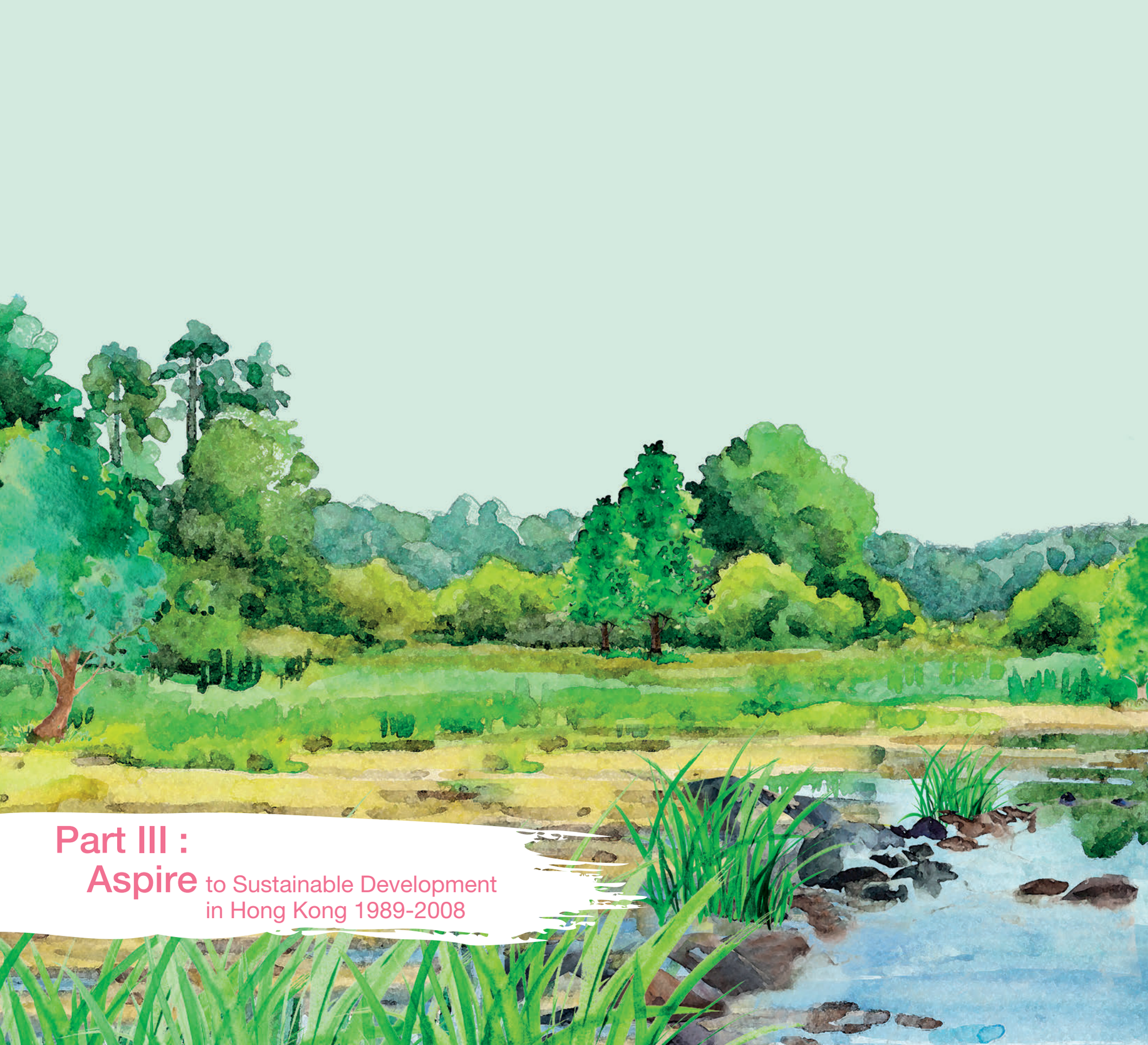

Charter
A
Vibrant
Course
1989-2008



Part III :
Aspire to Sustainable Development in Hong Kong 1989-2008

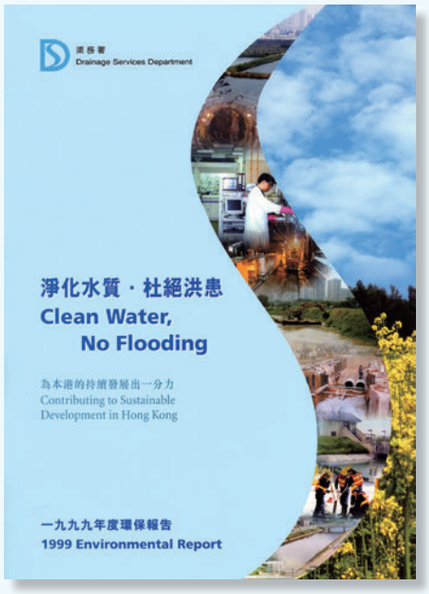
Chapter 6 : Sewage Collection and Treatment

The establishment of the Drainage Services Department

《White Paper: Pollution in Hong Kong — A Time to Act》

In 1989, the Government published the White Paper: Pollution in Hong Kong — A Time to Act ("White Paper"). This White Paper on environmental protection policy objectives and initiatives pointed out that the Hong Kong community generated over 2 million tonnes of wastewater daily in the late 1980s. The wastewater was discharged by multiple routes into the sea. Roughly 10% of the wastewater received biological treatment before discharge, 40% received partial treatment before discharge offshore through submarine outfalls, and the remaining 50% was discharged to the sea, near shore, without any treatment. The inadequacy of public sewerage and sewage treatment facilities led to the deterioration of the quality of the coastal waters and inland watercourses, and consequently the closure of bathing beaches, outbreaks of red tides, contaminated seafood, and visual pollution.

White Paper: Pollution in Hong Kong — A Time to Act published by the Government in 1989



As stated on the cover of this 1999 Environmental Report, the mission of the Drainage Services Department is to create a community of "clean water, no flooding" and "contributing to the sustainable development in Hong Kong".

The White Paper listed the new sewage facilities built in the 1980s. Wastewater collected in the sewerage systems was conveyed either to the eight secondary sewage treatment works at Sha Tin, Tai Po, Yuen Long, Shek Wu Hui, Sai Kung, Sha Tau Kok, Hei Ling Chau and Mui Wo, or to one of the screening plants, before discharge into inland watercourses or sea. As for places with insufficient or without sewerage system, (such as Middle Bay and Clear Water Bay), new developments were required to install biological treatment plants.

The White Paper further reviewed the prevailing pollution control regulations and introduced enactment of new legislation on water pollution control. According to the proposal made in the White Paper, the Government combined the Drainage Works Division under the Civil Engineering Services Department (CESD) with several divisions of the Electrical and Mechanical Services Department (EMSD) to form the new Drainage Services Department (DSD) as an executive arm for the Environmental Protection Department (EPD) to combat water pollution in Hong Kong.

The key responsibilities of the DSD are to manage the sewerage and stormwater drainage systems in Hong Kong. On sewerage, the Department is responsible for the implementation of sewerage proposals of the EPD, entailing design, construction, operation, maintenance and upgrading of the collection, treatment and disposal of wastewater. On stormwater drainage, the Department is responsible for implementing flood prevention measures to minimise the occurrence of flooding. Its roles also include strategic planning, design, construction, operation, maintenance and upgrading of drainage systems to collect stormwater runoff from the land and convey it to the receiving waters.

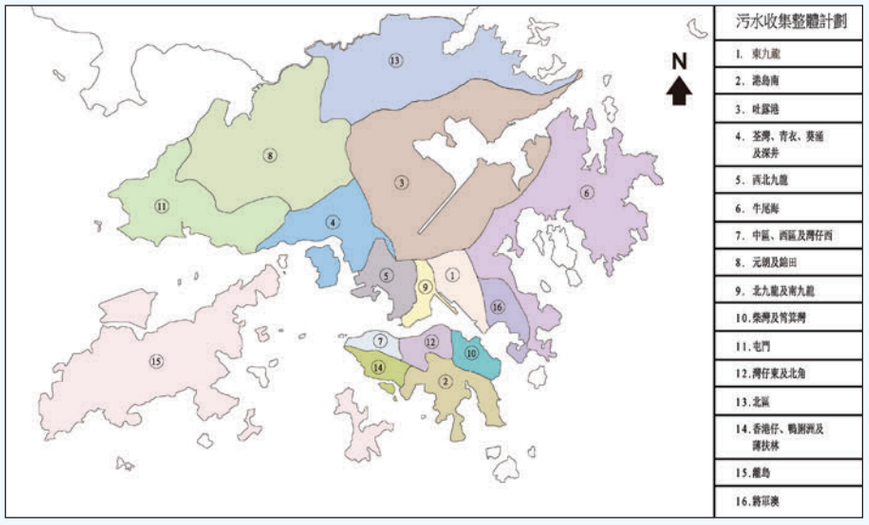
Improper discharge of wastewater had been the cause of odour nuisance on Kowloon Bay seafront for years. Such a phenomenon was also common in many areas on both sides of the Victoria Harbour.

Challenges abound

The inshore water quality problem in Hong Kong in the late 1980s was not merely due to the inadequacy of infrastructure. The crux of the problem was the widespread connection of sewers from industrial facilities, restaurants and residential buildings directly into stormwater drains. As a result, wastewater was carried along with stormwater to the vicinity of seawalls or even typhoon shelters for discharge, frequently causing sea seawater to turn black and foul in Kowloon Bay, Yau Ma Tei and Causeway Bay Typhoon Shelters. While as much as 90% of wastewater in some catchment areas was discharged into stormwater drains, it was common that 50% of wastewater in other catchment areas was discharged in the same manner. Another reason for the deterioration of water quality in inland waters was that public sewers had not yet been laid in rural areas such as the southern side of Hong Kong Island and Clear Water Bay.

