.

Since 2012, DSD has adopted the "3D hydrodynamic model" as a water quality forecast system to observe changes in bacteria level of the Tsuen Wan beaches under different operation settings of the disinfection system used in HATS. Making reference to the data collected, DSD has managed to adjust the disinfectant dosage for disinfection facilities in Stonecutters Island Sewage Treatment Works so that the E. Coli level in the Tsuen Wan beaches can be kept under control. The target is to minimise the use of disinfectant and make the beaches suitable for swimming.

There were a total of eight beaches in Tsuen Wan District, namely Approach Beach, Ting Kau Beach, Lido Beach, Casam Beach, Hoi Mei Wan Beach, Gemini Beaches, Ma Wan Tung Wan Beach and Anglers' Beach. Except Ma Wan Tung Wan Beach, all other seven beaches had been closed since 2003 due to poor water quality. Upon commissioning of the disinfection facilities in Stonecutters Island Sewage Treatment Works, the water quality of Lido Beach, Casam Beach, Approach Beach and Hoi Mei Wan Beach has been improved significantly. On 4 June 2011, the Leisure and Cultural Services Department (LCSD) announced the reopening of these four beaches. After being closed for nearly 20 years, Anglers' Beach was also reopened on 19 September 2013 and the nearby Ting Kau Beach reopened in the 2014 bathing season. As for the Gemini beaches, it will be reopened once the supporting facilities are in place.

Cleaning up Victoria Harbour

Harbour Area Treatment Scheme (HATS)

To thoroughly improve the water quality of Victoria Harbour, the Government commenced the Sewage Strategy Study in 1987 to formulate the Strategic Sewage Disposal Scheme for sewage collection, treatment and disposal for Victoria Harbour.

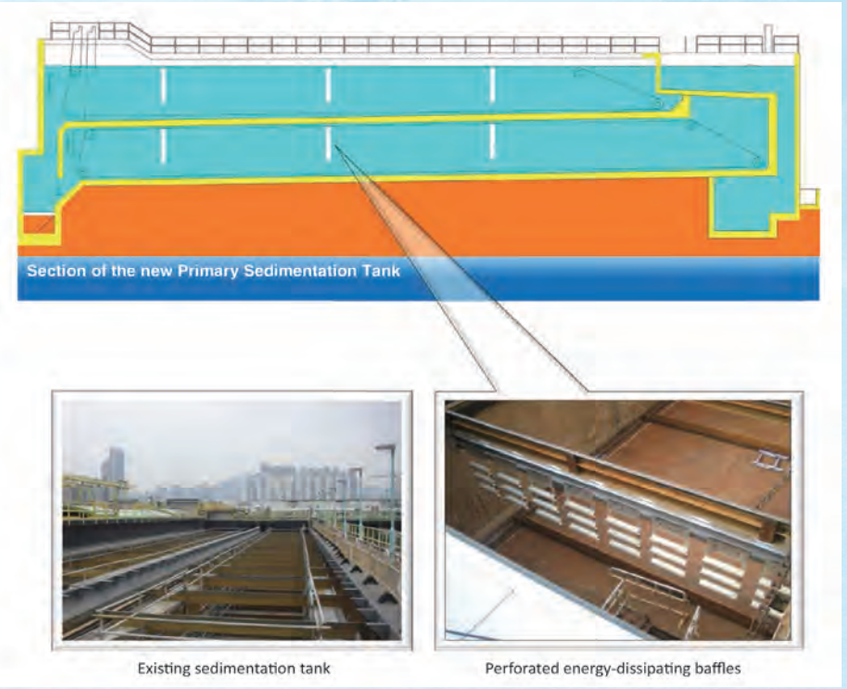
HATS, previously known as the Strategic Sewage Disposal Scheme, is a forward-looking environmental project being implemented in stages. The project comprises the construction of deep sewage tunnels along both sides of Victoria Harbour. After undergoing preliminary treatment, the sewage will be conveyed by the tunnels to Stonecutters Island Sewage Treatment Works for centralised treatment and the effluent would then be discharged through a submarine outfall. As the sewage tunnels are constructed deep underground, they are therefore not obstructed by building foundations, transport infrastructural tunnels, etc. This does not only allow the shortest alignment, but also reduces the adverse impacts on the public, environment, ecology, utilities, traffic, and the potential of future developments.

Alignment of the sewerage system under HATS Stage 1

HATS Stage 1 was completed in December 2001, comprising a 23.6 km-long system of deep underground tunnels, for conveyance of sewage from Kowloon, Tsing Yi, Kwai Chung, Tseung Kwan O and the Northeastern part of Hong Kong Island to Stonecutters Island Sewage Treatment Works. Since their commissioning in December 2001, the Stage 1 facilities have been collecting 75% of the sewage generated from both sides of Victoria Harbour, with current daily volume reaching 1 400 000 m^3. The sewage is then conveyed to Stonecutters Island Sewage Treatment Works for chemically enhanced primary treatment. This has effectively intercepted about 600 tonnes of sludge from entering the Harbour each day and thus greatly improved the water quality of the central and eastern Harbour.

