Different Courses Same Dream

2009-2018

Part IV :
Accomplish Remarkable Achievement 2009–2018

Chapter 8: Arrival of World-class Infrastructure

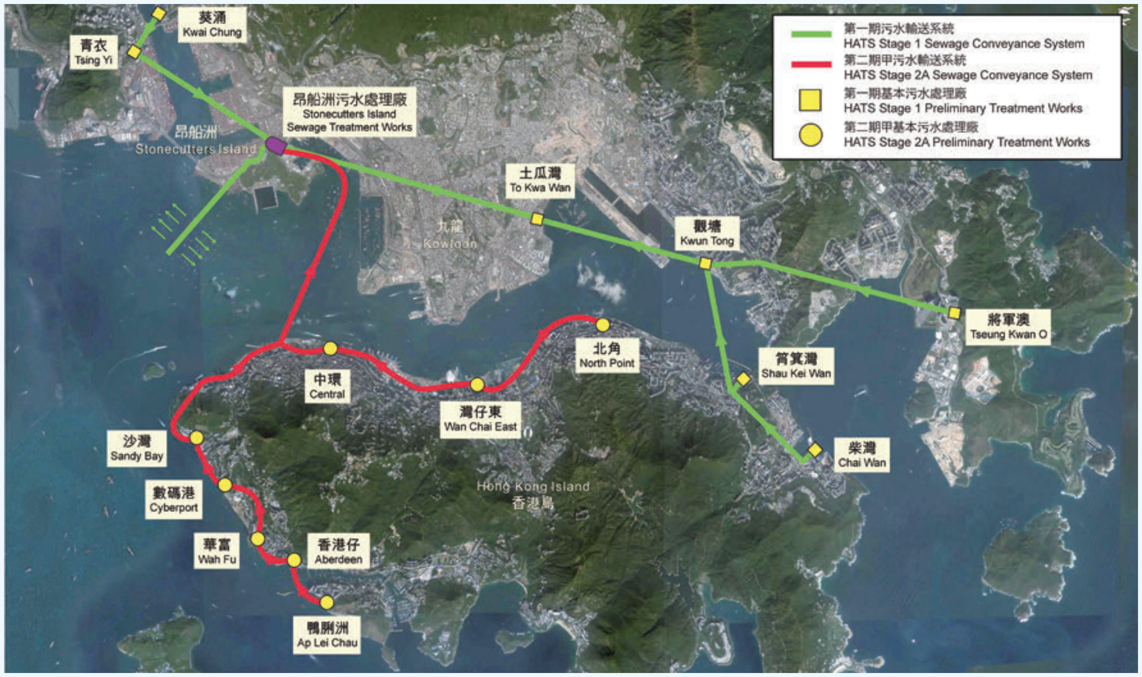
Around 1970s, the Government focused on new town developments in the New Territories. Civil, electrical and mechanical engineering works under the Mass Transit Railway Modified Initial System were rolled out. Completion of the High Island Reservoir had secured stable supply of fresh water. The city developed rapidly but at the great expense of environmental pollution. Since the Victoria Harbour (the Harbour) had become very polluted, the Cross Harbour Swimming Race was suspended after the 66th Race held in 1978.

The Strategic Sewage Disposal Scheme (SSDS) (renamed as Harbour Area Treatment Scheme (HATS) in 2001) is the largest ever world-class environmental infrastructure project undertaken in Hong Kong. The construction works spanned over 20 years with a total expenditure amounting to HK$25.8 billion. In 1987, in an effort to improve the overall water quality of the Harbour, the government conducted the Sewage Strategy Study and drew up a blueprint in connection with the Harbour for collection, treatment and disposal of wastewater. This visionary scheme was to be carried out in several stages, aiming at building a centralised system to collect wastewater from the huge catchment areas on both sides of the Harbour and convey the wastewater to the newly built Stonecutters Island Sewage Treatment Works for proper treatment.

A key component of the Scheme was the construction of a deep sewage conveyance tunnel conveyance system on both sides of the Harbour. The wastewater would undergo preliminary treatment before entering the tunnel and conveyed to the Stonecutters Island Sewage Treatment Works for chemically enhanced primary treatment before discharge to the sea via a submarine outfall.

A total of 44 kilometres of deep sewage tunnels, with diameters ranging from 1.23 metres to 3.54 metres, have been formed at depths of up to 163 metres. There is a minimum of 30 metres of sound rock above the tunnel crown. The tunnel system was carefully planned to avoid road excavation and hence major traffic and social disruptions were minimised. The tunnel would not have any conflict with the MTR underground railways, major underground public utilities and foundations of existing buildings. The sewage tunnel system is designed to operate as an inverted siphon whereby the wastewater collected is conveyed from the preliminary sewage treatment works and discharged into the tunnels before pumping out at the downstream end to Stonecutters Island Sewage Treatment Works for treatment. This inverted siphon design significantly reduces the energy consumption for pumping.

The HATS includes construction of the Stonecutters Island Sewage Treatment Works, one of the largest sewage treatment works of its type in the world.



The HATS Stage I and Stage IIA overall layout plan

In 1992, Stage I of the SSDS and the six related SMPs (including Chai Wan and Shau Kei Wan, Tseung Kwan O, the East Kowloon, North and South Kowloon, Northwest Kowloon and Tsuen Wan/Tsing Yi/Kwai Chung) were incorporated into the Sewage Services High Priority Programme.

Strategic Sewage Disposal Scheme Project

Works for SSDS Stage I took off in 1994, preluded by the construction of a chemically enhanced primary treatment (CEPT) plant on Stonecutters Island and a 90 metres deep and 1.7 kilometres long submarine outfall. All works were completed in 2001 and the Stage I system was commissioned and went into operation. It provides further purification for 75% of the preliminary treated sewage from both sides of the Harbour prior to discharge into the western side of the Harbour. Water quality in the Harbour was significantly improved.

Perched as a galaxy warrior's helmet in the movies, this is one of the 24 protective domes now laid at deep sea bottom to protect the diffusers of the submarine outfalls at the Stonecutters Island Sewage Treatment Works from damage by ship anchors.

According to the original scheme in early 1990s, the SSDS Stage 1 would be as follows:

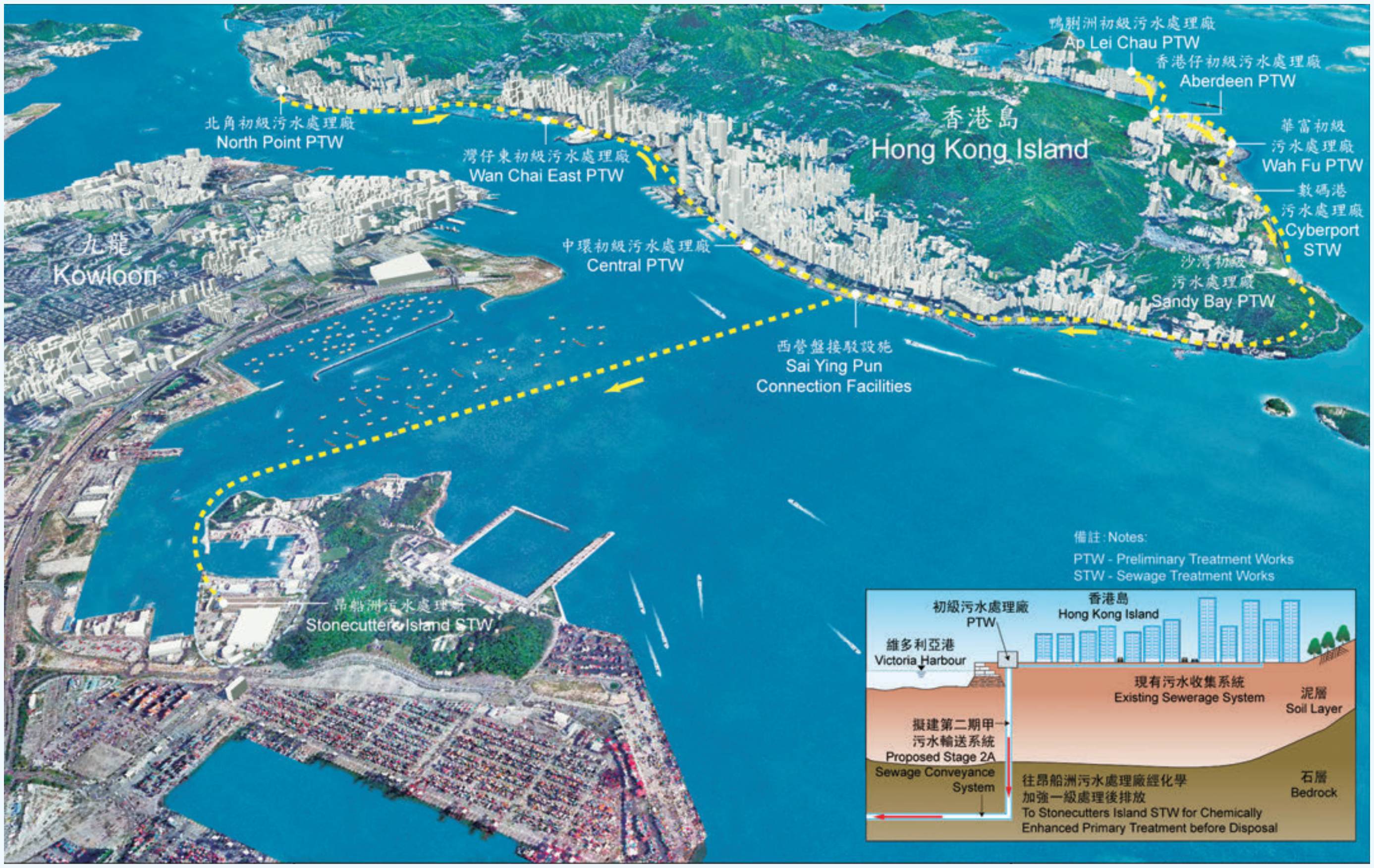
Stage 1: Kowloon and Northeast Hong Kong Island Collection and Treatment System

At a cost of HK$8.2 billion, Stage I works included the construction of a 23.6 kilometres long deep sewage conveyance tunnel system to transfer sewage from Kowloon stretching from Tsuen Wan to Tseung Kwan O, and from Chai Wan and Shau Kei Wan on Hong Kong Island to a new sewage treatment works on Stonecutters Island for chemically enhanced primary treatment before discharge to the western side of the Victoria Harbour. Stage I works would also include upgrading of the preliminary treatment works in Chai Wan, Shau Kei Wan, Tseung Kwan O, Kwun Tong, To Kwa Wan, Tsing Yi and Kwai Chung.

Construction of the deep tunnels started in early 1995, and several tunnel boring machines were deployed. Progress was hampered due to ground water ingress into the tunnel and contractual disputes with the contractor. The Government eventually forfeited the tunnelling contracts in December 1996 and re-awarded three tunnelling contracts in 1997. However, adverse geological conditions such as faults and weak ground continued to pose challenges to the tunnelling works. When faults or weak ground were encountered during tunnel excavation, stabilisation measures such as grouting and erection of temporary supports had to be taken before proceeding further.

Despite difficulties and challenges were encountered during construction, a major breakthrough was achieved with the boring through of the last tunnel section at the end of 2000, leading to the completion of the Stage 1 works in 2001. Since Stage 1 has come into full operation, the deep tunnel conveys about 1.7 million cubic metres of sewage to Stonecutters Island Sewage Treatment Works for treatment every day, thereby stopping the discharge of about 600 tonnes of sludge into the Harbour each day. The water quality in the central and eastern sides of the Harbour is greatly improved.

Tunnel boring machine (TBM) for HATS Stage 1 tunnel construction



HATS Stage 2A – Sewage collection and conveyance network

To sustain the water quality improvement in the Harbour, the Government commissioned an International Review Panel of local and overseas experts to review the planning of the remaining stages of SSDS in April 2000. In November of the same year, the Panel submitted its final report with four options for sewage treatment and discharge, all of these options recommending CEPT and Biological Aerated Filter treatment, deep sewage conveyance tunnel system and short outfall for disposal.

In 2001, the SSDS was renamed as HATS. In 2004, the Government conducted public consultation on the way forward for the project. The results reflected that the public were generally overwhelmed by the improvement of the water quality in the Harbour and supported the cleaning up of the Harbour in a step-wise but timely manner. Subsequently the Government decided to proceed with Stage 2 in 2 phases. The Stage 2A works would upgrade the preliminary treatment works on the northern and south western sides of Hong Kong Island and to convey sewage from these preliminary treatment works to Stonecutters Island; while the Stage 2B works would upgrade the Stonecutters Island Sewage Treatment Work to secondary biological treatment level.

Stage 2A

Stage 2A comprises the construction of a deep sewage tunnel system of about 21 kilometres long and from 70 metres to 163 metres below ground. The sewage from the preliminary treatment works on the northern and south western sides of Hong Kong Island would then be conveyed via deep sewage tunnels to the Stonecutters Island Sewage Treatment Works for centralised treatment. The CEPT capacity of the Stonecutters Island Sewage Treatment Works would be expanded from the original design level of 1.7 million cubic metres to 2.45 million cubic metres per day. The sewage conveyed and treated under Stage 2A of HATS is about 25% of the sewage collected from the urban areas around the Harbour.

During the Stage 1 deep sewage tunnel construction, the project team was relatively inexperienced to handle massive ingress of groundwater into the excavated tunnel and had reluctantly accepted to postpone the construction completion dates. Equipped with the experience from Stage I, for Stage 2A works the DSD decided to adopt high-pressure grouting and drill-and-blast method (including pre-excavation grouting, drilling holes on rock face to be filled with explosives, blasting and rubble removal) in lieu of tunnel boring machines. This method provides more working space at the excavation surface for temporary supports and for carrying out pre-grouting, and allowing more flexibilities on controlling groundwater ingress. The drill-and-blast method enables larger sizes of rocks be excavated, which are recycled as building materials after screening and sorting. A tunnel section between Ap Lei Chau and Aberdeen was constructed by horizontal directional drilling due to its smaller diameter.

In addition to the construction of deep sewage tunnel network, the Stage 2A works entail upgrading the CEPT capacity and the disinfection facilities of the Stonecutters Island Sewage Treatment Works in anticipation of the increased sewage flow and further water quality improvement.

After arriving at the Stonecutters Island Sewage Treatment Works, the sewage would undergo CEPT process by adding ferric chloride and polymer in the sedimentation tanks. The Stonecutters Island Sewage Treatment Works adopt double-decked sedimentation tanks to reduce the footprint area. No doubt the Stonecutters Island Sewage Treatment Works is regarded as one of the leading treatment works in the world, considering its footprint of only 10 hectares (about half the size of Victoria Park) but serving more than 5.7 million people.

After sedimentation, the treated effluent would enter a new effluent tunnel for disinfection using sodium hypochlorite solution to remove pathogens. Sodium bisulphite would then be added to the effluent to remove any residual chlorine before the effluent is discharged into the western side of the Harbour via the submarine outfalls.

This drop shaft was used as an access during construction down to the world's deepest sewage tunnel

In addition, Stage 2A works included upgrading the facilities at eight existing Preliminary Treatment Works at North Point, Wan Chai East, Central, Sandy Bay, Cyberport, Wah Fu, Aberdeen and Ap Lei Chau that had been operated for more than 20 years. After upgrading, solids and grits from the preliminary treatment works would be prevented from entering the deep sewage tunnel to protect downstream treatment facilities.

Stage 2A works commenced in 2009 and were completed and commissioned in 2015. It costs HK$17.5 billion, and together with Stage 1, can treat 2.45 million cubic metres of sewage per day, and intercept 1,200 tonnes of sludge daily which would otherwise be discharged into the sea and causing pollution to the Harbour. Commissioning of HATS Stage 2A has further improved the water quality of the Harbour. The Dissolved Oxygen of the seawater is increased by 13%, whereas 70% of Biochemical Oxygen Demand, 80% of Suspended Solids and more than 99% of E. coli are removed from the treated effluent before discharge to the Harbour.

The successful restoration of the water quality of the Harbour following the full commissioning of HATS Stage 2A has led to the long-awaited resumption of Cross-harbour Swimming Race in 2011 and re-opening of Tsuen Wan beaches.

Main Control Room in the Main Pumping Station at Stonecutters Island Sewage Treatment Works

The deepest tunnel section in North Point at 163.8 metres below sea level, equivalent to the height of a 50-storey commercial building.

Sedimentation Tanks at the Stonecutters Island Sewage Treatment Works

Stage 2B

Stage 2B includes a proposed additional underground biological treatment facility adjacent to the Stonecutters Island Sewage Treatment Works to treat all the effluent of Stages 1 and 2A. The Government will study and monitor the water quality of the Harbour and keep abreast of the latest developments in biological treatment technology and reviewing the timing and need of Stage 2B.

The HATS is honoured with multi-award winning in China and overseas. After being elected as one of the ten Hong Kong People Engineering Wonders in the 21st Century organised by the Hong Kong Institution of Engineers in 2013, in June 2018 the HATS was awarded the Tien-yow Jeme Civil Engineering Prize under the Municipal Engineering Category to recognise the outstanding achievements of HATS in scientific and technological innovation and application. The HATS was also awarded the 2018 Edmund Hambly Medal by the Institution of Civil Engineers in the United Kingdom for the outstanding achievements of the HATS in sustainable development.

The HATS is honoured with Edmund Hambly Medal from the Institution of Civil Engineers


The HATS is gradually rewarded with tangible results. The Hong Kong Amateur Swimming Association resumed the Cross-harbour Race in the eastern waters of the Harbour in 2011 and since 2017, returned to the legendary cross-harbour race route between Tsim Sha Tsui Public Pier and Golden Bauhinia Square.

Over 44 kilometres of deep sewage tunnels weaved between both sides of the Harbour. Full commissioning of HATS has substantially resolved the long endured water pollution in Victoria Harbour.

Regulation of Shenzhen River

The effectiveness of the flood prevention works in the northern New Territories depends on the drainage capacity of the middle stream and downstream of Shenzhen River. Therefore, regulation of Shenzhen River is of upmost importance.

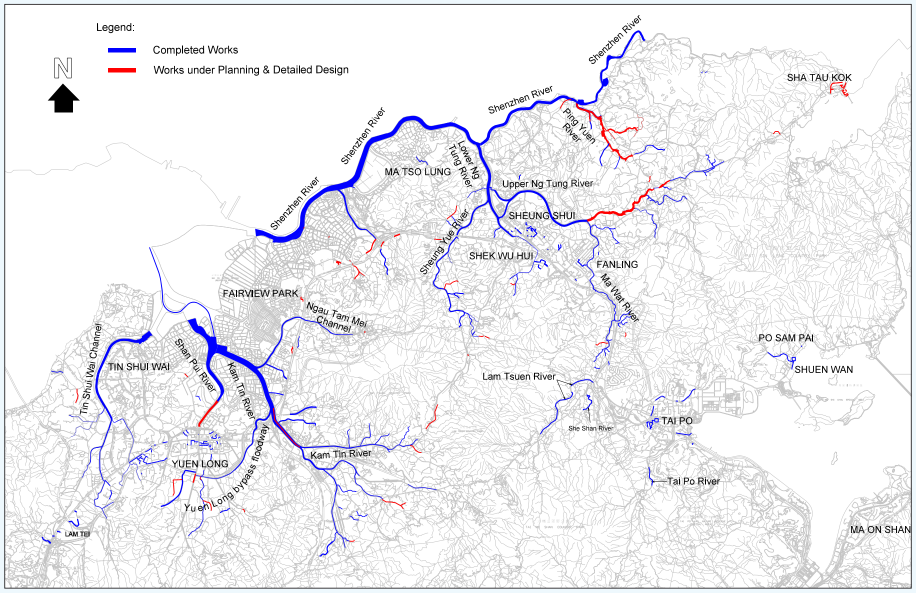
Originating from Lin Ma Hang near Pak Kung Au, Shenzhen River meanders south-westward into Deep Bay. The Shenzhen River is 27.5 kilometres long and has a catchment area of 313 square kilometres, with 60% of the catchment area falling in Shenzhen and 40% within Hong Kong. The original river channel of Shenzhen River was narrow. The average width was 15 metres at the upstream, 40 to 45 metres at the middle stream and 140 metres in the estuary. The main tributaries are Shawan River, Buji River and Futian River in Shenzhen, and Ping Yuen River, and Ng Tung River in Hong Kong.

Shenzhen River in the 1960s, distinct by its bends and narrowness, meandering through Lo Wu District in Bao An County. Residents on both sides of the river mainly worked on agricultural and fish farming.

In the past Shenzhen River was narrow and meandering and affected by tidal, which restricted its drainage capacity. Whenever heavy rainstorm hit the upstream catchments, the peak flow would quickly reach the urban areas of Shenzhen city and the northern New Territories of Hong Kong, causing flood damages on both sides of the river.

Over the years, the natural land on both sides of the Shenzhen River was replaced by paved areas causing deterioration in water infiltration. Soil erosion further reduced the drainage capacity of the river to a degree that the river could only be capable of handling rainstorm runoff of not more than a return period of 2 years.