The challenge posed to the Government was how to treat the wastewater collected from the sewerage systems in a cost-effective and environmentally friendly manner. There were two feasible options at that time. One option was to adopt an extremely high level of wastewater treatment and then dispose of the effluent in the vicinity of inshore waters. Another option was to adopt conventional treatment by which the effluent was to be discharged via especially long submarine outfalls into the waters well away from the shores, where it could be diluted and purified by seawater. Two months after the release of the White Paper, the Government completed the Sewage Strategy Study and made its decision, under which a long-term strategy for collection, treatment and disposal of municipal wastewater was formulated to meet the water quality objectives, while substantial improvements were recommended for the public sewerage facilities in Hong Kong. The strategy consisted of two parts: Strategic Sewage Disposal Scheme and Sewerage Master Plans.

Smooth seas never make good sailors. It can be seen from the preceding sections that the newly founded Drainage Services Department was to play a major role in accomplishing the specific goals set by the Government.



Coverage and Location of the 16 Sewerage Master Plans

Sewerage Master Plans

Between 1989 and 1996, EPD commissioned consultants to compile Sewerage Master Plans (SMPs) for 16 sewerage catchments in Hong Kong. Each of the 16 SMPs contained recommendations to upgrade and expand the sewerage, sewage pumping stations and sewage treatment facilities for the efficient collection, treatment and disposal of wastewater generated from each catchment. The objectives of SMPs were to ensure that the sewerage could cope with the existing and future development needs, and that the collection systems would have sufficient capacity to accommodate and convey all sewage collected instead of overflowing into stormwater drainage systems.

Overviews of the SMPs for three regions out of the 16 SMPs are described below to illustrate the general scopes and characteristics of the works under SMPs:

Hong Kong Island South

Completion and commissioning of the sewerage improvement works and sewage treatment and disposal facilities in the Southern District according to the recommendations in the Hong Kong Island South SMP is considered as one of the major achievements of the DSD in its first 10 years. Throughout the years before the works were completed, coastal water pollution in the district, particularly the beach areas from Shek O to Deep Water Bay, had deteriorated as a result of increase in population, tourism and commercial activities. The sewerage then had not been adequately extended to cover those areas and its treatment capacity could not cope with wastewater generated by new developments. Consequently, in 1989 the DSD began to implement a comprehensive collection, treatment and disposal system to raise the water quality in the coastal waters in the district to an acceptable standard. For instance, the beach at Repulse Bay was seriously polluted and almost on the verge of closure in the late 1980s. The annual geometric means of E. coli was over 400 counts per 100 millilitres of seawater and the beach water quality was ranked Poor. After implementation of the Hong Kong Island South SMP, the hygienic conditions of this reputable beach were gradually improved.

The Hong Kong Island South SMP works consisted of construction of 24 kilometres of sewers, 17 sewage pumping stations, a preliminary treatment works in Shek O, a secondary treatment works built inside cavern in Stanley, and rehabilitation of 8 km of sewers. All works were completed in 2000.

The wastewater collection, treatment and disposal systems under the Hong Kong Island South Sewerage Master Plan include a secondary treatment works at Stanley built inside cavern.

Yuen Long and Kam Tin

Implementation of sewerage improvement works would inevitably encounter with different challenges. The planning for the sewage treatment infrastructure under the Yuen Long and Kam Tin SMP had been carried out analytically and flexibly to meet future changes in land use and urban development in the north western New Territories.

Yuen Long Sewage Treatment Works was designed to treat domestic wastewater from Yuen Long Town, Nam Sang Wai and Kam Tin, and industrial wastewater from Yuen Long Industrial Estate. The plant was completed in two stages. When Stage I was commissioned in 1984, the plant could treat 53 000 cubic metres of wastewater per day, equivalent to a population of 194 000. After the commissioning of Stage II in 1992, the sewage treatment capacity increased to 70 000 cubic metres per day, equivalent to a population of 256 400. The treatment process comprised screening, primary sedimentation, biological treatment, anaerobic sludge digestion with energy recovery from biogas, and sludge dewatering.

To improve and protect the water quality of Deep Bay and its neighbouring ecological environment and to cope with the sewage increase based on the population forecast and due to extension of village sewerage, the DSD has planned to upgrade Yuen Long Sewage Treatment Works into Yuen Long Effluent Polishing Plant with tertiary treatment standard, with new facilities for effluent reuse, co-digestion for imported organic wastes, enhancement on deodorising system, energy recovery, extensive greening features and space for public amenity. These elements are aimed at improving the environmental performance and efficiency of the effluent polishing facility. The sewage treatment capacity will be increased in phases to 150 000 cubic metres per day.

The DSD has planned to upgrade the Yuen Long Sewage Treatment Works to effluent polishing plant with tertiary treatment

Wan Chai East and North Point

The sewers built in early years in Wan Chai East and North Point districts had insufficient capacity to cope with the development needs. Besides, more than a quarter of the sewage systems were seriously silted up due to inadequate gradients, which resulted in more than 10% of the untreated wastewater (about 10 000 cubic metres) overflowed into Victoria Harbour everyday through stormwater drainage systems.

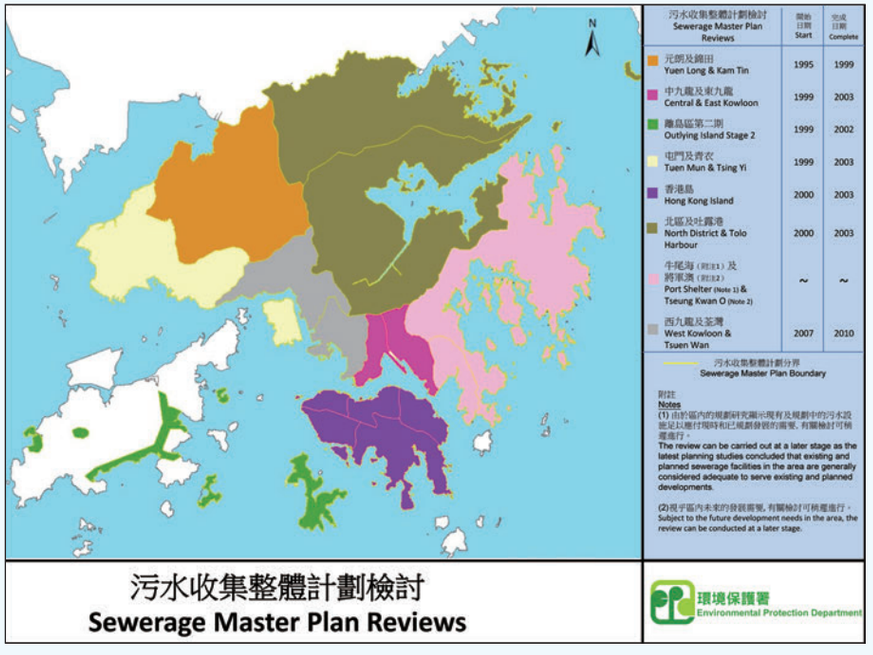
Works under the Wan Chai East and North Point SMP included the construction of more than 18 km of sewers, a new pumping station, and rectification of expedient connections in the area. An essential but a very difficult part of the works was the construction of the trunk sewer of diameter more than 1.8 metres and more than 10 metres below some of the busiest roads, including Electric Road, Java Road, Hennessy Road, Gloucester Road, Yee Wo Street and Percival Street, the construction activities of which would have serious impacts on the lives in the neighbourhood and the traffic. To minimise the adverse impact and to elicit supports from the local residents and shop operators, the sewerage works had adopted many innovative measures, including trenchless construction, transparent hoarding, and unprecedented engagement of community relations officers to enhance communication with the residents and shop operators. These measures to cultivate community relations have become an exemplar model for future road works to follow suit.

The Wan Chai East and North Point Sewerage Master Plan required the construction of sewers at heavily trafficked roads in Norht Point and Causeway Bay

Review of Sewerage Master Plans in eight regions

In the late 1990s, the EPD re-grouped the 16 SMPs into eight areas to conduct review studies on the SMPs. The scope of the review studies covered Hong Kong's latest population forecast, land use planning and new development proposals, with an aim to ensure that sewerage works proposed under the 16 SMPs would be able to keep in pace with the rapid changes in Hong Kong. The eight areas on Sewerage Master Plan Reviews are as follows:

- Yuen Long and Kam Tin
- Central Kowloon and East Kowloon
- Tuen Mun and Tsing Yi
- Outlying Islands Phase II
- Hong Kong Island
- North District and Tolo Harbour
- West Kowloon and Tsuen Wan
- Port Shelter and Tseung Kwan O



Delineation of the Eight Sewerage Master Plan Reviews

The DSD followed the recommendations in the Sewerage Master Plans and the Sewerage Master Plan Reviews and implemented the sewerage works in stages for the rehabilitation, expansion and upgrading of the existing sewerage infrastructures. Today, the DSD substantially completed the sewerage improvement works recommended under the SMPs. The DSD continues to review and carry out sewerage improvement works over the territory to cope with latest development of Hong Kong.

Sewage treatment works and sewage pumping stations in Hong Kong

Sewage treatment works

Sewage treatment facilities are important elements in the sewerage systems. The DSD has about 310 sewage treatment works, including sewage pumping stations and treatment works ranging from preliminary (screening) to tertiary treatment levels.

When the DSD was established in 1989, there were eight major sewage treatment works already in operation located in Sha Tin, Tai Po, Shek Wu Hui, Sai Kung, Yuen Long, Sha Tau Kok, Hei Ling Chau and Mui Wo. Since then, more major sewage treatment works were commissioned, including those in Stanley, Stonecutters Island, Sham Tseng, Siu Ho Wan and Ngong Ping. Over the years, the DSD continually upgrade the existing plants so that they perform as the forefront of world-class sewage treatment facilities.