Double-decked design to optimise the space

Stonecutters Island Sewage Treatment Works constructed under HATS is the largest chemically enhanced primary sewage treatment works in Hong Kong mainly for handling the sewage collected from both sides of Victoria Harbour. To maximize the treatment capacity, DSD has adopted double-decked sedimentation tanks for Stonecutters Island Sewage Treatment Works. At present, there are in total 38 double-decked sedimentation tanks. With each measuring 60 m in length and 7 m in width, the double-decked design requires much smaller footprint.

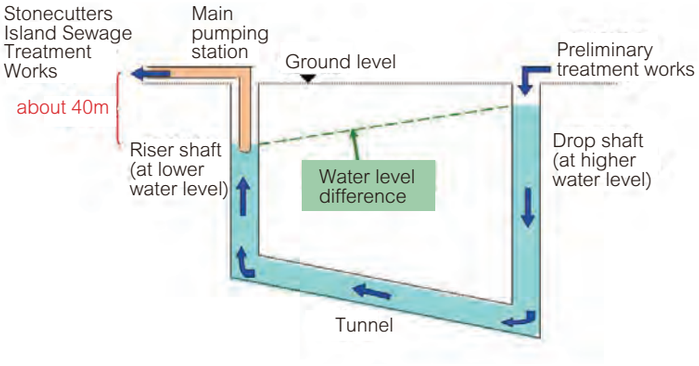


Double-decked sedimentation tanks

To effectively maintain the water quality of Victoria Harbour to a high level, the Government consulted the public on HATS Stage 2 in 2004. The findings suggested that the majority of the public valued the cleaning up of Victoria Harbour and supported the implementation of HATS Stage 2A and 2B in phases. DSD is carrying out the construction works for HATS Stage 2A and reviewing Stage 2B.

Alignment of the sewage conveyance system of HATS Stage 2A

HATS is the largest sewage infrastructure project in the Hong Kong history. HATS Stage 2A involves the construction of the deepest sewage tunnel in Hong Kong, with 21 km in total length and at a depth ranging from 70 m to 160 m below ground level. The deepest tunnel section at North Point is 163.8 m below sea level which is equivalent to the height of a 50-storey commercial building. This sewage conveyance tunnel will collect preliminarily treated sewage from coastal areas on the Northern and Southwestern Hong Kong Island, which accounts for 25% of the sewage generated from both sides of Victoria Harbour.



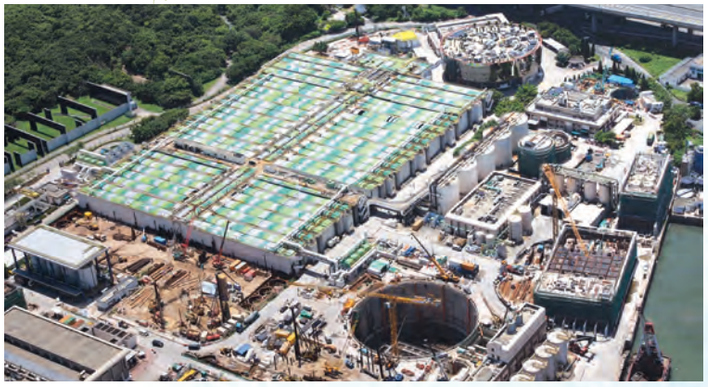
Following the "inverted siphon" principle, the difference in water level maintained between the two tunnel shafts would drive flow from the higher water level end at the upstream to the lower water level end at the downstream.

The whole sewage tunnel system was designed according to the "inverted siphon" principle for effective conveyance of the sewage generated from both sides of Victoria Harbour. Due to water level difference, the sewage will flow to the underground of Stonecutters Island Sewage Treatment Works and then be pumped from 40 m below ground level to the treatment facilities via the main pumping station. This process reduces the construction scale and lowers pumping costs.

Construction of deep sewage conveyance tunnels

In HATS Stage 2A, the construction of sewage tunnels deep underground with extremely high groundwater pressure poses a great challenge to the project team. For excavation of tunnels, drill-and-blast method (a process including drilling holes on the tunnel surface for charging and blasting as well as rock removal) was adopted. This method allows more working space at the excavation face, hence giving greater flexibility for installing temporary support and pre-grouting, and enables better control of groundwater infiltration. Also, the excavated rocks can be reused as construction materials.