In 1982, the Shenzhen Municipal People's Government and the Hong Kong Government established a Joint Working Group to jointly regulate the Shenzhen River. In April 1985, the Joint Working Group completed a report that detailed solutions to solve the flooding problem. Both sides had established a phased implementation plan to regulate Shenzhen River.



Major rivers belong to the Shenzhen River network within Hong Kong

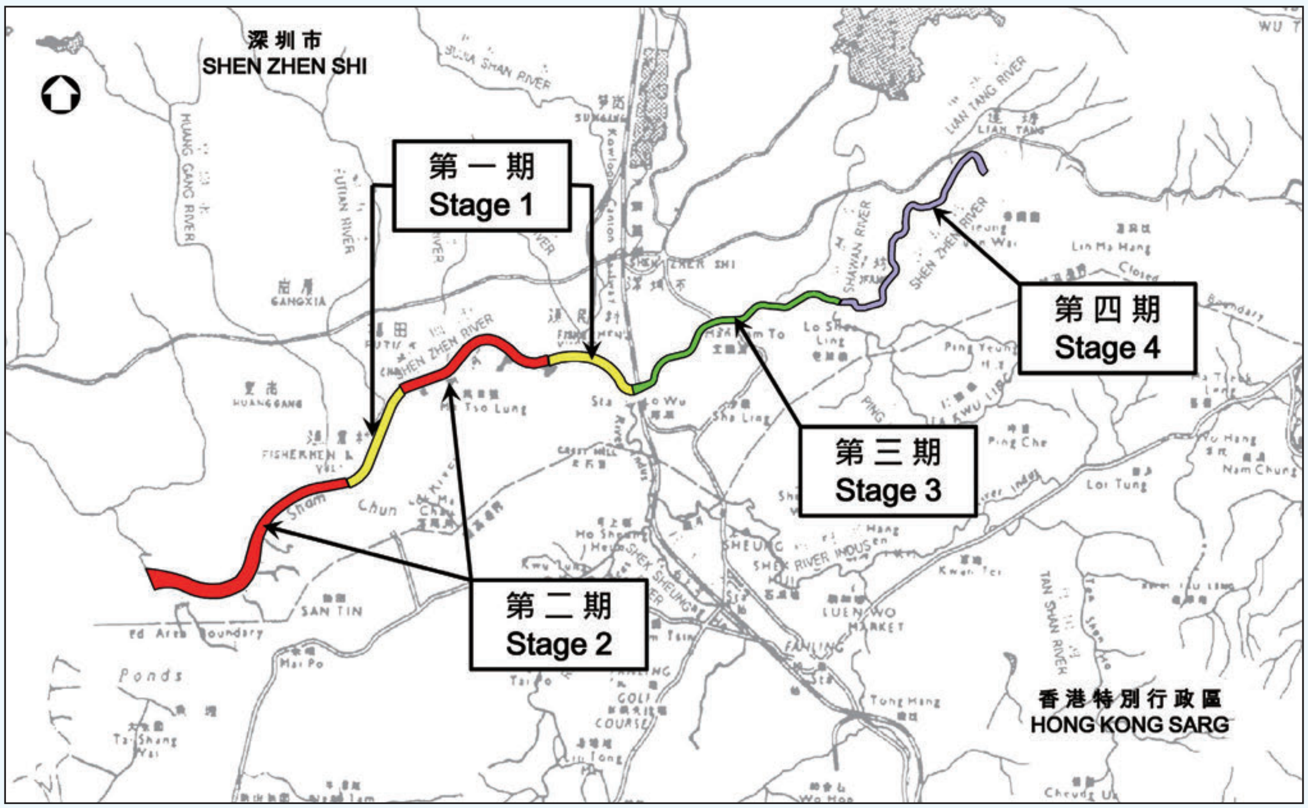
In the aftermath of Severe Tropical Storm Becky, which struck Hong Kong on 17 September 1993, Shenzhen River in the vicinity of Lo Wu and Ng Tung River were seriously flooded.

Section of Shenzhen River at Liu Pok downstream of the Lo Wu Control Point after river regulation to widen and straighten the river section

The Shenzhen River Regulation Project was planned to be implemented in four stages, to realign, widen and deepen about 18 kilometres of the middle stream and downstream of the existing river. According to the plan, the middle stream and the estuary of Shenzhen River would be widened to 80 metres and 210 metres respectively, while the hydraulic capacity would be increased from 600 cubic metres per second to 2 100 cubic metres per second. The flood protection standard will be substantially improved from 2 years return period to 50 years return period.

The Shenzhen River Regulation Project was one of the DSD's key projects to address the flooding problem in northern New Territories. At that time, the channel improvement works at the upper stream of Ng Tung River and Ping Yuen River were in full swing and hopefully would enable a completion date in tandem with that of the Shenzhen River Regulation Project, thus yielding a final solution to solve the flood threat in the northern New Territories.

On 11 May 1995, the representatives of the Shenzhen Municipal and Hong Kong governments formally signed an agreement on the regulation works. Stage 1 was wholly entrusted to Shenzhen Municipal government, though the cost would be shared by both parties. Yet, the overall project was supervised and monitored by the Joint Working Group. As a key member of the Joint Working Group representing Hong Kong, the DSD was responsible for vetting technical and contractual details and coordination among all parties.



Shenzhen River Regulation Plan

Stage 1

The major works included straightening of the river bends at Liu Pok and Lok Ma Chau, river channel widening and deepening, river bed protection under the Lo Wu railway bridge, excavation of the Lecky Pass, a flood control gate at Futian, new river embankments and landscaping works. Stage I works were substantially completed in April 1997. It was the first time that the Shenzhen Municipal and Hong Kong governments conducted a joint tendering exercise for the Shenzhen River Regulation project. Tender process was administered in compliance with the international practices, including open tendering, publication of tender notices on newspapers and prequalification assessments. After stringent prequalification and tendering exercises, 10 out of the 43 potential contractors were selected for bidding the Stage 1 tender.

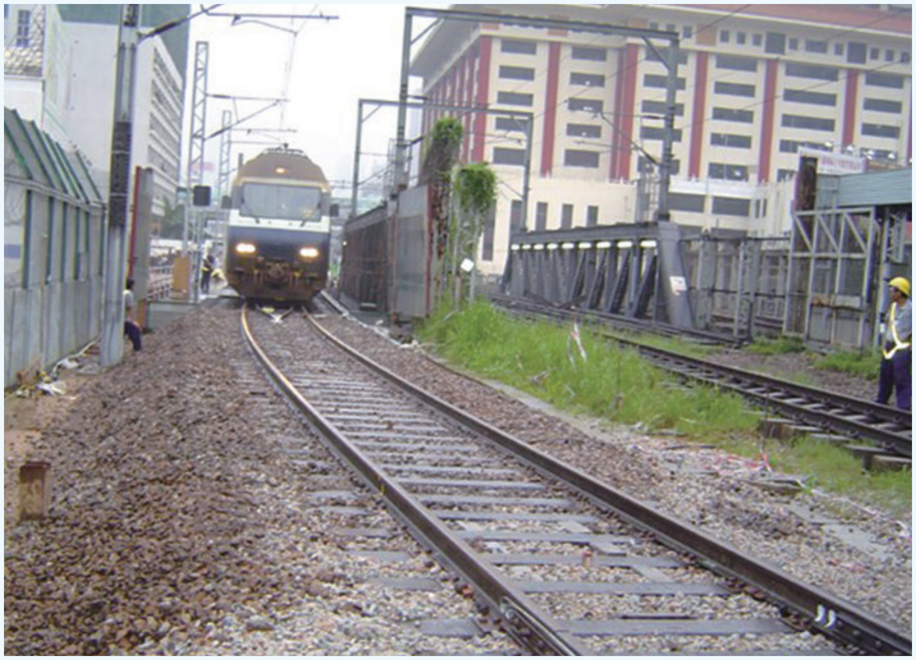
Completion of Stage 1 of Shenzhen River Regulation Project in April 1997 was followed by commencement of other cross-border infrastructure projects

Stage 2

While construction of the Stage 1 works was underway, planning for Stage 2 commenced concurrently. The Stage 2 works started in November 1996 and was completed in June 2000. The works involved widening, deepening and realignment of two sections of the river channel, from Buji River estuary to Futian River estuary, and from Huanggang Bridge to the estuary of Deep Bay. A total of 6.4 kilometres of new channels were built. The river channel at Lo Wu was widened to 105 metres and the estuary of Deep Bay was widened to 210 metres. Stage 2 works also included provisions of 5.8 hectares of mangroves on the south bank and 3 hectares in the Futian Mangrove Nature Reserve. Though two flood events occurred during Stage 2 construction, the flood menace was considered as less serious, compared with the condition prior to the project, as water levels during the floods remained low and flood water receded quickly. This showed that Stage 1 and 2 works have improved the drainage capacity of Shenzhen River.

Stage 3

After the completion of Stage 2, the DSD and the Shenzhen River Regulation Office immediately began the Stage 3 project to regulate approximately 4 kilometres of the upper stream of Shenzhen River, from the Ping Yuen River estuary to the Ng Tung River estuary at Lo Wu. Apart from river widening and deepening, embankment construction, and habitat conservation at river meanders, the Stage 3 works also covered more complicated works such as reconstruction of existing railway bridge, road bridges and footbridge and diversion of Dongjiang water pipes.



A great challenge in Stage 3 was to dismantle the former Lo Wu railway bridge and rebuild a new bridge at the original site. The picture depicts the instance when the first train was speeding across the temporary railway bridge.

A glimpse of Shenzhen River at Lo Wu Control Point after Stage 3 works. The span of the new Lo Wu railway bridge extended from 32 meters to 40 meters.

Cloud glowing at dusk over Shenzhen River and the glory of sunset filling both sides of the border river

A glimpse of Shenzhen River at Lo Wu Control Point after Stage 3 works. The span of the new Lo Wu railway bridge was extended from 32 metres to 40 metres.

Stage 4

On completion of Stages 1 to 3 of the Project, the 18-kilometre long Shenzhen River was transformed to a straighter and wider 13.5-kilometre long river channel.

In August 2013, the Shenzhen Municipal government and Hong Kong government officially kicked off Stage 4 of Shenzhen River Regulation Project that involved the regulation of about 4.5-kilometre section at the upstream of Shenzhen River from its confluence with Ping Yuen River to Pak Fu Shan. Besides raising the flood prevention standard of Shenzhen River, the Stage 4 works have incorporated ecological conservation elements into the design to enhance the ecological values of the river.

The design has abandoned the conventional approach by straightening, and instead followed the original river profile and meandering features as far as possible. Ecological conservation and environmental protection elements were adopted in the river training works (including use of ecological bank protection, river side greening and preservation of natural riverbed), to reduce downstream sedimentation. With the dry weather flow interception, pollution to the river was reduced.

A flood retention lake built at the largest meander of Shenzhen River. The Shenzhen River can be seen on the outskirts of the retention lake on the right of the picture.

The Stage 4 works include reconstruction of the Luofang footbridge across Shenzhen River as a re-provisioning of this historical boundary crossing which is a special land-crossing for Mainland residents holding valid cross-border farming permits to travel to and from Hong Kong for farming activities.

The meanders of the Shenzhen River were preserved to maintain the natural river and riparian habitats for the growth of fauna and flora. A 22 000 square metres of ecological flood retention lake with a storage capacity of 80 000 cubic metres was built at the largest meander. During heavy rainstorms, water would enter the flood retention lake through overflow weirs and return to the river through control gates when the water level in the river is lower than the flood retention lake, and as a result the peak flows downstream would be attenuated.

Spanning almost four decades and implemented in four stages, the Shenzhen River Regulation Project witnessed the seamless collaboration between the Shenzhen and Hong Kong governments. Upon completion of the Project, remarkable results were achieved. The boundary river also saw the tremendous changes and development on both sides of the river in the past 40 years. With Stage 4 of the Project fully commissioned in 2018, the Shenzhen River with its completely new look will continue to serve the places it intends to protect, nurturing more lives and ushering in even greater development.

Flood prevention strategy in urban area

Hong Kong has a complex topography. During the rainy seasons between April and October each year, sudden torrential rains may occur at times, which pose great challenges for flood prevention. The DSD has adopted a three-pronged flood prevention strategy, that is stormwater interception at upstream, stormwater storage at mid-stream and drainage improvement at downstream. A number of flood prevention projects have been implemented to solve flooding problems in urban areas, including stormwater storage schemes and drainage tunnels. These flood prevention works are complementary with each other for the most efficient and effective means to protect the urban areas from flooding threats.

Stormwater storage and interception schemes

Stormwater storage is a common approach to temporarily retain storm flow from upland catchment in order to attenuate the peak runoff loading on the downstream drainage system.

In Hong Kong, urban development is gradually moving to the upstream portion of the catchment and there is a need to improve the capacity of downstream drainage systems. Stormwater storage scheme facilitates effective flood control and helps to alleviate the burden to the downstream drainage system.

Sheung Wan Stormwater Storage Scheme

As mentioned in Chapter 7, the Tai Hang Tung Stormwater Storage Scheme commissioned in 2004 is the first underground stormwater storage scheme in Hong Kong. The second underground stormwater storage scheme was built in 2009 by the harbour front at the former Sheung Wan Gala Point site.

More than 10 hectares of land around Wing Lok Street in Sheung Wan on Hong Kong Island is low-lying. The lowest ground level is only 2.64 metres above the principal datum, barely above the sea level. At times of high tides coinciding with rainstorms, the drainage system would be under capacity and floods usually followed. Between 2001 and 2008, there had been five serious flooding incidents in this low-lying area, with flood depth reaching as much as 1.5 metres.

To resolve the flooding problem in Sheung Wan, the DSD constructed the Sheung Wan Stormwater Storage Scheme and the Queen's Road Central Intercepting Drains using the stormwater interception and storage approaches.

The Sheung Wan Stormwater Storage Scheme has a capacity of 9 000 cubic metres (equivalent to about four standard swimming pools) at a project cost of about HK$ 200 million.

A diversion chamber is built near to the outfall with penstocks to stop seawater backflow at high tides and to divert the stormwater from the upstream low-lying areas to the storage tank during rainstorms for storage before discharging it to the harbour.

Wing Lok Street and Hillier Street junction at the lowest point of Sheung Wan flooded by seawater backflow during astronomical tides

The pump house (left) under Sheung Wan Stormwater Storage Scheme and the landscaped open space above the underground flood storage tank (from middle to right)

While construction of the Sheung Wan Stormwater Storage Scheme was on-going, intercepting drains were being laid along Queen's Road Central to intercept the surface runoff from the Mid-levels catchment. The stormwater entering the low-lying area drainage system is reduced by about 30%.

The project raises the flood protection level in the Sheung Wan low-lying area to withstand rainstorms of a return period of 1 in 50 years.

To meet the public expectation, the project team endeavoured to design the pump house with minimum footprint and building height in order to reduce the visual barrier to the harbour. Electrical and mechanical facilities and pipe works are housed centrally underground and covered by multipart covers. An area of 320 square metres at the ground floor is created for public Tai Chi exercise area and recreational amenities. On top of the pump house is the first green roof built by the DSD. Above the underground storage tank at the ground level, a 5 700 square metres of public open space is created with facilities such as waterfront promenade and pet garden. The footprint of the above ground structure of the pump house occupies only 7% of the total public open space area.

In 2010, Sheung Wan Stormwater Storage Scheme was honoured with the Structural Excellence Award by the Hong Kong Institution of Engineers and the Institution of Structural Engineers in the United Kingdom.

The pump house under the Sheung Wan Stormwater Storage Scheme project adopted an innovative semi-open design and its ground level was developed as a public Tai Chi exercise area

The Happy Valley Recreation Ground was often turned into a swamp after heavy rain in the past

The HVUSSS was implemented in stages to achieve partial commissioning for early flood relief. Closure of the pitches in phases minimized disruptions to the public.

The Happy Valley Underground Stormwater Storage Scheme (HVUSSS)

In the past, a number of severe flooding incidents occurred at Wan Chai and Happy Valley during heavy rainstorms. In these densely populated urban areas, to improve the drainage systems by extensive upsizing of existing underground drains with conventional open-cut methods would have great impact to the local residents and shop operators and would be difficult to proceed due to congested underground utilities. Moreover, extreme rainstorms, rising sea level and rapid urbanisation, all continue to lead to the increase of stormwater runoff and further burden to the drainage system. Therefore, an innovative, viable and effective solution to the flooding problem is essential.

The HVUSSS would temporarily store part of the runoff from the upstream catchment during heavy rainstorms and attenuated the peak flow through the downstream drainage system. Stages 1 and 2 works were completed and operation commenced in 2015 and 2017 respectively. The storage scheme has a capacity of 60 000 cubic

The Happy Valley Underground Stormwater Storage Scheme with a flood storage capacity of 60 000 cubic metres

metres, which is equivalent to 24 standard swimming pools. The maximum pump rate of the pump house reaches 1.5 cubic metres per second. Since its commissioning, the storage scheme has proved its effectiveness many times during rainstorms and typhoons that Happy Valley and its adjoining areas are at last safeguarded from flooding threat.

The HVUSSS was the first flood storage scheme in Hong Kong equipped with a movable overflow weir system with a Supervisory Control and Data Acquisition (SCADA) system. This design effectively reduces the construction cost and time while saving power for operation. It fulfills the dual purposes of flood prevention and environmental protection. Compared to the conventional fixed weir design, this movable overflow weir system is controlled based on real-time tidal levels, water levels inside the storage tank and in the box culvert upstream and downstream of the storage tank. The operation system maximises the effectiveness of the flood storage tank and reduces the required design tank volume.

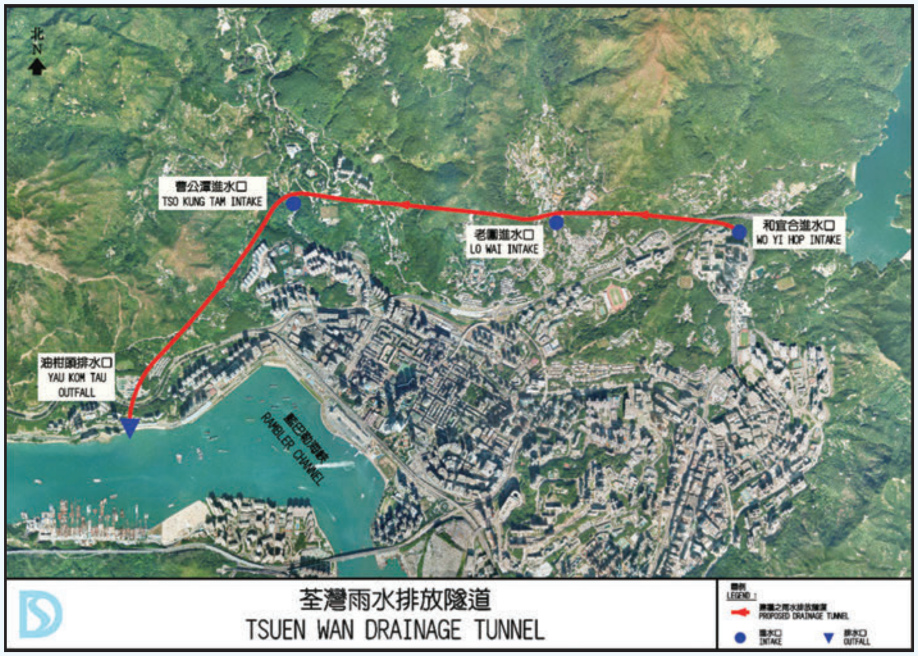
In addition, a mound is formed on the top of the pump house by turfing which acts as heat insulation for the pumping station below and provides a viewing platform for the public to enjoy the panoramic view of the Happy Valley Recreation Ground.