The Mui Wo sewage treatmeat works was one of the sewage treatment works already in operation when the DSD was established

Stanley Sewage Treatment Works

Stanley is a small coastal town south of Hong Kong Island renowned for its natural scenery, ethnic villages and market. The Stanley Sewage Treatment Works (Stanley STW) located at Wong Ma Kok was commissioned in 1995 with a designed treatment capacity of 11 600 cubic metres per day, serving a population of 27 000 in Stanley, Tai Tam, Chung Hom Kok and Red Hill areas. Sewage is conveyed from 13 sewage pumping stations in the area to the Stanley STW for secondary treatment.

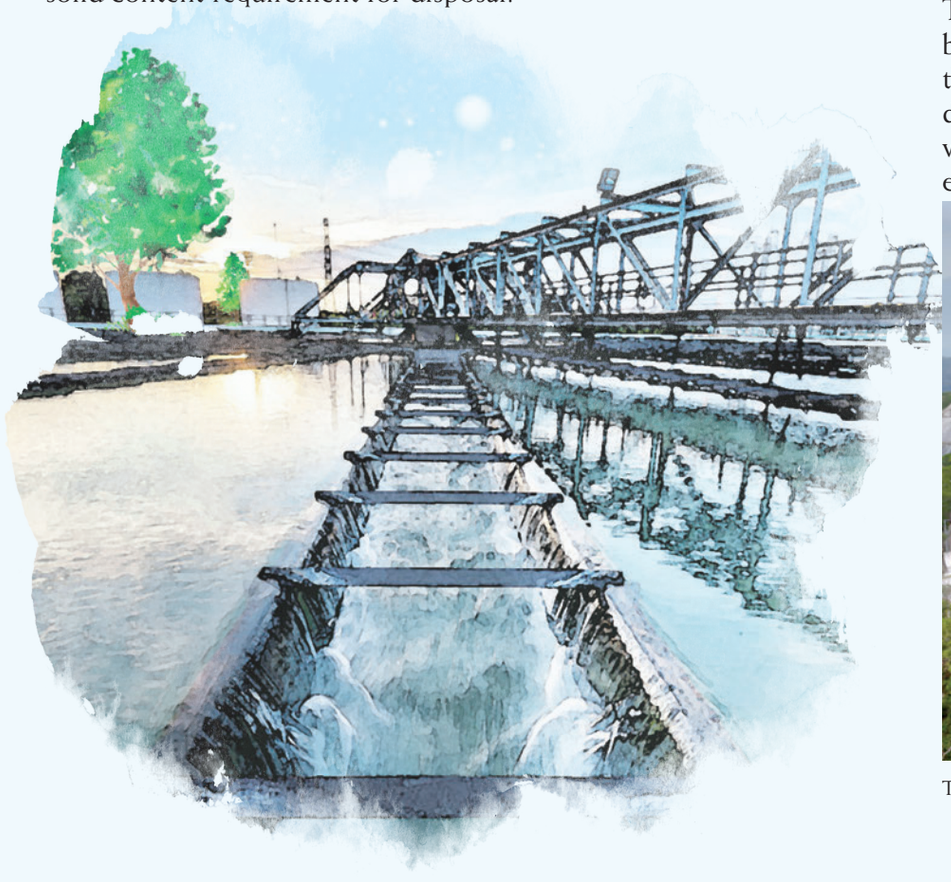
The Stanley STW was built inside three caverns, each about 120 metres long, 15 metres wide and 17 metres high, with over 450 metres of road access, ventilation tunnels and shafts. The sewage treatment works would hardly be noticed by the passers-by and its daily operation would cause minimal impact on the surrounding environment. The Stanley STW is the first of its kind built inside a cavern in Southeast Asia.

The Stanley STW originally adopted an "extended aeration activated sludge" treatment process. The sewage entered the bioreactor after screening and de-gritting. With extended retention time, the microorganism assimilated the pollutants and converted ammonia nitrogen in the sewage to nitrate. The final sedimentation tank was

Visitors to Stanley cannot easily notice the sewage treatment works inside the caverns

equipped with lamella plate settlers to increase the settling efficiency while requiring less floor space. The effluent was finally disinfected by multi-point chlorination systems before discharge to the sea through a submarine outfall. The settled sludge was dewatered and dispatched using sealed containers to the sludge treatment facility in T. PARK Tuen Mun.

To further improve the water quality in the Southern District of Hong Kong Island, the DSD introduced an advanced sewage treatment technology in the 2000s. The treatment process at the Stanley Sewage Treatment Works was upgraded to the "Combined Biofilm and Activated Sludge" process, with an enhanced anoxic zone installed for denitrification. After this upgrading, not only that the total nitrogen content in the effluent was substantially reduced, but the sewage treatment capacity of Stanley Sewage Treatment Works was also increased by more than 30%. In terms of sludge treatment, a filter press dehydrator was installed to replace the two original belt filter sludge dehydrators so that the sludge would comply with the revised solid content requirement for disposal.



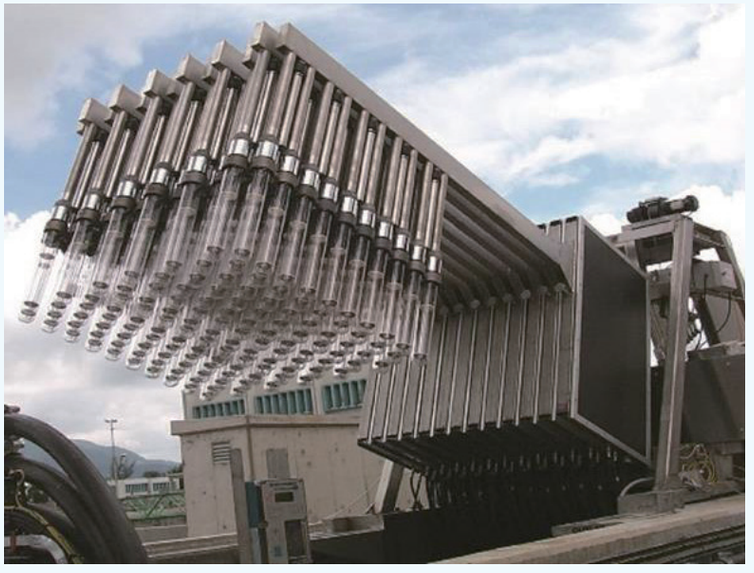
Ngong Ping Sewage Treatment Works

Ngong Ping Sewage Treatment Works was commissioned in 2005 and is the first tertiary treatment works with reclaimed water facilities in Hong Kong. Ngong Ping is situated on a plateau on Lantau Peak within the water-gathering ground for Shek Pik Reservoir. The area is nestled by verdant country parks, with nearby rivers and woods supporting the largest population of Romer's Tree Frog (Philautus romeri) in Hong Kong. To protect water quality in the water-gathering ground and nearby coasts, Ngong Ping Sewage Treatment Works adopts tertiary treatment process to treat and purify the sewage before discharge. The sewage treatment system consists of a sequencing batch reactor, a double-layer gravel filter and disinfection facilities to reduce organic pollutants, suspended solids, nutrients and pathogenic microorganisms in the sewage to extremely low levels. The plant recycles the treated effluent for toilet flushing in the nearby public lavatories and for irrigating plants and rearing fish within the treatment works.

The Ngong Ping Sewage Treatment Works compound is designed to blend harmoniously with the surrounding scenic environment. Most of the facilities are built underground to reduce the building heights. The design of the building facade is aesthetically pleasing, complemented with nicely designed landscaping to create an endearing and tranquil environment.

The Ngong Ping Sewage Treatment Works blends harmoniously with its surrounding natural environment

The Tai Po Sewage Treatment Works was the first large –scale secondary treatment works in Hong Kong



Ultraviolet disinfection system in Shek Wu Hui Sewage Treatment Works

Tai Po Sewage Treatment Works

Tai Po Sewage Treatment Works is located in the southeast of Tai Po Industrial Estate, and to the west of a defunct landfill. It provides sewage treatment services for a population of more than 300 000 in Tai Po District. The plant was commissioned in 1979 and was the first large-scale secondary sewage treatment works in Hong Kong. In the 1990s, the plant undertook improvement works to introduce nitrifying and denitrifying activated sludge systems to achieve a reduction of the total nitrogen level in the sewage by as much as 70%. To meet the rapid development in the District and more stringent effluent discharge standards, further expansion and upgrading works were completed in 2015 to increase the sewage treatment capacity from 90 000 cubic metres to 120 000 cubic metres per day. The improvement works included an ultraviolet disinfection system to improve the effluent quality. Digested sludge is dewatered by filter presses to reduce moisture content and volume before dispatch to the sludge treatment facility in T·PARK Tuen Mun.

The Government has commenced a pilot scheme in early 2019 to try out food waste/sewage sludge anaerobic co-digestion, under which Tai Po Sewage Treatment Works would receive a maximum of 50 tonnes of pre-treated food waste per day from Shuen Wan Leachate Pre-treatment Works for the trial. This co-digestion technology would help to raise the food waste treatment capability and biogas yield, which is a form of renewable energy, thus fulfilling the Turning Waste to Energy objective.

Shek Wu Hui Sewage Treatment Works

Shek Wu Hui Sewage Treatment Works commenced operation in 1984. It provides secondary treatment services for Sheung Shui, Fanling and areas in the vicinity. Today, the sewage treatment works adopts the activated sludge biological treatment process. The plant is designed for a sewage treatment capacity of 93 000 cubic metres per day. After treatment and ultraviolet disinfection, the effluent is discharged through Ng Tung River and Shenzhen River to Mai Po Inner Deep Bay. Along with the population growth and extension of the sewerage network to the unsewered areas, Shek Wu Hui Sewage Treatment Works is close to operate at its original designed capacity. To meet the increasing influent flow and to raise the effluent discharge quality, the DSD is undertaking expansion and upgrading works in Shek Wu Hui Sewage Treatment Works in stages. Advance engineering works for the expansion commenced in 2015 and expected to be completed by 2019. Upon completion, the sewage treatment capacity will be increased to 105 000 cubic metres per day. On

completion of the subsequent Main Works in 2034, Shek Wu Hui Effluent Polishing Plant will provide tertiary treatment standard with an ultimate designed treatment capacity of 190 000 cubic metres per day.