Besides the construction of deep sewage conveyance tunnels, HATS Stage 2A comprised the upgrading of Stonecutters Island Sewage Treatment Works and related disinfection facilities to cope with the increased sewage flow and ensure that the effluent quality meets the discharge standard. Meanwhile, DSD has been endeavouring to upgrade the eight preliminary treatment works on Hong Kong Island which have been in use for over 20 years. The upgrading works are to protect the sewage treatment facilities downstream by preventing solids and grits from entering the deep sewage tunnels.



Expansion works in Stonecutters Island Sewage Treatment Works
(The figure shows the new main pumping station under construction)

Not just a man's job: the first female Blasting Competent Supervisor working inside the deepest sewage tunnel in Hong Kong

In 2010, DSD trained a number of Blasting Competent Supervisors (BCS) designated for supervising the blasting works for HATS Stage 2A, with one becoming the first female BCS working inside the deepest sewage tunnel in Hong Kong.

The deepest sewage tunnel

Ms Edith Sia is a Resident Engineer for a consultant company of DSD as well as a BCS of HATS Stage 2A. Responsible for the works supervision of the sewage tunnel section from North Point to Wan Chai, Ms Sia has supervised over 200 blasting operations. She had never thought of participating in deep tunnel construction until her supervisor recommended her for a training course. After passing the examination, working as an intern and completing one-year in-service training, she finally obtained the BCS qualification.

At first, Ms Sia was worried about working inside a tunnel. However, with adequate safety measures, ventilation and lighting, she did not find the tunnel stuffy even when working some 100 m deep underground. Moreover, it only took four to five minutes by lift to reach the tunnel 163 m underground. This removed her worry. To her, the toughest job was in fact to wear the heavy personal safety equipment such as full body harness and self-rescue breathing apparatus, etc.

In the past, the engineering industry believed that allowing any woman entering a tunnel would bring bad fortune. There was even a superstition that this would affect the works progress. Ms Sia pointed out that there was virtually no difference between male and female engineers working inside the tunnel, and that the number of female engineers has been increasing these years. The real difference was that, unexpectedly, the construction workers would become refined and polite when she was inside the tunnel.

Improving the water quality of Victoria Harbour

The water quality of Victoria Harbour has been further improved since the commissioning of HATS Stage 1 and the impact is better than our expectation. The continuous enhancement of the water quality especially in the eastern Harbour, Eastern Buffer Water Control Zone and Junk Bay Water Control Zone[10] is particularly encouraging.

According to EPD's Report on Marine Water Quality in Hong Kong in 2011, the motion on "Comprehensively improving the water quality of Victoria Harbour" mentioned that since the operation of HATS, the E. coli level recorded at the monitoring points in Victoria Habour has been halved. In particular, the bacterial level in the eastern Harbour near Lei Yue Mun has dropped significantly by over 95%. In addition, the average dissolved oxygen level has increased by 15%, while the mean level of ammonia nitrogen has decreased by 27% together with a fall in the average nutrient level. To sum up, there has been a breakthrough improvement in the water quality of Victoria Harbour.

Changes in cross harbour swimming race

Over 100 years ago, there were many swimming sheds alongside Victoria Harbour as the popular spots for public recreation. The swimming sheds were heavily used by swimmers during holidays and evenings. The cross harbour swimming race held at Victoria Harbour is a long distance event with a history of over 100 years. In 1868, there were less than 20 participants in the competition and most of them were foreigners. The common route, 1.6 km in length, started from the KCRC pier in Tsim Sha Tsui and ended at a location between the Queen's Statue Wharf and the Victoria Swimming Club in Central, Hong Kong Island. The finishing point was later changed to the shore along the Queen's Statue Wharf. It is the only swimming race in the world history with a route across one of the busiest harbours. The race had been organised by different associations such as the South China Athletic Association, the Chinese Swimming Club,the Victoria Recreation Club, the Hong Kong and Kowloon Residents Society and the Hong Kong Amateur Swimming Association.

The cross harbour swimming race[Fig 1]

Swimming sheds put up on the beach, 1910[Fig 2]

Sharing from a race participant in the early days

Mr Wong Man-chiu was a three-time champion of the cross harbour swimming race. To him, the race is a big event in Hong Kong and a collective memory of the public. He added that the water of Victoria Harbour was so clear that marine species like fishes and seahorses could be seen. At that time, the swimming sheds alongside Victoria Harbour were places not only for swimming, but also for fishing, ball games and swimming practice. However, the harbour water quality gradually deteriorated in the 1960s, with rubbish afloat in the sea at times. The situation became even worse in the 1970s and with animal carcasses found in the sea. Owing to this, cross harbour swimmers had to apply body lotion as protection before swimming. Some participants of the race even found their bodies covered all over with greasy dirt after the event. Finally in 1979, the serious water pollution, heavy marine traffic and other factors prompted the suspension of the cross harbour swimming race.