On Sau Road Underground Stormwater Storage Scheme

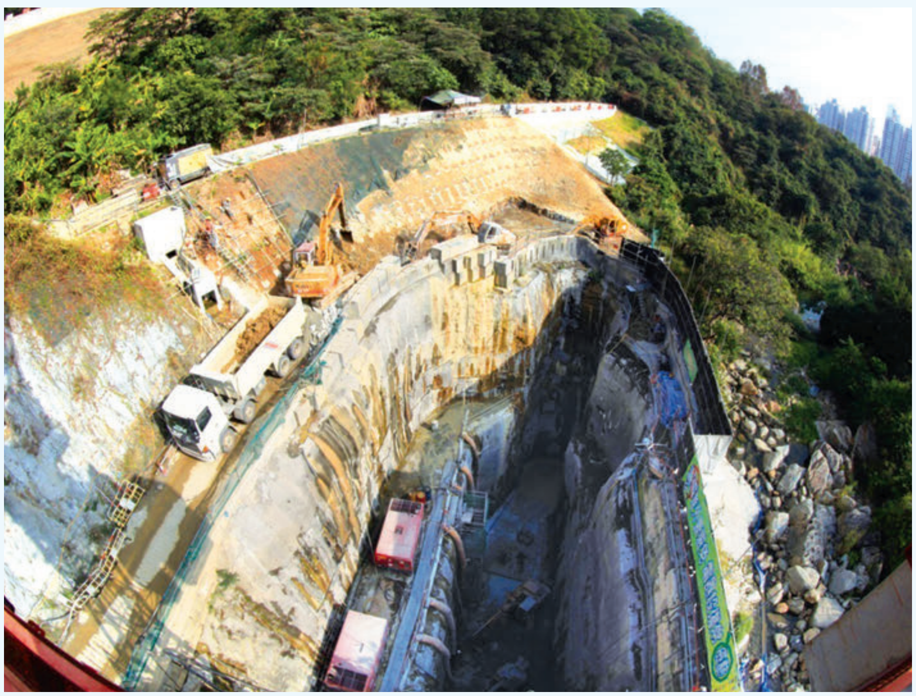
The underground stormwater storage tank beneath On Sau Road in Kwun Tong is the latest underground stormwater storage scheme in Hong Kong, and it came into operation in 2018 for storing stormwater during heavy rain so as to reduce the flood risk downstream. Football fields and recreational facilities are to be provided on the top of the underground storage tank for public use as a realisation of land co-use concept.

The landscaped mound on the rooftop of the pump house (left) and the fan room (bottom right) blend in harmony with the surrounding environment and provide leisurely space for the public

The On Sau Road Underground Stormwater Storage Scheme with a capacity of 18 000 cubic metres. Situated on a higher ground, the storage tank allows the stored stormwater to drain away by gravity without the need for pumping.



Tsuen Wan Drainage Tunnel Layout Plan


Use of silent rock breakers, pile hammers and drilling machines for excavating a large rectangular channel at the Tso Kung Tam intake.

Drainage tunnels

The Kai Tak Transfer Scheme introduced in Chapter 6 was the first drainage tunnel built in Hong Kong. In the 2000s, the DSD planned and built another three drainage tunnels in Tsuen Wan, Lai Chi Kok and Hong Kong Island West respectively. These three drainage tunnels were completed between 2012 and 2013. They are located at mid-hill to intercept surface runoff from uplands for discharge into the sea, bypassing the densely populated urban areas downstream. These tunnels are like a silent shield to protect the downstream areas from flooding.

Tsuen Wan Drainage Tunnel

The drainage systems in Tsuen Wan and Kwai Chung had been in place for over 30 years. Due to rapid urbanisation, the runoff had significantly increased, resulting in flooding during severe rainstorms. In May 1997, for example, several rainstorms caused flooding, extensive damage, power failure and landslip in many areas of the Tsuen Wan and Kwai Chung districts. The Tsuen Wan Drainage Tunnel would definitely provide a long-term flood prevention solution for the area.

The Tsuen Wan Drainage Tunnel is 5.1 kilometres long and 6.5 metres in diameter, running westward from the junction of Shing Mun Road and Wo Yi Hop Road in Kwai Chung, to the south of Yau Kam Tau in Tsuen Wan. The runoff collected from the upstream catchment is discharged through an outfall near Yau Kam Tau to the Rambler Channel, thereby alleviating the burden on the downstream drainage systems and obviating the need to carry out extensive pipe upgrading works in busy roads of Tsuen Wan and Kwai Chung.

The intake at Tso Kung Tam was situated at a natural stream. Natural boulders and boulder-like concrete units were used to construct the buffers for blending with the natural environment.

Buffer walls adjacent to the sea side of the outfall at Yau Kam Tau for modulating the speed of the collected stormwater to reduce the impact on seabed

Although Tsuen Wan Drainage Tunnel only has three intakes, its catchment area of 1 370 hectares is the largest among the four drainage tunnels. Its maximum flow rate of 223 cubic metres per second, which is capable of filling up a standard Olympic swimming pool in 11 seconds, is again the highest among all drainage tunnels. With such flow rate, the tunnel is well capable of intercepting the surface runoff from uphill catchment for discharging to the sea almost instantly.

To balance between ecology and flood relief objective, all intakes along the tunnel are designed to intercept surface runoff from natural streams only when rainstorm warning is in force. This will ensure adequate water flow to be maintained in the existing downstream drainage systems.

Construction of the intake shaft for the drainage tunnel

Lai Chi Kok Drainage Tunnel

The Lai Chi Kok Drainage Tunnel is located in the Northwest Kowloon, formed by a 2.5-kilometre long branch tunnel at mid-levels along Ching Cheung Road, a 1.2-kilometre long main tunnel running underneath Lai Chi Kok urban area, a stilling basin between the main tunnel and the branch tunnel and an outfall at Stonecutters Island. The tunnel provides a flood relief measure for the flood-prone urban areas in Lai Chi Kok, Cheung Sha Wan and Sham Shui Po. Construction commenced in November 2008 and the facility was commissioned in October 2012.

The Lai Chi Kok Drainage Tunnel is the only drainage tunnel in Hong Kong where high pressure tunnelling technology was applied in its construction. The technology was used to prevent infiltration of groundwater and erosion, and to reduce the impact on adjacent foundations and underground facilities. The main tunnel is located 45 metres below ground in an urban reclamation area. The geology is mainly soft ground, mixed boulders and debris. The tunnel was constructed in close proximity to major transport infrastructure including four railways in operation, the Express Rail Link under construction and the pile-foundations of highway viaducts.

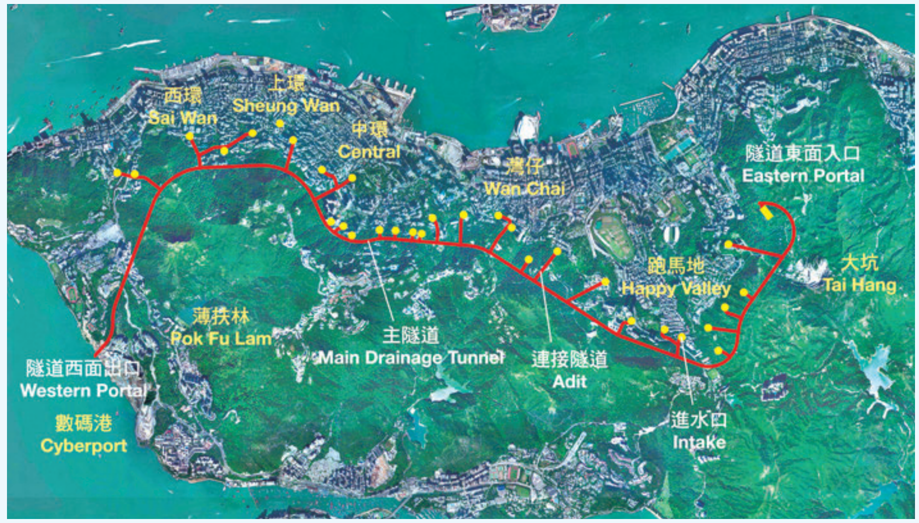
Lai Chi Kok Drainage Tunnel Layout Plan

The Lai Chi Kok Drainage Tunnel octagonal-shaped outfall (by the seawall) adopts an overflow method to slow down the stormwater discharged into the harbour and reduce the impact of the stormwater discharge on the neighbouring shipyards

Hong Kong West Drainage Tunnel

The northern part of Hong Kong Island had long been under the flooding threat in the past. To resolve the flooding problem, a stormwater interception approach is adopted by construction of a drainage tunnel to intercept surface runoff in the mid-hill for discharge to the sea near Cyberport.

The Hong Kong West Drainage Tunnel project includes 34 intakes to intercept the existing drains and streams. Surface runoff intercepted is discharged via dropshafts, adits and the main tunnel to the sea. Most of the intake dropshafts were built by the Raise Boring Method. Under the Raise Boring Method, a reverse drilling rig was erected at the ground surface of the shaft with a smaller reamer affixed to the drill rod to drill a smaller diameter pilot hole downwards from the ground to the tunnel. When this pilot hole is formed, the smaller reamer would be removed and replaced by a large diameter reaming head. The drilling would then be reversed by excavating upward to the ground surface, forming a large diameter dropshaft. All excavated spoils during downward or reverse drilling would fall to the adit and then carried away through the tunnel. Raise boring offers several advantages over the conventional shaft excavation from top to bottom including less construction vehicles on the road for spoil haulage, and reduced environmental nuisances.



Hong Kong West Drainage Tunnel Layout Plan


Hong Kong West Drainage Tunnel has a diameter varying from 6.25 to 7.25 metres, large enough to contain a 4.2 metres high double-decker bus.


The intake at Tai Hang Road marks the eastern starting point of Hong Kong West Drainage Tunnel

Excavation for the largest and longest drainage tunnel in Hong Kong amid hard rock stratum is much more than just a hole in the ground

The Hong Kong West Drainage Tunnel project made several breakthroughs in design and construction, and overcame many challenges. The project earned international recognitions, including the prestigious title of Tunnelling Project of the Year 2011 at the International Tunnelling Awards organised by British engineering magazines New Civil Engineer and Ground Engineering, and the second runner up of the Hong Kong People Engineering Wonders in the 21st Century organised by the Hong Kong Institution of Engineers.

Threat and damage by severe rainstorm from 2009 to 2018

Into the third decade since the founding of the DSD, severe typhoons and rainstorms continued to hit Hong Kong each year. Flood protection projects completed and commissioned during the years have garnered results in raising the flood protection levels in flood-prone areas. From 1995 to 2018, a total of 125 flooding blackspots were eliminated, reducing the number of flooding blackspots to six. Drainage improvement works for the remaining flooding blackspots have either been completed and under monitoring, or in various stages of planning and implementation. The accomplishment on flood prevention works by the DSD over the past 30 years is evident. Yet, Hong Kong is still under the menace of severe weather and rainstorms stemming from climate change.

In July 2010, unstable weather with heavy rain and thunderstorms affected Hong Kong when Tropical Storm Chanthu was approaching. On 22 July, the Observatory issued the Amber Rainstorm Warning and changed to Red Rainstorm Warning followed by the Black Rainstorm Warning in less than an hour (4:35 pm to 5:30 pm) during the afternoon rush hours. Rainfall exceeded 150 millimetres in many places within 3 hours and caused serious flooding and traffic standstill in major roads. A flash flood swept past Sha Po Tsai Village at Wun Yiu, Tai Po, claiming one life. When the tragedy occurred, the DSD was undertaking river training works at Sha Po Tsai Village. After the incident, the DSD conducted an investigation into the causes of this incident. An internationally renowned hydraulics expert was also appointed to conduct an independent review of the DSD's investigation report on the causes of flooding.

In 2014, Hong Kong experienced heavy rain and thunderstorms as in previous years. Showers and thunderstorms affected Hong Kong on 29 March, and became even more intense on the evening of 30 March. Over a period of 3 to 4 hours, more than 100 millimetres of rainfall were recorded in Kowloon and the New Territories. Rainfall in Yuen Long, Tuen Mun, Tsuen Wan and Sha Tin exceeded 150 millimetres. Black Rainstorm Warning was issued at 8:40 p.m., the first time in March since the Rainstorm Warning System commenced operation in 1992. Squalls and thunderstorms mixed with hail struck many locations in Hong Kong. During the period, the DSD received 29 reports of flooding cases, including a case related to flooding at a large shopping mall in Kowloon Tong due to ceiling leakage after damage by falling hailstones.

After the devastation by torrential rain on 22 July 2010, Sha Po Tsai Village in Tai Po was left with muds and boulders.

On 24 May 2017, heavy showers and squally thunderstorms swept through Hong Kong when a tropical depression affected the coast of Guangdong. The Observatory issued the first Black Rainstorm Warning that year. Rainfall exceeded 300 millimetres in Kwai Tsing and Sham Shui Po. During the period, the DSD received 19 reports of flooding cases. At Princess Margaret Road near Oi Man Estate, the flood depth was up to 400 millimetres. At Shau Kei Wan Main Street East, a taxi was stranded at a depressed area which caught much media attention.

On 23 August 2017, Super Typhoon Hato headed direct to Hong Kong. The Observatory issued the Gale or Storm Signals No. 8 and No. 9, and then Hurricane Signal No. 10, all within 4 hours. Hato caused storm surges of about 1.2 metres higher than normal which coincided with the astronomical high tide. The sea level at Quarry Bay reached a maximum of 3.57 metres above Chart Datum. Severe sea water flooding and damage occurred in many low-lying areas, such as Heng Fa Chuen, Lei Yue Mun and Tai O. Flooding in Tai O was reported to be more damaging than that of Hagupit in 2008. The Heng Fa Chuen promenade was inundated, with sea water filling up a nearby underground car park. On 27th and 28th of the same month, rain and squalls associated with the outer rainband north of Typhoon Pakhar affected the city. The Observatory issued Amber Rainstorm Warnings on two consecutive mornings. More than 250 millimetres of rainfall were recorded in most parts of Hong Kong, and 16 reports of flooding cases were received by the DSD within the period.

Tropical cyclones cause storm surges as well as torrential rains. In September 2018, Super Typhoon Mangkhut hit direct at Hong Kong and has become the strongest storm ever threatening the city. Typhoon Mangkhut registered the most extreme overall wind intensity in 35 years, second only to Typhoon Ellen in 1983. National Meteorological Information Center of CMA, Macao Meteorological and Geophysical Bureau and Hong Kong Observatory joined forces for the first time to devise precautionary measures.

The Hong Kong Observatory seldomly issues a Tropical Cyclone Warning Standby Signal No. 1 so much in advance as in the case when the fast-moving Typhoon Mangkhut was still 1,110 kilometres away. It is even rarer to issue Hurricane Signal No.10 for more than 10 hours such as that during the passage of Mangkhut, the second longest duration of Signal No. 10 since World War II, and next only to the record of 11 hours during the passage of Typhoon York in 1999. It was the first time in 56 years that the Observatory had issued Hurricane Signal No. 10 for two consecutive years. The passage of Mangkhut, which was characterised by its extensive circulation, violent winds, fast moving speed, record-breaking storm surges and the severe and widespread impacts, must have been engraved in the memories of many Hong Kong people in the years to come, just as Super Typhoon Wanda did in 1962.

Downpours on 19 July 2017 caused muddy flood water overflowing from Shan Liu River at Ting Kok Tsuen, Tai Po and gushing into the villages.

During the passage of Mangkhut, the DSD received 47 reports of flooding. Storm surge had caused serious damage to low-lying and coastal areas. The sea level of Quarry Bay rose to a maximum of 3.88 metres above Chart Datum. The storm surges recorded were up to 2.35 metres, surpassing the previous record high of 1.77 metres set by Wanda in 1962. At Tai Po Kau in Tolo Harbour, a maximum water level of 4.71 metres above Chart Datum and a record high storm surge of 3.40 metres were recorded. More than 100 millimetres of rainfall were recorded over most parts of the territory on that day, and exceeded 200 millimetres in some places. Sai Kung, Heng Fa Chuen and Tseung Kwan O South were devastatingly battered by huge waves. Structures along seafront facing southeast suffered different levels of damage. Huge overtopping waves and roaring seawater backflow caused serious flooding in the side streets in Heng Fa Chuen and the nearby Shing Tai Road, with flood water more than 300 millimetres deep. Sai Kung Town including the seawall and revetment in Tui Min Hoi and Sai Kung Sewage Treatment Works, sustained widespread damage. Over 60 000 trees were reported fallen. The typhoon also caused unstable power supply in some of the DSD sewage and flood control facilities. Thanks to the tireless effort of the emergency response teams in gearing up the precautionary measures and speedy recovery of facilities after the storm, the operation of malfunctioned flood protection facilities and sewerage works had resumed normal within the shortest possible period.

Low-lying coastal areas such as Tai O and Lei Yue Mun are prone to flooding when storm surge coincides with heavy rainfall. However, the DSD has learnt the lesson from Typhoon Hato in 2017. In 2018, resources were deployed much in advance of the approach of Mangkhut on installing demountable flood barriers, stacking up sand bags and other temporary flood protection measures in Tai O and Lei Yue Mun in order to mitigate the effects due to seawater backflow and storm surges. These precautionary measures turned out to be very effective in protecting these areas from the record high storm surges during the passage of Mangkhut.

For districts which were used to be susceptible to flooding during heavy rain (including West Kowloon, Happy Valley, Sheung Wan, Tsuen Wan and Northern New Territories), they have been spared from flooding in recent years, which have demonstrated the effectiveness of flood prevention works by the department.

Extreme weather including super typhoons will become more frequent under climatic change. The DSD will sum up the experience from Super Typhoon Mangkhut and adopt more forward-looking, more innovative mindset and more advanced technologies to improve the city's flood resilience and to implement sustainable flood prevention measures.

Demountable flood barriers have been installed in Tai O Creek along the river wall since 2014

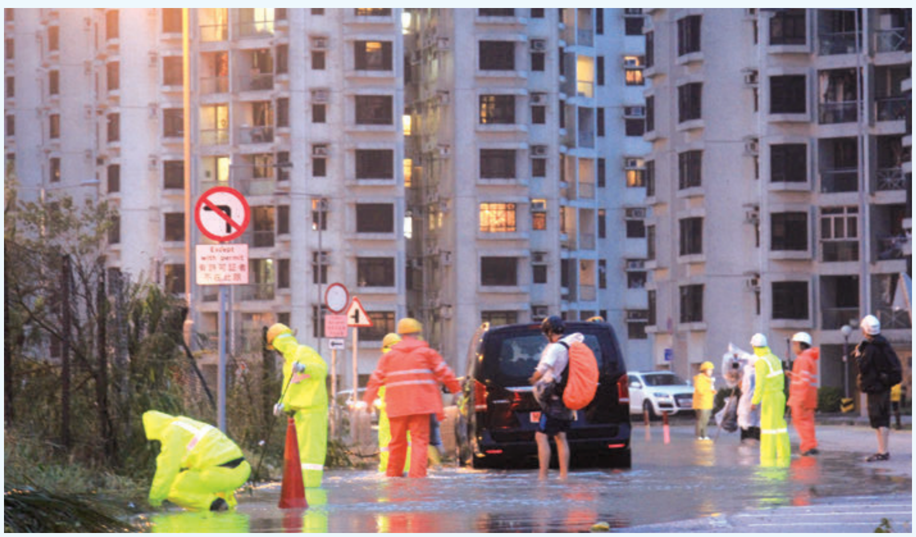
The low-lying village houses in Tai O effectively protected by demountable flood barriers installed along the river wall at times of high storm surges

Overview

Since its establishment, the DSD has completed a number of large-scale drainage and sewerage infrastructures, some of which were very challenging and fraught with difficulties.

HATS is the largest world-class environmental infrastructure project ever built in Hong Kong. With Stage 1 and Stage 2A works commissioned in 2001 and 2015 respectively, the water pollution problem in the Harbour was thoroughly solved. The Cross-harbour Swimming Race resumed in 2011 and returned to its legendary route in Central Harbour in 2017.

The Shenzhen River Regulation Project is one of the vital components of flood prevention networks in the northern New Territories. Upon completion of the first three stages of the Regulation Project, the flood protection capacity of the Shenzhen River has been greatly enhanced. Commenced in 2013, Stage IV of the Regulation Project covering the upstream section of the Shenzhen River was infused with a number of ecological conservation designs. The Shenzhen River Regulation Project witnessed the seemless collaboration between the governments of Shenzhen and Hong Kong in regulating the boundary river with remarkable results.



The DSD's Direct Labour Force worked painstakingly during adverse weather to clear drainage blockages so that traffic could resume normal as soon as possible

Following the commissioning of its second underground stormwater storage scheme at the waterfront of Sheung Wan, the DSD completed the Happy Valley Underground Stormwater Storage Scheme in 2015. In that project, the Movable Weir and Supervisory Control and Data Acquisition System with low energy consumption were adopted for the first time in Hong Kong to meet the dual objectives of flood prevention and environmental protection.

Having entered the 21st century, the DSD has constructed three drainage tunnels in Tsuen Wan, Lai Chi Kok and Hong Kong West respectively, thereby further improving the flood protection capacity of the urban areas. The notable success of the underground stormwater storage schemes and drainage interception tunnels testifies to the effectiveness of the DSD's three-pronged flood prevention strategy, i.e. stormwater interception at upstream, flood storage at mid-stream and drainage improvement at downstream.

Chapter 9: Maintenance and Revitalisation for Sustainability

Adapting to climate change

Drainage and sewerage infrastructure and services in Hong Kong have kept up with the development of the city to evolve from primitive in the mid-to-late 19th century to international standard, reliable and trustworthy in the 21st century. The DSD has worked to the public expectations of wastewater treatment and stormwater drainage, and yet, we are confronting with the long-term challenges tossed by climatic change. The community as a whole must stay alert and be prepared.