Sewage pumping stations

Sewage from residential, industrial or commercial buildings in Hong Kong is normally conveyed to the sewage treatment works by gravity sewers. However, if the building is distant from the sewage treatment works or situated at difficult topography, sewage pumping station will be required to pump the sewage via rising mains to downstream sewage treatment works.

There are basically four types of sewage pumping stations in Hong Kong, namely, wet/dry well pumping stations, submersible pumping stations, screw pumping stations and vacuum pumping stations. Centrifugal pumps and screw pumps are two main types of pumps used.

Cheung Sha Wan Sewage Pumping Station

The Cheung Sha Wan Sewage Pumping Station mainly handles wastewater collected in Sham Shui Po, Lai Chi Kok and Mei Foo. A total of ten sets of centrifugal sewage pumps are installed to convey sewage to the North West Kowloon Preliminary Treatment Works on Stonecutters Island via twin 2 metres diameter rising mains, which are the largest rising mains in Hong Kong. The pumping station has a maximum designed flow rate of 14.7 cubic metres per second. A 3.3 kilovolts high-voltage motor is installed to drive each high power centrifugal sewage pump. Compared with typical low-voltage system, the facility occupies less working space with higher energy-efficiency. The whole pumping system is automatically operated and performance of each sewage pump is monitored with sensors.

3.3 kilovolts high-voltage centrifugal sewage pump in the Cheung Sha Wan Sewage Pumping Station

Kwun Tong Intermediate Sewage Pumping Station

The Kwun Tong Intermediate Sewage Pumping Station (KTISPS) is another sewage pumping station in the town centre. Situated on Hoi Bun Road in Kwun Tong, and in the vicinity of Kwun Tong Public Pier, the pumping station has five sets of large-scale screw pumps with a maximum design flow of 9.2 cubic metres per second to convey wastewater collected from Kai Tak, Kowloon Bay and Kwun Tong to the Kwun Tong Preliminary Treatment Works for treatment. Keeping abreast with the neighbouring community development, the DSD infused landscaping and greening features into the KTISPS to make it integrate better with the community. Furthermore, the KTISPS is equipped with effective deodorisation system to eliminate the odour of wastewater, thereby mitigating its impact on the nearby environment.

Green roof and beautification works at the Kwun Tong Intermediate Sewage Pumping Station

Sewage pumping stations at Stonecutters Island Sewage Treatment Works

Under the Harbour Area Treatment Scheme (HATS), the Main Pumping Station No. 1 and the Main Pumping Station No. 2 at the Stonecutters Island Sewage Treatment Works are designed to lift the wastewater from the deep tunnels to the sedimentation tanks above ground for treatment. Both Main Pumping Stations are circular structures. The Main Pumping Station No. 1 is 50 metres in diameter and at a depth of 34 metres, while the Main Pumping Station No. 2 is 55 metres in diameter and at a depth of 40 metres. The latter is one of the largest underground sewage pumping stations in the world. Each Main Pumping Station is equipped with 8 giant centrifugal sewage pumps with four variable speed drives at the base level. Each pump is designed for a pump rate of 4 to 8 cubic metres per second, and when all pumps operate concurrently, they can achieve a maximum flow rate of 63.5 cubic metres per second. The two Main Pumping Stations are provided with automatic control systems to control all the peripheral preliminary treatment works under the HATS.

Eight sewage pump motors installed in the Main Pumping Station No. 1 at the Stonecutters Island Sewage Treatment Works under the Harbour Area Treatment Scheme

Bio-filter for odour removal

With the expansion of sewerage networks to cover remote unsewered areas, there is a need for better septicity and odour control for sewage pumping stations. When sewage remains in the sewerage for a period of time, chemical changes would take place and the sewage would release highly poisonous and corrosive hydrogen sulphide gas. To prevent sewage from becoming septic in the sewer and hence releasing of hydrogen sulphide, sewage pumping station design must adopt various preventive measures, including optimising the design of sewage collection systems, additions of oxygen or chemicals such as calcium nitrate. Besides, the DSD tackles the odour problem at source, for instance, by adding deodorising agents to the upstream systems, affixing covers to potential odourous facilities in sewage treatment works, installation of activated carbon systems, chemical scrubbers, as well as bio-filters for odour removal.

Moreover, to create a more pleasing surrounding environment, design of sewage pumping stations must also consider aesthetic appearance, odour and noise control, and landscaping works. Since 2006, construction or rehabilitation of above-ground buildings (including sewage pumping stations) by the department are required to consider aesthetically pleasing, greening and other related elements so that these buildings would be in harmony with the local environment.

Sewage pumping stations in the vicinity of villages will be designed to blend with the local environment

Landscape design in the Kowloon City Sewage Pumping Station

Green roof of the Kowloon City Sewage Pumping Station

Dealing with polluted flows in stormwater drains

Despite the expansion of the sewerage networks to collect wastewater discharged through proper means, a substantial quantity of wastewater was improperly disposed of and found their ways into the stormwater drainage systems. For example, sewerage outlets of some buildings were incorrectly connected to the public stormwater drainage systems in urban areas, and in the unsewered rural areas, sewage from village houses might go straight into nearby watercourses. In order to contain such pollution problem, the DSD has constructed a number of special facilities (including dry weather flow interceptors and inflatable rubber dams) to re-direct polluted flow from stormwater drainage systems back to the sewerage networks.

Dry weather flow interceptors

Dry weather flow interceptors intercept and divert polluted dry weather flows in stormwater drains to the sewerage systems, while allowing the stormwater drainage systems to accommodate the passage of high flows in rainy season. In general, the quantity of dry weather flow to be intercepted is controlled by adjusting the flow depth: flow below the control depth is discharged through the intercepting pipe into the sewerage system, while on rainy days, flow above the control depth is partly intercepted into the intercepting pipe and partly into the stormwater system downstream.

Kai Tak River Improvement Works include construction of dry weather flow interceptors to intercept and divert polluted flows to sewers

A large dry weather flow interception station in Kowloon Bay

Inflatable rubber dam

Many of the drainage channels in the northern and northwestern New Territories are affected by the polluted tidal waters of Deep Bay. The DSD not only needs to deal with polluted flow from upstream in these drainage channels, but also has to resolve the nuisance caused by the backflow of polluted tidal water. To address this problem, an inflatable rubber dam was first installed at Yuen Long Main Nullah in 1992, and subsequently a few more were installed in other locations alike. During high tides, the dams are inflated to their full heights and shut off the polluted tidal water. When there are high stormwater flows from upstream, the dams are deflated and lowered to allow the passage of high flow to downstream. Dry Weather Flow Interceptors are provided as part of the inflatable dam system to redirect the polluted dry weather flow to the sewerage.

Inflatable dam at San Tin Eastern Main Drainage Channel near its confluence with Shenzhen River, the highest inflatable dam in Hong Kong with a 5 metres full height.

Inflatable dam in Yuen Long Main Nullah near Tung Tau Wai was constructed in 1992 to prevent polluted tidal water from backflowing into the Yuen Long town centre

Village sewerage

The SMPs included implementation programmes to provide public sewerage to unsewered villages (commonly referred to as village sewerage) for collecting sewage from village houses for proper treatment and disposal as a long term solution to improve village environment and sanitary conditions in watercourses. Village houses in these areas generally use septic tanks and soakaway systems for sewage disposal. As the number of village houses increased, septic tanks and soakaway systems had shown increasing operation and maintenance problems, affecting the sanitary conditions and posing threats to public health.

Under the village sewerage projects, public sewerage networks are extended to the lot boundary of the village houses. Village house owners are then required to connect their own sewers to the public sewers in compliance with the Water Pollution Control (Sewerage) Regulation (Cap. 358, Laws of Hong Kong). Prior to any connection works by the villagers themselves, the DSD would provide technical advice to resolve any connection issues. For those villages where village sewerage works have been completed, the villagers should be delighted to share their experience on the improvement in both the environment and the quality of living, along with an appreciation of property value.

When planning for the village sewerage programmes, the DSD would systematically investigate those unsewered areas and consider the proposed extent of sewerage coverage, to ensure that it was both technically feasible and cost-effective to implement. For villages remote from the main sewerage, or incurring very costly sewage pumping facilities, or where the construction of the facilities would involve substantial land resumption, septic tank systems would remain as an acceptable sewage treatment option, as populations in these areas are usually small and its impact on the environment is often limited.

Village sewerage usually adopts gravity sewers for carrying wastewater. Yet, where topographic and site constraints prevail, sewage pumping stations and rising mains are constructed for wastewater conveyance. By the end of 2018, about 530 villages have been included in the village sewerage programme, among which about 240 villages are now served by public sewerage, and village sewerage in the remaining villages will be implemented according to the village sewerage programme in the coming decade.

When public sewers are extended to the lot boundary of the village houses, individual house owners are required to connect their own sewers to the public sewers.

Sewage pumping stations are constructed in some village sewerage projects to convey wastewater

Village sewerage fosters noticeable improvement in the environmental and hygienic conditions of villages in the New Territories where they were not previously connected to public sewers

Tolo Harbour Effluent Export Scheme

The Sha Tin and Tai Po New Town Developments in the 1980s have resulted in the population in the Tolo Harbour catchment area doubled from the previous 500 000 to 1 million in recent years. Due to the limited natural purification capacity of Tolo Harbour, the population growth inevitably affected its water quality with increasing red tide incidents. Besides, the original design of the Tai Po and Sha Tin Sewage Treatment Works on nutrient removal did not meet the prevailing higher effluent quality requirements. In the 1980s, the effluent from the sewage treatment works in Sha Tin and Tai Po were discharged into Tolo Harbour, and this had led to the increase of nitrogen loading in the water of the latter and the outbreak of red tides from time to time.