本屆渡海泳停辦

【本報訊】香港業餘游泳總會前天召開執委會議，決定本年度第六十七屆全港公開男女渡海游泳比賽暫停舉辦。

停辦原因是找不到適合的比賽地點，因維多利海峽交通繁忙，海事處認為不宜比賽。公開渡海泳已有數十年歷史，男子組由一九〇六年開辦，其中一九一四年，一九一五年因第一次世界大戰停辦，一九四二年至一九四六年因第二次世界大戰停辦。女子組由一九二〇年開辦，一九四二年、一九四六年第二次世界大戰停辦。

體育

A news article carried in *Ta Kung Pao*, 20 October 1979[Fig 3]

With the worsening water pollution, the swimming sheds on both sides of Victoria Harbour closed one by one. Two famous swimming sheds in Kennedy Town, namely "Gold and Silver Swimming Shed" and "Chung Sing Swimming Shed" were also pulled down in the 1970s. In 1988, the Government approved the reopening of the swimming shed at Victoria Road, which is the only one left in Hong Kong.

The revival of the cross harbour swimming race

The Honorary Secretary of the Hong Kong Amateur Swimming Association, Mr Wong Man-chiu, J.P., explained that the Association had hoped for years for the revival of the cross harbour swimming race for the public. Yet, their request was turned down by EPD as the harbour water quality was not up to standard. It was only after the implementation of HATS by DSD, the water quality has improved. In 2009, experts engaged by the Association confirmed that the water quality in certain sections of the Harbour was suitable for swimming. Following this confirmation, the Association recommended to the Government the revival of the race. With the support from a number of departments, including the Home Affairs Bureau, LCSD, and Marine Department, as well as the approval from EPD, the cross harbour swimming race was revived on 16 October 2011 after a suspension of 33 years[11]. In fact, a trial race was held in 2010, attracting over 1 000 participants. The route started at Tsim Sha Tsui Promenade and ended at the Yacht Club in Causeway Bay. In 2013, more than 3 500 swimmers took part in the race. The increase in the number of participants suggests that public confidence in the water quality of Victoria Harbour has been growing.

Mr Wong Man-chiu, J.P., at the Hong Kong Amateur Swimming Association Office

Photos taken at the cross harbour swimming race in 2013

Sharing from participants of the cross harbour swimming race in 2013

The winner of Women's Open Group (B), Ms Mary Kwoh, is an active participant in open swimming competitions. She commented that the water quality of Victoria Harbour was better than expected and she did not see any rubbish during the race.

Most competitors from the Leisure Group expressed their satisfaction with the harbour water quality. Some of them remarked that joining the race was their family tradition and they wished to pass this tradition to the next generation. While some swimmers said that they were looking forward to taking the old swimming route from Tsim Sha Tsui to Central.

The third New World Harbour Race since its revival took place on 6 October 2013. The route crossed the eastern Victoria Harbour, which was different from the route in the 1970s (from Tsim Sha Tsui to the already demolished Queen's Statue Wharf in Central). We envisage a cleaner Harbour upon completion of HATS Stage 2A. By then, swimming along the previous route will be just round the corner.

Conclusion

With urbanisation and population growth, sewage treatment has become a challenging task for Hong Kong. By implementing various large-scale projects, DSD has enhanced comprehensively the sewage collection, treatment and disposal to provide the public with a clean environment, purified waters and better living environment. These projects also serve to mitigate the environmental problems arising from rapid urbanisation, and have proven to be highly effective in improving the harbour water quality. DSD sincerely wishes to collaborate with the public in cherishing and conserving our harbour.

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9 Leisure and Cultural Services Department. *Leisure Services (Recreation and Sports Facilities) Statistics Report 2013*. Website: http://www.lcsd.gov.hk/en/ppr_statistic_ls.php#beach Accessed date: 3 October 2013.

10 Environmental Protection Department. *Marine Water Quality in Hong Kong in 2011*, Appendix A. Website: http://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/water/marine_quality/files/2011Eng-2.pdf Accessed date: 3 October 2013. The report suggested that the water quality in eastern harbour, Eastern Buffer Water Control Zone and Junk Bay Water Control Zone has been improving.

11 〈闊別31年海水含菌量劇減99%，維港已淨化渡海泳復辦〉載《蘋果日報》，2010年9月4日。

Fig. 1 was provided by courtesy of the Information Services Department.
Fig. 2 was provided by courtesy of the Hong Kong Museum of History.
Fig. 3 was provided by courtesy of *Ta Kung Pao*.