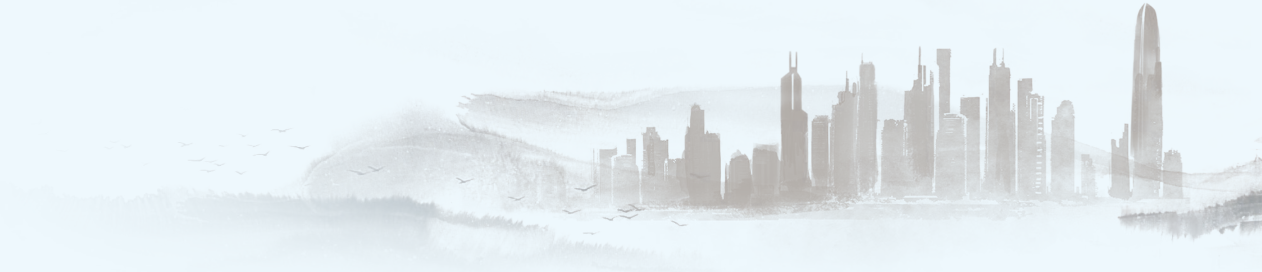
Human activities are impacting the climate system, resulted in more frequent occurrences of extreme weather events. According to the Hong Kong Observatory's records, the average temperature in Hong Kong has increased by 0.18°C every 10 years for the 30 years between 1988 and 2017. On the morning of 18 May 2018, the Observatory issued a Very Hot Weather Warning, which was in force for 348 hours till the evening of 1 June, a record since its introduction in 2000. On 16 September of the same year, record-breaking storm surges were triggered by Super Typhoon Mangkhut that most areas in Hong Kong were hazarded by severe floods. The maximum storm surges exceeded the records set by Typhoon Wanda in 1962 and Hope in 1979.

To combat the drastic challenges of climatic change and to ensure proper operation of its drainage and sewerage facilities, the DSD has to revive experience and knowledge acquired over past years on the development of drainage services and to upkeep all facilities through proper maintenance, enhancement, revitalisation, adoption of innovative technologies and sustainable designs with public engagement for providing quality services to the community.

Management and maintenance of drainage and sewerage systems

Before the DSD was established in 1989, management and maintenance of drainage and sewage treatment systems (including sewage treatment works and sewage pumping stations) were shared among the former Civil Engineering Services Department, Electrical and Mechanical Services Department, Architectural Services Department and Highways Department. These functions were gradually taken up by the DSD.

Sha Tin Sewage Treatment Works. The DSD has drawn up programmes for preventive inspections and maintenance, and contingency plans for possible emergency situations.



In 1998, a new Buildings and Civil Maintenance (BCM) Team was formed under the Hong Kong and Islands Division to take over the building and civil engineering maintenance for sewage treatment systems from Architectural Services Department for more efficient maintenance. Today, the BCM Team has also assumed the maintenance for drainage tunnels and underground stormwater storage schemes.

With sewage services covering nearly 94% of Hong Kong's population, it is imperative that each process of the sewerage system, namely, in the wastewater collection, conveyance and treatment functions properly to safeguard the environmental hygiene. On full commissioning of the HATS, the burdens on maintenance have inevitably increased.

Today, the DSD carries out preventive inspection and cleansing to sewers and drains, and preventive maintenance works in accordance with the preventive programmes. The internal conditions and structural integrities of sewers and drains are inspected by closed-circuit television surveys regularly. During dry seasons, the DSD will carry out routine inspection and maintenance for storm water pumps and the ancillary facilities.

Servicing and maintenance of sewage treatment facilities

To ensure the effective operation of sewage treatment facilities, the DSD has carried out regular maintenance and repair works, and has adopted measures for continual improvement in the operation performance and treatment standards, including timely upgrading, renewal, and regular maintenance of the plant facilities to reduce the risk of plant breakdown. Contingency plans for all facilities are established for possible emergency situations.

At the same time, the DSD has introduced different computer systems and operation platforms for supporting the sewage treatment facilities, such as Management Information System (MIS) and the Maintenance Management Systems (MMS), and the Sewage Treatment Operations and Maintenance Management Information System (STOMMIS) that combines the MIS and MMS. The STOMMIS allows the DSD staff to

Maintenance of stormwater pumps in Tai Hang Tung Underground Stormwater Storage Scheme

Inspection of stormwater pumping station in Tai O after passage of typhoon

Monthly inspection of the emergency generator at the Tai O Tai Ping Street Stormwater Pumping Station

Maintenance inside a double-decked sedimentation tank in the Stonecutters Island Sewage Treatment Works requires stringent safety precautionary measures

monitor unmanned plants in remote sites from a Regional Control Centre, and to collect real-time data for computer analysis, reporting and formulating E&M equipment maintenance schedules. In addition, the system has an automatic alert function, which sends out real-time alert messages to mobile phones so that the DSD staff can quickly attend to any plant equipment performance problems.

There is no doubt that the wider use of information technology systems has resulted in more effective operation of sewage treatment facilities and higher flexibility in resources deployment, which helps the department to deliver more cost-effective and quality sewage services.

Water purification equipment for the Lai Chi Kok Drainage Tunnel stormwater harvesting system

The composting facilities in North District put into operation in 2017

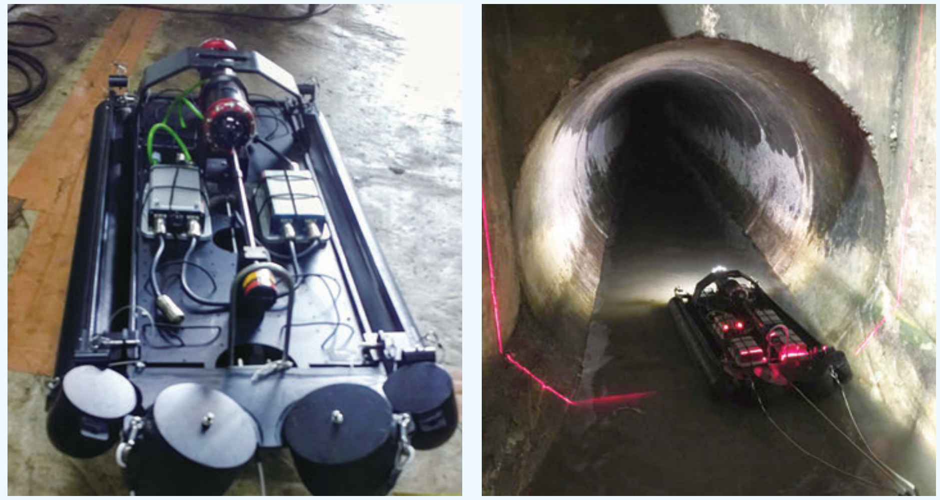
The DSD has incorporated energy conservation and emission reduction measures in its maintenance work. For instance, water collected at the Lai Chi Kok Drainage Tunnel stilling basin area is filtered and disinfected, and supplied to the Butterfly Valley Road pet garden for irrigation, toilet flushing and pipe cleansing. The DSD is in the process of acquiring more advanced high pressure water jetting units with water recycling system to capture and recycle jetting water, and hence reducing water usage.

The DSD generates about 480 tonnes of yard waste each year from river channel maintenance. Since the composting facility at the North District Drainage Maintenance Depot commenced operation in 2017, the department has begun to turn the yard waste to compost materials for use in the greening areas in the plants, instead of disposing the yard waste to landfill.

Dye test for the submarine outfall in Sha Tin Sewage Treatment Works. Non-toxic dye rose to the water surface at the diffuser locations.

The DSD completed digitization of all drainage records as early as 1996. In 2002, the Automated Mapping/Facilities Management (AM/FM) System was launched to form a central database for the drainage records. Starting from 2016, the public can gain access to the DSD's drainage records through the Lands Department's Geographic Information System as well as by visiting the Drawing Offices in DSD Operations and Maintenance Divisions.

Effluent from sewage treatment works is discharged to the receiving waters via submarine outfalls. In 2018, the DSD operates a total of 42 submarine outfalls and two effluent tunnels. Regular inspection and maintenance of the submarine outfalls are necessary. Among all methods for inspection, dye test is the one most commonly used. Preventive inspection and maintenance for submarine outfalls include underwater inspection, hydrological and sonar survey, flushing and de-silting.



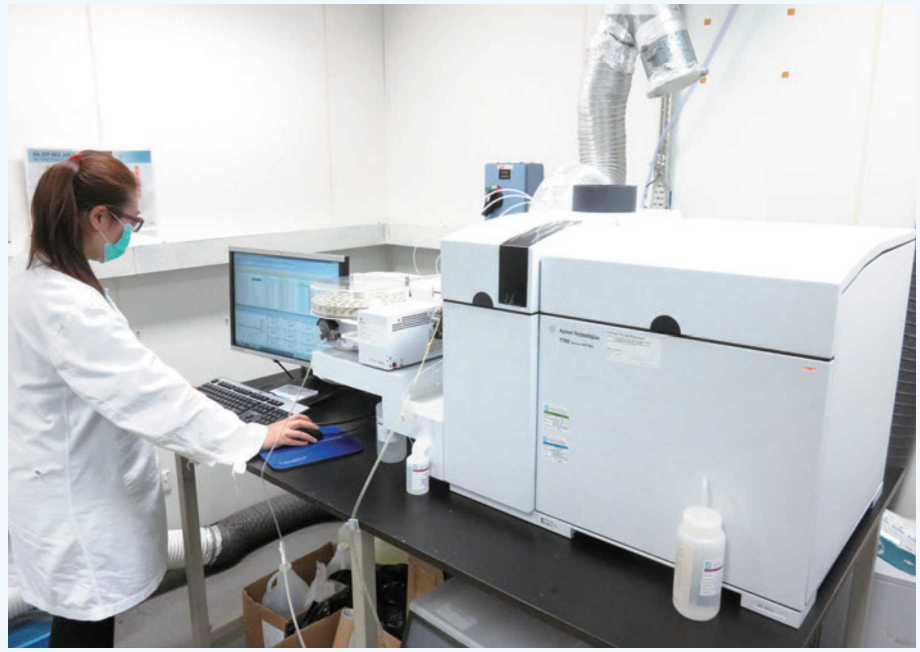
Remotely operated vehicle equipped with video camera, sonar and laser scanner for pipeline inspection.

The DSD Drawing Office. Digitization of drainage records has improved accessibility to drainage records.

Laboratory services

To ensure that treated sewage meets the statutory requirements, laboratory services for sewage treatment were set up in the sewage treatment works in Sha Tin, Tai Po, Sai Kung, Shek Wu Hui and Yuen Long before the DSD was established to conduct water and sludge sampling and testing.

To enhance the efficiency in coping with the mounting workload, in 2004 the DSD transferred the testing services to the new Sha Tin Central Laboratory at Sha Tin Sewage Treatment Works for processing centrally. In 2018, Sha Tin Central Laboratory has been accredited under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for 32 laboratory tests, including *E. Coli* count in disinfected effluent, while the Stonecutters Island Laboratory at Stonecutters Island Sewage Treatment Works has gained accreditation for 7 tests in the same year. Other smaller laboratories in sewage treatments works also provide laboratory testing services for individual sewage treatment works. The Laboratory Services Sub-division conducted more than 266 000 analyses in 2017, providing important analytical data to enable monitoring of the performance of wastewater and sludge treatment processes and ensure that the effluent quality meets the Discharge License Conditions set by the EPD.



Inductively coupled plasma-optical emission spectrometer for detecting heavy metals in sewage and sludge samples

Sha Tin Central Laboratory

In order to raise the efficiency of sewage treatment analytical testing, the DSD is committed to the automation of the laboratory work flow for its laboratory services as a long-term goal. The DSD is the first department in Hong Kong to adopt the Laboratory Information Management System (LIMS) to facilitate the consolidation of laboratory results and operation data, and a major upgrading of the System was carried out in 2011. Automated information management reduces staff resources required for processing the operation data with higher precision and improved efficiency. The updated and past laboratory test reports and analytical results can be quickly retrieved from DSD Intranet at any time and at any outpost stations. The LIMS has greatly improved the efficiency on management of the sewage and sludge treatment process in each sewage treatment works.

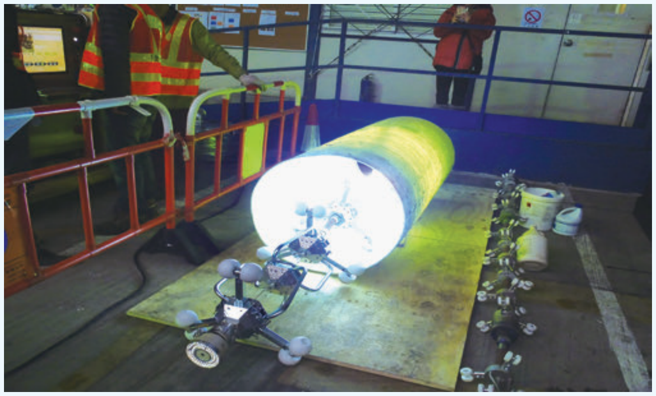
In 2016, a biochemical oxygen demand automatic analyser was installed in the Sha Tin Central Laboratory which is capable of processing more than 100 samples simultaneously. In the following year, the DSD purchased an inductively coupled plasma-optical emission spectrometer, which has further improved the performance on detecting heavy metals in sewage and sludge samples.

biochemical oxygen demand automatic analyser

Laboratory Information Management System displays an overall analysis of the Performance of Sewage Treatment Works

Management of underground drainage and sewerage networks

In 2018, the DSD managed more than 4 100 kilometres of underground sewers and stormwater drains, of which more than 1 800 kilometres have been in use for 30 years or more. Aging and wearing have been found in many sewers and drains. As mentioned in previous section, the DSD has scheduled regular inspections and monitoring on the conditions of the pipelines and carried out rehabilitation works as and when necessary. In 2016–17, the DSD rehabilitated 22 kilometres of sewers and drains at a cost of about HK$138 million. Since 2017, the DSD has implemented a territory-wide rehabilitation programme for the aged sewers and drains using risk-based approach. It is anticipated that the DSD will seek funding approval in the range of hundreds of millions dollars each year on condition survey and rehabilitation of high risk underground pipes in phases. At the same time, the Department endeavours to explore and adopt advanced technologies on the repairs and rehabilitation of underground pipes for achieving greater cost-effectiveness of the works.



Curing of internal liner by ultraviolet lamp is a new curing method

On pipe rehabilitation, the DSD would employ insitu internal lining method as an alternative to excavation and pipe replacement. This technique is especially suitable for pipes laid below heavily trafficked roads or for those pipes with slight damage. Insitu internal lining method was invented in early 1970s and introduced to Hong Kong in mid-1980s, initially for repairing defective sewers due to settlement and is now widely used to rehabilitate aged pipes. In general, internal lining works can be completed within 12 hours. Below are some common insitu internal lining methods used by the DSD.

Cured-in-place pipe lining

Glass fibre is a common material used in cured-in-place pipe lining method. The liner is first cut to the length of the pipeline under repair, and then impregnated with resin, pulled or pushed into the pipe through a manhole, and then expanded tight-fit against the pipe wall by water, compressed air or steam. The liner is then cured, by hot water or steam, for four or five hours until it hardens. A new curing method is to use ultraviolet lamp, which has shorter curing time compared with hot water or steam curing.

The liner is being pushed through a manhole into the underground pipe under repair

A lining is being steam-cured

Fiberglass reinforced pipe (FRP) slip-lining

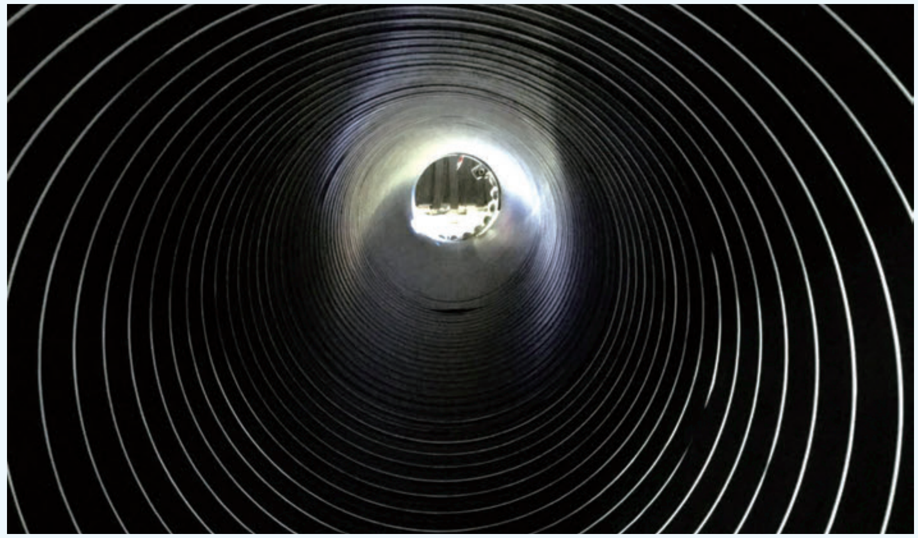
The FRP slip-lining method uses fiberglass reinforced pipe of diameter slightly smaller than that of the original pipe so that it can be pulled or pushed into the original pipe, and the annular space between the slip-lined pipe and the original pipe is filled with cement or chemical grouting. Temporary flow diversion during lining works is not necessary, which makes this lining method very suitable for sewers with high flow.

Hydraulic jack is used to push the fiberglass reinforced pipe into the underground pipe under repair

Steel-reinforced polyethylene strip is slowly wound by a winding machine and fed into the underground pipe from a manhole to form pipe lining

Spiral wound pipe rehabilitation

Spiral wound pipe lining is a new pipe rehabilitation method. Steel reinforced polyethylene strips are mechanically wound by a special winding machine to form a complete slip-lined pipe within the original pipe. The annular space between the slip-lined pipe and the original pipe is then grouted. Temporary flow diversion is not necessary, but the cost is relatively high.



A slip-lined pipe formed inside the original pipe

The project team is inspecting the spiral pipe liner wound by the winding machine

Emergency and Direct Labour Force

Emergency Control Centre

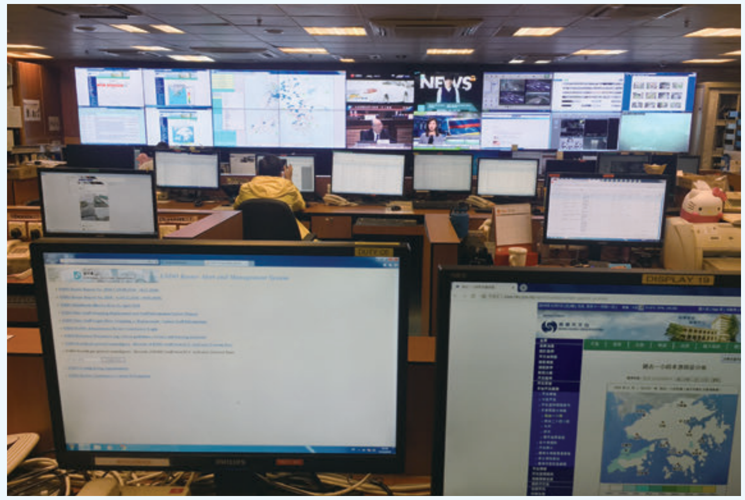
When the Water Supplies Department Kowloon West Regional Building at Lai Hong Street in Cheung Sha Wan was completed in 2001, the DSD relocated its Emergency Control Centre (ECC) from Kowloon Government Offices in Yau Ma Tei to this new building.

During severe weather condition or emergency requiring DSD's action, the DSD will activate the ECC. The duty staff drawn from the divisions under the Emergency and Storm Damage Organization (ESDO) will attend the ECC. The ECC will liaise with other government emergency organisations to deal with drainage related complaints and assign emergency work to DSD's Calls Coordination Centre, where the Direct Labour Force (DLF) or the maintenance term contractor's teams would be deployed to deal with the adverse situations on site if required. During adverse weather, the contractor's teams will station in flood-prone areas to expedite responses to any flooding incidents. In 2017, the DSD received a total of 37 000 calls for assistance, mostly related to drainage blockages or flooding.

The advance in technology in the past 30 years has transformed the communication equipment used in the ECC from radio broadcasting, fixed-line telephone, fax machine, and pager to wall-mounted multi-screen, desktop computer, Internet, and smart phone at present. As mentioned in Chapter 7 above, on 7 June 2008 the ECC received a record high of more than 1 000 reports of complaint cases, which well exceeded its handling capacity. To improve the flood relief services to the public, the DSD refurbished the ECC and restructured the ESDO in 2008. The DSD also joins forces with 1823 Call Centre of the Efficiency Unit to help the DSD receive and respond to emergency calls under critical circumstances. Needless to say, the DSD will continue to improve their service in keeping up with public expectations.

Direct Labour Force

The DSD took over the former Sewer Gang Section from the Highways Department and set up its own DLF after its establishment. The DLF consists of a number of sewer gangs to handle pipe blockage cases. After arriving at the location, the sewer gang will first use portable tools for clearing blockages. If the blockage problem persists, a high pressure water jetting unit will be deployed on site. The high pressure water jetting unit is equipped with a high pressure hose and other drain clearance equipment which can normally flush away the blockage to restore the flow conditions of the sewer or drain. For unresolved blockages or repeated complaint cases, the DLF will refer them to the district engineers for follow-up investigation.