As problems related to water quality in Tolo Harbour came to surface, the Government immediately drew up a Tolo Harbour Action Plan in 1986 declaring Water Control Zone, introducing livestock waste control, livestock ban and sewerage first-aid measures. Public consultation was made and the plan was rolled out in the following year.

To reduce the nitrogen content in the effluent, the DSD has implemented a series of measures. First of all, in 1992, upgrading works were undertaken within the sewage treatment works to improve nutrient removal level. Secondly, the sewerage were extended to cover the unsewered rural areas, such that wastewater from these areas could be intercepted and diverted. The third was the implementation of Tolo Harbour Effluent Export Scheme in 1994. From 1995 to 1998, the biologically treated effluent from the Sha Tin and Tai Po Sewage Treatment Works was gradually diverted through a new effluent tunnel below the Kowloon Hills to Kai Tak Nullah (today renamed as Kai Tak River) for discharge into Victoria Harbour. The Tolo Harbour Effluent Export Scheme had helped to resolve the red tide problem in Tolo Harbour and had a side benefit of improving the water quality at Kai Tak River due to flushing by the transferred effluent.

Kai Tak River at the downstream end of Tolo Harbour Effluent Export Scheme

Sha Tin Effluent Pumping Station

The major facilities of the Tolo Harbour Effluent Export Scheme are as follows:

Tai Po Effluent Export System — This comprises the Tai Po Effluent Pumping Station, a 500 metres long rising main and a 6 500 metres long submarine pipeline across Tolo Harbour to transport treated effluent from Tai Po Sewage Treatment Works to Sha Tin Sewage Treatment Works.

Sha Tin Effluent Export System — This comprises the Sha Tin Effluent Pumping Station and a 1 730 metres long twin pumping mains to transport the combined treated effluent from Tai Po and Sha Tin Sewage Treatment Works to the inlet of the effluent tunnel.

Effluent Tunnel System — Effluent from the two sewage treatment works is discharged by gravity from the Sha Tin Effluent Tunnel Portal, through a 3 metres diameter, 7.4 kilometres long tunnel, to the Terminal Access Shaft in Diamond Hill on Kowloon side, and subsequently to the downstream Kai Tak River and Victoria Harbour.

The water quality in Tolo Harbour has been steadily restored to normal after completion of the Tolo Harbour Effluent Export Scheme works in the mid-1990s

Overview

In 1989, following the recommendations in the White Paper: Pollution in Hong Kong — A Time to Act, the DSD was established to assume the great responsibilities for sewage treatment and stormwater drainage in Hong Kong.

In the same year, the Government formulated a long-term strategy and implemented the Sewerage Master Plans to meet the development needs. In accordance with the above Plans and the recommendations in the Review Studies on Sewerage Master Plans, the DSD designed and constructed sewage treatment works and facilities in various districts in stages, while improving the existing sewage treatment facilities and constructing village sewerage, with a view to increasing the sewage treatment capacity in various districts.

Water pollution in Tolo Harbour worsened in 1980s. The DSD then proposed expanding the sewage treatment works in the districts and diverting the effluent in stages from the treatment works via a newly-constructed drainage tunnel to Kai Tak Nullah for discharge into Victoria Harbour, which has higher purification capacity. From then onwards, the water quality of Tolo Harbour has been improving.

While the sewerage infrastructures in Hong Kong were being gradually enhanced, the Department should at the same time bear the yoke for flood prevention and control to safeguard the lives and property of the public.

Chapter 7 : Flood Prevention

Confluence of two river channels

Since the DSD was established in 1989, the Government has allocated more resources on provision of flood prevention infrastructure. Although planning for the respective improvement works commenced before 1989, it took time to complete the works and the facilities only came into operation in succession after 1989. To date, the total capital investment for flood prevention in Hong Kong has amounted to HK$30 billion.

When typhoon and rainstorm became a menace

Despite that Hong Kong still experienced typhoon and rainstorm damage each year, the situation had improved since the establishment of the DSD. The flood prevention works have started to take the effect.

In its early years, apart from handling emergency repairs or undertaking quick-fix improvement works, the DSD had to implement inspection and preventive maintenance programmes for the drainage and sewerage assets and strategic planning for medium and long term drainage and sewerage improvements. The DSD also set up an Emergency Control Centre and an Emergency and Storm Damage Organisation to attend to flood-related incidents during heavy rainstorms, and the subsequent follow-up, case studies and analyses. The Department also had a 24-hour hotline to receive public enquiries and flood reporting.

In addition, many natural watercourses in the New Territories lie within private land. In the past, some flood incidents were caused by the lack of maintenance of major watercourses in private land. The Government experienced great difficulties to obtain consent from private land owners so as to gain access to private land and to carry out maintenance works to the watercourses. To rectify the situation, the Government enacted the Land Drainage Ordinance in 1994, empowering the Government to gain access to private land for maintenance and removal of obstructions on those watercourses which are designated as main watercourses.

Threats and casualties caused by severe rainstorms in 1989-2008

In May 1989, Severe Tropical Storm Brenda swept across the Philippines and Mainland China, causing many casualties. As Brenda moved closer to Hong Kong, the Hong Kong Observatory hoisted the No. 8 Southeast Gale or Storm Signal on the afternoon of 20 May. During the storm, severe flooding occurred in the northern and north western parts of the New Territories, where areas from Sheung Shui to Yuen Long were submerged, and many pieces of agricultural land were inundated. Six people were reported dead and one missing. Brenda wreaked havoc and caused extensive damage in the northern and north western parts of the New Territories, underscoring the pressing need to improve the drainage systems in those areas. As a result, this issue was on the list of the priorities to be dealt with by the DSD after its establishment.

The New Territories was vulnerable to flooding in the past

On 8 May 1992, a trough of low pressure hit Hong Kong. In the early hours, the weather deteriorated rapidly, with thunder rumbling, lightning flashing and rain pouring down. The Observatory recorded 109.9 millimetres of rainfall between 6:00 am and 7:00 am, the third highest hourly rainfall recorded between 1884 and 2017. Many streets across Hong Kong were seriously flooded and road traffic was paralysed. It happened that the Hong Kong Certificate of Education Examination was held on that day. Since the then Education Department had not made any appropriate announcement to cancel the examination, students needed to get to examination venues despite the heavy rain. Eventually, the heavy rain claimed five lives, including an engineer from the Hong Kong and Islands Division of the DSD, who was investigating a flooding case in Baguio Villa. This rainstorm disaster prompted the Observatory to launch a system of rainstorm warning signals categorised into four levels, namely "Green", "Amber", "Red" and "Black".

It took the city by storm that on the first day rainstorm warning signal issued by the Observatory would necessarily soar to the highest "Black". From 17 to 18 July 1992, Tropical Storm Faye slammed Hong Kong. In the early morning of July 18, the weather turned worse and the wind rapidly gathered force and increased to full gale. As strong winds and heavy rain became rampant, the Observatory issued the first Red and Black rainstorm warning signals on record. The heaviest rain fell in the north western part of the New Territories that more than 300 millimetres of rainfall was recorded on that day. When Hong Kong was hit head-on by Faye, 152 cases of flooding were reported. The storm also caused 2 deaths and 24 injuries.

The year 1993 was just another stormy and wet year. Within the year, a total of eight typhoons affected Hong Kong. Four times had the Observatory issued No. 8 Gale or Storm Signals. On 17 September, as Typhoon Becky was closing in, the Observatory swiftly issued No. 8 Northeast Gale or Storm Signal at midnight. A total of 223.9 millimetres of rain was recorded during the passage of Becky. Sheung Shui and San Tin in the New Territories were severely flooded. The storm brought 1 death and 130 injuries. At sea, 6 vessels sank leaving 11 people dead and about 70 missing. The menace of Typhoon Becky spread to the neighbouring Shenzhen. On 26 and 27 September, heavy downpour caused extensive flooding at almost every street corner. Depths of flood water along the roads in Lo Wu District reached 2 metres. Earlier in the year on 16 June, Shenzhen was already struck by another torrential rain. As flood disasters took their toll, Shenzhen suffered from heavy direct economic loss. Shenzhen and Hong Kong governments established a Joint Working Group and decided to expedite the implementation of the Stage I and Stage II of Shenzhen River Regulation.

Wing Lok Street in Sheung Wan is low-lying. The area was inevitably flooded every time when hard hit by heavy rainfall in the past.

Torrential rain on 8th May 1992 caused 5 deaths and severe flooding affected many districts, including Queensway.

In the following years, typhoons and rainstorms had exerted particularly severe impact on the northern part of the New Territories. Typhoon Sibyl ripped through Hong Kong on 3 October 1995, causing serious flooding in Sheung Shui, where 25 villagers were stranded in Yin Kong Tsuen. Firefighter had to rescue the villagers by dinghies. By 1997, heavy rainstorms tended to haunt more frequently in the urban areas. Heavy rains led to serious landslips on 3 August 1997. A landslide near Ching Cheung Road forced the closure of this trunk road for several weeks for emergency repairs. On the 22 of the same month, Typhoon Zita battered Hong Kong. Red rainstorm warning signal was issued. Mong Kok was flooded where knee-deep flood water at Nathan Road paralyzed traffic and forced many stores to close. In 1998, flooding continued to batter almost everywhere on Nathan Road and Boundary Street in Mong Kok.

In 1998, the Observatory had refined the rainstorm warning system and streamlined it into three tiers, i.e., "Amber", "Red" and "Black", which are still applied to-date.

DSD staff on duty during rainstorm

In September 1999, Typhoon York caused 18 deaths in Manila and 25 in Zhuhai. The Hong Kong Observatory hoisted the Hurricane Signal No. 10 in the early morning of 16 September. During York's passage in Hong Kong, one windsurfer was killed in Cheung Chau and another man died in Tseung Kwan O. More than 4 000 trees were uprooted. Over 400 window glass panes in the Wan Chai Government Offices Buildings were shattered, including the DSD's offices on the 42nd to 44th floors of Revenue Tower.

In July 2001, it was unusual in Hong Kong that Gale or Storm Signal No. 8 was hoisted twice in two separate occasions in the same month. Typhoon Utor landed on 5 July, bringing 150 millimetres of rain to most parts of Hong Kong and more than 300 millimetres of rain to Lantau Island. A total of 25 cases of flooding were received by DSD. Storm surges caused severe flooding in many low-lying areas in Hong Kong, including Tai O, Lau Fau Shan and Sheung Wan. On 25 July, Typhoon Yutu struck Hong Kong, causing 10 injuries and numerous trees blown down.

On 16 July 2006, an active southwest monsoon brought heavy downpour and squally thunderstorms. The Observatory recorded 115.1 millimetres of rainfall within an hour between 2 a.m. and 3 a.m., the second highest hourly rainfall between 1884 and 2017 on record. Out of sheer luck, the rainstorm did not cause any serious damage.

In early June of 2001, the Rainstorm Warning Signal was issued for nine consecutive days. Torrential rain coupled with rising water level in Ping Yuen River had caused widespread flooding in northern part of the New Territories. This picture shows Fung Wong Wu Village in Ta Kwu Ling besieged by floodwater. Many villagers stranded and were rescued by helicopters and by firemen in dinghies.

At the end of May 2008, an active trough of low pressure affected the South China coastal areas and the northern part of South China Sea. Occasional heavy rain and squally thunderstorms persisted for the first seven days of the month. Around dawn on 7 June, torrential rain arrived in Hong Kong and focused on Lantau Island, Kowloon and Hong Kong Island. From 8:00 am to 9:00 am on that day, the Observatory recorded 145.5 millimetres of rainfall, the record-high one-hour rainfall since 1844. Floods and landslides triggered by heavy rains caused 2 deaths and 16 injuries.

The DSD received a total of 1,000 flooding cases on that day, the highest reported cases on record. Except two cases, all complaints were handled by noon of the day followed. With the full support of the Emergency Control Centre, the Direct Labour Force and the term contractors, the DSD was enabled to meet its performance pledges during such critical situations. Based on the experience on 7 June 2008, the Department thoroughly reviewed the Emergency and Storm Damage Organisation, re-allocated the resources and renovated the ancillary facilities at the Emergency Control Centre. The operation of the Emergency Control Centre will be described in Chapter 9 below.

On the morning of 7 June 2008, Hong Kong was wrecked by torrential rains and flooding. On the afternoon of that day, the then Secretary for Development Ms. Carrie Lam cordially visited the affected shop operators and residents in Wing Lok Street, Sheung Wan.

Torrential rain swept over Hong Kong on 7 June 2008 had caused debris flows onto the North Lantau Highway. Serious flooding followed. The DSD helped clear the devastated spots so that the carriageways could be opened to traffic as soon as possible.

Territorial Land Drainage and Flood Control Strategy Study — Phases I, II and III

A systematic solution to the drainage problem would necessitate a holistic flood control strategy. From 1988 to 1995, the Government commissioned the Territorial Land Drainage and Flood Control Strategy Study (TEL) — Phases I, II, and III to develop a comprehensive flood prevention strategy for the whole territory. The Study established flood protection standards for new drainage systems to withstand severe rainstorm events and overall flood control strategies for the New Territories. The DSD would formulate strategies to reflect the unique characteristics of each catchment area and to strike a balance between developments and engineering feasibility.

Drainage Master Plans and Review Studies

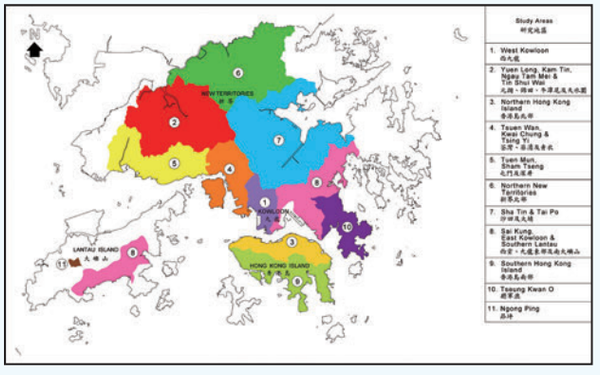
From 1994 to 2010, the DSD implemented eight Drainage Master Plan Studies and three Drainage Studies in phases to cover all flood-prone areas in Hong Kong:

- West Kowloon
- Yuen Long, Kam Tin, Ngau Tam Mei and Tin Shui Wai
- Northern Hong Kong Island
- Tsuen Wan, Kwai Chung and Tsing Yi
- Tuen Mun and Sham Tseng
- Northern New Territories
- Sha Tin and Tai Po
- Sai Kung, East Kowloon and South Lantau
- Southern Hong Kong Island
- Tseung Kwan O
- Ngong Ping

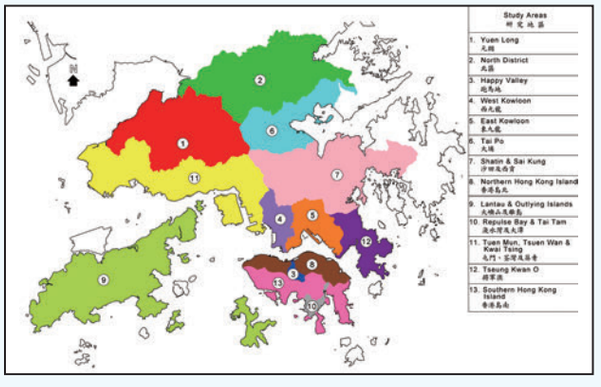
The Drainage Master Plans and Drainage Studies assessed the performance of existing drainage systems and recommended short-term and long-term drainage improvement measures to meet the current standards and future needs. According to the recommendations of TEL Phases I and II, computational hydrological and hydraulic models were widely used to evaluate the effectiveness of the proposed improvement measures. Computer model technology has advanced rapidly in the late 20th century and helped to secure more cost-effective solutions to flooding problems with more precise evaluations and prediction data.

The improvement works recommended under the Drainage Master Plans were very substantial, including the training of 120 kilometres of rivers and channels, and upgrading and construction of 130 kilometres of stormwater drains and drainage tunnels. By the late 2000s, the DSD completed the investigation, design and construction of most of the improvement works with the remaining in progress.

From 2008, the DSD had begun the Drainage Master Plan Review Studies to review the drainage capacity of the existing drainage systems and to propose improvement works to match with the latest development in the districts, effects of climate change and sustainable development. Review Studies on the Drainage Master Plans for Yuen Long, North District, Happy Valley and Kowloon have been completed, and those for Tai Po, Sha Tin and Sai Kung have been substantially completed, whereas Review Studies on Northern Hong Kong Island, Lantau Island and Outlying Islands, Tuen Mun, Tsuen Wan and Kwai Tsing, Repulse Bay and Tai Tam are in progress with Review Studies on the remaining areas in the planning stage.



Coverage of the Drainage Master Plan Studies



Coverage of the Drainage Master Plan Review Studies

Flood prevention in the New Territories

In the past, flooding was common in the New Territories, especially in the north and north western parts, due to their low-lying topography. In the 1980s and 1990s, flooding still occurred regularly in the New Territories, greatly affecting the daily life of the public.

In 1990, a year after its establishment, the DSD began constructing main drainage channels and local drainage improvement works to safeguard the life and property of villagers in low-lying areas in the North District. Flood prevention works in the New Territories can broadly be classified into two categories: drainage channels to collect and convey stormwater to the sea; and village flood protection schemes to protect villagers in low-lying areas from the threat of flooding.

Large-scale river training works in the New Territories

With extensive developments and changes in land use in the New Territories, improving the drainage capacities of existing rivers had become imminent. Drainage channels were no doubt the preferred option where the catchment areas were large in size, which could be aesthetically pleasant to blend with the natural surroundings.

In the past, some narrow and sinuous river sections in the New Territories were easily silted up. As a result, the flood plains along these old river sections were often threatened by flood of a depth of 1 metre to 1.5 metres. At that time, the river networks most in need of improvement works were scattered across the north and north western New Territories and Lam Tsuen River in Tai Po. The rivers in the north and north western New Territories basically belong to two major networks: 1) the Shenzhen River network including Ng Tung River, Sheung Yue River, Ping Yuen River etc., and 2) Yuen Long and Kam Tin Rivers network, both of which discharged into Deep Bay. The gradual completion of drainage channels and improvement works led to significant reduction of flooding risk in these regions.

River flood lashed a swathe of the flat plains in the New Territories before river improvement works commenced in the 1990s

Kam Tin River, Yuen Long

In early 1990s, the DSD began construction of new drainage channels to improve the drainage capacities of Kam Tin River and Shan Pui River. The DSD had subsequently awarded more than 10 construction contracts to regulate and train different river sections in the drainage networks. The lower reaches of the river channels in Yuen Long, Kam Tin and Ngau Tam Mei were completed in the late 1990s, and the upper tributaries were completed between 2002 and 2005. These drainage channel works had basically resolved the flooding problems in Kam Tin, Yuen Long and Tin Shui Wai areas.

Construction of Yuen Long Bypass Floodway started in early 2003 and was completed in 2006. At that time, the drainage network in Yuen Long Town was already under capacity. The above works had alleviated the flooding risk induced by the increased surface runoff due to urbanisation by diverting about 40% of the runoff away from Yuen Long Town through the bypass floodway to the downstream of Kam Tin River on the other side of the town. About 86 000 people benefited from this flood prevention project.