The DSD's Emergency Control Centre

When Super Typhoon "Mangkhut" struck Hong Kong in 2018, the DLF helped clear up drainage blockages in flooded areas while the Hurricane Warning Signal No. 10 was in force.

Harnessing renewable energy

The DSD operates over 300 flood control and sewage treatment facilities, which operate round the clock and consume a lot of energy. The electricity consumption of the DSD constitutes about 10% of overall electricity consumption of government departments. Therefore, the DSD has constantly explored opportunities on enhancement of energy management and emission control at different facilities through raising energy efficiency and wider use of renewable energy. To take forward the initiative, the DSD has conducted extensive research, developed and adopted various technologies, including reuse of effluent and effective use of biogas produced by sludge, turning waste into usable resources.

The DSD has also commissioned consultants to carry out research and development projects, such as anaerobic co-digestion, enhanced production of biogas and biogas-powered fuel cells. Among these, solar power and biogas are the most extensively used renewable energy sources in the department.

A high pressure water jetting unit uses rainwater harvested from a drainage tunnel for pipe cleansing in its daily operation

Solar energy

Over the years, the DSD has installed in its major facilities solar water heaters, photovoltaic (PV) panels and hybrid lamp posts equipped with solar panel and mini wind turbine for energy conservation. Standalone and grid-connected photovoltaic (PV) systems are installed to provide electricity for the plant equipment in its major facilities, including the sewage treatment works at Sha Tin, Sham Tseng, Yuen Long, Sai Kung, Shek Wu Hui, Siu Ho Wan, Sandy Bay and Stonecutters Island. These PV systems are usually mounted on the roofs or the walls to capture the solar energy. The following is an introduction on one of the largest solar farms in Hong Kong at the Siu Ho Wan Sewage Treatment Works.

The Siu Ho Wan Sewage Treatment Works located alongside the North Lantau Highway

When commissioned in 2016, the solar farm at the Siu Ho Wan Sewage Treatment Works was the largest PV system in Hong Kong at that time, with more than 4 200 polycrystalline silicon solar photovoltaic panels and total generation capacity of 1 100 kilowatts. The renewable energy generated can meet about one fifth of the current annual electricity demand of the Siu Ho Wan Sewage Treatment Works, equivalent to annual electricity consumption of 230 households. The electricity generated is fed through an internal power distribution network to various facilities inside the treatment works, such as screening facilities, a workshop, an administration building, sludge treatment facilities and an ultra-violet disinfection system, which results in the reduction of 770 tonnes of carbon dioxide emission per year.

One of the three solar farm areas at the Siu Ho Wan Sewage Treatment Works

The installation of the Solar Farm costs about HK$27 million. The Solar Farm works commenced in February 2015 and was completed in December of the following year. The Solar Farm has an intelligent detection system to enable speedy detection and identification of any faulty panel out of the 4 200 no. of PV panel.

A Paper on the Solar Farm at the Siu Ho Wan Sewage Treatment Works received the Hong Kong Institution of Engineers — Certificate of Merit of 2017 Environmental Paper Award and the CarbonCare® Label 2016 from CarbonCare InnoLab.

Biogas

Biogas is a by-product of anaerobic digestion process. It is produced after sewage sludge is digested and decomposed by anaerobic microorganisms in the absence of oxygen. Biogas is a mixture of gas, containing about 65% methane. It is a renewable energy source and can be used as a fuel for dual-fuel (biogas and diesel) generators, boilers and combined heat and power (CHP) system in power and/or heat generation. The heat generated is used for maintaining the optimum temperate of the digesters for anaerobic digestion of sludge.

The DSD has adopted the anaerobic digestion process for treatment of sludge at its four major secondary sewage treatment works in Sha Tin, Tai Po, Shek Wu Hui and Yuen Long. The biogas produced in the last few years at Sha Tin Sewage Treatment Works, for instance, has met nearly 40% of its energy demand.

Biogas storage tanks at the Sha Tin Sewage Treatment Works

Interior of biogas storage tank

The Tai Po Sewage Treatment Works uses biogas as fuel to supply heat and electricity to the power generation system. These generators are large capital investments as each generator costs more than a few million dollars, depending on its capacity.

By 2019, there are a total of six CHP generators at the sewage treatment works in Sha Tin, Tai Po and Shek Wu Hui. The first biogas-powered micro-turbine generator in Hong Kong, installed at the Yuen Long Sewage Treatment Works, has been in used for power generation since 2013.

CHP generator at the Sha Tin Sewage Treatment Works

Energy saving and emission reduction

The DSD has been committed to developing and using new sewage treatment technologies and equipment to save energy and reduce emission. High-efficiency pump motors and variable speed drives for sewage pumping and sludge dewatering, light emitting diode lamps and magnetic bearing high speed turbo blowers in aeration system are among the energy saving equipment that have been adopted for use in recent years. Ultra-fine bubble air diffusion system is also adopted for use in bioreactor for its higher oxygen transfer efficiency and improved energy effectiveness for aeration. Through monitoring the pressure of the air diffuser and various operation parameters, cleaning frequency for the air diffusion system could be optimized for better energy utilisation.

Furthermore, energy consumption of sewage treatment facilities can be reduced through enhancement of the control system. Oxygen demand for aeration fluctuates according to different seasons and different water temperatures. The smart aeration control system on trial use at Shek Wu Hui Sewage Treatment Works is able to monitor the ammonia and residual dissolved oxygen levels in the aeration basin and automatically adjust the total air supply to avoid over aeration and thus saving in energy consumption. On the other hand, using the novel variable speed blower technology combined with inlet guide vanes and variable outlet diffuser would further improve the energy efficiency of the aeration system during the biological treatment process.

Compact coagulation — flocculation — sedimentation technology

The DSD has adopted the innovative compact coagulation — flocculation — sedimentation technology when Pillar Point Sewage Treatment Works was upgraded in 2014 from preliminary treatment to chemically-enhanced primary treatment with UV disinfection. This technology is a combined physical-chemical settling system to remove scum and solid substances in the sewage, offering advantages such as rapid system start-up, shortening the treatment time, and smaller footprint. This technology involves an innovative and proprietary system and therefore joint-venture partnering with its proprietary manufacturer is necessary for its implementation.

The Pillar Point Sewage Treatment Works

Sponge City for adapting to climatic change

Over the past 30 years, the DSD has moved forth into a new era of drainage sustainability — water body revitalisation through adoption of the Sponge City concept.

Sponge City refers to a city that resembles a sponge in response to flooding threats and adaptable to environmental changes and natural disasters. During rainy days, a Sponge City absorbs, stores and purifies stormwater through natural means, and releases the stored rainwater to enhance the ecological function of the city and reduce flood risk. Sponge City is a modern urban stormwater management strategy that advocates reduction of urban impervious pavement to lessen the demand of large-scale flood prevention engineering works.

In recent years, the DSD has adopted the Sponge City concept and actively promoted Blue-Green Infrastructure to create more aesthetically pleasing and liveable spaces. For instance, green roofs, porous pavement, bio-swales, rain garden etc. are incorporated in DSD's facilities to improve filtration and reduce surface runoff. Recreational facilities with stormwater storage function, such as riverside parks and flood attenuation lakes, are planned to collect and store the stormwater. The stored stormwater can be purified through natural means and used as city water supply. Thus, Sponge City concept provides a sustainable solution to lower the burdens on the drainage systems, transforming the city with greener and healthier urban spaces while enhancing the flood resilience level of the city.

Black-faced Spoonbills and Little Egrets wading on the mudflats of Shan Pui River. The Mai Po Ramsar Site at Shan Pui River estuary is designated as a Wetland of International Importance.

River greening should consider scenic design and ecological conservation in tandem

Chapter 8 has illustrated some of the DSD's "flood interception and flood storage" projects. Other engineering works that have adopted the "Sponge City" concept are described below.

Blue-Green Infrastructure

In the light of increasing public concern on environmental protection in recent years, environmental and ecological considerations have to be taken into account in drainage projects so as to preserve the natural profile, landscape and ecological value of natural rivers and streams. In 2005, The DSD compiled a Practice Note "Guidelines on Environmental Considerations for River Channel Design". Drainage improvement works at Ma Wat River, Ho Chung River, River Silver of Pak Ngan Heung in Mui Wo, and Lam Tsuen River were designed in accordance with such guidelines, as well as in compliance with the Environmental Impact Assessment Ordinance

The Yuen Long Main Nullah built in the 1960s and 1970s were designed for fast flood relief. Aesthetic or ecological factors were secondary considerations.

The term "Blue" used in "Blue-Green Infrastructure" represents water bodies in the city and "Green" refers to plants. The synthesis of "Blue", "Green" and "Infrastructure" exhibits an urban drainage network that integrates natural environment, local characteristics and contemporary functions.

Green fields and blue running water within easy reach. Pleasing environment attributable to harmonious unison between flood control and ecology management.

The 2015 Policy Address promulgates that in large-scale drainage improvement works and planning drainage networks for New Development Areas, the concept of revitalisation of water body should be adopted. In this regard, the DSD, through incorporation of the "Blue-Green Infrastructure" concept, while enhancing the flood prevention capacity, would build a greener, healthier and cleaner environment with ecosystems, luxuriant vegetation and beautiful waterscape so that the public will have more opportunities to get closer to the water bodies of maximised biodiversity for learning to cherish natural resources. In 2015, the DSD updated the above Practice Note to "Guidelines on Environmental and Ecological Considerations for River Channel Design", with new contents covering Blue-Green Infrastructure, river greening and ecological design.

The 2017 Policy Agenda proposes to review and evaluate the revitalisation potential of all major nullahs in Hong Kong, and identify suitable nullahs for revitalisation so as to enhance their ecological value and provide a greener environment for the community. In 2018, the DSD has completed the review and evaluation, and developed revitalisation schemes for Tai Wai Nullah, Fo Tan Nullah and Jordan Valley Nullah. Through the revitalisation, a better living environment will be created for the public to cherish the natural beautification, biodiversity and water friendliness.

Insects found in the DSD river channels

Water management and sustainable drainage system

Global water resources are increasingly scarce. The DSD proactively studies and develops sustainable water resources on rainwater harvesting and use of reclaimed water. Later in this chapter there is an introduction to the proposed Inter-Reservoir Transfer Scheme to transfer the collected runoff from the Kowloon group of reservoirs to Lower Shing Mun Reservoir, yielding additional 3.4 million cubic metres of fresh water each year while achieving flood prevention objective. Firstly, below is a brief introduction to water harvesting in sewerage and drainage facilities of the DSD.

Happy Valley Underground Stormwater Storage Scheme

Happy Valley Underground Stormwater Storage Scheme is the first project in Hong Kong to apply the leading edge hydraulic mathematical modelling for more precise flood control design, further lowering the construction cost and time, and the operation power consumption, fulfilling dual purposes of flood protection and environmental protection.

The DSD has constructed a water harvesting system under the Happy Valley Underground Stormwater Storage Scheme to recover groundwater through the sub-soil drainage system, which after purification is used for irrigation, cleaning and toilet flushing in the adjacent Happy Valley Recreation Ground.

Groundwater harvested under the Happy Valley Underground Stormwater Storage Scheme is used for irrigation and other purposes

Kowloon City Sewage Pumping Stations

The Kowloon City Sewage Pumping Stations No.1 and No.2 adjacent to the Kai Tak Development have adopted sustainable design and created an oasis in the city. There are many green elements used in these two pumping stations, such as permeable pavement, vertical greening, green roof and rain garden, providing a green area of 4 300 square metres. The pumping stations are also provided with water harvesting systems to collect rainwater for irrigation. The green roofs also feature unique landscaping design by growing plants of different colours and textures to create vivid geometric patterns of high aesthetic and visual values.

The Kowloon City Sewage Pumping Station No.1 was commissioned in 2012. It is the first government infrastructure to be bestowed the highest BEAM Plus Final Platinum rating for New Buildings in 2016.

The Kowloon City Sewage Pumping Station No.1 bestowed the highest BEAM Plus Final Platinum rating for New Buildings

The rain garden inside the Kowloon City Sewage Pumping Station No.2 reduces runoff to the drainage system and uses the plants and soil to purify rainwater

Uses of reclaimed water

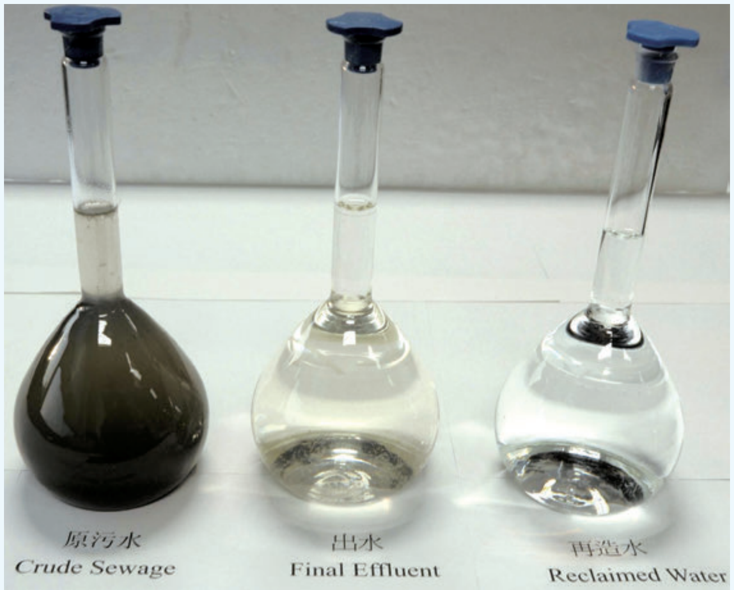
Use of reclaimed water is part of the total water management. At present, the DSD applies sewage purification technologies to further purify the secondary treated effluent to produce reclaimed water for non-potable uses.

Since 2006, the DSD and the EPD have been conducting tests to verify the purification process and applications of reclaimed water, at the Ngong Ping Sewage Treatment Works in Lantau Island and the Shek Wu Hui Sewage Treatment Works in Sheung Shui to purify and reuse the treated effluent for public toilet flushing and garden irrigation.

In the DSD, the water reclamation facility at Sha Tin Sewage Treatment Works is relatively large-scale. The facility is capable of producing 1 000 cubic metres of reclaimed water per day for irrigation, toilet flushing and chemical dilution at the plant.

It is the first time that the DSD uses pressure exchanger energy-saving technology in the reverse osmosis membrane facility for this water reclamation system, which results in power saving of 20% of the whole system.

Reverse osmosis membrane components



Comparison on the level of cleanliness amongst different water samples

River revitalisation

Eco-conservatory elements commonly used in recent major river improvement projects include:

1) grassed cellular paving at channel beds and riverbanks to create greenery and establish microbial environment — examples are Kam Tin River, Lam Tsuen River, Ng Tung River and Yuen Long Bypass Floodway;

2) gabion baskets and geotextile mattress to stabilise riverbank — examples are Tong Fuk, Sha Po River and Kam Tin River tributaries;

3) unlined riverbed to create natural river environment for procreation of flora and fauna — examples are Kam Tin River and Lower Ng Tung River;

4) unlined riverbank to provide natural ground for plant growth — examples are Ng Tung River and Sheung Yue River;

5) preservation of original or natural river meanders — examples are Ng Tung River, Kam Tin River and Sheung Yue River;

6) shallow ponds with aquatic vegetation to attract freshwater fish, amphibians and water birds — example is Ping Yuen River;

7) wetland and reed beds to increase biodiversity — examples are Yuen Long Bypass Floodway and San Tin Eastern Main Drainage Channel; and

8) bird holes, fish ladders, and in-stream boulders to attract birds and fishes — examples are Lam Tsuen River, Ho Chung River and Kai Tak River.

Aspirations for ecological river have prompted more and more requests from the public that channels be rehabilitated through revitalisation instead of decking over. Upcoming works such as revitalisation of Tsui Ping River, artificial flood attenuation lake in the development of Anderson Road Quarry Site and Tung Chung riverside park have attracted much public attention.

The Kai Tak River before river revitalisation

The Kai Tak River after revitalisation. In-stream boulders create pools and riffles and enhance benthic habitats for vertebrates.

Natural bedding at the Kam Tin River provides ideal feeding places for amphibians and wetland birds

Lam Tsuen River

To alleviate the flood risk in the Lam Tsuen River Basin, the DSD undertook the River Improvement Works in Upper Lam Tsuen River in 2007 with construction completed in 2012. Given the extraordinary ecological conservation value of the Upper Lam Tsuen River, the DSD proceeded with the design, construction and management of the project in such way that the impacts of the river improvement works on the environment and ecology would be minimized. In the design, the original natural river course was preserved as far as practical with river sections having sufficient drainage capacity being left undisturbed. Fish ladders are provided across cascades to maintain ecological continuity along the river channel. Other conservation measures include the use of gabion walls as river banks to cultivate a natural ecology within the riparian zones, re-use of the original riverbed materials for restoring the rip-rap base of the river channel, and avoiding the use of concrete to create a natural stream environment.

The Tin Shui Wai Channel is lined with mangroves. Its downstream is dwelled with the "Mai Po Bent-winged Firefly" *Pteroptyx maipo*, a species unique in the world.

The Hong Kong newt lives in clean aquatic environment and is a biological indicator of good water quality

After river improvement works, the natural environment of the Upper Lam Tsuen River is reinstated.

The Lam Tsuen River uses natural material for riverbed and gabion baskets for river bank

Aquatic and riparian vegetation was established quickly after completion of the river improvement works in Upper Lam Tsuen River. The number of rare species (such as Hong Kong newt) climbs even higher than that before the river improvement works. In addition, the biodiversity in the river course is also maintained, with the number and species of birds, fishes and dragonflies being restored to its pre-construction level.

The DSD has invited green groups, for the first time, to participate in formulating and assessing construction options during design stage. The green groups have provided valuable insights in areas such as biological migration. The successful collaboration with green groups in the river improvement works in this Upper Lam Tsuen River project has paved the path of collaboration between the DSD and the green groups on delivery of ecological river channel works thereafter.

Fish ladders allow fish and other aquatic creatures to travel between the upstream and downstream of the river

Kai Tak River

The 2.4 kilometres long Kai Tak River was previously known as Kai Tak Nullah and is one of the major drainage channels in East Kowloon. Due to urbanisation and extreme weather conditions, the drainage capacity of Kai Tak River could no longer meet the current flood protection standards. Serious flooding occurred in Choi Hung Road abutting Kai Tak River and affected Wong Tai Sin and San Po Kong during rainstorms. Kai Tak River is one of the 16 nullahs to be decked over within 10 years as announced in the 2005 Policy Address.

After river revitalisation, the public can take a stroll on the bridge over the Kai Tak River and enjoy a glimpse of the watery scenery beneath the bridge.

Through public engagement exercises before commencement of works, the DSD was able to conclude the design principles, with flood prevention as the priority focus, and surrendering the decking over option, replacing with the revitalisation of the Kai Tak River as an urban green river corridor.

The Kai Tak River Improvement Works commenced in 2011 and was completed in 2018.

The Kai Tak River passes through the public housing estates in Wong Tai Sin and witnesses the development taken place in Kowloon East

The Kai Tak River has cultivated a mangrove field, which is a rare wetland in the urban area of Hong Kong.

Engineered wetland of the Yuen Long Bypass Floodway

Yuen Long Bypass Floodway is a 3.8 kilometres long drainage channel built at the south of Yuen Long Town, intercepting 40% of the runoff originally flowing through Yuen Long Town Centre and diverting the runoff to the downstream of Kam Tin River. The project has affected some fish ponds and farmland. In order to make up for the ecological losses, the DSD has transformed three abandoned fish ponds into a 7 hectares engineered wetland to create ecologically enriched habitat for wild birds, amphibians and dragonflies.

The engineered wetland mainly consists of three main ponds, a seasonal shallow pond and a permanent shallow pond. It also includes a crushed brick pond, an oyster shell pond, reed beds and a deep pond. Various aquatic plants, reeds and trees are planted in the engineered wetland with a bamboo woodland in the south, which is suitable for habitation of herons.

Construction of the Yuen Long Drainage Bypass in full swing in 2004

The water from the low flow channel of the Yuen Long Bypass Floodway first flows through the sedimentation ponds to allow solid particles such as sand and silt to settle. After being filtered and purified by passing through the crushed brick pond and oyster shell pond, the water is equally distributed into four reed beds for removal of nutrients before discharging into the engineered wetland.

After years of cultivation, the 7-hectare engineered wetland is now developed into a sustainable ecological habitat.

Since the wetland was established in December 2006, an accumulation of 118 species of birds have been recorded. In addition, a total of 21 species of dragonflies, 30 species of butterflies, 7 species of amphibians and 4 species of reptiles were also recorded including 7 species of butterflies not commonly found in Hong Kong. A total of 130 plant species were recorded in September 2009, of which 68% were native species. The recorded biological species include black-faced spoonbills, needle-tailed ducks, frogs, fireflies and mudskippers.