Kam Tin River after completion of river improvement works in early 1990s

Although Kam Tin River was diverted and widened, the original river course was preserved to minimize the impact due to the drainage improvements on the ecological environment.

Yuen Long Bypass Floodway diverted part of the runoff from Yuen Long town centre to Kam Tin River east of Yuen Long to reduce the risk of flooding in the Yuen Long Town

Ping Yuen River and Ng Tung River

Improvement of Shenzhen River in stages (information related to this project is contained in Chapter 8 below) has provided an opportunity to improve the tributary networks, including Ng Tung River, Sheung Yue River and Ping Yuen River. The works at Sheung Yue River and Ng Tung River were completed in 2002 and 2003 respectively. Since then, the Lo Wu, Tin Ping Shan, Ho Sheung Heung and Yin Kong areas were no longer suffered from flooding threats. The works at Ping Yuen River were completed in 2006, and the Shenzhen River Regulation Project Stage III was completed in the same year, relieving the flooding risk in Ta Kwu Ling.

The original meanders in the upper reaches of the Ng Tung River were preserved to maintain the original river features and achieve biodiversity

Ho Chung River

Ho Chung River flows alongside Ho Chung Road and discharged to Hebe Haven. Owning to the rapid developments in Sai Kung, the surface runoff had increased significantly and the original Ho Chung River could not meet the flood protection standards. The DSD had based on the recommendations in the Drainage Master Plan and carried out improvement works in Ho Chung River to improve its drainage capacity and alleviate the flooding risks in the nearby areas. The project started in 2007 and was completed in 2009. The DSD had widened the river channel by setting back the southern river bank to relieve flood risks. In addition, new ecological conservation features were introduced to enrich the aquatic and riparian environment and thus enhancing the ecology of the river. The Ho Chung River improvement works have unfolded a new chapter in channel design and construction in respect of river ecology in Hong Kong.

The widened Ho Chung River in Sai Kung

The fish ladder features in Ho Chung River help migratory creatures to return to Ho Chung River

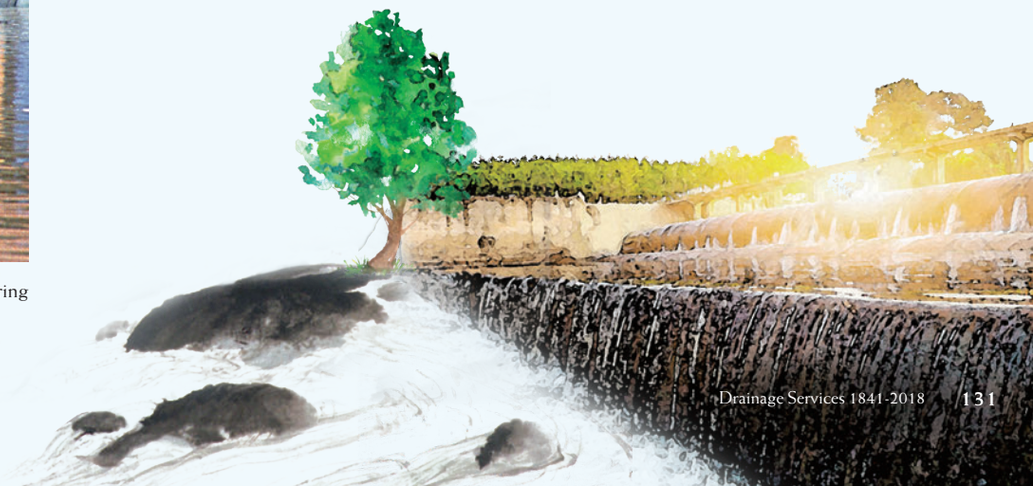
Village flood protection scheme — the polder construction

When the DSD was established in 1989, the two major river networks, the Shenzhen River network and the Yuen Long & Kam Tin Rivers network, in the north and north western New Territories discharged into Deep Bay were most in need of improvement. Once these two major river networks were improved, the flood risks in the north and north western New Territories were significantly reduced. To complement to these major river training works, village flood protection schemes were implemented in some villages in the New Territories to protect these villages from flooding.

Notwithstanding the construction of major drainage channels in the New Territories, there were 35 villages in low-lying areas which would still be susceptible to flooding due to natural topography or constraints by existing developments. Without any improvement, if the water levels in the drainage channels downstream were not too high, runoff from these low-lying villages could flow by gravity into the drainage channels via underground drains or surface channels. In the event of high water level in the downstream channels during heavy rainstorms, however, the floodwater could not be discharged by gravity to the downstream channels but would flow back to the low-lying villages, where it would cause flooding and threaten lives and property. Village flood protection schemes were therefore required.

Ma Tin Tsuen was vulnerable to inundation in the past due to river overflow nearby in Ma Tin Pok during heavy rain

Villages in the low-lying areas at San Tin swamped by floodwater backflow from the river downstream. The stormwater pumping station under construction can be seen in the background.



Village flood protection schemes address the flooding problem in the low-lying village areas by building a polder to prevent floodwater from entering the low-lying village areas, and draining the runoff from within the low-lying village areas to a flood storage pond and using pump to remove floodwater to outside of the polder.

To protect these flood-prone low-lying villages, the DSD has so far completed 27 village flood protection schemes, providing protection to 35 low-lying villages. The first polder was built in 1988 at Sik Kong Wai village in Tin Shui Wai. Other village flood protection schemes were subsequently completed providing flood protection to over 250 hectares of low-lying areas and rendering 31 000 people safe from the threat of flooding.

San Tin village flood protection scheme comprises a stormwater pumping station and flood storage pond, which can be seen at the top of this picture, and a ring road being part of the polder surrounding the low-lying villages.

The picture shows the flood storage pond in Ma Tin Tsuen, the design of which has to consider not only the feedbacks from the villagers, but also any planned infrastructures or developments in the vicinity.

The flood storage pond of the San Tin village flood protection scheme. Besides flood prevention, it facilitates the creation of a blue-green environment and brings forth enriched ecological values.

Multiple-solution approach — flood relief in Mong Kok

Repeated flooding in 1997 and 1998 in Mong Kok indicated an imminent flood problem. The DSD had implemented measures to raise the flow capacity of the drainage systems in West Kowloon. Apart from laying of 44 kilometres of underground drains using traditional method, the DSD had introduced new approaches of stormwater storage, flow interception and transfer to minimise trench excavations in this prominent commercial district in Kowloon.

The DSD began the drainage improvement works in Nathan Road first, and unprecedentedly, closed off Nathan Road between Lai Chi Kok Road and Boundary Street for traffic in two stages from October 1998, in a bid to shorten the construction period from 60 months to 19 months under such contentious temporary traffic arrangements. At the end, the project team had made a concerted effort to complete the works in less than a year, greatly lessening the inconvenience caused to the public by the works.

Drainage works at the junction of Nathan Road and Prince Edward Road in Mong Kok. Since the completion of the Mass Transit Railway in the 1970s, there had not been any such substantive construction works on Nathan Road.

Flooding at Nathan Road in Mong Kok during rainy seasons in the past

The Nathan Road Drainage Improvement Works necessitated temporary road closures in a number of roads in Mong Kok

A section of Nathan Road was closed for a year in 1998 to facilitate the drainage improvement works

The Tai Hang Tung Flood Storage Scheme included an underground flood storage tank with a capacity of 100 000 cubic metres at a depth of more than 10 metres underneath the Tai Hang Tung Recreation Ground, which would store excessive stormwater diverted from upstream under heavy rainstorm. When the heavy rainstorm had subsided, the stormwater in the flood storage tank would be pumped out to the downstream drainage system. This innovative flood storage scheme could attenuate the floodwater peak flows downstream, and reduce both the extent of drainage upgrading works in Mong Kok and the need for road excavation along heavily trafficked roads. The cost of the flood storage tank was HK$290 million, and the project was completed in 2004.

The Kai Tak Transfer Scheme utilised a 1.5- kilometre-long drainage tunnel of 4.4 metres inner diameter to intercept and transfer about 60% of the stormwater runoff from the existing nullah at the junction of Waterloo Road and Hereford Road in Kowloon Tong to the Kai Tak River in San Po Kong. The Kai Tak Transfer Scheme at a cost of about HK$380 million is the first drainage diversion tunnel system built in Hong Kong and is a vital part of the overall scheme to resolve the flooding problems in West Kowloon. The project was completed in 2004 summer. By diverting part of the stormwater runoff to Kai Tak River, the volume of stormwater flow entering the drainage system downstream in West Kowloon was reduced substantially.

The first underground stormwater storage scheme in Hong Kong under construction at Tai Hang Tung

Tunnel boring for the 1.5- kilometre-long drainage tunnel started at the junction of Waterloo Road and Hereford Road and finally breaking through at Choi Hung Road, the other end of the drainage tunnel under "the Kai Tak Transfer Scheme". The construction team gave a round of applause upon its completion.

Severe acute respiratory syndrome in 2003

From February to June 2003, a deadly acute respiratory syndrome (SARS) epidemic broke out in Hong Kong. A total of 1 755 cases were recorded, resulting in 299 deaths. The epidemic was the most severe in Hong Kong in recent years and caused far-reaching impacts on Hong Kong's politics, economy and society. The epidemic spread rapidly all over the world, with SARS cases appearing in countries from Southeast Asia to Australia, Europe and North America. Hong Kong was listed as a SARS affected place by the World Health Organization (WHO) on 15 April and was not removed from the list until 23 June.

During the SARS outbreak, Hong Kong people fought against the epidemic and worked together to stop its spread. According to the analysis of the infection cases, the virus was likely to spread through the sewerage system in buildings, people-to-people contact and the use of large public facilities. At that time, the DSD fought side by side with other departments of healthcare, home affairs, environmental hygiene in Hong Kong to respond to and act on territory-wide anti-epidemic work.