Japanese pipistrelles (Japanese House Bat) have been found inside these bat boxes in the engineered wetland

Reed is a common aquatic plant species in the engineered wetland at the Yuen Long Bypass Floodway

Nam Sang Wai River Education Trail

To educate the public on river training works done by the Government and to raise the public awareness on river conservation, the DSD has designated a Nam Sang Wai River Education Trail in November 2014. The trail begins at Castle Peak Road in Yuen Long, goes around Nam Sang Wai via the Yuen Long Bypass Floodway, new channel of Kam Tin River and Shan Pui River. The trail is about 5.5 kilometres long and takes 2 hours to complete. Ten exhibition panels are erected along the Trail to provide information on river training works and river ecology, as well as introduction on natural environment and species along the Trail. Visitors can read or listen to the education contents by scanning the QR code with their mobile phones.

Needle-tailed duck is a frequent visitor to the Nam Sang Wai River Education Trail

Plant facilities to change from grey to green.

Greening enhances the quality of life. The DSD has been striving to apply greening effort to soften its facilities in harmony with their surroundings, and making quality greening as an integral part in drainage and sewerage projects. To counter the adverse visual effects inherent to sewage treatment works and flood prevention facilities, different greening measures have been adopted to transform their outfits from dull and greyish to pleasant and chromatic. Besides, greening helps to improve biodiversity and microclimate, absorbing heat and reducing dust. Different species of trees and shrubs are planted to provide a sense of seasonal change.

The first vertical greening undertaken by the DSD, completed in 2006 at the Tai Hang Tung Flood Storage Scheme.

Peripheral landscape includes planter wall and buffer planting strip along the boundary, or landscaped podium opened for public use.

Landscaping works raise green coverage ratio and create harmonious visual effect, resituating the public impressions on concrete structures, sedimentation tanks, pumping stations, vents and boundary walls from solemn and monotonous to lively and appealing. Exemplars are the Stonecutters Island Sewage Treatment Works, Sha Tin Sewage Treatment Works and Cyberport Sewage Treatment Works.

In order to select suitable plants for planting at different facilities, the DSD set up a 2 000 square metres plant nursery at the Siu Ho Wan Sewage Treatment Works in 2014, in which more than 50 species of native plants were cultivated and were in trial planting under different conditions, including trial aquatic planting in water of different salinity. The Landscape Unit in the DSD selected appropriate plant species for planting in different facilities according to various site characteristics, not only beautifying the environment and maintaining biodiversity, but also bringing a new look to the facilities.

Green roof at the Central Sewage Pumping Station looks tranquil and refreshing against the buzzy and busy commercial district in the background

Greening can be found in every corner within the DSD's plants

The plant nursery at the Siu Ho Wan Sewage Treatment Works

The DSD also accords priority to green design when building new facilities. In 2016, the Kowloon Bay Sewage Interception Pumping Station was bestowed the highest BEAN Plus Final Platinum rating for New Buildings. The sewage interception facilities at the Kowloon Bay Sewage Interception Pumping Station operate its overflow weir automatically by analysing weather warning signals obtained from the Hong Kong Observatory. Polluted dry-weather flow from Jordan Valley box culvert is intercepted to the trunk sewers to reduce the dry-weather flow discharging to Kai Tak approach channel and Kwun Tong Typhoon Shelter, thus reducing pollution and odour nuisance. The design concept of this automatic overflow weir was later adopted in the Happy Valley Underground Stormwater Storage Scheme.

It is noteworthy that an eight metres high and over 40 years old Bead tree *Melia azedarach* was transplanted successfully during construction.

The Bead tree *Melia azedarach* at its new location

Skylights and solar photovoltaic panels are installed on the roof of the Kowloon Bay Sewage Interception Pumping Station. The transplanted Bead tree *Melia azedarach* can be seen. at the top right corner of the photo.

The Bead tree *Melia azedarach* sitting in a steel-made basin was getting ready for transplantation during construction of the Kowloon Bay Sewage Interception Pumping Station

Future plans for revitalization and optimization

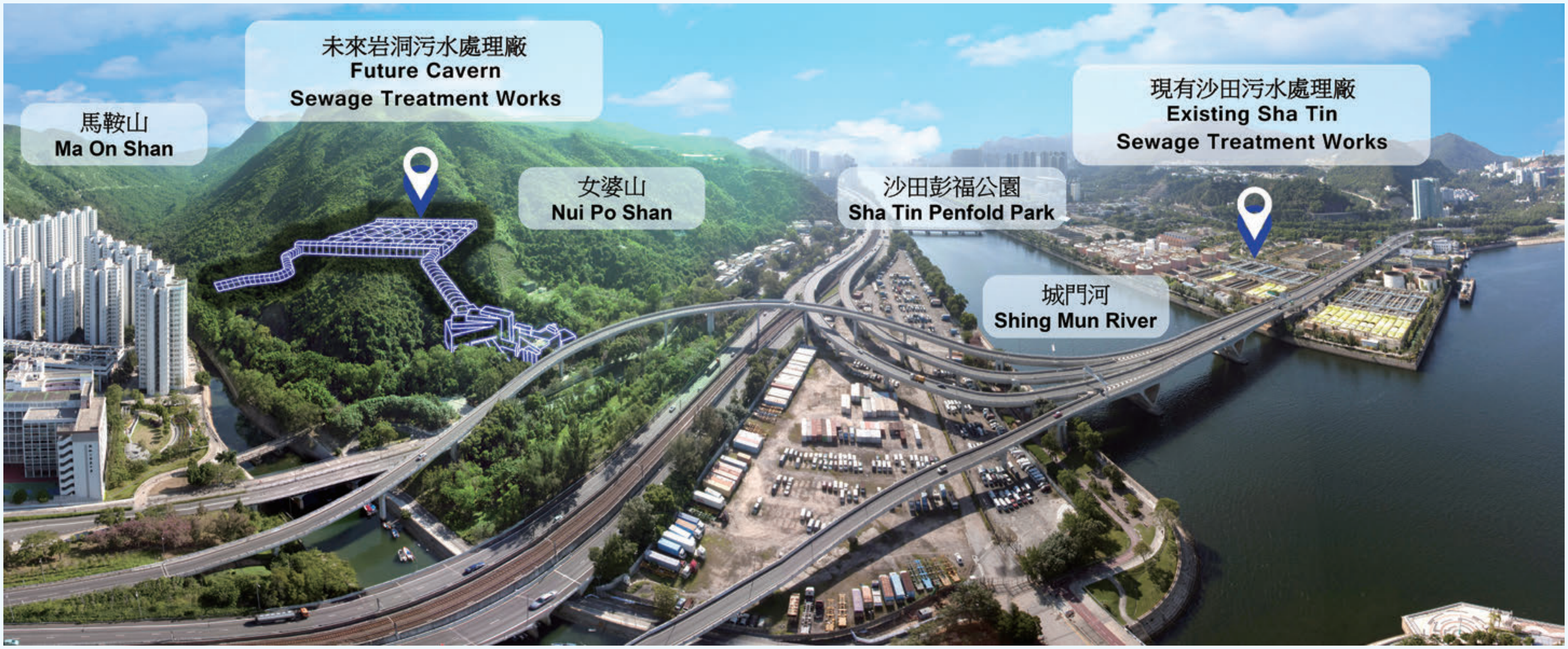
Relocation of Sha Tin Sewage Treatment Works to Caverns

Land supply has always been a great challenge to the development in Hong Kong. In Chapter 2 above, it has been mentioned about the large scale reclamation carried out as early as in 1860s by levelling hills and reclaiming the harbour to create new land for the sustainable development of Hong Kong.

The existing Sha Tin Sewage Treatment Works (STSTW) has been operating for more than 30 years. In facing the ever increasing amount of sewage from the district, the open-air designed STSTW would have to deal with a greater challenge on odour control. As such, the DSD initiated to relocate the STSTW into rock caverns in Nui Po Shan at Tai Shui Hang. The existing 28 hectares of land can be released for other beneficial uses, and will also improve the neighbouring environment.

The relocation also provides an opportunity to adopt the "state-of-the-art" sewage and sludge treatment technologies for improving its operational efficiency and enhancing its energy efficiency.

The first stage of the project comprising construction of a connecting tunnel has commenced in 2019 and the whole project is expected to take 11 years to complete.



The STSTW to be relocated to man-made caverns across the Shing Mun River

Inter-Reservoirs Transfer Scheme

The Kowloon group of reservoirs consists of the Kowloon Reservoir, the Shek Lei Pui Reservoir, the Kowloon Reception Reservoir and the Kowloon Byewash Reservoir. The Kowloon Byewash Reservoir is at the lowest geographical location, while the Kowloon Reservoir was the first reservoir among the group constructed in 1910. The Kowloon Byewash Reservoir was completed in 1931 and was the last reservoir built among the group. Under the Inter-Reservoir Transfer Scheme, the DSD is building a water tunnel of about 2.8 kilometres long and 3 metres in diameter from the Kowloon Byewash Reservoir to the Lower Shing Mun Reservoir to transfer the collected runoff from the Kowloon group of reservoirs to the Lower Shing Mun Reservoir. This Scheme, when completed in 2022, will improve the flood protection level in West Kowloon areas to combat climate change, and effectively create a designated storage capacity in the Kowloon Byewash Reservoir to receive further runoff from the catchment. It is estimated that an additional 3.4 million cubic metres of fresh water can be collected each year on average, thus achieving both flood prevention and water conservation objectives.

The proposed water intake will be overlooking at the Grade II historic structure of the Kowloon Byewash Reservoir Dam

Outfall structure will be built at the Lower Shing Mun Reservoir at the end of the 2.8 kilometres long water tunnel

Dry weather flow interceptor at the Cherry Street Box Culvert

The polluted dry weather flow from the stormwater drainage systems in Kowloon Tong, Mong Kok and Yau Ma Tei is discharged into the New Yau Ma Tei Typhoon Shelter, which creates serious water pollution problem and long-standing odour nuisance.

The stormwater drainage systems that serve the above districts are connected to the Cherry Street Box Culvert for discharging into the New Yau Ma Tei Typhoon Shelter. According to the West Kowloon and Tsuen Wan Sewerage Master Plans Study Review completed in 2010, the dry weather flow in the Cherry Street Box Culvert was polluted and affecting the water quality of the receiving waters at Kowloon West. Therefore, the Review recommended to build a dry weather flow interceptor at the outfall of the Cherry Street Box Culvert to intercept the polluted dry weather flow from the urban areas and prevent it from entering the New Yau Ma Tei Typhoon Shelter.

The proposed underground dry weather flow interceptor and the sewage pumping station will be built along the waterfront of the New Yau Ma Tei Typhoon Shelter with automatic penstocks and desilting facilities. The polluted dry weather flow in the Cherry Street Box Culvert will be intercepted and diverted to the sewerage at the nearby Lin Cheung Road and conveyed to the Stonecutters Island Sewage Treatment Works. It is estimated that the dry weather flow interceptor will reduce about 70% of the polluted dry weather flow that enters the typhoon shelter a year. The project involves construction of the dry weather flow interceptor and 85 metres long waterfront promenade. The superstructure of the dry weather flow interceptor will be designed as a green garden in harmony with the adjacent promenade, which will be opened to the public.

The construction works of the project started in 2017 for completion in 2022.

Photomontage of the dry weather flow interceptor at the Cherry Street Box Culvert and its promenade

Revitalisation of Tsui Ping River

Situated between residential area and bustling industrial and business districts, Tsui Ping River runs along Tsui Ping Road and King Yip Street at the heart of Kwun Tong. Given its superb location and unique riverine characteristics, Tsui Ping River is well-positioned to become a valuable urban riverside public space. The DSD plans to revitalize this one-kilometre-long existing open nullah through the provision of attractive waterscape, landscape and ecological enhancement works. Riverside walkways, cross-river walkways and landscaped decks will be built to enhance connectivity in the area and to provide riverside amenity. Public waterside sitting-out facilities will be provided for amenity. To achieve better results for this river revitalisation project, the DSD has conducted public engagement through which public opinions have been collected to refine the scheme. The Tsui Ping River Revitalization project will be one of the focal river revitalization projects in the urban areas in the coming years.

The Tsui Ping River is located in the central part of Kwun Tong. Public feedback has been collected on the design of the Tsui Ping River Revitalization project through public engagement activities.

Tsui Ping River passes through the industrial/business districts and the residential areas. It is one of the few river channels remains in Kowloon East.

Enhancement works for Kwun Tong Sewage Pumping Station

Kowloon East is the core business district in Hong Kong. To cope with its future development, the DSD is carrying out enhancement works for the Kwun Tong Sewage Pumping Station to build an underground sewage balancing facility of capacity 16 000 cubic metres to provide temporary storage of excessive preliminarily treated sewage from Kwun Tong Preliminary Treatment Works and balance the sewage flow rate during extreme peak flow periods.

The enhancement works involves construction of a landscaped deck with the theme "Dancing Ribbon", to be built on the roof of the pump house creating a pleasure ground for public enjoyment so as to achieve the purpose of space sharing and multi-use of one venue, releasing more open space for public enjoyment. The enhancement works for the Kwun Tong Sewage Pumping Station was commenced in 2017 for completion in 2022.

Design concept for the Tsui Ping River Revitalization project (near King Yip Street)

The landscaped deck will include green corridors, viewing platforms, picnic sites, children playground and fitness facilities for the elderly.

Overview

The DSD draws up annual programmes for inspection and preventive maintenance of its facilities to ensure their smooth operation. The DSD has digitized drainage records and set up central electronic database for ease of retrieval of drainage information. The DSD has set up laboratories in some sewage treatment works to ensure that the sewage treatment processes comply with the statutory requirements. The DSD will gear up automation of the laboratory work flows to further enhance the efficiency of laboratory work. When adverse weather prevails or an event of emergency occurs, the DSD will activate the Emergency Control Centre to provide mitigation service for the public, whereas its Direct Labour Force will handle the daily drainage blockage cases.

The DSD's 350 flood protection and sewage treatment facilities account for about 10% of the total electricity consumption of the Government. The Department is committed to developing renewable energy (solar energy and biogas, etc.) for energy conservation and emission reduction. Among the facilities, the Siu Ho Wan Sewage Treatment Works is equipped with one of the largest solar farms in Hong Kong.

In recent years, the DSD has been implementing "Blue-Green Infrastructure" based on the "Sponge City" concept to promote natural greening, revitalise water bodies and achieve sustainable development, while actively developing and adopting the latest smart technologies to provide world-class sewage treatment and stormwater drainage services to Hong Kong.

The DSD and the professional, academics and the industry sector join hands as one team to venture the path of research and development

Today, science and technology advance rapidly. If we remain too conservative and close-minded, we will not be able to keep up with the pace of the 21st century. It has been 30 years since the inception of the DSD, which is now managing about 350 drainage facilities (including 67 sewage treatment works) and 4 600 kilometres of drains and sewers. We have been moving with times and striving to promote innovation, scientific research in local engineering projects and environmental protection, with a view to applying the research results to enhance of our sewage treatment and stormwater drainage services.

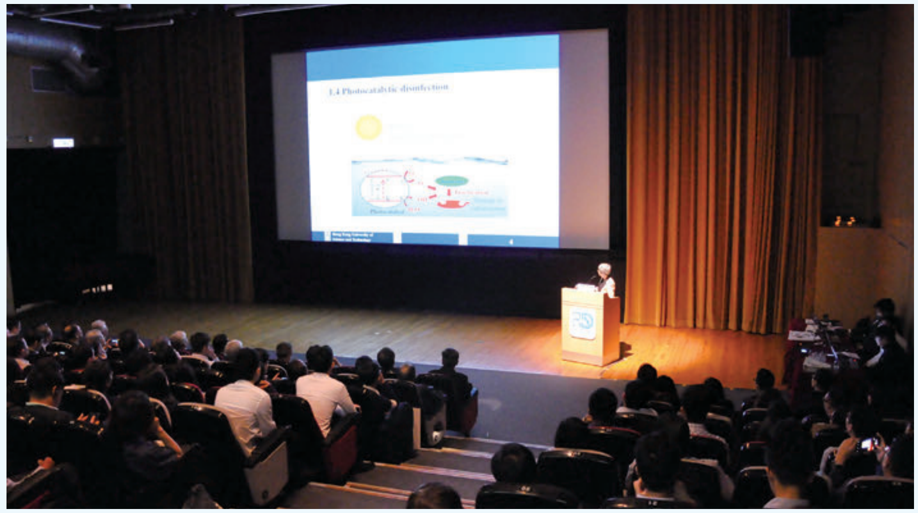
Research and development

In its early day, the DSD already had a senior engineer designated to co-ordinate and conduct research and development projects. The Department gradually anchored strong footholds in the research and development field over the course of time. A Research and Development Steering Committee chaired by the Deputy Director was even set up in 1998. The Committee comprises two research and development teams, co-ordinating scientific research activities in civil engineering and electrical and mechanical engineering.

Today, the DSD fosters collaboration with local and overseas experts, academics, international scientific research institutions and industry stakeholders on research and development projects across a wide spectrum of multi-disciplinary fields.

Since 2006, the Department has been holding the Research and Development Forum every year. Industry leaders, professors and experts are invited to deliver thematic speeches, while stakeholders exchange ideas, appraise the latest technologies and explore collaborative opportunities. Participants at the Forum include representatives from construction and environmental sectors, government departments, engineering consultants, contractors, and students from tertiary institutions. In addition, the DSD is frequently honoured with awards for its research and development findings presented and exhibited at international conferences.

In November 2014, to celebrate its 25th anniversary, the Department hosted the DSD International Conference 2014, which attracted more than 300 participants from Hong Kong and overseas, and a total of 36



The Research and Development Forum held by DSD has become one of the annual renowned events in the engineering, environmental and academic sectors

technical papers were published. In 2019, which falls in its 30th anniversary, the DSD co-organised the 8th IWA-APSIRE Conference and Exhibition with the International Water Association Asia Pacific Regional Group and other organisations. The 3-day Conference and Exhibition attracted over 1 000 participants from all over the world and hundreds of papers on wastewater and stormwater management were presented by international water professionals. On both occasions, the DSD and the IHE Delft Institute for Water Education (formerly known as UNESCO-IHE) signed the five-year-term Memorandum of Understanding on Knowledge and Capacity Development in Sustainable Stormwater Management.

The research and development projects undertaken by the DSD on sewage treatment focus on advancing sewage and sludge treatment technologies, odour management and renewable energy development, while those on stormwater drainage centre on hydrology and hydraulics, sustainable drainage system, asset management, smart drainage system, design and material applications, as well as project management.

In the past 10 years, the DSD completed nearly 100 research and development projects. Some of those 50 projects, which were ongoing during 2018, are outlined as follows:

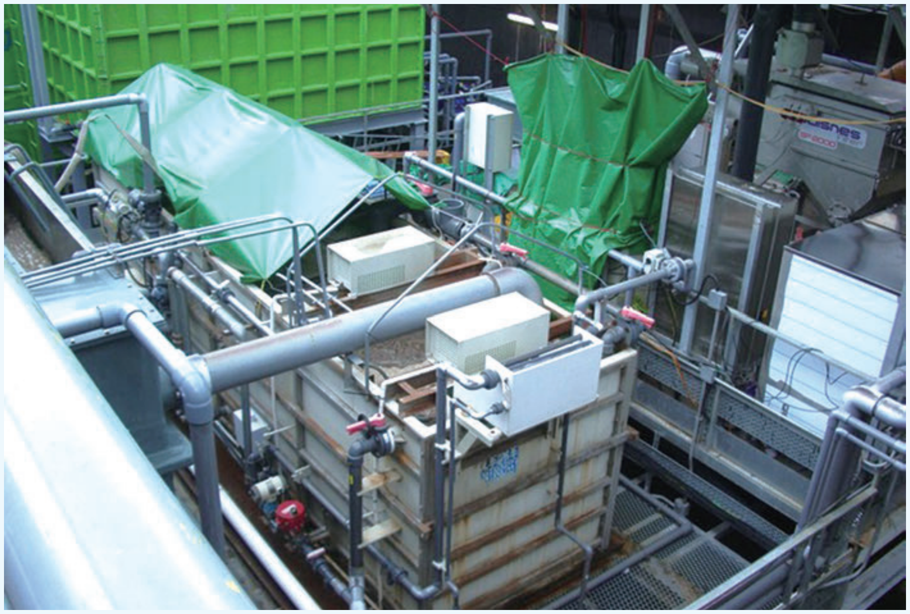
Compact sewage treatment technologies

Advances in sewage treatment technologies and equipment have provided the opportunities to build compact sewage treatment plants that are of smaller footprint and yet are able to produce high effluent quality. Many sewage treatment specialist firms design and build customised compact sewage treatment modules for individual plants and communities. The Department has carried out trials on different compact sewage treatment technologies to assess their suitability for wider use in Hong Kong.