Staff of the DSD entered the quarantine area to assist on epidemiological investigations despite maintenance of private drainage and sewerage systems was outside the department's purview

Staff of the DSD on the patio of Amoy Garden to help investigate the environmental factors that triggered the outbreak of SARS in the community

After receiving real-time information of suspected SARS infection cases through a dedicated online e-SARS database, the DSD staff worked with the drainage maintenance contractors to undertake thorough cleansing of the public drains and sewers in the areas where the suspected cases were located to minimize any possibilities of wastewater overflow, entering private streets for emergency cleansing if necessary. Stringent guidelines on occupational safety and personal hygiene were adhered to by the staff and contractors. In particular, those direct labour force workers and staff in the sewage treatment works were urged to strictly abide by the guidelines and take safety as the top priority. In order to replace any defective sewer pipes as soon as possible for prompt improvement to the sanitary conditions, the DSD adopted the "complete first, pay later" approach to assist residents to replace their defective private sewer pipes in private streets or patios. Although the DSD was not responsible for maintenance of drains and sewers in private buildings, colleagues from its Mainland South Division and the Laboratory Services Sub-division still entered the quarantine area of Block E of Amoy Gardens in Ngau Tau Kok during the SARS period to assist clinical experts on epidemiological investigations. The epidemic eased slightly at the end of April and the WHO lifted travel advisory for Hong Kong on 23 May, and removed Hong Kong from the list of epidemic areas on 23 June, ending the 106-day epidemic.

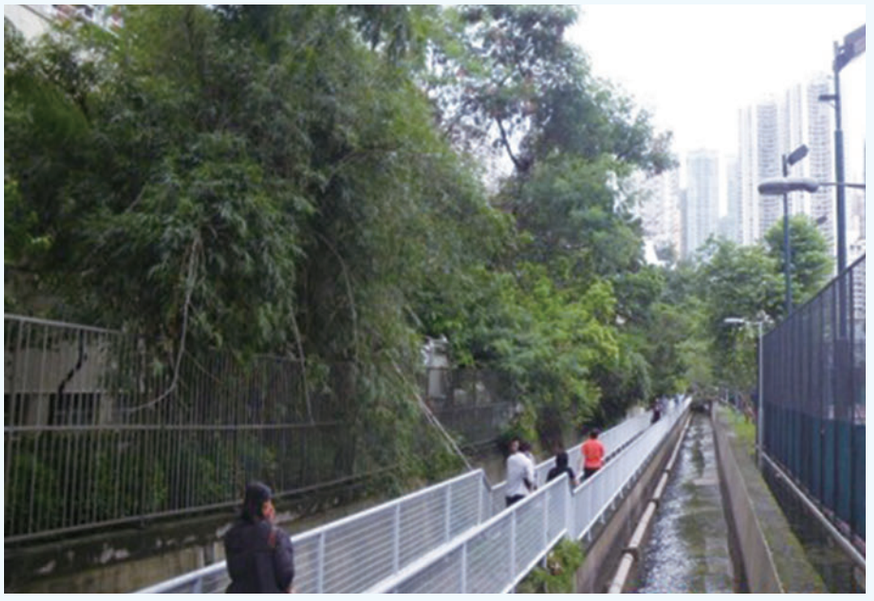
Nullah decking

After experiencing the SARS, the public's awareness of epidemic prevention had generally increased, and they were paying more attention to the sanitary conditions of nullahs in urban areas. The public considered nullahs as unsightly, incongruous with the surrounding environment, and often used as open sewers, causing public health hazards. The Chief Executive announced in his 2005 Policy Address that the Government planned to deck over 16 nullahs in the next 10 years, of which 3 nullahs were located in Hong Kong, 6 in Kowloon and 7 in the New Territories. However, during public consultation, the public had different expectations for nullahs (details are set out in Chapter 9). Therefore, some of the 16 nullahs planned to be decked over in the Policy Address were improved by river revitalisation instead. By 2008, a total of 8 nullahs out of these 16 nullahs were either decked over or revitalised, including the first one completed at Mong Kok Road. Works for the other 4 nullahs were completed by 2011. Decking over or river revitalisation for the remaining nullahs, including the Wong Chuk Hang Road nullah which overlapped with the South Island Line (East), and the section of Kai Tak River near Sha Tin Pass Road, were completed in recent years. The land created by nullah decking was used for public purposes, such as greening, recreation or road widening.

The Tonkin Street Nullah in Sham Shui Po emitted foul smell due to expedient connections

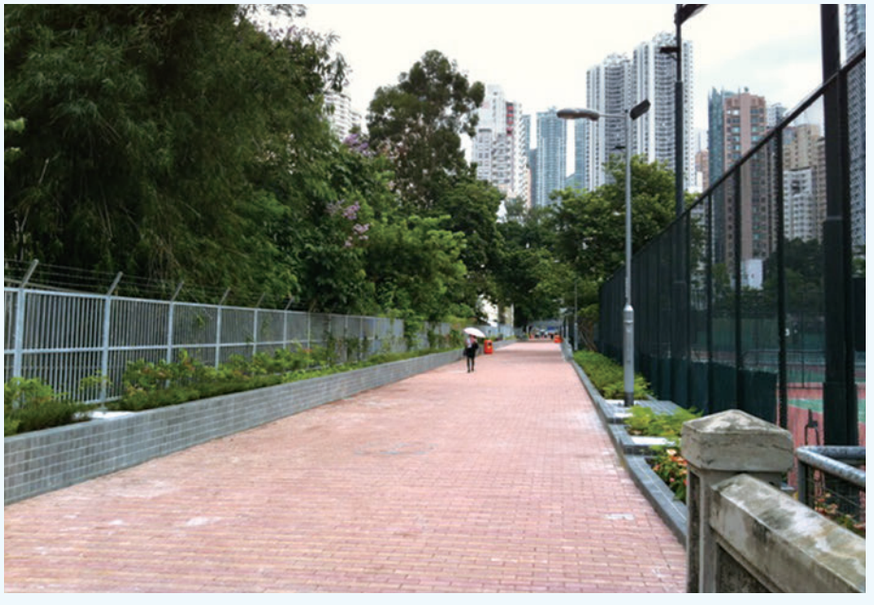
After the Tonkin Street nullah in Sham Shui Po was decked over, the decked area was turned into greening area, a marked improvement to the environment in the neighbourhood.

Jordan Valley Nullah in 1964



Tai Hang Nullah in Causeway Bay in 2000s

The decked area of Jordan Valley Nullah was developed into Choi Ha Road amenity area



Completion of the Fire Dragon Path above the Tai Hang Nullah between Tung Lo Wan Road and Causeway Bay Road in 2012 connotes the decking over of the entire Tai Hang nullah from Tai Hang Road to Causeway Bay Typhoon Shelter

Flood monitoring and reporting system

In the 1990s severe flooding frequently occurred in the northern districts. To assist in flood control, the DSD had developed a Flood Monitoring and Reporting System in 1994 to monitor the flooding locations in Tin Shui Wai, Yuen Long, San Tin, Sheung Shui and Ta Kwu Ling.

Gauging stations

The Flood Monitoring and Reporting System comprises more than 100 automated gauging stations installed at river channels for 24-hour real-time water level measurements and collecting hydrological data including rainfall intensity and tide levels. The real-time hydraulic data are sent back to the DSD's control centre through internet.

The officers on duty at the DSD's control centre would quickly analyse any flooding situation, using this real-time hydrometric information, video images and the operational status of the gauging stations. When necessary, the DSD's officers on duty would alert other departments, such as Hong Kong Police Force, Fire Services Department and the Home Affairs Department, to prepare for rescue, evacuation and the opening of flood shelters. At the same time, the drainage maintenance teams would be informed to take flood relief actions.

DSD Flood Monitoring and Reporting System Control Centre

A remote-controlled gauging station equipped with solar panel, rain gauge and water level sensor for real-time monitoring.

Hydrometric Information System

Besides its own gauging station networks, the DSD also obtains information on rainfall intensities and tide levels from the Observatory and the Civil Engineering and Development Department on other river basins through government network and transmits the information to the Hydrometric Information System. With the benefit of sufficient information, the DSD's duty officers at the control centre can assess more accurately the flooding situation and make timely and appropriate responses to deal with the incidents.

As an interim measure before long-term drainage improvement projects in the New Territories are completed, the DSD has provided flood alarm system at flood-prone villages to inform the villagers when the floodwater reaches a predetermined alert level. The purpose of the flood alarm system is to alert villagers before flooding occurs, so that they have enough time to prepare evacuation or take preventive measures. In the past, flood alarm systems were installed at various locations. Following the completion of more than 100 kilometres of river channels and the commissioning of 27 village flood protection schemes, many villages no longer needed these flood alarm systems.

River Silver at Mui Wo. Completion of river training works has effectively protected the low-lying villages.

The DSD has installed flood alarm systems to alert the local villagers at flood-prone areas before drainage improvement works are completed

Overview

After the establishment of the DSD, the Government had invested substantially more resources on provision of flood prevention infrastructure. However, it took time to complete the works and Hong Kong was still threatened by severe rainstorms each year.

Completion of the major river training works and village flood protection schemes in the early 1990s had effectively protected the low-lying villages in the New Territories. In mid-1990s, the DSD adopted a new approach of stormwater storage, interception and transfer to tackle flooding problems. The first underground stormwater storage scheme in Hong Kong was then built in Tai Hang Tung to relieve the flooding threat in West Kowloon. Between 1994 and 2010, the DSD rolled out the Drainage Master Plans to improve drainage systems in various districts. In 2008, to take into account of climate change and the latest land developments, the DSD launched the Drainage Master Plan Review Studies to review the flood resilient abilities in different districts.