The study on the application of hybrid biological sewage treatment technology using a combination of biofilm and activated sludge is a good example. Developed in northern Europe, this technology utilises specialised polyethylene media of complex profiles as biofilm carrier in activated sludge reactor to increase the total amount of micro-organisms for achieving greater and faster decomposition of pollutants. After trial use at the Stanley Sewage Treatment Works in 2009, this technology was proved to be successful in removing nitrogen. This technology requires a smaller footprint and is most suitable for upgrading that are the capacity of activated sludge system to meet increased demands.

Membrane Bioreactor (MBR) is another technology which has been studied. An MBR comprises a bioreactor and a membrane filtration unit. The membranes in an MBR can filter out suspended solids and produce high quality effluent. An MBR has the advantage of a small footprint and therefore it facilitates upgrading of a sewage treatment works with limited footprint. Between 2014 and 2015, the DSD carried out a pilot study to try out sidestream MBR and an immersed MBR at the Sha Tin Sewage Treatment Works. The results showed that both technologies could meet the specified effluent quality standards. The pilot project further revealed that the immersed MBR outperformed the sidestream MBR in terms of energy efficiency, chemical consumption, maintenance requirements and treatment capacity. A DSD engineer from the research and development team had written a paper based on this study and received the Hong Kong Institution of Engineers (HKIE) Outstanding Paper Award for Young Engineers/Researchers 2016.

The two reactors in Stanley Sewage Treatment Works have combined Biofilm with Activated Sludge process



A pilot compact sewage treatment plant comprising a mechanical filter mesh and membrane bioreactors was set up at the Sha Tin Sewage Treatment Works to investigate their performances

Co-settling technology

In 2011, the DSD started adopting the "Co-settling Technology" to recycle portion of surplus activated sludge after secondary biological treatment by returning the sludge back to the primary sedimentation tanks via specially designed return system. This technology enables sedimentation, biological treatment and sludge thickening processes to take place simultaneously, thus saving time and energy required by on sludge treatment and improving the efficiency in anaerobic digestion. With more biogas thereby produced, more electricity would be generated as another benefit of this technology.

While implementing this technology at the Sha Tin Sewage Treatment Works, the plant has saved its annual electricity consumption by about 40%. With the reduction of sludge and increased production of biogas, approximate $6 million could be saved in annual electricity cost. The project has received several awards including the Certificate of Merit in the 2012 Hong Kong Awards for Environmental Excellence, the 2013 Innovation Award for the Engineering Industry of the Hong Kong Institution of Engineers, and the 2014 International Water Association (IWA) Project Innovation Awards.

Odour control — Superoxygenation system at Tung Chung Sewage Pumping Station

Sewage collected at Tung Chung and Chek Lap Kok Airport is conveyed to the Tung Chung Sewage Pumping Station and then pumped to the Siu Ho Wan Sewage Treatment Works over a six kilometres long rising mains. Sewage would become septic over such a long sewage conveyance network in the absence of oxygen to form malodorous compounds. When these compounds are released to the atmosphere, they will cause odour nuisance and safety hazards to workers in sewage treatment works. Dosing sewage with calcium nitrate in sewage is a general approach for the abatement of odour due to sulphide formation.

In July 2010, the DSD conducted a study on the application of Superoxygenation technology developed in the United States at Tung Chung Sewage Pumping Station to suppress hydrogen sulfide (the malodorous compound) generation for tackling the odour problems. Test results have revealed that the Superoxygenation technology could reduce hydrogen sulfide concentration from 1 000 ppm to only 1.6 ppm. The recurrent cost of this technology is comparable to that of the current practice of adding calcium nitrate. The DSD continues to gain more experience in utilizing the technology and review its application and efficiency in odour abatement.

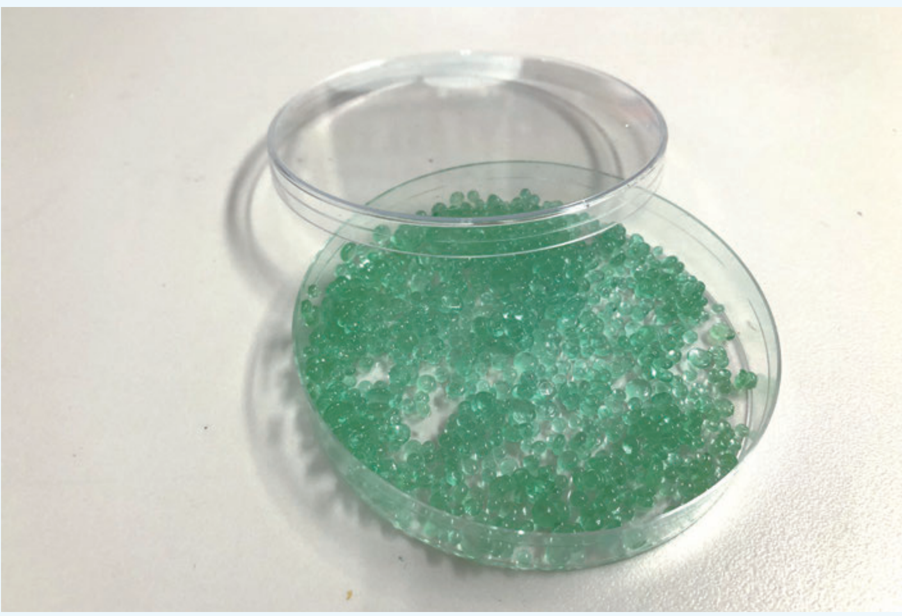
Part of the sewage will be conveyed to this conical oxygen dissolving tank where it is oxygenated and then returned to the main sewer

Odour control — Hydrogel

The malodour suppression Hydrogel is a revolutionary product developed in Hong Kong for inhibition of bacteria growth and odour control. The underground drainage systems provide suitable environment for anaerobic bacteria to grow and generate large amount of hydrogen sulfide which is a common malodour gas. At the end of 2016, the DSD invited the Hong Kong University of Science and Technology (HKUST) to develop a Hydrogel product that could control odour through smart inhibition of bacteria growth. The research team formulated a granular Hydrogel by mixing Hydrogel with catalysts that could inhibit bacteria growth and suppress hydrogen sulfide. The team conducted field study to evaluate the Hydrogel performance in stormwater and sewerage systems at 10 locations (including Shing Mun River, the Cherry Street box culvert, the Jordan Valley box culvert and Kowloon Bay Sewage Interception Pumping Station). The study confirmed that the Hydrogel could effectively reduce hydrogen sulphide concentration by 99% to 0.1 ppm (one ten-millionth), which is nearly undetectable.

SANI wastewater treatment technology

Another innovative technology developed in Hong Kong is the integrated wastewater treatment process called the Sulphate reduction, Autotrophic denitrification, and Nitrification Integrated (SANI) process. A demonstration of this technology was carried out at the Sha Tin Sewage Treatment Works by the DSD jointly with HKUST researchers in mid-2010s. Hong Kong has been using seawater for toilet flushing since 1950s, making it one of the few cities in the world that use seawater extensively for toilet flushing nowadays. In view of the characteristics of the sewage in Hong Kong with high sulphate content, the SANI wastewater treatment process pioneered the use of sulphate existing in the saline wastewater as a medium to introduce a sulphur cycle into the traditional carbon and nitrogen cycles for sulphate reduction, nitrification and autotrophic denitrification. Owing to the slow growth of micro-organisms in the process, this technology can significantly reduce sludge production by as much as 70%, thereby achieving energy and space efficiency.



The Hydrogel used in drainage systems could inhibit bacteria growth and control odour for 30 days

The SANI wastewater treatment technology was bestowed the Bronze Medal for Breakthroughs in Research and Development in the 2018 IWA Project Innovation Awards, and the Gold Award in the 2018 Hong Kong Green Innovations Awards

Study on operating conditions of food waste/sewage sludge anaerobic co-digestion

Hong Kong disposes of more than 3 600 tonnes of food waste daily to the landfill sites, which is not in line with the principle of sustainable development and has a negative impact on the environment. Therefore, in addition to providing organic waste treatment facilities to deal with the food waste, the Government advocated, in the 2016 Policy Address, the use of existing sewage treatment facilities for food waste/sewage sludge anaerobic co-digestion to raise food waste treatment capability. To this end, the DSD and the University of Hong Kong (HKU) conducted a series of tests called the Study on Operating Conditions of Food Waste/Sewage Sludge Anaerobic Co-digestion in the university's laboratory to establish the operating conditions required for the Food Waste/Sewage Sludge Anaerobic Co-digestion Trial Scheme, including quantitative studies on the increase in biogas production during the anaerobic co-digestion process and reduction in sludge volume.

Furthermore, the Government built the food waste pre-treatment facilities which commenced operation in 2019 at the Shuen Wan Leachate Pre-treatment Works in Tai Po. These facilities provide a maximum of 50 tonnes of pre-treated food waste a day to the sludge anaerobic digestion system at the Tai Po Sewage Treatment Works for food waste/sewage sludge anaerobic co-digestion.

Workers working inside the anaerobic sludge digester

A section of draft tube is being installed in the sludge anaerobic digester at the Tai Po Sewage Treatment Works to facilitate the Food Waste/Sewage Sludge Anaerobic Co-digestion Trial Scheme

Food waste/sewage sludge anaerobic co-digestion technology testing equipment in HKU laboratory

Conversion of a CHP system into a CCHP tri-generation system

To improve energy utilisation in sewage treatment works, the DSD and the Hong Kong Polytechnic University (PolyU) have jointly conducted a feasibility study on combined cooling, heating and power (CCHP) tri-generation system. The team has installed an absorption chiller at Sha Tin Sewage Treatment Works and connected it to the existing combined heat and power (CHP) biogas generator. The residual heat of the generator drives the absorption chiller to produce chilled water that cools the intake air of the generator, thereby improving its performance.

From a conventional single-function power generation system and municipal electricity supply to the CHP generator using the biogas generated during sludge treatment process, and then from that to the CCHP tri-generation system, these significant changes are the milestones in the DSD's persistent pursuit of improvements in energy efficiency and reduction in emissions and waste.

Heat island effect study

In mid-2016, the DSD commissioned the consultants on river revitalisation study and the Chinese University of Hong Kong (CUHK) to investigate the effect of various land covers on urban heat island effect and thermal comfort in Hong Kong. The study results show that rivers, streams and other water bodies improve thermal comfort. Different riverbed materials and design would have effects on the riverbed temperature. If Blue-Green elements could be added to the river revitalisation projects, they would improve the thermal environment and mitigate the heat island effect to create a more pleasant, water-friendly environment for the public. The findings of the study are useful for the formulation of river revitalisation design guidelines and management strategies.

The CCHP tri-generation system installed at Sha Tin Sewage Treatment Works utilises the residual heat of generators to produce chilled water for cooling some facilities within the plant

The heat island effect study has found that the surface temperature over concrete channel bed under sunlight could be as high as 62°C

Eco-hydraulics study on green channels

In recent years, the DSD has introduced the "Blue-Green Infrastructure" concept in green river channel design. To assess environmental benefits of green channel design and hydraulic characteristics of different ecological and environmental improvement measures, the Department has conducted an eco-hydraulics study on green channels to provide important insights into the merits and demerits of various green channel design in terms of ecological rehabilitation and hydraulic performance. The study also assessed the hydraulic resistance of green plants suitable for growing in green river channels. The first stage of the study commenced in early 2012 and was completed in mid-2014.

Site trials for the second stage began at the end of 2015, and the ecological enhancement works were completed in early 2017. One of the trials took place at a section of Lower Lam Tsuen River near Mui Shue Hang Playground in Tai Po. Different ecological environments, such as pools, rapids, bird habitats and aquatic plants were created, and natural materials were used to replace concrete riverbeds and riparian zones. Other trial sites include a section of the Ma Wat River near Fanling Highway and the downstream section near Jockey Club Road. After completion of the ecological enhancement project, plant varieties in river channels have increased. The native plants and wetland plants at both sides of the channels have created ecological environments suitable for animal inhabitation. The trial scheme includes drafting guidelines for green river channel maintenance and river ecological values for reference by green river management teams. This study won the Silver Award of the 2016 Hong Kong Institute of Landscape Architects Design Awards.

Ma Wat River before river ecological enhancement works

Lower Lam Tsuen River near Mui Shue Hang Playground before river ecological enhancement works

Ma Wat River after the rehabilitation of aquatic habitats

The riverbed and riparian zone of this section of Lower Lam Tsuen River has been given a new look after revitalisation using natural materials to replace the original concrete

Smart drainage monitoring system

The DSD endeavours to set up a smart drainage monitoring system that would allow real-time monitoring of the flow velocity of the drainage systems, water levels in manholes, gas concentrations, etc. In 2013, the DSD collaborated with the Department of Electrical Engineering of the CUHK to develop a wireless sensor network for monitoring changes in water levels, concentrations of three hazardous gases (i.e. hydrogen sulfide, sulphur dioxide and methane) and the opening status of manhole covers in the drainage systems. The monitoring devices transmit data through a wireless network to desktop computers or mobile applications, and thereby facilitating data analysis. The smart drainage monitoring system was tested in Kowloon Bay in 2016 with satisfactory results. Further studies on data transmission technology and system reliability in older urban districts such as Hung Hom are planned.

Data collection device (right) and ultrasonic sensor (left)

River biodiversity improvement

Fireflies require a high level of cleanliness in their natural habitats. The DSD invited the Firefly Conservation Foundation to jointly work on a pilot project to restore river ecology and improve biodiversity at several rivers in the New Territories. The improvement measures at Kwan Tei River achieved remarkable results and attracted fireflies to return. Within 12 months, the number of fireflies increased from a few to about 30 to 50, including *Luciola ficta*, a species of aquatic firefly that was considered to be extinct in Hong Kong for 100 years.

Luciola terminalis appeared after river ecological restoration

Aquatica ficta, a rare aquatic firefly species, seen in the river after ecological restoration.

A joint activity with students from a secondary school to bring fireflies back to nature

Shuen Wan Drainage Improvement Works

The Shuen Wan Drainage Improvement Works in Tai Po adopted stormwater storage and interception approaches in the flood prevention design. A box culvert was constructed in the upper stream of Wai Ha River to divert part of the runoff to Plover Cove, and excessive water would be stored in a 0.8 hectare low-lying wetland. Since commissioning in 2014, the works have been effective in mitigating the flood risks to Tung Tsz Road and nearby villages. Nevertheless, the ecological conditions of the wetland deteriorated due to less tidal water backflow into the wetland. To remedy the situation, the DSD engaged consultants to explore the feasibility of allowing more ingress of seawater into the wetland by lengthening the opening time of the automatic penstock (especially on clear days, or cloudy days with or without drizzle).

The original penstock operation was based solely on tidal levels. An optimisation scheme was then devised to take into account the weather forecast and real-time rainfall measurements. For instance, the penstock could be closed at a higher tide level during the winter period from December to February and on non-rainy days, whereas during other periods, the penstock would be closed at a lower tide level. Site trials and hydraulic model simulation were conducted to assess the potential flood risks under the optimisation scheme.

Following the study, the DSD engaged a contractor to design a new operation programme and provide ancillary facilities. The new operation programme determines the penstock operation mode based on the prevailing rainstorm warning signal, real-time rainfall measurements, as well as forecast rainfall amount from SWIRLS (Short-range Warning of Intense Rainstorms in Localised Systems) nowcasting system of the Hong Kong Observatory. This is the first flood prevention system in Hong Kong that takes into account regional weather forecasts and real-time rainfall measurements. After a phased trial in 2015, the system was officially implemented in 2017. Field tests confirmed that this optimisation scheme successfully extended the penstock opening time, allowing more ingress of seawater from Plover Cove to the upstream wetland without compromising the drainage capacity of the Shuen Wan stormwater drainage system. In the past few years, even in heavy rains and during the passage of the two super typhoons (i.e. Hato in 2017 and Mangkhut in 2018), there was no flood incident reported on Tung Tsz Road and in adjacent villages.

The inter-tidal wetland restored by optimisation of penstock operation modes

Creativity and Innovation

"Whether a community or industry can thrive on innovation is dependent on the willingness of the community to change in accepting innovation, and the room for allowing failure in being innovative", put forward by Mr. Edwin Tong Ka-hung, former Director of Drainage Services, in a forum hosted by the Civil Division of the Hong Kong Institution of Engineers, and at the Development Bureau "Project Capability Building Programme" in 2018. To thrive for application of innovative ideas, the DSD must brave the challenges and dare to bear the risks in order to implement the widely accepted innovative ideas.

The DSD is committed to promoting innovative culture and self-initiated research and development, nurturing creative and innovative mentality within the Department, consulting engineers, contractors, and working partners. Over the years, the DSD has initiated many innovative ideas within the fields of engineering design, construction and maintenance. Three of such innovative technologies adopted by the Department are cited in the following, while many others are illustrated in the previous chapters.

Tunnelling technology

Deep tunnelling

The HATS Stage 2A, apart from being a world-class environmental infrastructure project, has taken on cutting-edge deep tunneling technology. The works under the project comprised the construction of 21 kilometres of sewage tunnel located at depths varying from 70 metres to over 160 metres below sea level, using drill-and-blast for some sections. As the blasting took place in deep subsea levels, the amount of explosives to be deployed had to be carefully calculated, the locations of drill holes carefully chosen and the pre-excavation grouting (PEG) executed in order to control the groundwater ingress. Besides using the latest PEG technology to meet the stringent groundwater ingress levels during tunnel construction, at some difficult locations the project team used highly concentrated brine frozen to -30°C to freeze the ground around the tunnel before excavation. This artificial ground freezing method is applicable to tunnelling through complicated ground conditions such as mixed silt and gravel foundations adjoining seawalls.

Horizontal directional drilling technology was employed for construction of the twin sewage tunnels between Ap Lei Chau (shown in the picture) and Aberdeen bypassing high voltage sub-marine electric cables

Horizontal directional drilling

In 2010, the DSD constructed the twin 600 millimetres inner diameter sewage tunnel between Ap Lei Chau and Aberdeen under the HATS Stage 2A with the horizontal directional drilling (HDD) method. The tunnels are 1 400 metres long, reaching 100 metres below sea level. A pilot hole of 300 millimetres diameter was first drilled down from the ground surface at Ap Lei Chau along the designed alignment level in the seabed using bentonite slurry to stabilise the drilled hole. The pilot hole was then enlarged by reaming gradually till it reached 900 millimetres in diameter for a high density polyethylene pipe of 600 millimetres inner diameter to be pulled from the other side of the seashore, forming a new sewer.

After construction of the sewage tunnels between Ap Lei Chau and Aberdeen by HDD, the DSD employed the same technology to construct two submarine outfalls, each of 500 metres and 750 metres in length, in Yung Shue Wan and Sok Kwu Wan on Lamma Island to avoid disturbing the offshore corals and the fish culture zones. This is the first time Hong Kong applied the HDD technology in a "land-to-sea" circumstance, with the back reaming and pipe pull-back operations carried out seaward.

Trenchless technology — pipe jacking

Pipe laying is generally carried out by open-cut or trenchless excavation. Open-cut excavation is a traditional method of laying pipes in an open trench, while trenchless construction is similar to tunnelling method where most of the processes are taken place underground, causing less noise nuisance or impact on road users. Trenchless construction, however, requires more sophisticated technical skills and involves higher risks, putting its cost several times higher than that of open-cut excavation.

The DSD started using trenchless technology on laying trunk sewers in early 1990s for projects under the Sewerage Master Plans and Drainage Master Plans. Pipe jacking techniques are commonly adopted.

Pipe jacking (or micro-tunnelling) involves boring of a tunnel for laying pipes. A pipe is jacked forward incrementally by a hydraulic jack from a launching shaft towards a receiving shaft, while the ground materials would be excavated manually inside a hand shield, or more commonly by a automatic remote controlled tunnelling machine.

In early 1990s, a project team used the pipe jacking method to install pipelines successfully over 1 000 metres long under the West Kowloon Reclamation hinterland drainage works phase 2. In the late 1990s, another project team under Wan Chai East and North Point sewerage works made a breakthrough by using the pipe jacking method to lay 440 metres of trunk sewers with a diameter of 1 200 millimetres and hyperbolic alignments. In 2017, the DSD adopted the same method to lay a twin pipe trunk sewer of 250 metres with a diameter of 1 500 millimetres for each pipe underneath Shing Mun River Channel in Sha Tin.

In recent years, the DSD has adopted the pipe jacking method to lay pipes across major obstacles, such as the Dongjiang watermains, railway lines and trunk roads.

A jacking pipe is being lowered into the launching shaft

Set sail our own fleet of vessels

After commissioning of the HATS Stage 2A in 2015, the sewage treatment capacity of the Stonecutters Island Sewage Treatment Works (SISTW) is expected to be increased correspondingly, with the amount of sludge to be treated daily surging from 600 tonnes (about 50 sludge containers) to 800 tonnes (about 65 sludge containers). Should the conventional tug and barge transportation method continue to be used to transport the sludge from the SISTW to the sludge treatment facility in Tuen Mun, when typhoon signal No. 3 or above is hoisted, the barges would have to return to typhoon shelters and sludge would be disposed of by land transport. After the passage of typhoons, it would take much longer time to resume the marine transportation. As such, the DSD has decided to enlist its own fleets, that two ocean-going vessels, *Clean Harbour 1* and *Clean Harbour 2*, constructed by the DSD, officially set sail in 2015. These two vessels are also the first ever eco-friendly diesel-electric powered vessels registered in Hong Kong. Even if typhoon signal No. 3 is in force, the two *Clean Harbour* vessels can still operate, avoiding sludge piling up at the treatment plant. Each vessel has a displacement tonnage of 3 400 tonnes and accommodate up to 90 sludge containers, transporting about 1 200 tonnes of sludge.

The sludge vessel, *Clean Harbour 1*

The sludge vessel, *Clean Harbour 2*

Revitalisation of water bodies

The main objective of river improvement works in early days in Hong Kong was flood prevention with a prime aim that the flood prevention facilities could be commissioned as soon as possible for early flood risk mitigation. River channels built at that time were dull and plain with little ecological value. As times change, river channel design has undergone significant improvements, with more emphases being given on aesthetical appearance, ecological and environmental considerations.

The DSD is committed to revitalising the water bodies to create a lively and water-friendly environment for supporting more diverse flora and fauna, as well as attracting citizens to enjoy the waterfront, making the water bodies become local landmarks. Turning from open nullahs built during the 1960s to 1970s with mainly hard materials such as concrete, to channels with green elements in the 1990s, and to channels built today which fulfil the purposes of flood prevention, river revitalisation, eco-conservation and water-friendliness objectives, the DSD, as one of the major departments managing water bodies in Hong Kong, has made strenuous efforts to innovate.

The illustrations below depict some innovative green measures on river revitalisation.

Fish shelters and deflector stones at the Kai Tak River provide habitats for marine creatures

Various species of flowers and shrubs planted along the riverbanks of the Ng Tung River create a breath-taking scenery

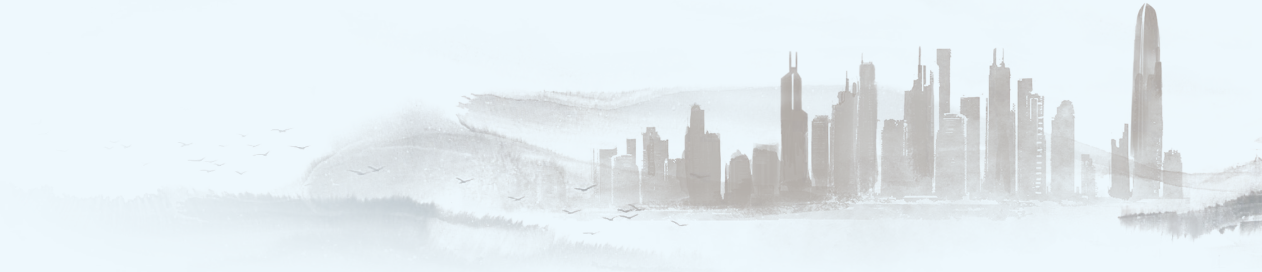
The use of natural materials for riverbed construction is a key element in the Revitalisation of Kai Tak River

Constructed wetland at the Ping Yuen River in the North District purifies river water and improves biodiversity

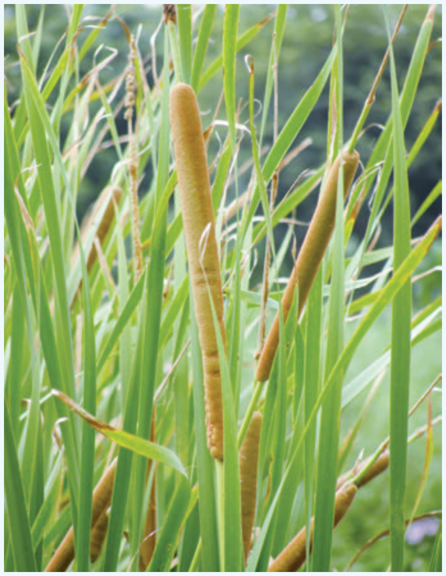
Gabions filled with bio-balls form biofilms for removing contaminants caused by livestock wastes

The planting raft at the Yuen Long Bypass Floodway on trial basis commenced in 2017, providing rest places for birds in deeper river channels

Trees reserved to form artificial tree island and enhance ecological conservation



The DSD will continue to incorporate innovative and creative water body revitalisation designs into the forthcoming river improvement projects and the daily river maintenance works, including the Revitalisation of Tsui Ping River which is under detailed design, as well as revitalisation of Tai Wai Nullah, Fo Tan Nullah and mid-stream of Tuen Mun River Channel, where the respective feasibility studies are in progress.



Typha orientalis Presl is one of the emergent plants selected for river greening works

Fish ladders placed at the downstream of a concrete weir at the Pak Ngan Heung River in Mui Wo to help maintain ecological continuity between the upstream and downstream waters

Pilot planting the urban on concrete embankments at the Yuen Long East Nullah provides urban greening and mitigates the urban heat island effect

Do it from the heart

Since its inception in 1989, the DSD has been committed to providing Hong Kong with world-class wastewater treatment and stormwater drainage services, while upholding the service motto "Do It from the Heart".

Public engagement Do it from the heart

In the late 1990s, during temporary closure of Nathan Road to make room for its drainage improvement works, the DSD specifically designed an "Apology" signage to show its apology to people affected by the works. Making an apology by the Government was extremely rare by then, but local shop operators, residents and road users welcomed it. Subsequently, the Joint Utilities Policy Group (comprising representatives of utility undertakers, the Highways Department, the Water Supplies Department and the DSD) accepted the DSD's design and today, the signage has become a standard signboard for road works. The Wan Chai East and North Point Sewerage Works also adopted a number of avant-garde concepts to strengthen communications with the communities. Examples are distributing telephone cards with the contact mobile phone numbers of the project team for public enquires, pioneering the use of transparent or translucent site hoardings, recruiting community relations officers, and delivering project newsletters and traffic notices on temporary road diversions. The aforementioned project unfolded a new chapter of public engagement for the DSD's works. The project team was honoured with the Silver Prize of Team Award in the Civil Service Outstanding Service Award Scheme 2005.

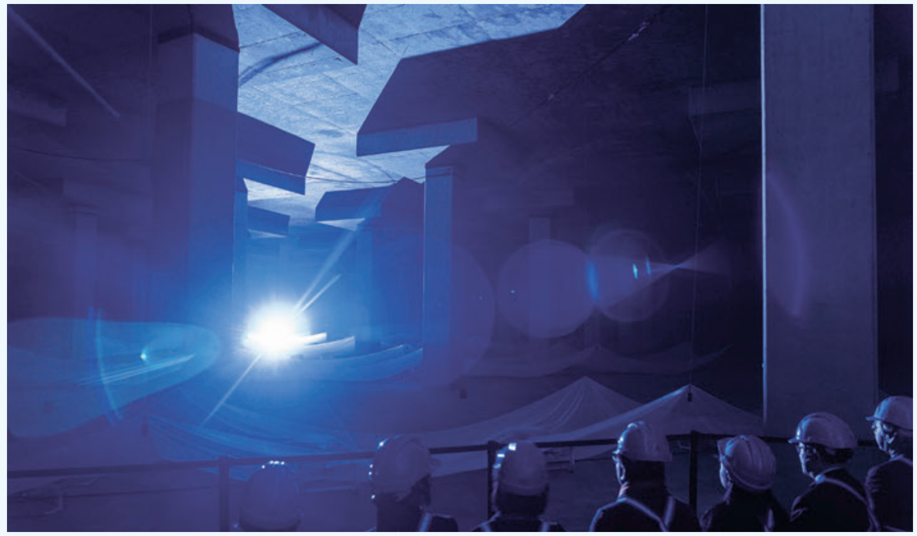
The "Apology" signage was originally designed by the DSD and used in the Nathan Road drainage improvement works for the first time

The Queen's Road Central Intercepting Drains project in the mid-2000s was boosted with even more innovative public engagement activities, including on-street exhibitions, public forums, newsletters, regular goodwill visits, project hotlines and stand-by liaison vehicles and work teams during inclement weather. As times change, these measures have become standard practice. In 2009, the project team was honoured with the Gold Prize of Team Award in the Civil Service Outstanding Service Award Scheme 2009.

The Queen's Road Central Intercepting Drains project team members regularly paid visits to over 200 shops and resident groups in the vicinity of the construction area to explain the works details and seek feedback

Connect with the public through multiple channels

The DSD values public feedback highly. Over the years, the Department has proactively arranged many public engagement exercises, such as open days, tea gatherings with the media and stakeholders, guided tours and school outreach activities, through various channels to interact with different sectors in society, disseminate information on major projects and their current status to the public, gauge their feedback and promote the image of the Department. In the past few years, the Department received over 12 000 visitors of the public (including primary school students) yearly on average through guided tours or outreach educational activities, introducing its daily operation. In early 2018, a new media art exhibition entitled "After the Deluge" was held jointly by the DSD and the Hong Kong Art Development Council (HKADC) at the Tai Hang Tung Stormwater Storage Tank (THTSST) for the first time. This exhibition used "water" as the main theme, combining the artwork and engineering, with the use of the Chinese classic mythology of "Dayu Tames the Water" to bring forth the contemporary "Dayu" flood prevention story. The event attracted over 10 000 visitors.


A new media art exhibition, "After the Deluge" staged inside the THTSST.


Primary school students at the Lai Chi Kok Drainage Tunnel Exhibition Centre


A new media art exhibition, co-organised with the HKADC at the THTSST, attracted over 10 000 visitors.

Sharing sessions with representatives from overseas governments and professional bodies

Holding forums with Mainland officials

Visitors took a glimpse of the DSD's routine operation on the Open Day at the ShaTin Sewage Treatment Works

Outreach educational programme at schools

Experience sharing forum with institutions and academic bodies from Mainland

Building a trustworthy partnership

New Engineering Contract

In 1997, the former Works Bureau implemented a non-contractual partnering trial scheme in the hope that through a partnership charter, mutual trust and collaborative working relationship would be strengthened with the contractors to jointly manage construction risks, improve contract management efficiency and minimise contractual dispute. The DSD's Kai Tak Transfer Scheme was one of the works contracts participating in this scheme.

In 2005, the DSD was invited by the former Environment, Transport and Works Bureau (renamed the Development Bureau in July 2007) to roll out a contractual partnering pilot scheme. To this end, the department set up a working group with the Legal Advisory Division (Works) of the Bureau to draft the implementation proposal, and prepare a sample contract form applicable to Hong Kong based on the New Engineering Contract (NEC) suite of contract forms of the Institution of Civil Engineers (ICE). The modified NEC model document was then submitted to a steering committee under the Bureau for endorsement. Members of the steering committee comprises representatives from the Works Branch of the Development Bureau, various works departments and the Independent Commission Against Corruption (ICAC).

The contract of the Improvement of Fuk Man Road Nullah in Sai Kung was awarded in 2009, becoming the first public works contract using the NEC outside the United Kingdom. The contract was completed six months ahead of schedule with a cost saving of about 5% (about HK$4 million dollars). The DSD convened a number of seminars and workshops for various works departments, the Hong Kong Construction Association (HKCA) and utility undertakers to brief the contractual partnering scheme. Mock tendering sessions were also organised for the contractors.

Today, the DSD has used the NEC in about 88 works contracts and 20 consultancy contracts, among which, the Happy Valley Underground Stormwater Storage Scheme is the largest project ever completed so far in Hong Kong using the NEC. The completion date of this project was 14 months earlier than scheduled, enabling the storage scheme to commence operation in one rainy season earlier and accruing a cost saving of about 10% (approximately HK$110 million).

Through implementation of the NEC, the DSD achieves the original objectives of establishing mutual trust and collaboration among contracting parties and promoting gradual changes to the work culture on construction sites.

Experience sharing session on the NEC organised by the Happy Valley Underground Stormwater Storage Scheme project team for staff from other works departments

The Department convened seminars on the contractual partnering for various works departments, the HKCA and utility undertakers. Mock tendering exercises were also organised for the contractors.

Design-Build-Operate

Besides the New Engineering Contract (NEC) form of contract, the DSD has also adopted the Design-Build-Operate (DBO) form of contract for sewage treatment works projects in recent years. The Pillar Point Sewage Treatment Works (PPSTW), commissioned in 2014, is the first sewage treatment works operated under the DBO contract in the DSD. This contract form specifies a longer operation period for bringing in longer term operating partners to build a mutual and trustworthy relationship and encouraging the contractors to make their designs of plant facilities more durable and cost-effective in terms of operation and maintenance. The DBO contract of PPSTW has successfully attracted the contractor to adopt cutting-edge wastewater treatment technologies developed in Europe. Based on the experience from the PPSTW, the DSD has modified the contract arrangement and adopted the same DBO form of contract on the Upgrading of San Wai Sewage Treatment Works, which is under construction for anticipated commissioning in 2020.

Photomontage of the upgraded San Wai Sewage Treatment Works

Green partners

The DSD attaches great importance to ecological conservation and environmental protection for boosting the sustainable development in Hong Kong. The Department started to collaborate with green groups in mid-2000s on the River Improvement Works in Lam Tsuen River to seek their expert advice on ecological conservation issues including fauna migration. The DSD and green groups began to have regular meetings and site visits from early 2010 to exchange views on proposed works involving water ecology and conservation, and to discuss measures on enhancing ecological conservation and environmental protection during construction stage. Representatives from green groups have been very generous in offering precious information and professional advice, bringing much benefit to the DSD project teams. More importantly, through ongoing communication, the previous tense relationship between government project teams and green groups has turned to a long-term collaborative one.

Regular gatherings with green groups to facilitate exchange of views

To cultivate further collaboration and strengthen the awareness of its project teams on ecological conservation, the Department often invites green groups to co-organise training courses, seminars and research and development forums on river ecology to share and consolidate experience gained in drainage works, as well as to explore opportunities for river revitalisation in Hong Kong.

At thirty, we stand firm and upon solid rock we built

Knowledge management

Today, the DSD possesses specialised and highly efficient teams. For this, the Department is obliged to invest more resources in knowledge management and staff development.

The DSD organises nearly 700 training courses each year, including induction courses, in-house training, duty visits, overseas conferences, seminars and workshops. These diversified programmes help enhance its staff's professional skills and knowledge. The average number of training hours per staff member each year is over 33 hours, far above that of employees in Hong Kong according to statistics from the Hong Kong Institute of Human Resource Management (18.3 hours in 2016).

To cope with forthcoming greater challenges, the DSD not only continuously encourages its staff to take part in local training courses and overseas duty visits to broaden their vision and learn about the latest technological management, but also arranges secondment to policy bureaux or overseas trainings for them. Through active participation and experience sharing with experts in the industry, innovative concepts could be introduced into the Department, hence improving its overall quality of service.

The transfer and management of knowledge is crucial to a works department. The DSD endeavours to promote experience sharing activities, talks and task groups for in-depth discussions on specific subjects, rendering support to less experienced colleagues. Electronic knowledge management portal is also set up for storing and sharing valuable information and experience.

Duty visit

Electronic platform

Apart from establishing the electronic knowledge management portal, the DSD has long been striving for improvement of efficiency, energy saving and waste reduction through computerisation and digitalised operations, in the pursuit of greener office and construction site.

For instance, in 2011 the DSD launched a paperless meeting portal, where meeting documents could be directly uploaded to it and attendees view the documents via tablets any time, without having to print out hardcopies, which greatly reduces the use of paper. Moreover, various office workflows have been computerised to replace paper forms or records, thereby saving substantial amount of paper and staff resources on circulation and filing of documents.

In 2015, the DSD asserted further on the paperless initiative and took the lead in establishing a certified electronic recordkeeping system. Apart from facilitating dispatch of files and archives, the system incorporates customised workflows for individual divisions, allowing better communication and coordination among team members without relying on hardcopy circulation. In early 2018, the Department was one of the first few departments having its electronic recordkeeping systems certified as official electronic archive systems. The Department also endeavours to introduce digitalised operations and practices to construction sites to keep abreast with the widely used Building Information Modelling (BIM), enabling personnel on design, construction, site management and operations and maintenance, to work on a common electronic management or BIM platform for information sharing and problem discussion under a paperless environment.

Paperless meeting

Cultural changes, different mindset, boosted skill and capability

While striving to promote innovation and scientific research, forge contractual partnerships, liaise with stakeholders from various sectors and nurture supporting staff through in-house training, the DSD, being a government department, fully understands that it must maintain integrity, comply with procedures, make good use of public money and be accountable to various sectors. Wavering and vacillating in the course of striking a balance and making a choice are sometimes inevitable. Against the constraints under the existing system, the social trend towards criticism in recent years, and the succession problem resulting from the post-war baby boomers reaching retirement age in the civil service, any slackness might easily lead to conservatism, bureaucracy and traditionalism. It will sure be a long-term challenge for the Department to stay open-minded, embrace changes, take initiatives and grasp the nettle.

On the firm foundation built by all workmates, old or new, the DSD will make steady strides, both internally and externally, in improving on hard-earned results; continuing with open-mindedness, team spirit, partnering culture and people-oriented pragmatism; as well as leveraging professional skills to interact and co-operate with the public, industry, academia and researchers.

Policy driven Full consideration To scale new heights

The construction industry has played an instrumental driver of the development of Hong Kong's economy and community, making Hong Kong one of the most reputable and dynamic cities in the world. The Government has launched Construction 2.0 in 2018 to maintain and strengthen Hong Kong's leading position in the construction industry, whilst enhancing the sustainability and long term growth of the industry. The three key pillars embodied in Construction 2.0 : innovation, professionalisation and revitalisation, will undoubtedly help the Hong Kong construction industry reach a new milestone. Being part of the construction industry, the DSD will join force with its industrial partners to facilitate continuous advancement of the construction industry in Hong Kong.

Responding to the Construction 2.0 initiatives on the existing basis, the DSD has consolidated the drives in respect of Innovation, Smart and Interaction. This sets a new stage for the Department to grasp development opportunities and reach a new horizon, with a principal objective of providing strong and sustainable world-class wastewater and stormwater drainage services.

"Innovation" includes innovation in procurement, design, technological applications and facility management. The DSD is striving to push the boundaries on exploring various possible non-conventional procurement modes, like inclusion of "life cycle cost" estimation in tender evaluation, use of different options in "NEC" forms of contract. Over the years, the Department fosters innovation and applies cutting edge technologies in engineering design, construction, operation and maintenance. In terms of research and development, the DSD has made strenuous efforts to undertake diversified and multi-disciplinary innovative research projects.

"Smart" is a predominant trend worldwide. The DSD is committed to digitalised management, wider use of BIM and other technologies, within the department and with industry partners, to enhance the quality of its assets during their life cycles, from conception to commission.

"Interaction" applies both internally and externally. This includes provision of facilities ranging from intangible platforms and spaces to tangible landscaped gardens and water features, for its staff, industry partners, academics, community groups and citizens, equipped with highly efficient management, quality support, and intelligent facilities in order to promote mutual communication and collaboration.

To this end, the Expansion of the Sha Tau Kok Sewage Treatment Works Phase 1 works with a project cost of HK$1 billion has been selected as a pilot project to adopt Construction 2.0. Along the direction of the three key pillars under Construction 2.0, the DSD puts into the practice the "off-site construction", "digitalisation of management", BIM, to raise the standards of site safety, innovation and technological advancement.

The Department will take the lead to launch more pilot projects on trying out the new generation of construction models; further our knowledge exchange with science and technology talents; set up local and overseas R&D information exchange networks; and encourage and support stakeholders to promote innovation and technology development with an aim to boost better results on interaction and collaboration. The DSD endeavours to provide highly intelligent, more environmentally friendly and more operationally efficient wastewater and stormwater drainage services, by joining hands with different sectors of the community to make Hong Kong a more liveable city.

The DSD has the great honour in its 30th Anniversary to be one of the co-organisers of the 8th International Water Association Asia-Pacific Regional Group Conference and Exhibition held in Hong Kong under the theme of "Smart Solutions for Water Resilience", joining hands with local and overseas water professionals for sustainable and equitable water management.

Expansion of the Sha Tau Kok Sewage Treatment Works Phase 1 is DSD's first pilot project adopting "Construction 2.0"

The DSD has the great honour to co-organise the 8th IWA-ASPIRE Conference and Exhibition in 2019

Overview

The DSD has been moving with the times since its establishment 30 years ago, endeavouring to promote innovative thinking and scientific research development. Set up in 1998, the Research and Development Steering Committee was chaired by the Deputy Director, with two research and development teams co-ordinating scientific research activities in collaboration with academics, the industry stakeholders and researchers.

The DSD is striving for innovation, while adopting cutting-edge technologies and novel ideas in its projects. Looking ahead, the DSD will continue to promote innovation and scientific research, cherishing its traditions and passing them on to the coming generations, with a view to striving for excellence and enabling Hong Kong to reach a new milestone towards a smart and environmental-friendly city.